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A1-T-01

Modelling the climate change signal in the Canarian Eastern Current Upwelling System with a regional coupled model

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The Eastern Boundary Upwelling systems (EBUS) have large ecological and socio-economic importance as major fishery grounds. However, EBUSs future behaviour is still uncertain due to the limitations of the global climate models to properly represent the coastal processes because of their coarse resolution. In the case of the Canary Current Upwelling System (CCUS), we show that a regional climate system model can fill this gap. The climate change signal over the CCUS is studied under RCP8.5 scenario. We identify the upwelling favourable winds along with the ocean stratification as key factors in the future changes in the CCUS. It is the combined effect of changes in both the wind patterns and ocean stratification that will impact the future of the vulnerable ecosystems that inhabit the CCUS.

The wind changes are seasonally dependent: in summer (winter), the upwelling favorable winds increase (decrease) along the Iberian coast and decrease (increase) for the African region. The model suggest that the Azores high is the main driver of these variations in winter, while in summer, the changes are attributed to the intensification of the Iberian thermal low along with an increase in mean sea level pressure over the British islands, which may be associated with a weakening of the Atlantic meridional overturning circulation (AMOC).

Along with changes in the wind patterns, our study reveals an increase of the ocean stratification in the CCUS, being more evident in the norther regions. This is due to a freshening in the upper layers of the north Atlantic in the future. This freshening is limited to the upper 200 m, which will generate an increase of the stratification in the shallow regions as the coastal upwelling. We found that ocean stratification plays a primary role in the northern regions of the CCUS, whilst its role decrease with latitude. Nevertheless, both ocean stratification and wind patterns have a significant impact on the future, showing the importance of studying both mechanisms under global warming conditions.

A1-T-02

Regional coupled modeling to improve understanding of the Southeast Asian climate

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Southeast Asia (SEA) gathers 9% of the world's population, with a population growth rate of 1% per year [1]. Both regional and global analyses have identified extreme weather and climate events as major climate change risks in the region [2, 3]. More recent global studies have also pointed out its increasing vulnerability to sea level rise, coastal floods and erosion, marine heatwaves and ocean acidity [3]. Implementing reduction, mitigation, and adaptation measures is therefore mandatory, and requires deeper regional knowledge about today and tomorrow's climate in SEA.

So far, Regional Climate Models (RCM) have performed generally better than Global Climate Models [4, 5, 2, 6], when most experiments in the region were based on single-component models. However, for the atmosphere, those uncoupled RCM runs were shown for instance to produce unrealistic rainfall over mainland SEA [7]. On oceanographers' side, the lack of interactive atmosphere often introduced uncertainties, when it was to simulate e.g. upwellings [8], or to estimate heat and salt budget in the South China Sea [9]. These reflections naturally led to the development of a coupled regional model, with the purpose of understanding more accurately the role of air-sea interactions in the SEA climate.

RegCM5 and Symphonie were chosen, as the atmosphere and the ocean components, respectively [10, 11]. OASIS coupler was implemented for handling both-way exchanges [12]. Parameterization with assessment of precipitation, wind fields, radiation budget, near-surface and sea-surface temperature, and salinity has been thoroughly conducted, comparing the model with satellite and in-situ data. Validation of the mean behaviour shows comparable or better results than uncoupled versions, depending on the metrics. Strong differences are identified locally in time and space, and we propose an analysis of these phenomena, pointing out through it the added value of air-sea coupling in SEA.

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A1-T-03

Coupled groundwater-to-atmosphere simulations with the regional climate system model TSMP as a contribution to the new European CORDEX-CMIP6 ensemble

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Explicitly considering groundwater and subsurface hydrodynamics can add value to regional climate model (RCM) ensembles. In such groundwater-to-atmosphere simulations typical feedback mechanisms and interactions in the terrestrial water cycle are altered, e.g., by a lateral redistribution of surface and subsurface water. It has been shown that this can, for example, change the land-atmosphere coupling, leading to an attenuation of extreme hydroclimatic events, such as droughts and heat waves, and it also allows for an assessment of the evolution water storage anomalies with relevance for many sectors. As part of the new CORDEX-CMIP6 experiment design, models with a higher complexity are encouraged, towards regional Earth or climate system models (RCSM). In this context, we run the coupled Terrestrial Systems Modelling Platform (TSMP, https://www.terrsysmp.org) RCSM as part of a Climate Limited-area Modelling Community (CLM-Community) (https://www.clm-community.eu/) RCSM ensemble over the EUR-11 (12km) EURO-CORDEX domain. This RCSM ensemble is complimentary to the balanced GCM-RCM downscaling matrix of EURO-CORDEX. TSMP consists of the COSMO (or alternatively ICON) atmospheric model, the Community Land Model, and the integrated hydrological model ParFlow, linked through the OASIS3-MCT coupler. TSMP simulates a closed terrestrial water cycle from the groundwater to the top of the atmosphere with a 3D variably saturated subsurface flow representation and a free-surface overland flow boundary condition. Here we show latest TSMP results for the EUR-11 domain of ERA5-driven ongoing CORDEX evaluation runs using an all-new hydrogeology. In addition to the baseline simulation, a simulation with human water use (HWU, water abstraction and irrigation) is run in parallel. Previous TSMP runs with HWU indicated (remote) impacts on atmospheric water budgets and terrestrial water resources. The current simulations are part of the German Research Foundation Collaborative Research Centre project DETECT that explores whether, aside from greenhouse gas forcing and natural variability, decades of human-induced land-use change, and intensified water use and management have modified water and energy cycles persistently, contributing to observed hydrological trends, e.g., in water storage, at a regional scale in Europe.

A1-T-04

Himalayan glacial anomaly as simulated by a coupled regional glacier-climate model and its synoptic-scale drivers

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Glacier retreat is a crucial indicator of climate variability and change. Karakoram-Himalaya (KH) glaciers are the source of several perennial rivers, fulfilling the water needs of nearly one-fifth of the earth's population. A coupled dynamical glacier-climate model simulation study revealed that snowfall variability is the primary factor, explaining~60% of regional glacier mass balance variability[1]. The model successfully captured the recent divergent response of the Karakoram glaciers (called the "Karakoram Anomaly"), underlining the need for careful measurements and model representations of snowfall spatiotemporal variability. Snowfall is one of least-studied meteorological variables of KH and Western Disturbances (WDs) are widely considered to be the chief provider of snowfall influx during the accumulation period of glaciers[2]. To capture the large-scale but region-specific glacier changes at the third pole, the present study applied a tracking algorithm to three global reanalysis datasets for 39 seasons (1980-2019; Nov-Mar). Composite statistics for tracks passing through Karakoram revealed a ~10% increase in the WD-associated precipitation intensity. WDs were found to provide ~65% of the total seasonal snowfall in the region, establishing them as the primary source of accumulation. Moreover, their contribution to snowfall volume over the core glaciated regions of Karakoram has increased by ~27% in recent decades. A simultaneous decline of about ~17% in the precipitation received from non-WD sources was also observed.

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The latest projected climate change signal over Southern Africa using the Conformal Cubic Atmospheric Model (CCAM)

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We report on the most detailed ensemble of projections of future climate change performed over southern Africa to date, obtained using the Variable Resolution GCM, CCAM, at a resolution of about 8 km in the horizontal and covering a domain of about 2000 km^2. The simulations span the period 1961-2100 and are nudged within the output of 10 different CMIP6 GCMs, for mitigation scenarios SSP3-7.0 and SSP1-2.6. A novel aspect of these simulations is the regional climate model used is a fully coupled atmosphere-ocean model, and a particular interest in our work is to investigate how the southern African Benguela system and Agulhas current may change in a changing climate. The simulations are performed on the Lengau cluster of South Africa's Centre for High Performance Computing and are expected to take all of 2023 to 2024 to be completed, with the first ensemble members to be generated during the course of 2023. The simulations are performed in support of the SASSCAL 2.0 research programme project TIPPECC, which deals with the potential occurrence of regional climate change tipping points in southern Africa. We share in our presentation the first results obtained from the projections, with a focus on projected changes in rainfall, temperature and sea-surface temperatures along the southern African coastline.

A1-T-06

Development of a regional earth system model using a variable resolution global grid

Marcus Thatcher, Sonny Truong, Tony Rafter and Ben Ng

The emergence of regional earth system models (RESMs) provides an opportunity to reconsider some aspects of traditional regional climate model design. As an example, this presentation describes how earth system components have been incorporated into the non-hydrostatic Conformal Cubic Atmospheric Model (CCAM). CCAM is based on a global variable-resolution cubic grid with a higher resolution over a target domain. In the absence of lateral boundaries, CCAM is constrained by GCM projections using spectral nudging with air temperature, winds and surface pressure nudged at wavelengths above 3,000km. A hydrostatic Boussinesq ocean model has been integrated into the CCAM dynamical core, but instead of using a coupler, we have combined the atmosphere and ocean turbulent mixing into a single implicit solution. Prognostic aerosols for the sulphur cycle, carbonaceous, dust and sea-salt are also included with direct and indirect feedbacks, constrained by surface emissions consistent with CMIP GCMs. A terrestrial carbon cycle is also available, allowing for feedbacks with vegetation, although it is not used in our current studies. A challenge for RESMs is the availability of sub-daily boundary conditions for earth system components, although this can be avoided with the stretched grid approach. For example, we have chosen to constrain the ocean mixed layer temperature based on spectral nudging with a correction for sea surface temperatures, while salinity, currents and ocean surface height remain unconstrained. However, our stretched grid approach does require care in developing scale-aware parameterisations for convection, cloud microphysics and boundary layer turbulent mixing.

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A2-T-02 - CURIO Julia

The role of Tibetan Plateau Vortices in extreme precipitation events in the Tibetan Plateau region

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BARPA-C: Kilometre-scale climate modelling development based on ACCESS

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Detection and sensitivity to global warming of disastrous-like storms in the complex alpine area

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Brand new Convection-Permitting simulations over South America: a look at the uncertainty sources at the sub-daily time scale

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Session A2: Convection Permitting Modelling. Title: A new method for dynamical downscaling of heatwaves by convection-permitting climate models: event-based downscaling

A2-T-01

Tropical cyclone changes in convection-permitting regional climate projections: a study over the Shanghai region

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Changes in tropical cyclones due to greenhouse-gas forcing in the Shanghai area have been studied in a double-nesting regional model experiment using the Met Office convection-permitting model HadREM3-RA1T at 4km resolution and the regional model HadREM3-GA7.05 at 12km for the intermediate nest. Boundary conditions for the experiment have been constructed from HadGEM2-ES, a General Circulation Model (GCM) from the 5th Coupled Model Intercomparison Project (CMIP5), directly using high-frequency data for the atmosphere (6-hourly) and the ocean (daily), for the historical period (1981-2000) and under the Representative Concentration Pathway 8.5 (2080-2099). The choices identify one of the warmest climate scenarios available from CMIP5. Given the direct use of GCM data for the baseline, large scale conditions relevant for tropical cyclones have been analysed, giving a realistic representation of environmental conditions off the coast of eastern China. GCM large scale changes show a reduction in wind shear in addition to the expected strong increase in sea surface temperature. Tropical cyclones from the 4km historical simulation have a negative bias in intensity, not exceeding Category 4, and a wet bias in the rainfall associated with these cyclones. However, there is a clear improvement in cyclone intensity and rainfall at 4km in comparison with the 12km simulation. Climate change responses in the 4km simulation include an extension of the tropical cyclone season, and strong increases in frequency of the most intense cyclones (approximately by a factor 10) and associated rainfall. These are consistent with the results from the 12km simulation.

A2-T-02

The role of Tibetan Plateau Vortices in extreme precipitation events in the Tibetan Plateau region

Julia Curio , Julia Kukulies, Tinghai Ou and Deliang Chen

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Mesoscale Tibetan Plateau Vortices (TPVs) have been identified as major precipitation-bearing systems in the Tibetan Plateau (TP) region. TPVs originate over the TP and, while the majority of TPVs remain on the TP throughout their lifetime, a fraction (~20%) of TPVs moves east off the TP into densely populated downstream regions, such as the Sichuan basin. These moving-off TPVs can pose a risk to people's lives and livelihoods, by causing heavy rainfall and subsequent flooding and landslides amplified by the complex terrain. An extreme precipitation event in the Sichuan Basin in July 2008 caused by a mesoscale convective system (MCS) was associated to the occurrence of a moving-off TPV. Results from a set of kilometre-scale simulations for this event suggest that the moving-off TPV indeed plays a key role in the initiation of the MCS and the ability of the simulations to capture the observed precipitation in the Sichuan basin. This finding raised the question of how often extreme precipitation events in the Sichuan Basin are linked to the occurrence of TPVs.
We will use 1-year kilometre-scale simulations generated in the CORDEX Flagship Pilot Study “Convection Permitting Third Pole” to identify and analyse extreme precipitation events and track TPVs in order to assess how many extreme precipitation events are connected to mesoscale TPVs. We will analyse the moisture supply to the Sichuan Basin and the large-scale circulation during the events. Preliminary results from reanalysis data show anomalous moisture transport into the Sichuan Basin and a southward shift of the subtropical westerly jet for a small set of extreme precipitation events associated with TPVs.
An improved understanding of how the combination of favourable large-scale atmospheric conditions and the occurrence of TPVs and MCSs can create and affect extreme precipitation events in the downstream regions of the TP might enable us to improve their forecasts and projections in a climate change context.

A2-T-03

Session A2: Convection Permitting Modelling

BARPA-C: Kilometre-scale climate modelling development based on ACCESS

Emma Howard[1], Christian Stassen[2], Chun-Hsu Su[2], Harvey Ye[2], Andrew Dowdy[2], Simon Tucker[3], Charmaine Franklin[2]

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The Australian Climate Service (ACS) is developing new climate and hazard information, which will enhance our ability to prepare for, respond to, and recover from the impacts of natural hazards under a changing climate for Australia. This year, ACS will begin production of the first Australia-wide convective-scale climate downscaling projections. With a 4-km grid spacing, these projections have the potential to provide a step-change improvement in the representation of hazardous weather such as heavy rainfall, extreme wind, floods, and fire weather. The goal of these projections is to enable the delivery of increasingly reliable climate change information at the regional and local scales relevant for informing climate adaptation decisions. ACS will apply a multi-model approach to generate an ensemble of convective-scale projections using multiple GCMs and multiple RCMs, to be applied in hazard risk assessments across the country.

This study describes the new development of one of the ACS component convection permitting models, BARPA-C (Bureau of Meteorology Atmospheric Regional Projections for Australia – Convective) based on the Australian Community Climate and Earth-System Simulator (ACCESS). An overview is given of the experiment design and model configuration, including improvements to the land surface ancillaries. Trial experiments, constructed to test the ability of the model to reproduce Australian temperatures and precipitation, to qualitatively assess the structure of modelled tropical cyclones and to determine an appropriate domain size, are presented. We demonstrate the added value of the proposed BARPA-C configuration compared to the 17-km regional BARPA-R simulations.

A2-T-04

Detection and sensitivity to global warming of disastrous-like storms in the complex alpine area

Emanuela Pichelli (*) and the CORDEX-FPSCONV Team

A group of high-impact storms occurred within a present day decade over the great alpine region (1°–17° East, 40°–50° North) has been selected to build a method to detect and characterize disastrous-like events within a 10-year long dataset of high-resolution observations.

The same method has been then applied to an ensemble of models run at the convection permitting scale within the framework of the CORDEX-FPS on convection, in order to evaluate their capacity to reproduce such kind of events. Their main drivers are analysed and the factors affecting the model ability in correctly reproducing the unsuccessful cases are investigated. The models have been found able to represent the most calamitous storms in the 70% of cases, in particular when these are driven by well set forcings (orographic and/or cold fronts), but tend to fail in case of more complex mesoscale interactions.

Finally the method has been applied to model projections under warming conditions scenario to study the sensitivity to the climate change of such disastrous-like storms in terms of frequency, intensity, impact and driving forcing.

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A2-T-05

Brand new Convection-Permitting simulations over South America: a look at the uncertainty sources at the sub-daily time scale

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The increase in spatial resolution of the regional climate model (RCM) simulations allows us to investigate more in depth the daily and hourly timescales.
Such high resolution simulations have been performed over the La Plata region in South America, and a brand new multi-model ensemble of Convection-Permitting simulations has been produced for a 3-years period (2018-2021).
The available satellite and gridded observational datasets show a clear uncertainty when going to sub-daily timescale, therefore the validation of the model ensemble mean and extreme precipitation is performed by including also a station based observational dataset at both daily and hourly time scale, to assess the model uncertainty within the context of the aforementioned observational uncertainty.
An additional important source of uncertainty, especially when going to sub-daily timescale, are parameterizations that RCMs use to represent sub-grid scale processes like for example those used in the PBL schemes. A specific analysis on the diurnal cycle is presented to highlight the different contribution of model and parameterization to the final ensemble uncertainty.

A2-T-06

A new method for dynamical downscaling of heatwaves by convection-permitting climate models: event-based downscaling

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Heatwaves in urban areas can amplify urban heat island effects, which can further increase the risk of morbidity and mortality. To take into account the meteorological effects in urban planning and climate change adaptation, climate information at high spatial resolution is needed. The km scale simulations by Convection Permitting Regional Climate Models (CPRCM) provide detailed climate information at regional scale, but the computational cost of performing CPRCM simulations is very high. The standard regional climate downscaling with an ensemble of GCMs and RCMs and scenarios over 100 - 150 years is beyond the reach of CPRCMs and improved downscaling procedures are required to fully benefit from their unique characteristics. One such approach is to downscale targeted heatwave events of interest. However, CPRCMs usually need months to years of spin-up to reach physical equilibrium. Clearly, running a long spin-up to simulate e.g. weeks-long heatwave event defies the purpose.

This study optimises the procedure for downscaling of heatwave events from coarse resolution models (e.g., GCM) to kilometer scale resolution using CPRCMs. A novel approach combining offline LSM and coupled simulations is proposed to speed up the initialization procedure for the simulation of a larger ensemble of heatwave events at kilometre or even sub-kilometre scale. The pseudo-global warming (PGW) approach is applied to create the boundary conditions for the CPRCM. We will downscale and analyze a couple of heatwave events over southern Sweden during historical and future periods under different warming levels. The CPRCM used in the study is the Harmonie-Climate (HCLIM) model. The optimized event-based downscaling method significantly reduces high computational costs and improves the productivity of simulations associated with the current downscaling procedure.

A3-T-01 - ALMEIDA VIVACQUA Carla

Design of Experiments and Machine Learning (DoE & ML)-based approach to better capture uncertainty in future climate projections

A3-T-02 - ANDRADE CARDOSO Andressa

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain

A3-T-03 - BETTOLLI Maria Laura

Convolutional neural networks for local climate downscaling: precipitation extremes in the FPS in Southeastern South America

A3-T-04 - DOURY Antoine

RCM-emulators: A study of applicability to large GCM ensembles.

A3-T-05 - EVANS Jason

Should we bias correct boundary conditions for regional climate models?

A3-T-06 - GONZÁLEZ-ABAD Jose

Introducing eXplainable Artificial Intelligence to assess Deep Learning Models for Statistical Downscaling

A3-T-07 - RAMPAL Neelesh

Can deep-learning models extrapolate to downscaling rainfall in future climates?

A3-T-01

Design of Experiments and Machine Learning (DoE & ML)-based approach to better capture uncertainty in future climate projections

Carla A. Vivacqua [1], **Priscilla A. Mooney** [2], **and Alok K. Samantaray** [2]

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The next frontier of climate modelling is not in producing more data, but in producing more information. Numerical climate model simulations have become the largest and fastest growing source of climate data. This is largely due to societal demands for climate information that is both relevant and useful. To satisfy this demand, numerical models need to run large ensembles to quantify uncertainties. Traditionally, the simulations that constitute members of an ensemble are chosen in an ad hoc way leading to what is called an 'ensemble of opportunity'. The current 'ensemble of opportunity' approach is inefficient and incomplete, since only part of the parameter space is covered by the framework. Can the 'ensemble of opportunity' be replaced by something better?

Our objective is to mitigate challenges in data production and analysis by efficiently integrating traditional statistical methods and machine learning (ML) techniques. Their complementary application plays a key role in guiding the tasks of generating and making sense out of the available data.

We aim to provide a fundamental advance on how climate model ensembles are designed and analyzed. The proposal allows us to provide the same high quality climate information using less data and computational resources. This new approach is based on the intertwined use of Design of Experiments (DoE) and ML. We provide an overview of a DoE&ML-based-approach, which makes it possible to fully sample the uncertainty space, while saving computation cost. Future work will exploit the comprehensive model ensemble from the EURO-CORDEX data.

A3-T-02

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain

Andressa A. Cardoso[1,2], Erika Coppola[2], Julia Mindlin[3,4,5] and Theodore G. Shepherd[6,7]

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Selecting the most appropriate global climate models (GCM) is necessary to provide the initial and boundary conditions for downscaling regional climate models (RCM). The methodology to select the GCMs is related to the physical processes we wish to study and the main drivers in a specific domain. A large amount of large-scale circulation occurs in the South American domain (SAM), which impacts a wide variety of meteorological variables and several geographical patterns that influence the climate. In order to develop the methodology, we identified which climate features are relevant to the SAM region or, in other words, which storylines we would like to explore. We used two large-scale circulations during this work: the South American Monsoon System (SAMS) and the extratropical cyclones. This work aims to select which CMIP6 ensemble is more suitable for the large-scale circulations that affect the SAM, and to represent uncertainty in their future evolution. We characterize the large circulation based on a set of variables (mean sea level pressure and wind at 850 hPa and 200 hPa) over South America such as South American Low-Level jets, South Atlantic Subtropical High, South Pacific Subtropical High, trade winds, Bolivian High, cyclonic circulation vortex and upper-level jet stream based on a set of indicators. By means of these indicators, a subset of models was identified based on their large-scale circulation patterns. To be able to sample the whole range of future uncertainty it is common to use different model climate sensitivities. In this work, a different approach is adopted which represents the uncertainty in terms of the influence of a small set of local circulation drivers which in turn are mediated by large-scale circulation drivers, including tropical and polar regions. Storylines of the large-scale drivers are analyzed and the response of local circulation of interest is studied to confirm that they cover the local circulation response uncertainty range. Uncertainty in climate sensitivity is addressed by expressing these dynamic storylines of change in terms of global warming levels. Finally, a subset of storylines that corresponds to climate risk of interest is selected and the small set of CMIP6 models that correspond to each storyline is defined. This methodology allows finding which model ensemble is fit for the purpose and avoids missing plausible worst-case scenarios for regional climate risk.

A3-T-03

Convolutional neural networks for local climate downscaling: precipitation extremes in the FPS in Southeastern South America

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Southeastern South America (SESA) is one of the regions of the planet where extreme precipitation events occur and have high impacts on socio-economic activities. The understanding of the physical processes that lead these events and their modeling and projections in a changing climate continue to be a challenging task. The CORDEX Flagship Pilot Study (FPS) in SESA addresses this topic based on coordinated experiments using different downscaling approaches. In this work we present the results of the second phase of this initiative where ESD simulations were performed based on deep learning methods and inter-compared with previous ESD models constructed during the first phase of the FPS-SESA (based on regression and analog families). To this end, the ability of convolutional neural networks (CNN) downscaling models in simulating daily precipitation in SESA with special focus on extremes was evaluated. The models were calibrated and cross-validated during the 1979-2017 period and also validated in the independent period 2018-2021. This period, with unprecedented dry conditions over SESA, is the target period to perform convection-permitting RCM simulations as well, and therefore it allows for comparisons between both approaches. The CNN models showed overall skilful performance in simulating daily precipitation characteristics over the region, outperforming the more classic ESD models when the spatial characteristics of extremes are considered. Explainable artificial intelligence methods revealed that CNN models are able to successfully select informative predictors capturing the physical relationships between the large-scale environment associated with precipitation and its extreme events.

A3-T-04

RCM-emulators: A study of applicability to large GCM ensembles.

RCM-emulators have emerged as a promising tool for delivering a comprehensive assessment of local impacts under different socioeconomic trajectories. By combining the strengths of dynamical and statistical downscaling, RCM-emulators can overcome the limitations of individual approaches. While dynamical downscaling is capable of representing fine-scale phenomena impacting the signal of local changes [2], its high computational cost limits the exploration of uncertainty sources. In contrast, statistical downscaling approaches can model efficiently large-scale/local-scale relationships [3] but their dependence on observational data limits their applicability to few regions, few variables and questions their validity in a future/different climate. RCM-emulators [4] aim to apply statistical downscaling framework within the RCM world to learn the downscaling function for any variable, anywhere on the globe, and under different climates. This approach would open the door to downscale all available GCM simulations and so to large ensembles of high-resolution simulations.

[1] presents an emulator for the ALADIN63 RCM focused on the near-surface temperature. In this talk, I propose to recall the methodological choices behind this specific RCM-emulator and the main results. Moreover, ALADIN63 has downscaled various transient simulations driven by different GCMs and RCP scenarios. This offers an ideal framework to assess the transferability of the estimated function accurately and precisely. I will present some results on the applicability of the RCM-emulator to different GCM and RCP scenarios. The aim of the presentation will be to demonstrate its potential as a powerful tool for downscaling large GCM ensembles but also to highlight the importance of methodological choices for the calibration of the emulator.

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A3-T-05

Should we bias correct boundary conditions for regional climate models?

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One of the main limitations for regional climate modelling is the "Garbage in – garbage out" issue. That is, if the input boundary conditions from a GCM are far from realistic (garbage) then the regional climate model (RCM) is not able to correct this and will, in turn, produce garbage. This is a major problem given that all GCMs, even the best ones, contain biases. It has been proposed that performing bias correction of the GCM boundary conditions would alleviate this problem and produce better RCM simulations. In this talk we present evidence that bias correction of the boundary conditions does result in improved RCM simulations. We examine the affect of using various bias correction techniques[1], the role of the relaxation zone in transferring these corrections to the interior domain[2], and the importance of physical consistency within the boundary conditions[3]. We show that the corrected boundary conditions improve multiple aspects of the simulated climate including: the mean climate[1], extremes[4], compound events[5] and synoptic systems.

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2. Rocheta, E., Evans, J. P. & Sharma, A. Correcting lateral boundary biases in regional climate modelling: the effect of the relaxation zone. *Clim. Dyn.* **55**, 2511–2521 (2020).
3. Kim, Y., Evans, J. P., Sharma, A. & Rocheta, E. Spatial, Temporal, and Multivariate Bias in Regional Climate Model Simulations. *Geophys. Res. Lett.* **48**, e2020GL092058 (2021).
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A3-T-06

Introducing eXplainable Artificial Intelligence to assess Deep Learning Models for Statistical Downscaling

J. González-Abad, J. Baño-Medina, J.M. Gutiérrez

Deep learning models have become an effective technique to generate high-resolution climate variables at regional scales from large-scale atmospheric fields, following the perfect-prognosis approach. These models have been applied to downscale climate projections from Global Climate Models (GCMs) over different CORDEX domains. However, the black-box nature of these models hinders their evaluation to produce trustworthy regional climate change projections

Recently, eXplainable Artificial Intelligence (XAI) techniques have been developed to improve the understanding of the decision-making process of deep learning models. In this study, we propose a set of XAI-based indices to enhance the evaluation of deep learning-based downscaling models beyond standard evaluation metrics. We use these metrics to analyze the suitability of different state-of-the-art deep learning models for downscaling over the North America CORDEX domain. We find that the XAI metrics report important differences between the deep statistical models not observed using conventional standards (e.g., cross-validation), that helps to understand the performance of each model in the climate change regime.

A3-T-07

Can deep-learning models extrapolate to downscaling rainfall in future climates?

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Downscaling with deep learning can be orders of magnitude more computationally efficient than dynamical downscaling. Deep learning techniques have largely alleviated longstanding issues with empirical downscaling techniques, such as resolving climate extremes and capturing local-scale processes that vary non-linearly with the boundary conditions. However, there is still a lack of understanding of whether learnt relationships from deep learning models trained on observations can extrapolate to future climates. Our study aims to address this issue of "extrapolation" in deep learning techniques, in the context of downscaling extreme rainfall. In this study, we train a Convolutional Neural Network (CNN) that maps large-scale circulation fields from ERA5 reanalysis ($\mathbf{1.5}$ °) to high-resolution rainfall observations over New Zealand. We then applied our CNN offline to the output from three different General Circulation Models (GCMs) over the historical period of simulation. When assessed over the historical simulation period, our results show that rainfall projections downscaled with CNNs are equally skillful in characterizing rainfall extremes as dynamical downscaling. However, when the CNN is applied to large-scale-circulation fields from future climate projections from GCMs, it underestimates trends in extreme rainfall compared to the host GCM and dynamically downscaled simulations. This suggests that a typical deep-learning model trained on the observational record cannot learn relationships that are generalizable to future climates. However, here we show that a novel approach to pre-training can alleviate this issue. We train our CNN in two stages, which helps incorporate information from two-separate problems and enables better generalization to future climates. First, we pre-train our model as an unsupervised variational autoencoder and then fine-tune our model to downscale high-resolution rainfall. Through training in two stages, we can reproduce better trends in extreme rainfall, which are now consistent with dynamically downscaled simulations.

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B-T-01 - BENESTAD Rasmus

Lessons learned about the use of downscaled climate model results for practical use

B-T-02 - GUTOWSKI William

Decision-Relevant Climate Storylines from Object-Oriented Analysis

B-T-03 - LENNARD Christopher James

Capacity development for climate science – CORDEX and the WCRP Academy

B-T-04 - MEARNS Linda

Regional Climate Modeling in North America and Europe: Why such Different Paths?

B-T-01

Lessons learned about the use of downscaled climate model results for practical use

Rasmus Benestad [1] , **Andreas Dobler**[1], **Kajsa M. Parding**[1] **and Abdelkader Mezghani** [1]

[1]*The Norwegian Meteorological Institute*

We follow up on the discussions during a hybrid workshop "ConCord" with physical attendance in Oslo October 2022, and share thoughts and experience on practices regarding downscaling global climate models and producing regional climate information for society. The regional climate modelling group at the Norwegian Meteorological Institute has embraced two different approaches for downscaling: dynamical and empirical-statistical downscaling. They are based on different assumptions and have different strengths and weaknesses. Hence, they compliment each other, but a fusion between these two approaches to downscaling is fairly uncommon despite several reasons for bringing them together [1,2]. One important consideration is that small ensembles are prone to "the law of small numbers" when it comes to regional climate projections, since they are dominated by stochastic variations even on decadal time scales [3]. An ensembles-based approach requires different criteria for evaluation than downscaling single models, and in addition to cross-validation, it's important to assess whether the ensembles give a good statistical representation of historic climate. When the results are used for climate change adaptation, the evaluation of the downscaling must comprise the GCM's ability to reproduce the large-scale information embedded in the predictors of empirical-statistical downscaling, in addition to whether the statistical models themselves capture the inter-scale dependencies. A framework involving common EOFs has proven to be suitable for such [1]. Another issue is whether single-variable predictors are better to use than predictors consisting of more than one physical variable, as non-stationarity in the structural relationship between different atmospheric variables may be problematic. Finally, statistical information, such as probabilities and parameters defining statistical distributions (e.g. mean, standard deviation or frequency), are often easy to predict and it is in our experience easier to get robust and reliable statistical information rather than traditional time series representation of the atmosphere, although the latter is often still requested by impact modellers . We bring all these aspects together to produce robust and actionable information to support climate change adaptation.

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B-T-02

Decision-Relevant Climate Storylines from Object-Oriented Analysis

William J. Gutowski, Jr., Linda S. Shenk, and Brandon J. Fisel
Iowa State University, USA

Climate storylines have emerged as an important way for researchers to convey relevant climate-change information to diverse groups of decision-makers. With storylines, researchers describe climate change in terms of impactful weather and climate events, frequently wet or dry extremes, that stakeholders have likely already experienced and responded to, thus providing decision-relevant information on ways these events may evolve in future climate. In this talk, we discuss how object-oriented analysis can advance stakeholder-scientist collaboration by tailoring the climate-change storylines to decisionmakers' specific needs.

Object-oriented analysis can identify decision-relevant events of interest in observations and climate simulations by seeking "objects" in a space-time domain whose diagnosed variables meet specified, decision-relevant criteria, such as exceeding an extreme precipitation threshold. The collection of these objects yields event climatologies that, in turn, lead to decision-relevant storylines. A further benefit of object-oriented analysis arises from pooling together impactful events of different types, thus promoting systematic exploration of the compound behavior of two event types when they occur simultaneously or sequentially. The flexibility of object-oriented analysis plays a key role here by allowing stakeholder interests to determine the event characteristics to diagnose. Further, because the flexibility of object-oriented analysis allows stakeholders of any group to deJne the events relevant to their needs, interests, and values, object-oriented analyses can give a quantitative voice to the climate-impact concerns of all groups. It thus facilitates equity in the production of decision-relevant understanding of hydroclimatic extremes and their impacts.

B-T-03

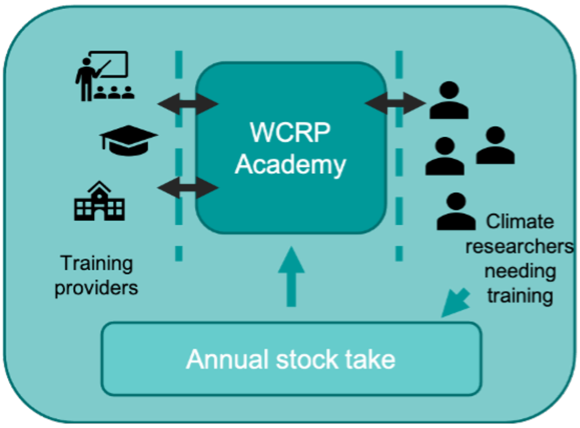
Capacity development for climate science – CORDEX and the WCRP Academy

Christopher Lennard[1] **, Melissa Hart**[2]

[1] *University of Cape Town, South Africa (WCRP Academy Co-chair)*
[2] *University of New South Wales, Australia (WCRP Academy Co-chair)*

The World Climate Research Programme (WCRP) Academy is the research training advisory and coordination arm of the WCRP. Its mission is to equip current and future climate scientists with the knowledge, skills and attributes to tackle the world's most pressing climate research questions and advance lifelong learning opportunities and global equity in climate science.

In fulfilling this goal, the Academy will regularly survey required climate research training across the globe and build enabling mechanisms to meet these training requirements. This includes an online marketplace for climate science training providers to connect with climate scientists seeking training in a particular field.



Contributing to this is an annual climate training stocktake that aims to keep track of and respond to the rapid changes in the education and training space around climate variability and change. To date three surveys have been conducted to understand what climate science training is being sought, what is available, where the gaps are, and how WCRP Academy can help address these gaps.

This paper will report on the Academy goals, structure and plans and will also reflect on the implications of several survey results for the CORDEX and the WCRP more generally. It will also explore the rich history of capacity development within CORDEX and solicit thoughts and recommendations to strengthen the CORDEX-WCRP Academy collaboration.

B-T-04

Regional Climate Modeling in North America and Europe: Why such Different Paths?

L. O. Mearns [1], M. Bukovsky [1], E. Coppola[2], J. Christensen[3], D. Paquin[4] , and F. Giorgi[5]

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5 ICTP, Trieste, Italy

Regional climate modeling was initially developed in the United States and soon spread to Europe and other parts of the world. However, developments in North America and Europe took very different approaches. Work has always been somewhat more advanced in Europe (e.g., Prudence), but multiple RCM-GCM programs also developed in North America (e.g., NARCCAP). With the development of CORDEX many regions of the world developed such programs, but in the United States financial support for such programs became very limited. Funding for individual research that involved regional modeling did exist, but large multiple RCM-GCM efforts were not supported. Moreover, regional modeling became dominated by one model: WRF.

In Canada, however, a different regional model dominated (CRCM5). Note that in both cases, the RCMs were those developed in those countries. But in Europe multiple RCMs were always used. While NA-CORDEX did come into being, it was very difficult to finance, and the program was not as large as was originally hoped for. We explore why these efforts developed so differently in North America and Europe and the implications of these differences for regional knowledge regarding climate change and its impacts.

C1-T-01 - ASSELIN Olivier

Climate Response to Land-Use Changes over North America and Europe

C1-T-02 - CARDOSO TAVARES Rita Margarida

17th of June 2017, an Extreme Fire Event in Pedrogão Grande, Central Portugal

C1-T-03 - CASTILLO BAUTISTA Blanca Natalia

Impact of climate change in Mexican wine grape regions

C1-T-04 - HAHMANN ROBINOVICH Andrea

The Intersection of Climate and Renewable Energy Research: Successes and Limitations

C1-T-05 - KJELLSTROM Erik

Climate change in Sweden with impacts for reindeer husbandry

C1-T-06 - NONKI Rodric Merime

Quantification and allocation of uncertainties of climate change impacts on hydropower potential under 1.50C and 2.00C Global Warming Levels in the the Benue River Basin, Cameroon

C1-T-07 - SINGH Hrishikesh

Checking the performance of Regional Climate models in determining Flooding at Basin Scale using Global Hydrodynamic model

C1-T-01

Climate Response to Land-Use Changes over North America and Europe

O. Asselin [1] , **M. Leduc** [1] , **and D. Paquin** [1]

[1]*Ouranos, Montréal, Qc*

Afforestation and reforestation offer a strong technical potential for reducing atmospheric concentration of CO_2. However, large-scale implementation of such mitigation strategies would not only impact the chemical composition of the atmosphere, but also the energy and water exchanges between the land and the atmosphere. Replacing grassland with forests, for instance, may lower albedo, increase surface roughness and affect evapotranspiration rates, with important effects on the regional climate. Since afforestation and reforestation are expected to contribute about a quarter of mitigation efforts pledged under the Paris agreement, it is essential that these so-called 'biogeophysical' effects are accounted for when assessing their mitigation potential.

The Land-Use and Climate Across Scales (LUCAS) project — a CORDEX flagship pilot study — aims to integrate land-use changes in regional climate models and to quantify their biogeophysical effects on climate. Davin et al. [1] compared the response of nine combinations of climate and land surface models to severe afforestation and deforestation in Europe. Asselin et al. [2] carried a similar experiment over North America. Three regional climate models were run with two configurations, FOREST and GRASS, representing worlds in which all vegetation is replaced by forests and grasses, respectively. Models respond significantly to such drastic vegetation changes. In wintertime, severe afforestation causes widespread warming in all models, although with different magnitude and distribution. Analysis reveals that the snow-masking albedo effect of northern needleleaf forests dominates the response. Crucially, these snow-masking needleleaf forests populate lower, hence sunnier latitudes in North America than in Europe. Snow masking reduces albedo similarly on both continents, but stronger insolation amplifies the net shortwave radiation and warming simulated over North America. In summertime, there is a large inter-model divergence in the temperature response which can be traced to the partition between sensible and latent heat fluxes.

In the second phase of this experiment, realistic vegetation maps [3,4] are used to evaluate the impacts of anticipated land-use change over the current century, for both North America and Europe. A multi-member ensemble of regional climate simulations has been produced to evaluate the respective contributions of natural variability, greenhouse gas emissions and land-use change on regional climate. Preliminary analysis suggests that land-use changes exert a notable influence on the regional energy and water budgets, but that some of these effects differ under current and future climate conditions. In this talk, the first-phase (idealised LUC) conclusions and second-phase (realistic LUC) preliminary results will be discussed.

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[4] P. Hoffmann et al., Earth System Science Data Discussions 1-43 (2022)

C1-T-02

17th of June 2017, an Extreme Fire Event in Pedrogão Grande, Central Portugal

Rita M. Cardoso[1], Pedro M.M. Soares [1], Miguel Lima[1], Luana Santos[1], Ricardo M Trigo[1]

(1) Universidade de Lisboa, Faculdade de Ciências, Instituto Dom Luiz, Lisboa, Portugal

Wildland fire spread and behaviour are complex phenomena owing to both the number of involved Physicochemical factors and the non-linear relationship between variables. In Portugal, forest and bush fires occur every summer and are exacerbated when extremely dry weather sets in along with high temperatures. On the 17th of June 2017, an extreme heatwave associated with a severe drought and compounded by extreme atmospheric instability led to a multiplicity of wildfires with many active fire fronts and the formation of pyro-cumulus with explosive fire behaviour. All contributed to the catastrophic fires in Pedrogão, with heavy impacts on human lives and assets. The June 2017 extreme fire event in Pedrogão Grande is simulated with the WRF- Fire and Sfire model using a high-resolution regional scale (2 km), local (400 m) and Large Eddy Simulation (80 m) resolution. Three distinct microphysics schemes and three boundary layer parameterisations were employed to fully understand this complex event. Prior to and during the event, a series of downbursts contribute to the atmospheric instability. WRF can simulate these incidents as well as the pyro-cumulus formation, yet their development is highly dependent on the interaction between the microphysics and the boundary layer schemes. As in the observed event, the fire spread is accelerated westwards in association with the pyro-cumulus. However, the initial simulated fire spread is faster than the observed in all simulations while the extent of the pyro-cumulus is shorter. An analysis of the atmospheric conditions prior to and during the episode, as well as their interaction with the surface fire is performed in all domains.

Acknowledgements

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C1-T-03

Impact of climate change in Mexican wine grape regions

Natalia Castillo [1,2], **Tereza Cavazos** [2] , **and Edgar Pavia** [2]

[1] *IUSS Pavia*
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We analysed the current climate of seven wine-growing regions of Mexico and their possible changes during the 21st century. Various bioclimate indices were calculated over a wide domain that covers Mexico and the south and southwest United States with observations and simulations from two regional climate models (RegCM4.7 and RCA4) for historical (1981-2010), near future (NF: 2021-2050), and far future (FF: 2070-2099) periods under two emission scenarios (RCP2.6 and RCP8.5). Both models reproduced the main characteristics of the Mediterranean and semiarid climates typical of the wine grape regions with some biases. Despite the biases, the models suggest similar future changes during the growing season (GS: April-October) in wine grape regions. Increases in temperature (~ 1.2°C) are expected in the NF period, which could produce an early start of the growth (mid-March) and flowering seasons. More significant changes are expected in the FF under the RCP8.5 scenario; temperature during April-October may increase ~4.3°C, and growing degree days and minimum temperature could also increase (~ 800°C GDD and 4.5°C, respectively), especially in the northern Mexican high plateau region (HP), substantially reducing the suitable areas for viticulture. Moreover, annual precipitation may decrease ~200 mm in the central HP and the onset of the GS may start in early March in most viticulture regions in the FF. In the Mediterranean California's, cool nights (< 12°C) could be reduced during the current harvest season (September) affecting the acidity and flavour. Thus, viticulture in Mexico could be significantly affected at the end of the 21st century under the RCP8.5 scenario, suggesting the need for early adaptation/mitigation measures to overcome these possible changes.

C1-T-04

The Intersection of Climate and Renewable Energy Research: Successes and Limitations

Andrea N. Hahmann
Technical University of Denmark, Department of Wind and Energy Systems

Harvesting electricity from renewable energy (RE) sources is vital in climate change mitigation. Energy transformation scenarios estimate a need to increase the installed wind and solar capacity almost tenfold in the coming decades. However, **climate change may influence the conditions in which wind turbines and PV panels operate and the resource they are designed to harness.** The latest IPCC energy transformation scenarios are based on renewable energy resources from historical data. Still, there is a risk that these will change due to climate change. The renewable energy industry considers future weather and climate a threat to wind energy expansion. The rapidly evolving size, number and location of RE installations amplify the risks and the opportunities posed by climate change.

There needs to be more integrated interdisciplinary research to understand better the risks associated with climate change and renewable energy. However, current scientific literature shows that model simulations often lack the necessary output for renewable energy research regarding fields and temporal resolution. Additionally, renewable energy studies need to consider the limitations of climate model output. During my presentation, I will highlight the limitations of current simulations and showcase successful datasets, such as CORDEX, that can aid in renewable energy research.

C1-T-05

Climate change in Sweden with impacts for reindeer husbandry

Erik Kjellström [1,4], Erik Holmgren [1], Changgui Lin [2,3], Gunhild Rosqvist [4,5], Gustav Strandberg [1,4], Renate Wilcke [1], and Carl Österlin [4,5]

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[5] *Bolin Centre for climate research, Stockholm University, Stockholm Sweden*

Impacts of global warming is a major concern among all Sámi reindeer herding communities (RHCs) in northern Sweden. Traditional nature-based reindeer herding involves moving over large distances between winter pastures in the forested lowlands and summer pastures in the mountains, and between pastures within seasons. Such practice allows reindeer to adapt to the seasonal changes in weather and to variable snow conditions. Observed changes in climate have impacted reindeer herding.

We use a large number of EURO-CORDEX regional climate model (RCM) simulations to address questions on how future changes may look like. The RCMs have downscaled a range of different global climate models under the future scenarios RCP4.5 and RCP8.5 to 12.5 km spatial resolution. Climate change information in the form of indicators is derived for future climate conditions at different levels of global warming. Indicators of climate change have been defined in a dialogue between researchers and reindeer herders. The process allows for addressing impacts of relevance for the RHCs using climate model data deemed to be fit for purpose.

The scenarios indicate continued trends towards shorter and milder winters with less cold days and more precipitation. This is expected to increase problems related to thawing and freezing cycles in combination with freezing rain that may lead to difficulties for reindeer grazing as access to the lichens on the ground can be "locked". The models also indicate warmer summers with risk of too dry conditions.

Despite biases in RCMs impeding the calculation of some indicators (mainly related to snow on ground), it is concluded that RCMs add value compared to coarse-scale GCMs and that the information derived can be used to assess impacts and address different adaptation strategies. The results indicate that impacts differ regionally and over the year, implying that different adaptation strategies may be needed in different locations and different parts of the year.

C1-T-06

Quantification and allocation of uncertainties of climate change impacts on hydropower potential under 1.5^{0}C and 2.0^{0}C Global Warming Levels in the the Benue River Basin, Cameroon

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Hydropower is the world's largest producer of renewable energy and represents more than 43% of the Low-carbon energy [1]. It is an efficient, flexible, reliable and friendly environmentally renewable source of energy, and has also been considered as one of the options for climate change mitigation and adaptation. However, it is the most sensitive industry to climate variability and changes because small, sometimes insignificant variations in climate often lead to significant changes on the water availability and water regularity in reservoirs or rivers which are the main drivers of hydroelectric production. Uncertainty quantification of climate change impacts on hydropower generation is more useful for science-based decision making and highly important for climate adaptation purposes. This study evaluates the climate change impacts on hydrological components and hydropower potential in the headwaters of the Benue River Basin (HBRB) under 1.5o and 2.0oC global warming levels (GWLs) and quantifies the main sources of uncertainty in the modeling chain. Precipitation and temperature from 17 CORDEX-Africa members combined 09 general circulation models (GCMs) and five high-resolution (0.44o) regional climate models (RCMs) under two representative concentration pathways (RCPs) 4.5 and 8.5 were used to run two calibrated Lumped-conceptual hydrological models (HMs) (HBV-Light and HYMOD). An analysis of variance (ANOVA, [2]) decomposition was used to quantify the uncertainties related to each impact modeling chain step for hydrological projections and hydropower potential calculation process, namely RCP scenarios, GCMs, RCMs and HMs. Results reveal a high uncertainty in both climatic and hydrologic parameters. The change in precipitation associated with the increase of PET causes a significant decrease in hydropower generation associated with the large uncertainty range. The ANOVA sensitivity test reveals that the dominant contributor source to hydropower projections uncertainty varies according to GWLs. These findings should alert the water resources planners and the decision-makers about the sensitivity of the water resources and hydro-energy under GWLs in this region.

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C1-T-07

Checking the performance of Regional Climate models in determining Flooding at Basin Scale using Global Hydrodynamic model

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Understanding flood hazards due to climate changes requires studying global weather patterns. Climate science has advanced, aiding the development of Global Flood Models (GFMs). General Circulation Models (GCMs) are traditionally used, but their effectiveness in representing local features and extreme events is limited. Regional Climate Models (RCMs) offer higher spatial and temporal scales. This study utilizes CORDEX RCMs to drive a high-resolution GFM for the flood-prone Mahanadi River basin in India. RCMs are bias-corrected and compared with APRODITE. Rainfall data, along with spatial inputs, are used in LISFLOOD-FP, a two-dimensional GFM. Model outputs are validated with MODIS satellite imagery. The study advances our understanding of RCMs' capability for regional flood mapping in data-scarce areas.

Understanding the mechanisms driving the dynamics of flood dangers is crucial due to global changes in weather patterns and concurrent climatic changes. In recent years, climate science has advanced rapidly, which has greatly aided us in using so-called climate models to Global Flood Models (GFMs). Traditionally, to incorporate the effects of climate change through GFMs, hydrologists and flood modellers have relied on General Circulation Models (GCMs), such as precipitation, runoff, etc. However, due to their coarse resolution in the range of 100–300 km, GCMs may lose some of their usefulness when attempting to describe local and regional variables, such as topography and land-surface characteristics. Additionally, several research point out that GCMs might not be able to replicate extreme occurrences at long time scales. As they can capture weather and climate processes at larger spatial and temporal scales, Regional Climate Models (RCMs), which are available at sub-GCM resolutions, are an appropriate substitute in these circumstances. A group of high-resolution RCM ensembles known as the Coordinated Regional Climate Downscaling Experiment (CORDEX) is a part of the World Climate Research Programme. Although their spatial and temporal properties promise to accurately capture flood threats at regional sizes, it is less clear how effective they are at inundation levels. This allows us to investigate the accuracy of CORDEX products in recording flood inundation and dangers over substantial watersheds. The RCMs are bias adjusted and compared with APRODITE to guarantee that gridded estimations are accurate. In order to capture flood data over the Mahanadi River basin, India's most severely impacted area

by flooding, at high resolutions (35 km x 35 km), this study, for the first time, takes into account a suite of CORDEX South Asia RCMs.

The General Extreme Value (GEV) distribution is fitted to the rainfall data from 1980 to 2020 to derive design rainfalls for various return periods. The rainfalls are sent to LISFLOOD-FP, a two-dimensional GFM, together with geomorphic (river width, depth, etc.) and spatial (Digital Elevation Model, Land use Land Cover) inputs to determine flood inundation statistics for the area. By comparing historical flood maps from MODIS satellite photography, the model results were also confirmed. The study increases our knowledge of RCMs' capacity for regional flood inundation mapping in situations with scant station-level data, which is a significant challenge in many data-scarce or ungauged flood-prone watersheds in low- and middle-income countries.

Keywords: CORDEX; LIS-FLOOD FP; Flood hazards; Mahanadi River Basin; MODIS; Regional Climate Models;

C2-T-01 - BRHANE Ermias Sisay

Modeling the Impact of Climate Change on Flood and Drought: case study Awash River Basin, Ethiopia

C2-T-02 - DECORTE Laura

Evaluation Of High-Resolution Climate Run Of Alaro-0 Over The CORDEX-Africa Domain

C2-T-03 - MELAKU CANU Donata

The coupled physical-biogeochemical model SHYFEM-BFM for scenario analysis in the regulated Venice Lagoon system

C2-T-04 - SEMENOVA Inna

Future wildfire conditions in Ukraine under the RCP 8.5 climate scenario

C2-T-05 - STRUGLIA Maria Vittoria

DYNAMICAL DOWNSCALING OF CMIP6 MODELS OVER THE MED-CORDEX REGION: AN APPLICATION OF ENEA-REG 2.0 TO THE ASSESSMENT OF EXPECTED CLIMATE CHANGHE IMPACTS

C2-T-06 - YAO Eric Martial

Assessment of the regional climate model RegCM5 and atmospheric chemistry simulation over Africa

The International Conference on Regional Climate-CORDEX 2023
(IITM HUB **ICRC-CORDEX 2023***)*

Modeling the Impact of Climate Change on Flood and Drought: case study Awash River Basin, Ethiopia

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This study aims to assess the potential impacts of climate change on floods and droughts in the Awash River basin, Ethiopia with the application of the hydrological model HEC-HMS, Standardized Climate Indices (SCI), and RCM model. Climate projections under the RCP4.5 and RCP8.5 scenarios were obtained from CORDEX for the near (2021-2050) and far future (2071-2100) periods. The hydrological model, HEC-HMS was used to simulate runoff (flood event). The model performance was assessed through the calibration and validation process and the model performs well with values of NSE and $R2>0.7$ with reasonable accuracy. The SPI was applied to identify the characteristics of droughts. The result of the study reveals that for the next 80 years, the average precipitation is expected to both increase and decrease. Maximum and minimum temperatures indicated an increasing trend for both RCP scenarios. Peak river flows were expected to be high and more variable in magnitude and irregular occurrence. In addition, the drought categories from mild to severe droughts occurred, and the basin is most frequently affected by droughts. Findings can provide scientific and technical support for basin-level planning of flood and drought control.

Keywords: Climate change, Flood, RCM, HEC-HMS, SPI

I prefer: ORAL/ POSTER presentation

C2-T-02

Evaluation Of High-Resolution Climate Run Of Alaro-0 Over The CORDEX-Africa Domain

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The project "ClimaVin" aims to investigate the impact of climate change on grapevine yield, quality and its microbiome in three New World Wine producing countries: Belgium, China and South-Africa. To fulfil this objective, high-resolution climate data is needed for these regions, which is currently lacking especially for the African region. Therefore, high-resolution climate data is produced over the CORDEX-Africa domain by running the regional climate model ALARO-0 at a resolution of 12.5 km. This is the first time the ALARO-0 model is used to simulate past climate over the African domain, thus the performance of the model for this specific region is investigated. In order to do this, the ERA5 reanalysis dataset is used to drive the model for the period 2000-2020. Output of this simulation is compared with gridded observational datasets CRU, MW and CPC, as well as with similar simulations by different models over the CORDEX-Africa domain. Several metrics like mean seasonal near-surface temperature and precipitation are calculated. A division of the domain in different subregions according to the IPCC reference regions as presented in Iturbide et al. (2020) [1] enables us to have a more in-depth insight on how the model is reproducing regional climate features. Results of this evaluation will prove useful to analyse the climate change signal over the CORDEX-Africa domain by running ALARO-0 driven by global CMIP6 simulations for a historical and future period under different SSPs. Further downscaling will be performed resulting in higher resolution data of ~ 4.5 km over a smaller domain encompassing the region of interest in the ClimaVin project (South-Africa). This new climate information over South-Africa will then later be related to grape growth and quality, enabling us to estimate future trends of grapevines under different climate scenarios.

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C2-T-03

The coupled biogeochemical model SHYFEM-BFM for scenario analysis in the regulated Venice Lagoon system

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Aveytua Leslie - National Institute of Oceanography and Applied Geophysics, OGS
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A high-resolution finite element coupled physical-biogeochemical model, SHYFEM-BFM, is applied and parameterized for the Venice Lagoon. The dynamics of the Venice Lagoon are described, taking into account both natural variations and human activities, acting both locally and globally. The biogeochemical cycles and trophic state of the lagoon play a central role in maintaining the ecological health and services it provides to society. Therefore, it is critical to understand, assess, and predict changes in lagoon biogeochemistry, taking into account different management strategies and global change scenarios. This understanding is critical to maintaining the natural functioning of the lagoon and the benefits it provides to the environment and society. The model, forced with high-frequency observational data, shows good ability to reproduce physical and biogeochemical spatial and temporal variability. Two climate scenarios were created under extreme (RCP 8.5) and intermediate (RCP 4.5) climate conditions, using downscaled meteorological forcing and boundary conditions. Scenario analysis was used to assess the state of the lagoon considering climate change and the operation of MOSE, the seawater control system that prevents flooding of the city of Venice.

C2-T-04

Future wildfire conditions in Ukraine under the RCP 8.5 climate scenario

Inna Semenova [1], **Ruslan Koval** [1]

[1] *Odessa state environmental university*

Wildfires in a climate change world are exacerbated by high air temperatures and low relative humidity, as well as an increase in overall drought, leading to stronger fire seasons. According to a report [1], climate change is projected to make wildfires more frequent and intense, with a global increase of extreme fires of up to 50 % by the end of the 21st century. To analyse future fire weather conditions on the territory of Ukraine in the period 2021-2070, the Angström index (AI) [2], which is based on data on air temperature and relative humidity was taken. According to the AI values, the weather conditions are favorable for a fire if $2.0 < AI < 2.5$, and the occurrence of a fire is very likely if $AI < 2.0$. For the calculation AI the high-resolution regional climate model's data from the framework of the CORDEX (RCM is MPI-CSC-REMO2009) was used. The assessment was made for the RCP 8.5 climate scenario, which is the most severe scenario, assuming warming at the end of the 21st century by more than 4°C compared to the pre-industrial period [3].

In accordance with the seasonal distribution of air temperature and relative air humidity, AI has a clearly defined seasonal course on the territory of Ukraine: maximum values are observed in winter and autumn, and minimum values are observed in summer and spring. In all seasons, the averaged index has a quasi-zonal distribution with the minimum values in the southern steppe regions, and the maximum values in the north of the forest-steppe and in the zone of mixed forests.

An analysis of the time course of the area-averaged monthly AI index and its anomalies showed that there is a pronounced trend towards the decrease in AI values and predominance of negative anomalies after 2045–2050. Significant negative AI trends across the country are typical for April-May. In summer, the most intense decrease in the AI values is expected in June and July, and significant trends in all summer months are predicted in the western regions and the Carpathian Mountains, with large forests. In September-October, predicted AI trends are close to zero or positive and insignificant across the country.

The maximum number of days per year with $AI < 2.0$ is expected in the sothern steppe zone of Ukraine. In the first decade 2021-2030, on average, 70-85 days with fire risk are predicted per year in the steppe zone, and in the forest-steppe and mixed forests this number will be 40-45 days. In the next two decades, the number of fire days is expected to increase throughout the country by an average of 8-10 days per decade. In 2051-2060, a slight decrease in the number of days is expected compared to the previous decade (by 5-7 days) in all regions. However, in the next decade 2061-2070, the annual number of days will increase again and will vary from 110-115 in the south and southeast to 60-70 days in the north and northwest of the country.

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C2-T-05

DYNAMICAL DOWNSCALING OF CMIP6 MODELS OVER THE MED-CORDEX REGION: AN APPLICATION OF ENEA-REG 2.0 TO THE ASSESSMENT OF EXPECTED CLIMATE CHANGHE IMPACTS

Anav A. [1,2], Antonelli M.[1], Calmanti S.[1] , Carillo A.[1], Catalano F[1,2] , Dell'Aquila A.[1], Iacono R.[1,2], Napolitano E.[1], Palma M.[1], Pisacane G.[1], Sannino G.[1,2], Struglia M.V.[1,2]

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[2] *ICSC-Super Computing Centro Nazionale di Ricerca in High Performance Computing, Big Data e Quantum Computing*

We present recent results obtained with the latest version of the regional Earth System Models ENEA-REG designed to downscale, over the Mediterranean basin, the models used in the Coupled Model Intercomparison Project (CMIP6).
A hindcast simulation has been performed, driven by the ERA5 reanalysis and using ORAS5 as boundary conditions at the Atlantic open boundary, and a historical simulation forced with the MPI-ESM1-2-HR model. Comparing the two simulations and the observed values allows us to make an initial assessment of the effect of dynamic downscaling in evaluating the impacts of climate change.
In particular, among the various observables we will select those that can be most affected by a better numerical representation of air-sea interactions: marine heat waves, changes in sea level, and occurrence of locally developed cyclones.
Simulations were also run for different scenarios using the MPI model as the driver again, and analyses of climate change impacts will be presented in analogy with the analyses done for the present climate, for some regions of greatest interest within the simulation domain.

C2-T-06

Assessment of the regional climate model RegCM5 and atmospheric chemistry simulation over Africa

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In a context of climate change and increasing anthropogenic pressure in Africa, it is crucial to understand the interactions between atmospheric chemistry, climate and biogeochemical cycles. This study aims at improving and evaluating the regional coupled climate-chemistry model RegCM5 [1], for further application to the study of the atmospheric nitrogen cycle in Africa and its variability under the influence of different controlling factors. The presentation will focus on simulation validations of regional climate (precipitations, monsoon activity, temperature) driven by ERA5 [2] and atmospheric chemistry. In particular, the tropospheric ozone cycle photo-chemistry, which notably regulates the level of atmospheric nitrogen, will be analyzed with reference to in-situ observations INDAAF (International Network to study Depositions and atmospheric chemistry in AFrica) and chemical reanalyses. Then, improvements to the model in key processes such as anthropogenic and biogenic nitrogen emissions, dry and wet deposition processes will be discussed. Finally, a special focus is given to nitrogen deposition and seasonal and interannual variability of the regional nitrogen budget in sensitive ecosystems such as savannas.

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[2] H. Hersbach, B. Bell, P. Berrisford, S. Hirahara, A. Horányi, J. Muñoz-Sabater, J. Nicolas, C. Peubey, R. Radu, D. Schepers, *Q. J. R. Meteorol. Soc.* 146, 1999–2049 (2020).

D1-T-01 - CETINA HEREDIA Paulina

Dynamical downscaling of future ocean climate for Mexican coastlines, towards the evaluation of future species’ ranges and ecosystems shifts

D1-T-02 - ESTRADA-ALLIS Sheila

Regional physical-biogeochemical coupled ocean modeling at the Gulf of Mexico

D1-T-03 - HERRMANN Juile Marine Anne

High-resolution studies of the South East Asia regional climate system with a focus on ocean.

D1-T-04 - MEIER Hans Eberhard Markus

Regional Climate System Modeling for the Baltic Sea region – an overview about Baltic Earth activities

D1-T-05 - NGUYEN Thi Thanh Hue

Quantifying air-sea heat fluxes over Southeast Asia and their response to climate change

D1-T-06 - ROSATI Ginevra

Mercury fate and transport in the Mediterranean Sea: current state and projected changes under RCP4.5 and RCP8.5 emission scenarios.

D1-T-07 - SOMOT Samuel

Modelling the Sea in Med-CORDEX: a review

D1-T-01

CORDEX 2023, parallel session D1. CORDEX-Ocean: Towards a CORDEX framework for Ocean Regional Climate Modelling

Dynamical downscaling of future ocean climate for Mexican coastlines, towards the evaluation of future species' ranges and ecosystems shifts

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Species distributions are strongly influenced by temperature and the dispersal of larvae by ocean currents; both ocean temperature and circulation have been impacted by ongoing climate change with consequences on species biogeography [1]. For instance, climate-driven strengthening of Western Boundary Currents has been linked to warming in mid-latitudes and the tropicalisation of temperate ecosystems [2]. Different climate-driven processes appear to be having similar consequences in the Eastern Pacific, along North America and the Mexican coastline, where kelp forests with ecosystem-services valued in 35 USD billion per year are under threat [3]. Thus, devising future-proof strategies for marine resource management requires tools that allow anticipating future species distribution, and potential ecosystems shifts. Such tools include downscaling global climate change models into regional ocean models with spatial and temporal resolutions that resolve mesoscale-submesoscale processes affecting marine life (e.g., biodispersal, upwelling).
In this talk I will first give an example of how an ocean model that dynamically downscales future climate scenarios was used to project changes in species distribution and inform management [4,5]; secondly, I will motivate the implementation of dynamically-downscaled ocean regional models for Mexican coastlines, and finally, I will conclude with an overview of the project involving the development of such a state-of-the-art product, and the planned approach for its configuration (e.g., ideal characteristics and forcing fields for the proposed downscaling models).

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D1-T-02

Regional physical-biogeochemical coupled ocean modeling at the Gulf of Mexico

Estrada-Allis, Sheila[1], **Julio Sheinbaum**[1], **Paulina Cetina**[1], **Luisa Andrade**[1], **Paula Perez**[1] and **Tereza Cavazos**[1]

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The significant socio-economic impact of anthropogenic accidents and natural events in the Gulf of Mexico (GoM) waters has encouraged oceanographic research to improve ocean regional modeling systems in the GoM. Since 2015, massive arrivals of sargassum on the Mexican coast have disconcerted the ocean research community. Despite the fact that the origin is probably related to anthropogenic sources, there are still important unresolved questions.

Recent findings pointed out the need for a better understanding of the physical-biogeochemical coupled process key to reproducing correct patterns of sargassum. Here, we set up and validate a 20-year regional model of the Gulf of Mexico [1], coupling the dynamics of the GoM and its biogeochemical conditions. In order to investigate the impact of the submesoscale process as a precursor of strong vertical velocities, we also run a nested configuration centered in two regions, at the center of the GOM, where mesoscale eddies detach, and at the Mexican Caribbean, where the sargassum arrives. The results show that the correct representation of submesoscale processes is key to understanding the vertical transport at the GoM in terms of heat and nutrients [1,2]. Results also show that to comprehend how the sargassum interacts with nutrients and currents inside the GoM, it is necessary to have long-term model outputs and high resolution to permit submesoscale. An approach to improving knowledge of Sargassum issues is also suggested.

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D1-T-03

High-resolution studies of the South East Asia regional climate system with a focus on ocean.

Marine Herrmann[1], Patrick Marsaleix[1], Ngo-Duc Thanh[2], Adrien Garinet[1], Quentin Desmet[1], Nguyen Thanh Hue[1], Trinh Bich Ngoc[2], To Duy Thai[3], Claude Estournel[1], Thomas Duhaut[1]

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Southeast Asia (SEA), including the maritime continent and at the interface between the Pacific and Indian Oceans, has a unique geographical configuration formed by a mosaic of islands, straits and basins. It is a key region for the understanding of the coupled ocean-atmosphere climate system, at both local and global scales. However, its active system and complex configuration make it one of the most difficult regions to model, both from an atmospheric and oceanic point of view.

In this context, we are conducting a methodological work to improve the understanding and modeling of the processes involved in the functioning and variability at different scales of the SEA regional climate system, of its role in the global climate and of its evolution in response to climate change.

We first focused on the study of key oceanic processes, in particular on the South Vietnam Upwelling (SVU), which plays a major role in the South China Sea physical and biological ocean dynamics and could influence the local climate. We identified and explained through ensemble high-resolution simulations the respective contributions of atmospheric forcing, large-scale circulation and chaotic oceanic variability in the SVU daily to interannual variability. We then investigated water and heat budgets within the South China Sea system, quantifying the contributions of different factors (atmospheric, oceanic and continental fluxes, internal variations) from seasonal to interannual scales. We are continuing at the scale of the CORDEX-SEA domain this parallel work of process study and regional approach. We are specifically working on the analysis of small-scale processes involved in water mass mixing, on their representation in the model schemes/parametrizations, and on their feedback on atmosphere, via a coupling between the SYMPHONIE ocean and RegCM atmosphere models. We will present a synthesis of these past and ongoing works and their perspectives in the framework of CORDEX-SEA.

D1-T-04

Regional Climate System Modeling for the Baltic Sea region – an overview about Baltic Earth activities

H. E. Markus Meier [1] and the Baltic Earth Assessment Report team

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Baltic Earth is a regional hydroclimate project (RHP) under GEWEX with focus on Earth system science in the Baltic Sea region [1]. The size of the catchment area is four times as large as the sea surface of the semi-enclosed Baltic Sea and its climate is humid so that, due to the excess of freshwater, the salinity decreases considerably from the entrance area in the south-west towards the north and east. Since more than two decades regional coupled atmosphere-sea-ice-ocean system models (RCSM) including the land-surface and the marine biogeochemistry have been developed [2], with the aim to understand the climate variability of the last thousand years including the influence of the North Atlantic and Arctic region on the Baltic Sea and to make projections up to the year 2100 [3, 4, 5]. Selected highlights on multi-stressor, ensemble modeling for the Baltic Sea [3], changes in climatic extremes such as marine heat waves [6], and uncertainty analysis of projections [3] will be presented. The latter examples are documented in the recently published Baltic Earth Assessment Reports (BEARs) that summarise the current knowledge on the environmental and climatic state of the Earth system in the Baltic Sea region and its changes in the past, present and future caused by natural variability, climate change and other human activities [7].

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D1-T-05

Quantifying air-sea heat fluxes over Southeast Asia and their response to climate change

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Abstract: Simulations of the oceanic heat fluxes over Southeast Asia in the CMIP6 multi-model ensemble (MME) were evaluated in comparison with seven other heat flux products. By comparing with the reference net heat fluxes (Q_{net}) estimates, we found that five products (NCEP1, ERA5, CFSR, J-OFURO3 and OAFlux) overestimate Q_{net}, with magnitude ranging from 6 to 37 W m^{-2}, while two products underestimate Qnet by -3 Wm^{-2} (JRA55) and 1 Wm^{-2} (NCEP2). The CMIP6 MME mean estimation shows that the net downward shortwave radiation (SW) (211 ± 18 Wm^{-2}) is balanced by latent heat flux (LH) (142 ± 12 Wm^{-2}), followed by net longwave radiation (LW) (-51 ± 11 Wm^{-2}) and sensible heat flux (SH) (-13 ± 4 Wm^{-2}). The resulting net heat budget (Q_{net}) is 3 ± 12 Wm^{-2} into the ocean, which appears to be warm-biased. Lastly, we performed an analysis of the models' sensitivity to heat fluxes, with a focus on the warmest and coldest model groups selected based on changes in sea surface temperature (SST). The model group with warmer SST projected higher increased LH, and stronger decreased LW and SH. However, the relationship between the change of SW and SST remains unclear. in both two groups. Further investigation of the relationship curves between SST and heat flux components shows a clear flipping point as well as the shift of this point in the future CMIP6 projection, in comparison with historical periods. These relationship curves reflect the interactions between wind-driven dynamic and thermodynamic factors (controlled by humidity gradient). Current findings of these relationships are expected to be useful for designing regional ocean modeling experiments at the climate scale over Southeast Asia.

D1-T-06

Mercury fate and transport in the Mediterranean Sea: current state and projected changes under RCP4.5 and RCP8.5 emission scenarios.

Rosati G., Canu D., Lazzari P., Reale M., Solidoro C.

Climate change affects the dynamics of bioaccumulative pollutants, such as mercury (Hg), through direct and indirect effects, possibly increasing bioaccumulation and human exposure. Numerical models are needed for integrating and interpreting interdisciplinary data and foreseeing possible outcomes of environmental changes, also taking into account the different sources of uncertainties.

A 3D biogeochemical model (OGSTM-BFM-Hg model) was recently developed (Rosati et al., 2022) by coupling a model for Hg biogeochemistry with the 3D transport biogeochemical model OGSTM and the biogeochemical reactor BFM. The model has been used to investigate spatial-temporal variability of Hg species concentrations in the water column and levels of bioaccumulation in the plankton food web of the Mediterranean Sea in the present climate (2004-2017). The model has a horizontal resolution of about 6 km and 70 unevenly distributed vertical levels, allowing to resolve mesoscale processes, such as eddies, that affect the biogeochemical dynamics in various areas of the basin.

The evaluation of model performances in the present climate showed that the model reproduced well the observed zonal gradients of MeHg concentrations related to spatial patterns of primary production, as well as its vertical distributions. The analysis of the MeHg seasonal cycle in different subbasins showed that summer stratification plays an important role in the buildup of the MeHg sub-surficial maximum, which is then disrupted by open ocean convection in winter. This has suggested that the increasing stratification of the water column, driven by the overall warming of the Mediterranean Sea during the 21st century, may lead to an increase in MeHg concentrations in the intermediate waters (200-400m), possibly enhancing bioaccumulation. Here, the OGSTM-BFM-Hg model is used to run long-term simulations for the 21st century under the climate change emission scenarios RCP 4.5 and 8.5 to explore the magnitude of these cascading effects.

D1-T-07

Modelling the Sea in Med-CORDEX: a review

S. Somot[1] **, on behalf of the Med-CORDEX community**

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Since its inception in 2009, the Med-CORDEX initiative has included the high-resolution representation and coupling of the Mediterranean Sea in its modelling framework. The initial goal was double, from one side to deliver robust regional climate information for the Mediterranean Sea and associated impacts and on the other side to improve the representation of the ocean surface boundary conditions for the regional climate models describing the climate of the surrounding land surfaces.

In this contribution, we review the way the Med-CORDEX initiative has included the ocean component in its work with for example dedicated modeling exercise, or by adopting experimental protocols, with coordinated ensembles of ocean-stand alone regional climate models, with the development of full-coupled regional climate system models, by using dedicated forcing datasets, by completing multi-model evaluation and future projection assessment studies, by reaching regional ocean data sharing standards, by creating links with the community studying the marine ecosystems and the maritime activities and last but not least by delivering data to the IPCC-AR6 Interactive Atlas.

International Conference on Regional Climate ICRC-CORDEX 2023 | (SMR 3878)

25/09/2023 - 29/09/2023
ICTP

D2-T-01 - LANDWEHRS Jan

Arctic Climate Simulations with the ICON Model - Comparison with Reanalyses and Observations, with a Focus on Intrusion Events

D2-T-02 - MATTHES Heidrun

Developing climate information for Arctic reindeer herding communities

D2-T-03 - MOONEY Priscilla

Developing future climate projections for impact assessments in the polar regions

Arctic Climate Simulations with the ICON Model – Comparison with Reanalyses and Observations, with a Focus on Intrusion Events

Jan Landwehrs [1] , Raphael Köhler [1] , Sofie Tiedeck [1] , Ralf Jaiser [1] , Sonja Murto [2] and Annette Rinke [1]

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The Arctic is experiencing rapid climate change, with a crucial role of heat and moisture intrusion events and resulting positive anomalies of the surface energy balance (SEB). We present a contribution to the PolarRES project (https://polarres.eu/), which has the goal to provide and analyze regional multi-model climate hindcasts and storyline projections for both polar regions for the entire 21st century.

For this purpose, we conducted simulations with the ICON weather and climate model in limited area mode (ICON-LAM), spanning the years from 2000 to 2021. The model runs on an Arctic domain with ~11 km (0.1°) horizontal resolution and is nudged to ERA5 data at the lateral and upper boundaries. The results are compared with ERA5 and CARRA reanalyses and observations, particularly from the MOSAiC expedition in 2019-2020.

We show that general conditions, such as the overall state of the surface and the atmosphere in the Arctic are reasonably reproduced by ICON, demonstrating the proper functioning of this Arctic ICON-LAM set-up. Some systematic differences to ERA5 exist, but a favorable agreement with the CARRA reanalysis is found, which has a higher resolution than ERA5 and includes effects of snow on sea ice.

Based on our model experiments, we additionally demonstrate that the snow-on-ice effect is relevant during warm and moist air intrusion events. Assessing intrusion events in November 2019 and April 2020, occurring during the MOSAiC expedition, ERA5 indicates an overestimation of positive anomalies in the surface sensible heat fluxes, resulting e.g. from larger temperature differences between surface and air, due to a missing insulating snow layer. Such strong positive heat flux anomalies are much less pronounced in the MOSAiC observations as well as in ICON-LAM and CARRA with at least a simplified representation of snow-on-ice effects.

In ongoing work, we aim to generalize such case studies of warm intrusion events in a climatological perspective on the relation of SEB anomalies and Atmospheric Rivers in the Arctic during winter.

D2-T-02

Abstract for ICRC-CORDEX 2023, Session D2

Developing climate information for Arctic reindeer herding communities

H. Matthes [1], H. Tømmervik [2], A. Rinke [1], S. Rasmus [3], R. Mottram [12], P. Mooney [4], R. Laptander [5], J. Landwehrs [1], O. Landgren [6], T. Komu [3], K. Istomin [5], T. Horstkotte [7], J. O. Habeck [3], E. Gilbert [8], B. C. Forbes [3], X. Fettweis [9], J. T. Eronen [10], C. van Dalum [11], W. J. van de Berg [11]

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In the framework of the H2020 project CHARTER, we developed a range of climate indices reflecting critical events in the reindeer herding year, which arise from combinations of the operational system of reindeer herding and meteorological seasonality. The purpose of defining these climate indices was to create a capability for analysing different projections of the future and deliver relevant information on climate change to reindeer herding communities.
Within CHARTER, we have looked at different sources of climate model output we can use to calculate future changes in our climate indices, with three important criteria in mind. 1) We want to be able to look at different possible future developments (different SSP-RCPs). 2) we want a multi-model approach so we can give estimates of uncertainty. And 3) we want high resolution data sets both in time, since the climate indices are based on daily meteorological data and spatially, so we can provide relevant information for herders on a local scale. A number of different model intercomparison projects fulfil two of the three criteria (eg the CMIP6 model ensemble fails for criterion 3, the ISIMP3 ensemble for criterion 1, CORDEX ARC-44 still fails criterion 3). CORDEX EUR-11 fulfils all three criteria, but only covers the Fennoscandian part of the Arctic. In addition, the selection of global models was not based on specific physical targets.
Within the H2020 project PolarRES, a high-resolution ensemble of Arctic climate projections is created using regional climate models to dynamically downscale GCMs selected in a storyline approach. In a first step, the RCMs produce hindcast simulations driven by ERA5 reanalysis. This study uses these simulations to evaluate model performance with respect to the climate indices relevant for reindeer herders to gain confidence in future projections of said models. We use in-situ based observations from the data set Global Summary of the day to evaluate onset and end of the continuous freezing period, hot summer days, thawing days in autumn and freeze-thaw cycles in both spring and autumn.

D2-T-03

Developing future climate projections for impact assessments in the polar regions

Priscilla A. Mooney[1]

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Polar climates in a global context remain poorly understood, as does the interactions between the different components of the Polar climate system. These knowledge gaps are leading to large uncertainties in climate change projections for the Polar regions, which together with other sources of uncertainty hampers mitigation and adaptation efforts. The PolarRES project funded by the European Commission under the Horizon 2020 programme is addressing these uncertainties by (1) narrowing some of the important knowledge gaps on atmosphere-ocean-sea ice interactions, and (2) using a storylines approach to develop future climate projections. This presentation will briefly introduce and highlight recent progress made in (1) but primarily focus on the novel innovative approach and multi-disciplinary framework taken in (2) for developing impact-relevant climate projections in the Arctic and Antarctica using an ensemble of regional climate models.

D3-T-01 - . Misnawati

Assessing Rice Yield Change based on CORDEX-Southeast Asia simulations in Sumatra

D3-T-02 - AMADOU MALAM LACHO Almoustapha

Impacts of ocean-atmosphere coupling on precipitation in small islands: a case study of the Cape Verde archipelago.

D3-T-03 - BEL MADANI Ali

Downscaling climate projections over small islands and territories : The cases of French West Indies and French Guiana

D3-T-04 - LEROUX Marie Dominique

Producing climate services in the Southwest Indian Ocean from CMIP6 Downscaled Data

D3-T-05 - SASIDHARAN NAIR Vishnu

CLIPSSA: High-Resolution Island Scale Climate Simulation for Improved Adaptation Strategies in the Southwest Pacific Region

D3-T-01

Assessing Rice Yield Change based on CORDEX-Southeast Asia simulations in Sumatra

Misnawati [1] , **Erni Susanti** [1] , **Elsa Rakhmi Dewi**[1] , **Elza Surmaini**[1], **Yudi Riadi Fanggidae**[1], **Ardhasena Sopaheluwakan**[2]

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Climate change has become a global problem for many countries that significantly affect various sectors, including the agriculture sector [1]. Rice is a major crop and staple food in Indonesia and Sumatra has the third largest rice area in Indonesia. Rice is one of the food crops that are most vulnerable to climate change. Assessing the change in rice production is necessary to find which area will experience increasing and decreasing rice production in the future. In 2045, Indonesia's population is projected approximately 300 million people (BPS: Statistic Agency, 2018). Stability in rice production is essential to ensure food security and sustainability with the projected population increases in the future [2,3]. This study aims to assess the projected change of rice productivity in Sumatra by 2045. APSIM crop model was applied to simulate future rice production using the outputs from three global climate models (GCM) from the Coupled Model Intercomparison Project Phase 5 with Representative Concentration Pathways 4.5 and 8.5 are CSIRO-Mk3.6.0, HadGEM, and CNRM that simulated under Coordinated Regional Climate Downscaling Experiment - Southeast Asia (CORDEX-SEA) covering the historical period 1996-2005 and the near future period 2026-2045 slice to the rainy season and the dry season. The results show that CSIRO-Mk3.6.0 projected an increase in rice production in Sumatra under both scenarios RCP4.5 and RCP8.5. While HadGEM and CNRM indicate that projected rice production will decrease under both emission scenarios either rainy season or dry season. The projected rice production may support climate change adaptation strategies to reduce vulnerability in the agriculture sector and strengthen future food security in Indonesia.

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D3-T-02

Impacts of ocean-atmosphere coupling on precipitation in small islands: a case study of the Cape Verde archipelago. ICRC-CORDEX 2023 to be held in Trieste, Italy between 25 - 29 September 2023

Almoustapha Amadou Malam Lacho[1], Torsten Weber[2], William Cabos[3], Dmitry V. Sein[4], Armelle Remedio[2], Nilton Évora do Rosário [5]

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Understanding and predicting the climate as well as its variability over small islands are crucial for planning and adaptation for future changes. Using high-resolution simulations of 0.22 x 0.22 degree from a regionally coupled ocean-atmosphere modeling system called GERICS-AWI REMO-OASIS-MPIOM (ROM), we analyzed the precipitation characteristics as well as its interannual variability over the Cape Verde Islands. A 10-island archipelago located off West Africa's Atlantic coast, Cape Verde precipitation presents high interannual variability mainly driven by the strength and duration of the West African Monsoon. Comparing the coupled and uncoupled ocean-atmosphere simulations of ROM with the satellite-based observational dataset from CHIRPS and local rain gauges network during the ERA-Interim period from 1981 to 2010, the precipitation biases from the coupled simulation were lower than the uncoupled simulation. The regions where the added value of the coupled simulation was also identified. This reduction of the bias could be due to the improved representation of localized processes, such as coastal upwelling, air-sea heat fluxes, and feedback mechanisms specific to coastal regions.

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[2] Sein, D. V., Gröger, M., Cabos, W., Alvarez-Garcia, F. J., Hagemann, S., Pinto, J. G., Izquierdo, A., de la Vara, A., Koldunov, N. V., Dvornikov, A. Y., Limareva, N., Alekseeva, E., Martinez-Lopez, B., & Jacob, D. (2020). Regionally Coupled Atmosphere-Ocean-Marine Biogeochemistry Model ROM: 2. Studying the Climate Change Signal in the North Atlantic and Europe. Journal of Advances in Modeling Earth Systems, 12(8). https://doi.org/10.1029/2019MS001646

D3-T-03

Downscaling climate projections over small islands and territories : The cases of French West Indies and French Guiana

A. Belmadani[1,2], P.C. Dutrieux[3], P. Cantet[4], F. Chauvin[2], B. Suez-Panama-Bouton[3], C. Decourcelle[5], A. Dalphinet[6], S. Selbonne[7], J.M. Blazy[7], F. Longueville[8], and P. Palany[3]

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Projecting climate change over small islands is key for designing adaptation strategies for isolated communities particularly vulnerable to climate hazards such as tropical cyclones, flash floods, storm surge, sea level rise, or drought. Yet, small islands are ignored by the global climate model (GCM) coarse grids, complicating the retrieval of relevant data and calling for dedicated downscaling efforts.

Here we present the results of dynamical and statistical downscaling for the islands of Guadeloupe and Martinique and for the small territory of French Guiana, respectively. In contrast to most dynamical approaches based on regional climate models constrained by GCMs, a global atmospheric model with a refined grid in the tropical North Atlantic (~15 km) is driven by surface forcing from a coarse GCM. It not only allows explicit representation of the island masses as well as reasonable rainfall climatology, but also adequate reproduction of tropical cyclones and the associated strong winds, heavy rainfall, and large waves obtained from nested ocean wave models. Projections are then bias-corrected and statistically downscaled with long daily surface temperature and precipitation timeseries from island stations, and used to compute climate indices with a focus on agriculture.

The larger size of French Guiana makes the direct use of GCMs possible, although statistical downscaling remains relevant for bias correction, mapping (the territory is covered by few grid points), and computing sector-based indices. Obvious advantages are cost-effectiveness and the processing of GCM ensembles (CMIP6) that provide more reliable uncertainty estimates made difficult with the more expensive dynamical methods. However, systematic GCM biases such as a displaced Intertropical Convergence Zone may challenge model uncertainty assessment and rather call for a storyline approach supported by selected, skilled GCMs, which all project warming and drying trends over French Guiana.

The International Conference on Regional Climate-CORDEX 2023
(IITM HUB ICRC-CORDEX 2023*)*

Producing climate services in the Southwest Indian Ocean from CMIP6 Downscaled Data

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Abstract

Dynamical downscaling was used to derive regional climate information over a large area of the southwest Indian Ocean that includes most of the inhabited countries from the coasts of Mozambique (33°E) to 74°E as well as the main area of tropical cyclone genesis [2-28°S]. The 12-km resolution limited area model ALADIN was driven by CNRM-ESM2-1 outputs for SSP1-2.6, SSP2-4.5 and SSP5-8.5 scenarios over the 2015-2100 period. Bias corrections were then applied on the main islands where observations were available: Madagascar, Reunion, Mauritius, Seychelles, and Comoros.

The possible climate futures for these countries will be illustrated with climate variables and indices already available on a regional free access portal: a surface temperature expected to increase by the end of the century by +1,5 to +2°C in the low emission scenario up to +3,5-5°C in the worst case scenario; fewer precipitation overall with the largest decrease occurring during the dry season, a dry season extending to the whole second semester (delay in the wet season start); more frequent and more severe extreme events such as droughts, heavy rain and heat waves; an increase of intense cyclonic damages.

Statistical downscaling was also performed on an ensemble of twenty CMIP6 simulations using 850 hPa winds to distinguish 5 precipitation regimes over La Reunion island. Results from both statistical and dynamical downscaling will be compared for CNRM-ESM2-1 to show the potential value of using dynamical downscaling over statistical downscaling. The statistical downscaling method tested here for an insular tropical context can easily be applied on other islands of the region with steep orography such as Madagascar and Mauritius where reliable climate observations are available. It will allow climate uncertainty assessment of temperature and precipitation variables and of climate indices.

I prefer: ORAL presentation (delete as appropriate)

D3-T-05

CLIPSSA: High-Resolution Island Scale Climate Simulation for Improved Adaptation Strategies in the Southwest Pacific Region

Vishnu S.[1,2] , **CORRE L.**[2], **DROUIN A.**[2], **DUTHEIL, C.**[3], **LENGAIGNE M.**[4], **Antoinette ALIAS**[5] **Jean-François GUEREMY**[5], **Bellon G.**[5], **Martinoni-Lapierre S.**[6], **Laurent V.**[6], **Peltier A.**[7] , **MENKES C.**[1]

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The CLIPSSA (CLImats du Pacifique, Savoirs locaux et Stratégies d'Adaptation) project aims to facilitate climate change adaptation strategies in Wallis and Futuna, French Polynesia, New Caledonia, and Vanuatu in the Southwest Pacific. The project will give access to a stronger knowledge of the region's future climate and analyse the sectoral impacts of climate change. Toward those ends, uncertainties of future climates available from CMIP5 and CMIP6 models in the southwest Pacific region and the South Pacific Convergence Zone (SPCZ) must be reduced. To address this, ALADIN 20km regional climate simulations are run in a series of experiments. The model skills are assessed based on precipitation, SPCZ and tropical cyclone characteristics. The model skills are more sensitive to domain size than model physics and cumulus parameterization. The domain giving better skills, especially in terms of cyclones, consists of part of the western Indian Ocean, incorporating Madden-Julian Oscillation-tropical cyclone interaction and a poleward extension consisting of middle latitude-tropical cyclone interaction. Using this setup, a long-term ERA5 forced historical simulation well reproduces the interannual variability associated with the El-Nino Southern Oscillation, the primary mode of interannual variation. Then pseudo-warming experiments with emergent constraints using a series of selected CMIP6 global climate models at the boundaries are run from the ERA5 reference simulation for the next 100 years under the climate change scenarios. The high-resolution climate simulation provides a better understanding of future climate extremes, including heat waves, precipitation, drought, and cyclone activities, informing the formulation of climate change adaptation strategies in the region.

D4-T-01 - FERNANDEZ DE LA GRANJA Juan Antonio

Performance, Dependencies and Spread of the CMIP Global Climate Models for selected CORDEX domains as described by the low-level circulation.

D4-T-02 - HORANYI Andras

Climate projection datasets in the Copernicus Climate Change Service's (C3S) Climate Data Store (CDS)

D4-T-03 - STEFAN Sobolowski

EURO-CORDEX CMIP6 GCM Selection & Ensemble Design: Best Practices and Recommendations

D4-T-04 - STRANDBERG Gustav Mattias

Tailored CORDEX data for the Swedish energy sector - a stakeholder focused approach

D4-T-01

Performance, Dependencies and Spread of the CMIP Global Climate Models for selected CORDEX domains as described by the low-level circulation

Juan Antonio Fernández-Granja[1], **Swen Brands**[1,2], **Ana Casanueva**[3,4], **Joaquín Bedia**[3,4], **Jesús Fernández**[1]

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Driving Global Climate Model (GCM) choice remains as one of the major sources of uncertainty in future Regional Climate Model (RCM) projections. Given the high computational cost of RCM projections, GCM selection is a key activity for CORDEX. There have been collective efforts to select a few GCMs that exhibit a plausible past climate, develop different future climate evolutions, and are sufficiently independent of each other (Sobolowski et al., 2023, https://doi.org/10.5281/zenodo.7673400). In general, these characteristics depend on the CORDEX domain and also on the variables and scores used in the evaluation. In this work, we use scores based on the Jenkinson-Collison (JC) weather type classification to evaluate a large multi-model ensemble of GCM configurations from CMIP5 and 6 in terms of low-level atmospheric circulation. We show that this large-scale characterization of the GCMs can be used to assess the 3 aspects above (performance, spread and dependence). Our assessment provides metrics for all CORDEX domains compatible with the limitations of the JC method (no polar or tropical band). Past performance rankings are remarkably similar across domains, with some model families performing well anywhere and no relationship between performance and model complexity. Scenario spread is assessed as differences in the time of emergence of the most frequent JC classes and special emphasis is put on the effect of including individual climate system components, such as dynamic vegetation properties, on the spread. Substantial dependencies reduce the effective sample size of the 61 nominally distinct participating GCMs.

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D4-T-02

Climate projection datasets in the Copernicus Climate Change Service's (C3S) Climate Data Store (CDS)

<u>András Horányi</u>

European Centre for Medium-Range Weather Forecasts

This presentation gives a brief overview of the Climate Data Store (CDS) of the Copernicus Climate Change Service (C3S) with special emphasis on the climate projection datasets.

The details of the CMIP6 global and CORDEX regional climate projection data in the CDS will be discussed. Particular details will be given what additional services C3S can provide to the users including user support and forum, training and others.

The plans for the Copernicus Interactive Climate Atlas (built on the IPCC Interactive Atlas) will be introduced showing the first datasets and snapshots of the Atlas viewer prototype.

D4-T-03

EURO-CORDEX CMIP6 GCM Selection & Ensemble Design: Best Practices and Recommendations

Stefan Sobolowski[1], Samuel Somot[2], Jesus Fernandez[3], Guillaume Evin[4], Douglas Maraun[5], Sven Kotlarski[6], Martin Jury[5], Rasmus E. Benestad[7], Claas Teichmann[8], Ole B. Christensen[9], Katharina Bülow[8], Erasmo Buonomo[10], Eleni Katragkou[11], Christian Steger[12], Silje Sørland[13], Grigory Nikulin[14], Carol McSweeney[10], Andreas Dobler[7], Tamzin Palmer[10], Renate Wilcke[14], Julien Boé[15], Lukas Brunner[16], Aurélien Ribes[2], Said Qasmi[2], Pierre Nabat[2], Florence Sevault[2], Thomas Oudar[17], Swen Brands[18]

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For CORDEX-CMIP6, the EURO-CORDEX community embarked on a mission to address common criticisms of the earlier approach to ensemble design and assessment of its driving GCMs from CMIP5. Addressing these issues will help bolster the credibility and increase the usefulness of the upcoming CORDEX ensemble for the broader Vulnerability, Impacts, Adaptation and Climate Services (VIACS) communities. This presentation, and the accompanying white paper (https://doi.org/10.5281/zenodo.7673399) and tables (https://wcrp-cordex.github.io/cmip6-for-cordex) are meant to help modellers in EURO-CORDEX, and elsewhere, make informed decisions when it comes to selecting GCMs for downscaling from the CMIP6 archive.

While the approach to GCM selection during the CMIP5 downscaling phase cannot be wholly considered an "ensemble of opportunity" it is also true that the selection of GCMs was not as rigorous as it could have been. We aim to improve upon this situation and help us construct smarter, more reliable and more useful downscaled ensembles (dynamical, statistical and hybrid) and make the selection process more transparent. The community should consider this a living exercise that will evolve along with our scientific understanding. We identified the key categories and metrics that we deem important for evaluation of GCMs for downscaling and ultimately construct an ensemble that covers the range of possible outcomes given the scenarios and simulations currently available. For this purpose we also included matrix design considerations. In particular, we wish to design a matrix that is balanced and accessible/usable for downstream VIACS communities. We rely mostly on peer-reviewed literature for the assessment of CMIP6 models and have devised innovative ways to include relevant metadata and update the synthetic spreadsheet with new results on the fly. We encourage the wider EURO-CORDEX community to become active in this activity, suggest ways to improve and alert us when new results become available or mistakes are noted in the evaluation tables. We also hope that this EURO-CORDEX GCM selection work can inspire good practices or at least contribute to fruitful discussions in other CORDEX domains and CORDEX-FPS activities.

D4-T-04

Tailored CORDEX data for the Swedish energy sector - a stakeholder focused approach

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Climate change concerns the energy sector to a high degree as it is sensitive both to changing conditions for power and heat production, as well as changing demand for electricity, heating and cooling. Potential consequences of climate change on different parts of the energy sector in Sweden were assessed in a series of workshops, where climate and energy scientists, energy systems experts and analysts met with representatives of the energy sector to assess the vulnerability and what climate indicators that could be used to assess impacts of relevance. Based on CORDEX data a large number of climatic indicators relevant for the energy sector were computed. The indicators were then matched with potential consequences to describe the impact of climate change on the energy sector.

The impact of climate change depends on the energy type. Hydropower, for which the production is naturally linked to weather and climate, are significantly impacted by climate change, although changes in the energy system may have larger consequences in a systems perspective. For others, like nuclear power in Sweden, other factors such as e.g. policy and technology development are more important. It is efficient and valuable to initiate studies and forums where climate experts can meet with experts from the energy sector to discuss climate change, its impacts and relevant adaptation measures. The series of workshops held in this study proved very successful and has increased our understanding of climate impacts and consequences on the energy system.

We suggest a few generic climate adaptation measures that apply to most of the identified consequences: (1) raise the awareness of local variations in climate change; (2) pursue the work of understanding the consequences for the energy sector; (3) monitor developments regarding climate change and its consequences; (4) identify responsible actors and stakeholders and establish effective collaborations; (5) learn from others.

D6-T-01 - BASTIN Sophie Francoise

Representation of UHI characteristics of different european cities by the first ensemble of convective-permitting simulations.

D6-T-02 - FERNANDEZ FERNANDEZ Jesus

Representation of the Urban Heat Island in CORDEX-CORE: A global multi-city analysis from the CORDEX FPS URB-RCC

D6-T-03 - HALENKA Tomas

Climate Change Scenarios and Urban Modelling for City of Prague

D6-T-04 - HOFFMANN Peter

Towards climate services for health based on very high-resolution future climate information for cities

D6-T-05 - KONSTANTINIDOU Katerina

WRF projected temperature change over MENA from regional to urban scales

D6-T-06 - LEMONSU Aude

Evaluation of the AROME CP-RCM for the study of urban climate in the Paris region and impacts under hot weather conditions

D6-T-07 - LENNARD Christopher James

Where to for CORDEX downscaling in the global south. Is the answer in the clouds?

D6-T-08 - MUÑOZ PABÓN Luis Eduardo

Urban Climate Simulation in the Metropolitan Area of Buenos Aires (SUrAMBA): Sensitivity study on model configuration.

D6-T-09 - SHIN Seok-Woo

Impact of planetary boundary layer schemes on simulation of East Asian winter monsoon using a regional climate model

D6-T-10 - YUAN Jiacan

The contributions of urbanization to a mega-heatwave in the Yangtze River Delta urban agglomerations

D6-T-01

Representation of UHI characteristics of different european cities by the first ensemble of convective-permitting simulations.

Sophie Bastin [1] **, Aude Lemonsu** [2] **, Yohanna Michau** [2] **and FPS "URB-RCC" community**

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As part of the Flagship Pilot Study (FPS) "Convection over Europe" of the CORDEX program and the H2020 project "European Climate Prediction", a set of very high resolution (~3 km) climate simulations covering several 10-year periods has been produced over Europe for the first time. The analyzes of these simulations showed a significant added value in representing the characteristics of precipitation as well as an added value compared to CORDEX climate simulations at 12km resolution on mountainous regions where horizontal resolution plays an important role on atmospheric dynamics and vertical gradients [1]. As part of the new FPS "Urban environment and Regional Climate Change (URB-RCC)", these high-resolution simulations, not specifically dedicated to the study of urban environments, are analyzed to assess their ability to represent the interactions between cities and climate at this resolution. The first object of the study is the urban heat island. The variability of their representation depending on the seasons, the cities and the models used is presented in this study. Comparison with observations is done according to their availability.

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D6-T-02

Representation of the Urban Heat Island in CORDEX-CORE: A global multi-city analysis from the CORDEX FPS URB-RCC

Jesus Fernandez[1], **Javier Diez-Sierra**[1], **Gaby Langendijk**[2], **Matthias Demuzere**[3], **Lluís Fita**[4], **Louisa Bell**[5], **Michal Belda**[6], **Eleni Katragkou**[7], **Rafiq Hamdi**[8,9], **Tomas Halenka**[6], **Peter Hoffmann**[5], **Lin Pei**[10], **Diana Rechid**[5], **Jiacan Yuan**[11]

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Urban areas modify atmospheric processes at scales that can only be represented in detail by km-scale simulations, and even at this scale, their effects need to be parameterized. Such simulations are only available for short periods at very specific sites. The CORDEX Flagship Pilot Study on Urban environments and Regional Climate Change (FPS-URB-RCC) aims to coordinate next-generation km-scale simulations to understand the two-way effect between urban areas and regional climate. In the meantime, the highest resolution resource to explore globally and from a multi-model perspective the effect of climate change on cities is the CORDEX-CORE experiment, which provides Regional Climate Model (RCM) projections with 0.22º grid spacing for most inhabited areas in the world.

In this work, we evaluate the representation of cities within CORDEX-CORE. For this purpose, we compare the nocturnal urban heat island against daily observations for a selection of more than 30 cities in different CORDEX domains with varied climates, degrees of continentality, and elevation. At this coarse resolution, cities are represented by few model grid cells, making it challenging to discern urban effects from other regional climate forcings, such as nearby seashores or complex terrain. Moreover, we show that the representation of urban areas within the different models varies widely, adding extra challenges to define reference urban surrounding areas and to systematically compare the results across models.

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D6-T-03

Climate Change Scenarios and Urban Modelling for City of Prague

Tomas Halenka, Charles University, Dept. of Atmospheric Physics, Prague, 180, Czech Republic, Michal Belda, Peter Huszár, Jan Karlický, Saoussen Dhib

Abstract Text:
Cities play a fundamental role on climate at local to regional scales through modification of heat and moisture fluxes, as well as affecting local atmospheric chemistry and composition, alongside air-pollution dispersion. Vice versa, regional climate change impacts urban areas and is expected to increasingly affect cities and their citizens in upcoming decades. To assess the impact of cities and urban structures on weather, climate and air-quality, modelling approach is commonly used and the inclusion of urban parameterization in land-surface interactions is of primary importance to capture the urban effects properly. This is especially important when going to higher resolution, which is common trend in operational weather forecast, air-quality prediction as well as regional climate modeling. As the most of population is living in the cities and the ratio is increasing, we need proper description of urban processes to assess impacts within the cities and the effectiveness of adaptation and mitigation options applied in cities in connection with climate change as well as the urban heat island itself. This is critical in connection to extreme events, for instance heat waves with extremely high temperature exacerbated by the urban heat island effect, in particular during night-time, with significant consequences for human health. In the City of Prague this can achieve about 4-5°C. This is studied in local PERUN project dealing with very high resolution (convection permitting) to localize climate change scenarios.

D6-T-04

Towards climate services for health based on very high-resolution future climate information for cities

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With the increase in extreme heat events caused by climate change, policymakers, urban planners, and public health officials need to take action to protect the health of the urban population, such as implementing climate adaptation measures, preparing for emergency response, and establishing heat warning systems. Hence, there is a growing need for detailed climate information for urban areas, which create their own local climate (i.e. urban climate). At the same time, climate mitigation measures need to be planned for cities, which are currently responsible for over 70% of the global CO_2 emissions. However, these measures can have unintended negative impacts on exposure of urban dwellers to heat stress. Currently, the conflicts and synergies between the climate mitigation and adaptation measures are not fully understood because such an effort requires very high-resolution representation of future climate conditions in cities.

The CoSynHealth project will close this gap using an integrative urban system approach, which considers complex interactions between the urban environment, urban morphology, urban society, urban dwellers, and urban health. Based on this approach new climate services will be co-developed together with relevant stakeholders to fulfill the need for climate- and health-related information during the scenario design process. In particular, the future heat stress will be assessed using very high-resolution urban climate modelling with the obstacle-resolving model PALM-4U, incorporating climate change information from regional climate model output. Future exposure to heat stress as a function of different lifestyles will be explored by integrating the future thermal comfort assessment with agent-based modelling.

D6-T-05

WRF projected temperature change over MENA from regional to urban scales

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We present new high resolution climate change simulations for the region of Middle East and North Africa (MENA) emphasizing on the projected temperature changes over model resolved urban areas in the eastern Mediterranean/Middle East (EMME). For this purpose, the WRF model was applied in a nested domain configuration at 16 km resolution (sub-regional scale) over the MENA-CORDEX domain and 4 km (near-urban scale) over the EMME, to downscale the global fields of a CMIP5 model (CCSM4). WRF was coupled with the NoahMP land surface scheme with the bulk urban option in order to take into account, at some degree, the effect of urban surfaces (defined by the MODIS land cover). Previous analysis has shown that even this simple treatment can generate plausible urban-rural differences in model air temperature. Two 5-year simulations were performed, to account for control (2000-2004) and future (2056-2060) under the RCP8.5 and the model derived air temperature was analysed with emphasis on the EMME. The projected warming was revealed for selected cities and especially in the context of urban-rural difference and in conjunction with the regional warming.

D6-T-06

Evaluation of the AROME CP-RCM for the study of urban climate in the Paris region and impacts under hot weather conditions

D6-T-07

Where to for CORDEX downscaling in the global south. Is the answer in the clouds?

Christopher Lennard[1] , Rodger Duffett[1] , and Alicia Karspeck[2]

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[2] Silver Lining, Boulder, USA

Through the Coordinated Regional Downscaling Experiment (CORDEX), the African domain enjoys a very large ensemble with over 14500 data files available on ESGF. These downscaled data were generated by 10 modelling groups and have resulted in over 270 research papers by the climate, hydrology, agriculture, health and other communities. However, none of the CORDEX-Africa downscalings were performed by an African institution. Additionally, as CORDEX has begun downscaling CMIP6 GCMs, no modelling group has committed to the downscaling the African domain.

Developing countries scientists face barriers to conducting large climate downscaling experiments including lack of infrastructure (compute nodes, storage, air conditioning), erratic power supply, lack of support (for hardware and software) and of sufficient bandwidth. What potential solutions exist to overcome these barriers and capacitate developing nation scientists to conduct computationally expensive downscaling activities, including CORDEX CMIP6 downscaling?

Here we show how cloud computing offers a solution, not only to run regional climate models on remote infrastructure, but also to analyze output from these simulations, all on the cloud.

We present performance results from a CORDEX-Africa downscaling run on the Amazon Web Server (AWS) infrastructure forced by ERA5, some test results created on the cloud through JupyterHub, and project the resource cost of downscaling 10 CMIP6 GCMS over Africa. We discuss the benefits and challenges of this process and conclude by describing how this process, with sustained investment and support, has the potential to capacitate developing nation scientists to contribute to advances in regional climate modelling together with their developed nation colleagues.

D6-T-08

Urban Climate Simulation in the Metropolitan Area of Buenos Aires (SUrAMBA): Sensitivity study on model configuration

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Abstract

Urban areas are highly vulnerable to extreme weather events, which are expected to be worsened due to climate change. However, both existing observation networks and current climate models lack the capacity to effectively evaluate urban climates at required scales for informed decision-making. With the global projection of widespread urban growth, the vulnerability and weather-related risks to urban populations, already exposed to heat waves episodes and floods, will be exacerbated. While a limited number of studies have explored the impact of weather and climate change over the Metropolitan Area of Buenos Aires (AMBA), preliminary findings indicate AMBA's sensitivity to increased heat waves and an overall significant temperature rise. Consequently, the urgent need to assess climate change effects on AMBA at an urban scale, considering its complex structure (limited permeability, high thermal inertia, and high rugosity, high heterogeneity of suburbs), has led to the development of an urban climate simulation project (SUrAMBA). This project aims to generate high-resolution data for policymakers and evaluate the effectiveness of adaptation measurements in co-construction with the local Environment Protection Agency (APrA). The climate simulations use the regional model WRF-ARW, incorporating its "*urban canopy*" and "*local climate zone (LCZ)*" schemes to enhance the urban climate features. The project's first stage involved a model's sensibility test to properly determine the nested domains and resolution to characterize AMBA. This stage is crucial in the project as it ensures that the high-resolution domain accurately captures the structure of the city, enclosing the city center, high and low vertical urban areas, and low-income informal settlements. Accurate categorization will facilitate policy evaluation in the project, and it is expected to motivate targeted studies and on-site solutions that address local vulnerabilities and align with the urban structure.

D6-T-09

Impact of planetary boundary layer schemes on simulation of East Asian winter monsoon using a regional climate model

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The East Asian Winter Monsoon (EAWM) is a crucial system influencing extreme winter events in East Asia and the Korean Peninsula. It is characterized by the Siberian high with cold air, the Aleutian low with warm air, low-level northerly winds, the East Asian trough in the middle troposphere, and the East Asian jet stream in the upper troposphere (Chang et al., 2006). To obtain more accurate and detailed scenarios, it's important to identify systematic errors in regional climate models (RCMs) during evaluation experiments. Dynamic downscaling studies for the second phase of CORDEX-East Asia (CORDEX-EA-II, Gutowski et al., 2016) are being conducted using RCMs. In one such evaluation experiment, significant systematic errors were found in the SNURCM (Cha and Lee, 2009) and WRF (V3.7, Skamarock et al., 2008) during the strong EAWM years. These errors included cold near-surface air temperature over Manchuria, overestimated zonal pressure contrast between the Siberian high and Aleutian low, overestimated low-level wind over East Asia, and overestimated sensible and latent heat flux over the East Sea and ocean around Japan. Understanding the thermodynamic processes in the planetary boundary layer (PBL) could potentially reduce WRF errors. Therefore, we tested various PBL schemes (e. g. YSU, Shin and Hong, MYJ, and MRF) for the WRF under the reanalysis dataset to evaluate whether they could reduce the existing systematic errors.

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D6-T-10

Contributions of urbanization on a miga-heatwave in the Yangtze River Delta urban agglomerations

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During the summer of 2022, a record-breaking heatwave occurred in the Yangtze River Delta urban agglomerations, causing significant damage to health and livelihoods of local residents. In this study, we used the Weather Research and Forecasting (WRF) model coupled with an urban canopy model (UCM) to investigate the contributions of urban effects on the mid-July extreme heatwave event, as well as their mechanisms. The model utilized a double-nested grid with a high resolution of 3 km in the central area, incorporating the up-to-date urban surface changes and localized anthropogenic heat emissions. Our results show that urban effects increased the daily average temperature by 0.83°C, decreased specific humidity by 0.5 g/kg, and reduced near-surface wind speed by 0.15 m/s across the entire Yangtze River Delta region. The primary mechanisms through which urban effects intensified the heatwave differed between daytime and nighttime: during daytime, compared to natural surfaces, urban surfaces were able to increase sensible heat and decrease latent heat while storing more soil heat flux; whereas at nighttime, cities released more soil heat flux and directly transferred energy through sensible heat, thus heating near-surface atmosphere more efficiently.

D9-T-01 - AWOLEYE Peace Olubukunmi

Characterization of Aerosol Radiative Forcing under Clear-Sky Conditions during a Typical Dry Season period over West Africa.

D9-T-02 - BOOTH Ben

Exploring CORDEX and driving GCM differences, in the context of time evolving aerosols

D9-T-03 - LANDGREN Oskar

Recent aerosol developments in the HCLIM regional climate model

D9-T-04 - NABAT Pierre Jean Alain

Multi-model assessment of the role of anthropogenic aerosols in European summertime climate change

D9-T-05 - SOLMON Fabien

Aerosol Climate Interactions over Africa analyzed through Regional Climate Modelling.

D9-T-06 - THOMAS Manu

Response of clouds and aerosols to natural atmospheric variability in the EC-Earth3-AerChem model

D9-T-07 - WANG Shiyu

Evaluation of Aerosols impact on the Asian summer monsoon with EC-Earth3-AerChem model

D9-T-01

Characterization of Aerosol Radiative Forcing under Clear-Sky Conditions during a Typical Dry Season period over West Africa.

Peace O. Awoleye [1], **Kehinde O. Ogunjobi** [1, 2], **and Ifeoluwa A. Balogun** [3]

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The significance of quantifying the interaction of other non-dust particles with solar radiation cannot be over emphasized. This paper presents the radiative forcing aerosol effects of some non-dust particles over four different climatic zones of West Africa. Radiative effects at the surface and top of the atmosphere requires accurate analysis of optical and radiative properties. The study retrieved outgoing longwave and shortwave radiation at the TOA from CORDEX, which was analyzed to forcing from anthropogenic, dust, marine, and non-dust aerosols governed by their size distribution and concentration. A consistent increase in daily AOD values was observed with decreasing angstrom exponent. Results showed that high negative forcing was experienced in the Savanna and Guinea zones, which can be attributed to the addition of black carbon and organic matter aerosols to the heavily deposited dust in the atmosphere. Non-dust and anthropogenic aerosols were found to be major contributors to the high atmospheric absorption. However, the result also shows that the variations in the aerosol properties lead to a consistent increase in the surface cooling in the early days of February. Therefore, a larger quantity of anthropogenic and non-dust aerosols, apart from the predominant dust, could cause and boost the radiative forcing of aerosols over West Africa.

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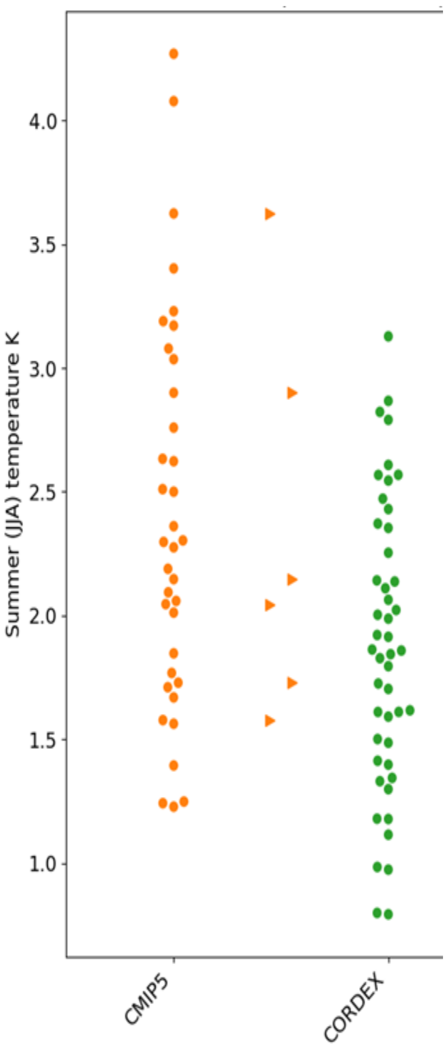
D9-T-02

Exploring CORDEX and driving GCM differences, in the context of time evolving aerosols

Authors: Ben Booth, Tom Crocker, Carol McSweeney, Citlali Solis Salas, Tim Andrews



An emerging literature has been exploring RCM-GCM differences over Europe and linking many of these differences to the lack (or in a few cases, underestimation) of aerosol "Brightening" in the RCMs (Boe et al, 2019, Gutiérrez et al, 2020, Tarana et al, 2022). Here we illustrate these differences for mid-century European surface SW, temperature and rainfall projections, with a focus on the spread. The tendency for the RCMs to underestimate the GCM warming and drying is evident. For example, the RCMs at the lower end show roughly half the warming of the lowest driving CMIP5 GCM and roughly 50% of the RCMs suggest wetter projections that 6 out of 7 driving CMIP5 GCMs. We extend this analysis to the wider CORDEX regions and identify where lack of time varying aerosol representation does, and does not, matter. We also use single forcing (RFMIP SSP245) CMIP6 experiments, to illustrate how this data can be a useful tool to predict where time varying aerosol representation is (and where it is not) likely to be important in CMIP6 downscaling.

Figure Caption: Projected temperature changes over central Europe for mid-century (2039-2060) compared to AR6 baseline (1995-2014) for RCP8.5. EURO-CORDEX (11) simulations are shown (green) with respect to the spread of CMIP5 projections (orange) highlighting the CMIP5 simulations used as boundary conditions (triangles)

D9-T-03

Recent aerosol developments in the HCLIM regional climate model

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We present status and recent developments in representation of aerosols in the regional climate modelling system HARMONIE-Climate (HCLIM). In the latest HCLIM version (HCLIM43), there are two supported atmospheric physics packages, i.e., HARMONIE-AROME for convection-permitting (typically ~3 km horizontal grid spacing or finer) simulations and ALADIN for coarser resolutions (≳10 km). In the international HCLIM development team there are now two parallel aerosol development tracks with different levels of detail and input data requirements: a "fast" and a "slow" track. The "fast track" only impacts the radiation physics and uses monthly data based on aerosol optical depth at 550 nm. This was until recently based on an older aerosol climatology dataset from Tegen et al. (1997) but has been updated to use monthly data from MERRA-2 as well as GCMs for Euro-CORDEX6 production. We compare results from the different climatologies as well as the impact of transient (varying from year to year at monthly resolution) aerosols. The "slow track" includes more sophisticated changes in both radiation and microphysics schemes to introduce spatio-temporally varying aerosols using 6-hourly input from the Copernicus Atmospheric Monitoring Service (CAMS). We show results from simulations covering different regions including Spain, Scandinavia and the Arctic.

D9-T-04

Multi-model assessment of the role of anthropogenic aerosols in European summertime climate change

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Europe is subject to numerous and various aerosol loads, interacting with radiation, clouds and atmospheric dynamics, with ensuing impact on regional climate. However up to now, aerosol variations are hardly taken into account in most regional climate simulations, although anthropogenic emissions have been dramatically reduced in Europe since the 1980s. Besides, inconsistencies between regional climate models (RCMs) and their driving global model (GCM) have recently been identified in terms of future radiation and temperature evolution, in particular for summertime climate change in Europe. These conflicting information between GCMs and RCMs could be related to differences in aerosol forcing.

This study aims at assessing the role of anthropogenic aerosols in these inconsistencies, using a dedicated multi-model ensemble of GCM-RCM simulations. This ensemble is composed of 9 GCM-RCM pairs, for which regional future simulations (2021-2050) with and without the evolution of anthropogenic aerosols, with respect to equivalent historical simulations (1971-2000), are compared and analysed.

Our results show that anthropogenic aerosols play an essential role in the future evolution of solar radiation and near-surface temperature. The decrease of their concentrations due to reduced anthropogenic emissions leads to an increase of shortwave surface radiation and an associated decrease of shortwave radiation at the top of the atmosphere, as well as an extra warming near the surface. Time-varying anthropogenic aerosols are thus contributing to improve GCM/RCM consistency in Europe for these three variables, contrary to variables of water cycle, namely precipitation, evapotranspiration and cloud cover, for which no clear effect has been found. The results obtained in this study underline the necessity to better consider aerosols in upcoming regional climate simulations.

D9-T-05

Aerosol Monsoon Interactions over Africa Analyzed through Regional Climate Modelling

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The understanding of climate variability in West Africa is of prime importance for regional socio-economic sustainability, especially in the context of climate change and population growth. Since the dramatic Sahelian droughts of the eighties, much effort has been devoted to a better scientific understanding and modeling of the West African Monsoon (WAM) system and its connection to global dynamics and to regional factors, including anthropogenic perturbations. For example, at the regional scale, the Saharan heat low and the South East Atlantic (SEA) cold tongue activity, land use changes and soil moisture feedbacks have been shown to affect the meridional distribution of diabatic and moisture sources impacting the WAM regional moist static energy gradient, convective activity and rainfall. Absorbing aerosol particles, which are emitted both naturally and as a result of anthropogenic activity in large quantity over Africa, may also impact monsoon dynamics through complex interactions initiated with radiation and cloud microphysics perturbations.
Mostly based on regional climate modelling analysis, this presentation will particularly focus on the role of dust and biomass burning aerosol and the regional mechanisms through which they impact african regional climate and monsoon. These mechanisms are notably mediated by cloud, ocean and continental suface adjustments, the importance of which will be outlined. Finally and relevant to future CORDEX-Africa activities, a perspective (and hopefully some results) on the potential impact of observed aerosol trend on african regional climate for the hitorical period and possibly the future will be proposed.

D9-T-06

Response of clouds and aerosols to natural atmospheric variability in the EC-Earth3-AerChem model

Manu Anna Thomas[1]***, Klaus Wyser***[1]***, Abhay Devasthale***[1]***, and Shiyu Wang***[1]
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Clouds respond to atmospheric circulation (and vice versa), and their spatiotemporal distribution is influenced by atmospheric dynamics as well as local meteorology. Given the tight coupling between clouds and aerosols, their fate evolves together in response to natural variability. As a result, understanding the relationship between atmospheric variability and clouds and aerosols is critical for determining the extent to which natural atmospheric variability may explain the underlying variability in their radiative effects.

Here, we use unsupervised neural network clustering like self-organizing maps to deduce the response of clouds and aerosols to the dominant modes of atmospheric variability using both the state-of-the-art EC-Earth3-AerChem model simulations and satellite-based multidecadal cloud and aerosol climate data records in the 1980-2020 period. The model simulations were done in atmosphere-only mode with observed sea surface temperature and sea ice concentrations. We investigate if this connection between natural variability and cloud response is similar in the EC-Earth3 model simulations and observations. The analysis will be carried out using the latest simulations that are performed in the context of the FORCeS project (https://forces-project.eu/). Compared to the CMIP6 simulations, these latest FORCeS simulations include updated process descriptions that possibly could reduce the uncertainty in aerosol and cloud forcings such as a new cloud activation scheme, size-resolved dust mineralogy, and secondary ice production, to name a few. So, the emphasis will also be given to determining whether the recent improvements in this model in comparison to its version of CMIP6 are closer to observed responses.

D9-T-07

Evaluation of Aerosols impact on the Asian summer monsoon with EC-Earth3-AerChem model

Shiyu Wang [1], **Klaus Wyser** [1], **and Manu Thomas** [1]

[1]*Swedish Meteorological and Hydrological Institute*

Over the Asian monsoon region, atmospheric aerosols are one of the largest sources of uncertainty in the interpretation of climate change in the past and future projections, and they have a considerable influence, both directly and indirectly, on Asian monsoon weather and climate. However, the influence of aerosol-induced climate forcing, particularly indirect radiative forcing, is still poorly understood. This study aims to evaluate the effects of aerosols on the interaction between large circulation patterns and Asian summer monsoon, based on numerical experiments conducted using the state-of-the-art EC-Earth3-AerChem model. This model simulates the microphysical and chemical interaction of aerosols and trace gases in the troposphere. The model configuration comprises the atmospheric component of EC-Earth3 model and the TM5 atmospheric chemistry and transport model. The experiment is integrated over the period 1979-2020 with observed SST and Sea Ice Concentration forcing. The result is compared against observations/Reanalysis datasets and CMIP6 simulations. Our analyses show that aerosol-cloud interaction leads to significant changes in large circulation and atmospheric temperature, particularly in the higher troposphere and stratosphere. The intensified westerly jet further alters the variability of Asian summer monsoon precipitation, especially over the maritime continent. The impact of aerosols on large circulation and precipitation during strong and weak monsoon periods will be discussed.

D10-T-01 - CORRE Lola Marion

Reference trajectory for adaptation in metropolitan France: describing the impact of global warming levels at the local scale.

D10-T-02 - KOTLARSKI Sven

Deriving GWL-based products for modern climate services

D10-T-03 - SIECK Kevin

Developing a concept for GWL with users - Experiences from the NUKLEUS project

D10-T-01

Reference trajectory for adaptation in metropolitan France: describing the impact of global warming levels at the local scale.

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French policy makers have recently chosen to adopt a global warming level (GWL) approach to define a reference warming trajectory for adaptation in France. The objective is to set a reference for adaptation actions to global warming, common to all sectors and territories. Two warming targets have been selected: the +1.5°C GWL, corresponding to a strong mitigation, consistent with the Paris agreement and a target where the GWL reaches 3°C. In order to meet the needs of adaptation stakeholders, the GWLs have been translated in terms of impacts on the scale of metropolitan France.
The data used are those of the DRIAS-2020 dataset, distributed on the Drias – Futures of Climate portal, and consisting of a selection of bias-corrected EURO-CORDEX simulations. The application of the GWL approach to regional climate projections, based on global/regional model pairs, involves combining data from global and regional projections. Applying the approach adopted by the IPCC to the DRIAS-2020 dataset is not satisfactory. In particular, we do not find the order of magnitude of the difference between the warming in France and the global warming (typically +20% to +30%) as estimated by combining CMIP6 simulations and historical observations (Ribes et al., 2022). We propose here an alternative method, based on the introduction of a regional warming level, which allows to make the DRIAS-2020 simulations consistent with the CMIP6 projections and observational constraints.

Ribes, A., Boé, J., Qasmi, S., Dubuisson, B., Douville, H., and Terray, L.: An updated assessment of past and future warming over France based on a regional observational constraint, Earth Syst. Dynam., 13, 1397–1415, https://doi.org/10.5194/esd-13-1397-2022, 2022.

D10-T-02

Deriving GWL-based products for modern climate services

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Global Warming Levels (GWLs) have evolved to a central element of the political discussion on climate mitigation, triggering an increased requirement for GWL-based information on future climate change that has to be met by modern climate services. While often being straightforward in terms of communication, GWL-based climate service products are subject to certain shortcomings that are rooted in the neglect of important uncertainty sources and in methodological choices with potentially important effects on the final product(s).

The three D-A-CH national meteorological services of Germany (DWD), Austria (Geosphere Austria) and Switzerland (MeteoSwiss) currently seek to harmonize their strategy for producing GWL-based climate service products. For this purpose, a comprehensive review of advantages and shortcomings of GWL-based analysis methods has been produced. Among others, the challenges of deriving GWL periods from underlying GCM ensembles and of translating GCM-based information into locally relevant information based on downscaled and bias-adjusted data are covered. The corresponding effects on actual climate scenario products have been quantified for specific use cases.

We here present an overview of our findings and suggestions on how to move forward.

D10-T-03

Developing a concept for GWL with users - Experiences from the NUKLEUS project

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The nationally funded NUKLEUS project has the aim to provide climate information down to convection-permitting scales to users in Germany. The ambitious goal during the first funding phase from 2020-2023 was to use three regional climate models (RCMs) to downscale output of three global climate models (GCMs) creating a mini-ensemble of nine GCM-RCM combinations for one SSP scenario. Due to the limitations in computing resources, the convection-permitting scale simulations could only be carried out in time-slices of 30 years. In a dialog process with the users, a decision was taken to use the resources on global warming levels (GWLs) rather than classical time-slice simulations with fixed time periods. To satisfy the needs of the users, a method by Vautard et al. (2014) originally developed for the European project IMPACT2C was adopted creating a GWL concept for NUKLEUS. We will present the used method and user demands that motivated certain steps in creating the concept.

A1-P-01 - ABEL Daniel

Multilayer soil and interactive vegetation in regional climate models – A case study using REMO in Mainland Southeast Asia

A1-P-02 - ALIZADEH Omid

The response of atmospheric circulation to orographic forcing: application of a regional climate model

A1-P-03 - ASHFAQ Moetasim

Evaluation of CMIP6 GCMs Over the CONUS for Downscaling Studies

A1-P-04 - CHERICONI Marco

Impact of the Ocean-Atmosphere coupling on extratropical cyclones around the Mediterranean basin

A1-P-05 - COLLINS Emmanuel

Importance of Regional Climate Change ICRC-CORDEX to \mano River Union States

A1-P-06 - HAGEMANN Ha

Regional Earth System Models for CMIP6 downscaling over the EURO-CORDEX domain

A1-P-07 - HALENKA Tomas

Urban Environments and Regional Climate Change - CORDEX Flagship Pilot Study URB-RCC

A1-P-08 - JORDA SANCHEZ Gabriel

The MED-CORDEX ensemble of climate projections for the Mediterranean Sea: impacts of the high resolution and ocean-atmosphere coupling

A1-P-09 - KIM Eunji

Future Characteristics of Tropical Cyclones under the SSP scenarios over CORDEX-East Asia domain using Multi-RCMs

A1-P-10 - KOMKOUA MBIENDA Armand Joel

Investigation of aerosol effects on diurnal cycle of precipitation amount, frequency and intensity over Central Africa by a regional climate model

A1-P-11 - MAGNAYE Angela Monina

Investigating sea surface temperature impacts on Philippine climate in CORDEX-SEA simulations

A1-P-12 - MAURER Vera

Calibration of the new regional ocean-atmosphere model based on ICON and NEMO for the EURO-CORDEX domain

A1-P-13 - MUN Taeho

Regional climate simulation of the record-breaking heavy rainfall over East Asia in 2020: model evaluation and impact of global warming

A1-P-14 - PANT Manas

Evaluation of CORDEX-CORE Simulations in Revealing the Physical Mechanisms Behind the Rainfall Extremes over the Indo-Gangetic Plains

A1-P-15 - PIETIKÄINEN Joni-Pekka Samuel

The new modernized version of the regional model REMO

A1-P-16 - SYKTUS Jozef

Dynamical downscaling of CMIP6 models over Australia: Climate projections data submission to the Australasia CORDEX domain.

A1-P-17 - TAMOFFO TCHIO Alain

Understanding the diversity of the West African monsoon system change projected by CORDEX-CORE regional climate models

A1-P-18 - TRUONG Cong Hoang

Evaluation and improvement of cloud microphysics in the Conformal Cubic Atmospheric Model

A1-P-19 - ZITTIS Georgios

WRF-based hindcast simulations in the MENA region: modeling advances and contribution to CORDEX Phase II

A1-P-01

Multilayer soil and interactive vegetation in regional climate models – A case study using REMO in Mainland Southeast Asia

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Soil hydrology and vegetation play a key role for mass and energy fluxes between the land surface and the atmosphere. Thus, their adequate representation by the schemes implemented to climate models is very important to simulate these fluxes. However, regional climate models (RCMs) sometimes are using simple schemes soil hydrological and vegetation processes. An example for this is REMO (v2015) where a bucket-type single-layer soil hydrological scheme and a static vegetation is applied in the recent CORDEX and CORDEX-CORE simulations.

Hence, we replace REMO's single-layer soil scheme by a multilayer one which allows a vertical water movement in the soil. Its application in Central Europe led to improved land surface-atmosphere fluxes [1]. Additionally, the static vegetation is replaced by an interactive vegetation module, called iMOVE, which was applied successfully in Europe [2] and Central Asia [3]. It allows the interaction of various plant characteristics with environmental conditions, like a decrease of LAI during dry conditions, while the former static version prescribes monthly static values independent of the prevailing conditions.

We'll show results of the effects both individual changes have on the mentioned fluxes and related variables in the study area of Mainland Southeast Asia. Additionally, we'll present first results of the promising combination of both individual schemes.

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[3] Rai, P. K., Ziegler, K., Abel, D., Pollinger, F. & Paeth, H. Performance of a regional climate model with interactive vegetation (REMO-iMOVE) over Central Asia. *Theor. Appl. Climatol.* **150**, 1385–1405 (2022).

A1-P-02

The response of atmospheric circulation to orographic forcing: application of a regional climate model

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Orography has considerable impacts on large-scale atmospheric circulation, emphasizing the necessity of adequate representation of the impacts of orography in numerical models. The regional climate model version 4 (RegCM4) is used to investigate the impacts of orography on large-scale atmospheric circulation. Three numerical experiments in four different years for winter and summer were conducted over a large geographical area, covering Eurasia, Africa, and Oceania. These experiments include control simulations using the real orography, simulations with the removed orography of the whole domain, and simulations with the removed orography of the whole domain except the Tibetan Plateau. In winter, the Tibetan Plateau prevents the development of sea-level high pressure in South Asia and contributes to the intensification of the Siberian high through blocking cold air advection from Siberia toward India. The Tibetan Plateau is also responsible for the southward displacement of low-level easterly flows in the North Indian Ocean, such that the elimination of this Plateau is associated with more zonal orientation and intensification of easterly winds, and an increase of moisture flux over India and the Arabian Sea. Descending motions associated with lee waves of the Western Ghat Mountains contribute to a decrease in precipitation over the Arabian Sea. In summer, the Tibetan Plateau reinforces the South Asian low-pressure system and pushes the South Asian monsoon to South Asia. Both the tropical easterly jet stream over the southern Tibetan Plateau and the subtropical westerly jet stream over the Tibetan Plateau are weakened when the whole orography is removed. The removal of the whole orography is also associated with a considerable equatorward displacement of the intertropical convergence zone over South Asia. In austral winter, low-level subtropical anticyclones in Southern Africa and Australia are intensified when the whole orography is removed.

A1-P-03

Evaluation of CMIP6 GCMs over the CONUS for downscaling studies

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Despite the necessity of Global Climate Models (GCMs) sub-selection in downscaling studies, an objective approach for their selection is currently lacking. Building on the previously established concepts in GCMs evaluation frameworks, we develop a weighted averaging technique to remove the redundancy in the evaluation criteria and rank 37 GCMs from the sixth phase of the Coupled Models Intercomparison Project over the contiguous United States. GCMs are rated based on their average performance across 66 evaluation measures in the historical period (1981–2014) after each metric is weighted between zero and one, depending on its uniqueness. The robustness of the outcome is tested by repeating the process with the empirical orthogonal function analysis in which each GCM is ranked based on its sum of distances from the reference in the principal component space. The two methodologies work in contrasting ways to remove the metrics redundancy but eventually develop similar GCM rankings. A disparity in GCMs' behavior related to their sensitivity to the size of the evaluation suite is observed, highlighting the need for comprehensive multi-variable GCMs evaluation at varying timescales for determining their skillfulness over a region. The sub-selection goal is to use a representative set of skillful models over the region of interest without substantial overlap in their future climate responses and modeling errors in representing historical climate. Additional analyses of GCMs' independence and spread in their future projections provide the necessary information to objectively select GCMs while keeping all aspects of necessity in view.

Ashfaq, M., D. Rastogi, M.A. Abid, et al. (2022) Evaluation of CMIP6 GCMs over the CONUS for downscaling studies, *J. Geophys. Res.-Atmos.*, https://doi.org/10.1002/essoar.10510589.1

A1-P-04

Impact of the Ocean-Atmosphere coupling on extratropical cyclones around the Mediterranean basin

The Mediterranean basin is well recognized as one of the main climate change hotspots; besides, this region is one the most active cyclogenetic area of the Northern Hemisphere with a large number of intense cyclones occurring every year mainly during winter and fall. The climatology of Mediterranean cyclones has been deeply investigated in the past years, leading to a high agreement on the tracks density, seasonal cycle and favourite locations of cyclogenesis. Nevertheless, open questions still remain on the future evolution of Mediterranean cyclogenesis and associated impacts. Mediterranean cyclones typically present weaker intensities, smaller sizes and shorter lifetimes than tropical cyclones or other mid-latitude cyclones that develop over open oceans. However, they are often responsible for extreme precipitation and wind events leading to severe socio-economic and environmental impacts especially over densely populated regions and coastal areas. Thus, studying the feedbacks of air-sea interactions on Mediterranean cyclones will bring to a better understanding of both the contribution of cyclones to the variability in and extremes of the regional climate and the impacts on the marine ecosystems as well as the associated risks in maritime transportation and coastal structures.

This study aims to investigate the added values of the ocean-atmosphere coupling in regional climate models in reproducing Mediterranean cyclones. To this end, two simulations are performed using the ENEA-REG regional earth system model at 12 km over the Med-CORDEX domain. The first experiment uses the mesoscale WRF model with prescribed Sea Surface Temperature (SST), while in the second WRF is coupled to the MITgcm ocean model. Different tracking methods, based on sea level pressure, are used to account for the uncertainties linked with mathematical and physical definitions of cyclone itself. The simulations are validated against ERA5 reanalysis dataset in terms of their ability to reproduce the statistics (intensity, lifetime and speed) and the seasonal distribution of the cyclones but also to represent sub-daily fields, such as precipitation, evaporation and wind speed, in the area of influence of the cyclone. Here we show how the use of coupled simulations has to offer a better and deeper understanding of high frequency dynamical processes which take place during the development of intense Mediterranean cyclones.

A1-P-05

Name: Emmanuel T. Collins

Applicant – International Conference on Regional Climate ICRC – CORDEX 2023

Topic: Importance of Regional Climate Change ICRC – CORDEX to Mano River Union States

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Abstract

The Mano River Union (MRU) is a sub-regional organization in West Africa comprising four countries: Guinea, Liberia, Sierra Leone, and Cote d'Ivoire. The MRU countries are highly vulnerable to the impacts of climate change, including sea-level rise, droughts, floods, and the spread of diseases. The Regional Climate Change CORDEX initiative is an important tool for these countries to develop effective adaptation and mitigation strategies.

The RCC-CORDEX project produces high-resolution climate estimates for MRU nations, which can assist guide policies and planning for climate change consequences. Climate forecasts may be used to construct early warning systems for extreme weather events, design robust infrastructure, and assist adaptation initiatives for agriculture, water resources, and public health.

The creation of specialized climate models for the area is one of the primary benefits of RCC-CORDEX for MRU nations. These models can better reflect the MRU nations' local climatic features, which are underrepresented in global climate models. This can result in more accurate climate estimates that are more tailored to the demands of regional policymakers and other stakeholders.

The RCC-CORDEX project also offers training and capacity-building programs for stakeholders in MRU nations, which can aid in the development of skills and knowledge about climate change and its consequences. This can assist local communities and organizations in taking climate change action and promoting sustainable development.

In summary, the RCC-CORDEX effort is crucial for MRU nations in increasing resilience to the effects of climate change. By providing accurate and customized climate estimates, as well as supporting capacity development and training programs, the project is assisting in empowering local people and policymakers to take action on climate change and establish a sustainable future for the MRU area.

Key search words: “Mano River Union”, “Regional Climate Change”, “Coordinated Regional Downscaling Experiment”,

A1-P-06

Regional Earth System Models for CMIP6 downscaling over the EURO-CORDEX domain

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In the Climate Limited-area Modelling Community (CLM-community), several Regional Earth System Models (RESMs) have been developed for dynamic downscaling over the EURO-CORDEX domain since more than a decade. The atmospheric model components are COSMO-CLM (or in short CCLM) and ICON-CLM; the latter has been developed recently. CCLM has been widely coupled to various Earth System component models. These comprise 1) different ocean models (some include also sea ice) such as NEMO, MOM5, ROMS, TRIMNP, etc., 2) the hydrological discharge model HD, and 3) recently the wave model WAM. The land surface is either included in CCLM or can be coupled as an external model (e.g. the Community Land Model (CLM) or the Veg3D model). The OASIS coupler is used to let the model components exchange states or heat and momentum fluxes amongst each other. ICON-CLM is referred to the Icosahedral Nonhydrostatic (ICON) model in Climate Limited-area Mode. The OASIS3-MCT coupling interface has been implemented into ICON-CLM to enable coupling with regional setups of the models NEMO, HD, or CLM.
This study provides an overview of the aforementioned RESMs with a focus on results of state-of-the art coupled atmosphere – ocean – sea ice – hydrology systems. Dependent on the considered ocean model, the ocean domain covers either only the Baltic Sea (with the MOM5 model) or both the Baltic Sea, North Sea, and a part of the North Atlantic (with the NEMO-GCOAST model) or the Mediterranean Sea (with the NEMO-MED model). Different coupling strategies (i.e. exchanging fluxes or state variables between atmosphere-ocean) are investigated. In principle, river runoff should be addressed in the coupled systems to close the water balance within the climate system. However, on the one hand, some coupled systems do not incorporate a respective hydrological component. On the other hand, it is an open topic how to deal with biases in discharge that may influence the salinity simulation in the ocean model, which requires further consideration. Our plans to share the load on downscaling CMIP6 over the EURO-CORDEX domain will also be presented.

A1-P-07

Urban Environments and Regional Climate Change - CORDEX Flagship Pilot Study URB-RCC

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Abstract Text:
Cities play a fundamental role on climate at local to regional scales through modification of heat and moisture fluxes, as well as affecting local atmospheric chemistry and composition, alongside air-pollution dispersion. Vice versa, regional climate change impacts urban areas and is expected to increasingly affect cities and their citizens in the upcoming decades. Simultaneously, the share of the population living in urban areas is growing, and is projected to reach about 70 % of the world population up to 2050. This is especially critical in connection to extreme events, for instance heat waves with extremely high temperature exacerbated by the urban heat island effect, in particular during night-time, with significant consequences for human health. Additionally, from the perspective of recent regional climate model development with increasing resolution down to the city scale, proper parameterization of urban processes plays an important role to understand local/regional climate change. The inclusion of the individual urban processes affecting energy balance and transport (i.e. heat, humidity, momentum fluxes, emissions) via special urban land-surface interaction parameterization of local processes becomes vital to simulate the urban effects properly. This will enable improved assessment of climate change impacts in cities and inform adaptation and/or mitigation options, as well as adequately prepare for climate related risks (e.g. heat waves, smog conditions etc.). Cities are becoming one of the most vulnerable environments under climate change. Therefore, we introduced this topic to the CORDEX platform, within the framework of so-called flagship pilot studies. Main aims and progress of this activity will be presented.

A1-P-08

The MED-CORDEX ensemble of future climate projections for the Mediterranean Sea: impacts of the high resolution and ocean-atmosphere coupling

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Med-CORDEX is an international initiative that aims at developing fully coupled high resolution Regional Climate System Models (RCSMs) for the Mediterranean basin. After 11 years of work an ensemble of more than 25 multi-model and multi–scenario climatic simulations is now available. In this study, we analyze the impact of the high-resolution representation of the Mediterranean Sea and of the interaction between ocean and atmosphere, explicitly resolved in the Med-CORDEX simulations, in the projected evolution of the most relevant climatic variables for the Mediterranean basin and the adjacent regions during the 21st century. The final goal is to quantify up to what extent including the explicit and high-resolution representation of the ocean-atmosphere coupling is relevant for regional climate projections. The preliminary results show that, in general, higher resolution coupled simulations project a lower increase in the Sea Surface Temperature (SST) than lower resolution runs. This translates in a smaller input of heat and humidity to the atmosphere that, in turn, affect the cloud cover and precipitation over the basin and the adjacent continental areas. These changes are the result of a better representation of the Mediterranean Sea functioning in the Med-CORDEX RCSMs. In particular, they resolve better the mesoscale processes of the basin, which are partly responsible of the heat transport from the surface to deeper layers, and the ocean-atmosphere feedback that regulates the heat exchange.

A1-P-09

Future Characteristics of Tropical Cyclones under the SSP scenarios over CORDEX-East Asia domain using Multi-RCMs

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Tropical cyclone (TC) activity is active in the western North Pacific (WNP). They result in destructive damages in East Asian countries including South Korea. The investigation is conducted using five regional climate models (RCMs), RegCM4, GRIMs, WRF, CCLM, and HadGEM3-RA, forced by UK Earth System Model (UKESM) under the historical and two Shared Socioeconomic Pathways (SSP) scenarios (SSP1-2.6 and SSP5-8.5). The simulation experiments are conducted over the Coordinated Regional Climate Downscaling Experiment (CORDEX) East Asia domain with 25-km horizontal resolution. The performance based-ensemble mean method is applied to reduce the uncertainty of a single RCM. The multi-model ensemble reasonably captured the number of TC genesis observed in the historical (1985-2014) period but simulated the intensity weakly. Comparing the historical and the near-future (2031-2060) and far-future (2071-2100) periods, the RCMs show similar features that the core region of TCs genesis migrates northwards. As the migration of the genesis region, the activities of TCs also moved northward. It is related to several synoptic fields; increased relative vorticity and specific humidity of 850 hPa, and weakened vertical wind shear over the mid-latitudes, due to higher sea level pressure than in the historical period.

A1-P-10

Investigation of aerosol effects on diurnal cycle of precipitation amount, frequency and intensity over Central Africa by a regional climate model

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Regional climate is affected by a wide variety of aerosols which modify through their radiative effect the precipitation distribution. In this article, the effects of aerosols, mainly dust aerosols on diurnal cycle of precipitation amount, frequency and intensity are investigated over central Africa by using the latest version of the Abdu Salam ICTP regional climate model coupled with Community Land Model 4.5 as land surface scheme. Two sets of experiments have been conducted (one with aerosols interaction with dynamics and thermodynamics processes and another without this interaction) for a 10-year study period (2002-2011) and the Fourier transformation is used to study the 24-hour cycle. In order to clearly understand spatial differences in RegCM experiments over central Africa, three subregions have been considered according to their land cover and climate characteristics. Our results indicate that the pattern of simulated Aerosol Optical Depth (AOD) is well represented particularly northward of the study region compared to AOD from Moderate Resolution Imaging Spectroradiometer (MODIS) even if some differences in terms of magnitude are reported. The aerosols effects on diurnal cycle are generally not similar to those found in the amplitude and phase. The result pointed out that over the Sahelan region, atmospheric aerosol in general and dust in particular always induced a positive effect on diurnal cycle of precipitation intensities and in precipitation amount and precipitation frequency as well. But, the change is opposite in terms of amplitude and peak time over some subregions. It appears that the forcing of aerosols in solar radiations as well as in latent heat flux leads to the changes in the amplitude of the precipitation amount during the DJF and JAS seasons particularly during daytime. The changes in amplitude of the precipitation frequency are not consistent eventhe corresponding phase always tends to increase by up to 5 hours.

A1-P-11

Investigating sea surface temperature impacts on Philippine climate in CORDEX-SEA simulations

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Abstract

The potential process behind climate model biases, especially in rainfall, during the southwest (June to August; JJA) and northeast monsoon (December to February; DJF) seasons are investigated over the Philippines using the downscaled Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations of the Southeast Asia Regional Climate Downscaling/Coordinated Regional Climate Downscaling Experiment-Southeast Asia (SEACLID/CORDEX-SEA). Performance metrics such as bias, standard deviation, and pattern correlation in the surface and near-surface climate were assessed over land in eastern (EastPH) and western (WestPH) Philippines using observation and reanalysis datasets [1]. Results show that models with well-represented sea surface temperature (SST) had a well-simulated climate [1] and provided better added values after downscaling. Although the CMIP5-driven models tend to overestimate both surface energy and water partitioning, simulations with well-represented SST have better surface energy partitions. In contrast to the reference simulation driven by ERA-Interim reanalysis, the CMIP5-driven simulations tend to underestimate (overestimate) moisture flux convergence during the DJF (JJA) season, which might have contributed to the overall underestimation (overestimation) of rainfall in this season. Further analysis along a vertical transect shows the differences in governing mechanisms for each season. During DJF (JJA) season, the simulation with underestimated (overestimated) SST, near-surface air temperature, and mixing ratio results in underestimated (overestimated) rainfall over EastPH (WestPH). CMIP5-driven models also overestimated low-level winds, which may have enabled the deep convection regardless of season, suggesting

the role of low-level winds in the convection scheme used in RegCM4 aside from topography and land cover.

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A1-P-12

Calibration of the new regional ocean-atmosphere model based on ICON and NEMO for the EURO-CORDEX domain

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The Icosahedral Nonhydrostatic (ICON) model has been used for operational numerical weather prediction (NWP) in Germany for more than 8 years in the global configuration and 2 years, respectively, in the limited-area configuration.
The ICON earth system model (ICON-Seamless) is still under development. It consists of the atmospheric model ICON-NWP, the ocean model ICON-O and the hydrological discharge model HD, all coupled via YAC. The development is currently focussing on seasonal predictions, but the plan is to make ICON-Seamless applicable for a wide range of both temporal and spatial scales. However, the limited-area version of ICON-Seamless is not yet available.
Within the Climate Limited-area Modelling (CLM) Community, regional configurations of the ocean model NEMO were coupled to COSMO-CLM. Therefore, it was decided to build a regional earth-system model based on ICON and NEMO. The components are coupled using the OASIS3-MCT coupler.
In our setup, the Climate Limited-area Mode of ICON (ICON-CLM) is adapted for the EURO-CORDEX domain and NEMO is encompassing the North and Baltic Seas as well as parts of the Atlantic Ocean. With the downscaling of CMIP6 climate projections, we aim at providing information about climate change along the German coast.
The setups of both the atmospheric and the ocean component were further refined and the coupling was adapted as far as possible and reasonable to the one of ICON-Seamless. Options to use different coupling approaches are included. The results of the evaluation simulation are compared to standalone versions of both ICON and NEMO. The coupled model is cooler over the Baltic Sea compared to the standalone NEMO, while a warm bias in the North Sea and Atlantic Ocean is enhanced in the coupled model. Current calibration activities are addressing surface fluxes of both heat and momentum, clouds and radiation, but also a refined initial state and improved lateral boundary conditions for the ocean model.

A1-P-13

Regional climate simulation of the record-breaking heavy rainfall over East Asia in 2020: model evaluation and impact of global warming

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In this study, we conducted regional climate simulations for the extreme East Asian summer monsoon (EASM) and associated record-breaking heavy precipitation in 2020, which resulted in severe casualty and property damages in Korea, China, and Japan. By analysing the synoptic-scale circulation that caused the extraordinary EASM event, we investigated the ability of a regional climate model to simulate such extreme seasonal characteristics. We conducted control experiments to simulate the EASM and the synoptic patterns in 2020. The western North Pacific subtropical high (WNPSH) expanded significantly northwestward compared to the climatology, low-level zonal wind converged near the Philippines which supplied moisture to East Asia along the edge of the WNPSH where the strong ascending motion was detected in summer 2020. Our results showed that the RCM reasonably simulated the synoptic and precipitation patterns of the EASM and the Western North Pacific summer monsoon. Additionally, sea surface temperature (SST) sensitivity experiments were conducted to investigate the impacts of global warming on the EASM. There was a positive correlation between SST and precipitation change in the tropics, but a negative correlation in the EASM region. When comparing the experiment in which the SST increased due to global warming (PT) and the control experiment (CTL), increased SST due to global warming provided moisture to the tropics, and strengthened convection in PT. And the zonal SST gradient between the Indian Ocean and the western North Pacific was increased in the PT because the linear trend of SST warming in the western North Pacific was larger than that in the Indian Ocean. This enhanced westerly wind in the tropics and convection activity in the South China Sea, which dynamically inhibited convection in East Asia by strengthening of the local Hadley cell. Meanwhile, there was a positive correlation between changes in SST and the frequency of extreme precipitation in both tropical and extratropical regions. This study can contribute to advancing our understanding of the RCM's ability to simulate extreme seasonal characteristics such as the monsoon and the potential impacts of global warming on vulnerable regions.

A1-P-14

Evaluation of CORDEX-CORE Simulations in Revealing the Physical Mechanisms Behind the Rainfall Extremes over the Indo-Gangetic Plains

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Abstract

The densely populated Indo-Gangetic Plain (IGP) region covers nearly 15% of India's landmass and is a highly fertile area, renowned for being the site of India's Green Revolution. As a significant contributor to India's GDP, the IGP's socioeconomic facets hold great importance. The study analyzes 25 years (1981-2005) of rainfall data and finds that 1- 10mm/day of rainfall occurs over IGP in the summer monsoon season with the higher tail of the distribution lying over lower/eastern regions. The RCMs efficiently reproduced the mean summer precipitation patterns over the IGP region and reduced the inherent biases present in parent data sets. The study showcases the Indian Summer Monsoon (ISM) dynamics, including the distribution patterns of various dynamical and thermodynamic parameters, and demonstrates that RCMs are able to simulate the ISM features robustly over the region of interest. The research identifies the monsoon extremes over IGP and performs a comprehensive analysis to understand their underlying mechanisms. The efficiency of high-resolution CORDEX-CORE simulations in representing rainfall extremes and underlying mechanisms at localized scales with their evolution 6 days prior as precursors has been demonstrated. This study provides valuable insight into the mechanisms behind rainfall extremes in a socioeconomically vulnerable region, and offers a pathway for climatologists and policymakers to develop effective mitigation strategies in order to face the challenges of climate change.

Keywords: IGP; CORDEX-CORE; RCM;ISM; Monsoon Extremes; Climate Change

A1-P-15

The new modernized version of the regional model REMO

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We present the new, modernized version of the regional climate model REMO. REMO is a three-dimensional limited-area atmosphere model originally developed at the Max Planck Institute for Meteorology in Hamburg, Germany, and currently maintained at the Climate Service Center Germany (GERICS) in Hamburg. REMO has a long and succesfull history in regional modelling community and it has been part of many high-level projects, such as PRUDENCE, ENSEMBLES and several CORDEX activities.

In this work, we show the latest version of the REMO model. It is a major update and combines many of the separate recent years' developments into one modular structure. The new versions incorporates seemlesly many of the regional earth-system model (RESM) components into the main atmoshperic driver, such as interactive lake module (FLake), interactive mosaic-based vegetation module (iMove) and state-of-the-art aerosol climatologies (MACv2-SP, MERRA2-CORDEX). The physics of the model have undergone updates, for example, in terms of clouds, radiation and model tuning, and the dynamics have been re-written and support both hydrostatic and non-hydrostatic approaches including different mass conserving approaches for advection of different water-based species. The new structure of the model allows easier coupling to external ocean component, thus making the model ready for full RESM simulations. Overall, we show validation results from many analyzed variables mainly for the European domain including convection permitting sub-domain(s), although the model has been tested also on other domains keeping REMO's well known multi-domain model capability.

A1-P-16

Dynamical downscaling of CMIP6 models over Australia: Climate projections data submission to the Australasia CORDEX

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Understanding the impact of climate change in Australia is vital to ensure infrastructure planned today will be resilient to future climatic changes. It is also important for the planning of emergency services, such as for fire and health services, and to inform policy decisions around agriculture, water supply and other industries. Global Climate Models (GCMs) provide climate information at too coarse a resolution for regional and local adaptation planning, and high-resolution downscaled regional scale projections are required. We dynamically downscaled 15 CMIP6 simulations to a 10 km spatial resolution over Australia using CCAM (Conformal Cubic Atmospheric model) for SSPs 126, 245 and 370 for 1960-2100 period. We compared the host CMIP6 models and downscaled simulations to the AGCD observational dataset, and evaluated performance using Kling-Gupta efficiency, and the Perkins skill score. The new added value index was derived by assessing the daily, monthly (annual cycle and amplitude) and seasonal climate for 1981-2100 period by comparing combined skill of CMIP6 host models and CCAM downscaled simulations. In addition to assessing the Perkins score for entire PDF, the 5 and 95 percentile for mean, minimum and maximum temperatures and fraction of dry days and 95 percentile of precipitation were considered. The combined skill score index/added value of downscaling was normalised and relative skill score of individual models can be compared. Evaluation of downscaled simulations show that in the historical period they add value compared to the global models especially for coastal and mountainous regions and for climate extremes (Chapman et. al., 2023).

We found that under the ssp126 (low emissions) scenario the annual average warming for Queensland is 1.4°C (0.6 to 1.9°C) by 2050 and 1.6°C (0.6 to 2.2°C) by 2100. Under the ssp370 (high emissions) scenario, temperatures warm by 1.9°C (range 1.4 to 2.5°C) by 2050 and 3.9°C (3.0 to 4.6°C) by 2100. In general, the warming over summer (DJF) is smaller than in winter (JJA). Projected changes in annual rainfall show rainfall decrease of <10% for ssp370 and similar decrease for summer rainfall for ssp126 and ssp245 by 2100. By contrast summer rainfall for ssp370 is projected to slightly increase by 2100 compared to historical baseline. Comparing the downscaled projections to corresponding CMIP6 host models projected temperature show slightly greater warming and smaller rainfall decline in all seasons over Queensland. The projected range of temperature and rainfall changes are smaller in downscaled projections compared to host CMIP6 global models. Talk will present details of projected changes compared to CMIP6 global models for Australian region. In addition talk will details of data processing and quality checking to meet the CORDEX submission requirements and data publication in Australasia CODEX archive.

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A1-P-17

Understanding the Diversity of the West African Monsoon System Change Projected by CORDEX-CORE Regional Climate Models

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Submission preferences

- Poster
- session A

Abstract

Understanding real uncertainties in projections is needed to support actions of decision and policy makers. In this study, two state-of-the-art regional climate models with *~25 km* horizontal resolution forced with three different global climate models are employed to investigate the response of the West African Monsoon (WAM) system under the low (RCP2.6) and high (RCP8.5) emission scenarios. We make a step towards assessing the plausibility of rainfall change (*ΔPr*) patterns based on the models' ability to realistically represent the WAM system under the historical period, and by analyzing changes in mechanisms associated with *ΔPr* patterns. Under global warming, experiments exhibit diverse *ΔPr* patterns underpinned by different combinations of mechanisms operating simultaneously. A dipole-like surface pressure change between the Sahara Desert and the Guinea Coast appears to be a differentiating factor between experiments featuring homogeneous or increased rainfall over all or a part of the Sahel from those simulating heterogeneous or reduced rainfall over the same domain. This dipole acts by modulating the amount and the extent of deepening of the monsoon flux inland, and hence the latitudinal positioning of the monsoon convective system. This process contributes to moistening the whole or central and eastern Sahel in some experiments while drying the Guinea Coast. The West African Westerly Jet (WAWJ) is responsible for strengthening and moistening the western Sahel under RCP2.6. However, the WAMJ becomes much stronger under RCP8.5 and may have contributed to the drying of the western Sahel by shifting moisture eastwards in addition to the mid-tropospheric moisture divergence through enhanced African Easterly Jet. Furthermore, for experiments expecting wetting (drying) of the Sahel, the strengthening (weakening) of the tropical easterly jet may have contributed to the projected intensification (reduction) of WAM rainfall by favoring uplift (downlift) above 600 hPa. It also emerges that the *ΔPr* patterns from REMO2015 experiments are likely more plausible than those from RegCM4-v7. The impacts of strong warming on the regional hydrological cycle are further investigated and we found that changes gradually intensify with the level of radiative forcing, highlighting the importance of mitigating warming as recommended by the Paris agreement.

Keywords: Global warming · Monsoon system · Rainfall changes · West Africa · RCPs · CORDEX-CORE

A1-P-18

Evaluation and improvement of cloud microphysics in the Conformal Cubic Atmospheric Model

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Clouds are an essential part of the climate system that interact with various elements of the atmosphere and hydrological cycles over a range of spatial and temporal scales. This includes interactions with aerosols, turbulence, radiative transfer, and surface processes. Although clouds have a considerable impact on the energy balance of the atmosphere, the physical processes of clouds remain poorly understood. Therefore, the projected changes in precipitation under global warming scenarios are subject to large uncertainties. In this research, we investigate the difference between the single and double-moment cloud microphysics schemes and the impact of these parameterisations on future regional climate projections within the Conformal Cubic Atmospheric Model (CCAM). CCAM employs a variable resolution global grid that requires the microphysics parameterisations to operate over a range of spatial scales. CCAM can also accommodate indirect feedbacks on the cloud microphysics due to the inclusion of a prognostic aerosol scheme. We first evaluate the global distribution and seasonal variation of simulated clouds in CCAM-regular grid by using CALIPSO observations and a cloud simulator (COSP) from 2006 to 2016. We further validate the modelled cloud and its cloud radiative effect in CCAM-sketched grid over the Coordinated Regional Downscaling Experiment (CORDEX) Australasia region against CERES datasets. The implications of the findings for projections and regional climate simulations will be discussed, including some of the advantages of using double-moment cloud microphysics.

Keywords
cloud microphysics; cloud radiative effect; CORDEX; CCAM

A1-P-19

WRF-based hindcast simulations in the MENA region: modeling advances and contribution to CORDEX Phase II

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The Middle East and North Africa (MENA) is a climate change hotspot that currently warms faster than the average global warming rates [1-2]. Global climate projections suggest a further warming intensification, particularly regarding summertime heat extremes in the region. To assess regional impacts, and underpin mitigation and adaptation measures, robust information is required from climate downscaling studies, which has been lacking for the region. MENA-CORDEX (http://mena-cordex.cyi.ac.cy/), a region-focused climate downscaling initiative that considers the particularities of the region, was established to provide the much-needed high-quality regionalized information and is dedicated to the modelling of this extraordinary climate change hotspot.

During CORDEX Phase I, several studies focused on hindcast and model optimization experiments, while fewer discussed regional future climate projections [3-5]. These studies were based on a 50-km predefined domain for the region and were mainly driven by the Representative Concentration Pathways (RCP) family of scenarios, most of them considering intermediate and high emissions of greenhouse gases, and contributed to assess regional climate change in the Atlas of the 6th IPCC Assessment Report (AR6) [6].

Here, we present the first analysis of the ongoing ERA5-driven hindcast simulations of CORDEX Phase II for the MENA domain, using WRF as a dynamical downscaling tool. Besides refinements in the horizontal (0.22×0.22°) and vertical (35 levels) resolutions, the model advancements since the previous phase experiments include a dynamic-vegetation land surface model [7] and a better treatment of aerosols, including online dust emissions. In this evaluation study, we focus on temperature and precipitation characteristics, including mean climatological values, intra-annual variability and trends, and how these compare to observations.

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A2-P-01

On convective enhancement of Vb-events in present and warmer climate

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An important source of floods in Central Europe are so-called Vb cyclones (i.e., cyclones that move across the Mediterranean Sea and then move northward toward Central Europe along the eastern flank of the European Alps). Embedded convective precipitation contributes to flood risk through Vb precipitation events. This contribution depends on temperature.

This study presents km-scale simulations with COSMO-CLM using the MedCORDEX domain and quantification of the convective precipitation contribution during a set of Vb events using a Lagrangian method for tracking convective cells [1]. In addition, this set of km-scale Vb event simulations is used to train a diagnostic of the convective fraction (based on simulated vertical velocity and vorticity in the mid-troposphere) following [2]. This diagnostic method, applied to a coupled MedCORDEX COSMO-CLM/NEMO simulation with an atmospheric grid spacing of about 12 km, allows us to investigate and visualize the change in the convective fraction of Vb precipitation in an SSP5-8.5 scenario. In this simulation, the mean Vb precipitation decreases over the course of the century, but the convective fraction, and thus the flood risk associated with locally intense precipitation, increases.

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A2-P-02

Analyzing simulated irrigation effects on convection-permitting scale – Does irrigation in northern Italy affect convective processes?

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As land use practice, irrigation aims to provide plants with water to improve growing conditions. Irrigation modifies the biogeophysical and biogeochemical conditions of the land surface and the soil and interferes with the local water balance. Through land-atmosphere interaction, this perturbation is transmitted to the atmosphere. Multiple numerical modeling studies on different scales show the irrigation effects on the atmosphere using different irrigation parameterizations. In particular, effects on near surface variables, such as the reduction of the 2 m temperature or the increased humidity in the atmosphere, are well understood. However, the effects on precipitation remain unclear, as the convective processes behind them are often not resolved by regional climate models.
Therefore, we conduct high-resolution simulations using the non-hydrostatic version of the regional climate model REMO on convection-permitting scale. In our setup, we use REMO fully coupled to interactive mosaic-based vegetation iMOVE considering vegetation processes. Irrigation is represented with our newly developed irrigation parameterization, which is based on a fractional approach and represents the heterogeneous irrigation conditions in high-resolution studies. We conduct our simulations for northern Italy as one of the most intensely irrigated regions in Europe and as region known for convective processes. By presenting the results of our simulations with the irrigation parameterization turned on and off, we will show how irrigation affects convective processes in northern Italy.

A2-P-03

An ecological index for arthropod habitats in the Circum-Sicilian islands using Convection Permitting data

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Arthropods (mainly insects) play a vital role in ecosystems, and hence are excellent indicators of ecosystem integrity. Recently, anthropogenic processes (such as climate change and land-use change) have contributed to the degradation of ecosystems. The multidisciplinary PALEOSIM project (PALEOclimate modelling of Small Islands in the Mediterranean and possible impacts on arthropod habitats) aims to shed light on the processes (natural and anthropogenic) that contributed to the ecological changes of small islands such as the Circum-Sicilian islands in the central Mediterranean.

The project showcases the use of environmental parameters (e.g., air temperature, rainfall, wind speed) to establish an ecological index and describe the potential habitat range for a selection of arthropod species. The method makes use of modified Mahalonobis distances (based on the observed locations of specific organisms) to construct environmental indices based on each parameter relevant to an individual species. The final index is obtained by combining these individual indices to obtain a spatial distribution of potential habitats. This is applied to existing Regional Climate Model (RCM) data from the CORDEX dataset. Furthermore, the RegCM5 model is being used to run 12km European simulation using CMIP6 data, and in turn, these will drive new 3km convection permitting simulations of the Mediterranean for historical, future, and paleoclimate scenarios.

Keywords: convection permitting, ecological index, CMIP6, PALEOSIM, climate impacts

A2-P-04

An overview of the onset and cessation of the biannual rainy seasons in the Coastal areas of West Africa

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Abstract: The coastal areas of West Africa are strong climatic hotspots where high population density and many major cities are located. The majority of the population (85%) and economic activity (93%) in ECOWAS member states is concentrated in the 12 coastal countries with only 49% of the area. The economic growth of this region is mainly based on the agricultural sector with the value-added ranging from 9 – 67% of GDP. However, agriculture in this region remains mostly rainfall dependent. By contrast to the Sahel region, studies on the rainfall climatology of coastal West Africa are few. Assessing the specific biannual behaviour of the rainy seasons in terms of onset, cessation and duration is crucial to improve our understanding on the impacts of rainfall variability on agricultural production.

Two major climatic zones are considered in this study: the Guinea Coast (4°N – 8°N, 18°W – 18°E) located along the Gulf of Guinea characterized by annual average precipitation higher than 1500 mm, and the Savannah (8°N – 12°N, 18°W – 18°E), a semiarid zone with annual mean precipitation between 750 and 1250 mm. Although many observational and reanalysis dataset correctly identify the biannual rainfall regime of the coastal zones, they exhibit some inconsistent deviations over this region. This study aims to evaluate the impact of climate change on the characteristics (onset, cessation and duration) of coastal West African rainfall using both WRF-ARW, with resolution based on [1] and CCCma-CanRCM4 models, with ERA-Interim and CFSv2 as forcing data, and two representative concentration pathways (RCP 4.5 and RCP 8.5 emission scenarios). Calculation of rainy season parameters will follow the definitions used by [2] and [3].

Key words: Onset dates, cessation dates, rainy season duration, Costal zones, West Africa, climate change

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A2-P-05

Evaluation of rainfall in high-resolution simulations over Mindanao

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The second phase of the Southeast Asia Regional Climate Downscaling/Coordinated Regional Climate Downscaling Experiment-Southeast Asia (SEACLID/CORDEX-SEA) project aims to provide high-resolution climate information for key areas in the region. One of the selected sites is the island of Mindanao, a major agricultural area in the southern Philippines. In this study, we assess the performance of two regional climate models (RCMs), the ICTP Regional Climate Model version 4.7 (RegCM) [1] and the Non-hydrostatic Regional Climate Model (NHRCM) [2], in simulating historical climate over Mindanao. RegCM is used to downscale the 25 km SEA model output forced by three CMIP5 global climate models (GCMs) to 5 km over Mindanao. NHRCM, on the other hand, is used to downscale the MRI-AGCM3.2 [3] first to 5 km over the Philippines, and then to 2 km convective-permitting resolution over Mindanao. A cumulus scheme was used in both 5 km simulations, unlike in the 2 km run. Both RCMs showed boreal summer rainfall biases against APHRODITE gridded dataset [4]. In general, RegCM underestimates mean rainfall in Mindanao while NHRCM overestimates it. These biases were propagated in further downscaling which may be due to the inherent biases from the driving GCMs. Both RCMs have a tendency to produce anomalously high rainfall values in high elevation locations. Although the 2 km convective-permitting simulations reduced the mean bias, extreme rainfall is still largely overestimated. Still, further downscaling to high resolution improves spatial rainfall distribution.

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A2-P-06

An African-based climate change event-attribution system using a regional climate model

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The attribution of severe weather events to climate change is becoming an increasingly important research field, which directly underpins the UNFCCC's 'International Mechanism for Loss and Damage'. Most climate change attribution systems are based on large ensembles of GCMs that are used to compare the statistics of severe weather events of pre-industrial climate to today's anthropogenic-warmed climate. We argue that RCMs can add value to such investigations through their ability to better resolve the dynamics of extreme weather events. Regional climate models are also well suited to be applied for a specific type of attribution analysis, namely 'weather event attribution'. Here the dynamics of a specific extreme event are simulated in great spatial detail for 'warmer' and 'pre-industrial' climates. Specifically, we present a new African-based event-attribution system, using an RCM, which can be applied at convection-resolving resolutions over an area of interest.

The modelling system employs a perturbed-physics ensemble to explore the role of circulation dynamics in the occurrence of a severe weather event. We subsequently use reanalysis data for the last four decades to detrend the initial state of the above mentioned simulations. The perturbed physics ensemble is then reconstructed, this time for the weather system in question inserted into a 'cooler world'. A statistical comparison between ensembles is undertaken to quantify the role of climate change in the severity of the event. We apply this approach to the 'Durban floods', which killed more than 540 people in South Africa in April 2022. By resolving the dynamics of this mesoscale event at the convective scale, we demonstrate that regional warming of the southwest Indian Ocean intensified this event. The Global Change Institute's high-resolution modelling of climate change over southern Africa is supported by the NRF Earth System Science Research Program, Project ID 136480.

A2-P-07

WRF ensemble dynamical downscaling of precipitation over China using different cumulus convective schemes

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Ensemble dynamical downscaling of precipitation over China was conducted based on simulations of the Weather and Research Forecasting model using both Kain–Fritsch and Grell cumulus convective parameterization schemes. The simulations were driven by ERA-Interim reanalysis data with 25-km horizontal resolution for the period 1980–2015. Results indicated that superior performance was achieved by the ensemble based on the two different schemes because certain observed signals were captured complementarily by each scheme over distinct regions. For climatological mean precipitation, the ensemble improved the annual mean pattern, probability distribution, and seasonal evolution of precipitation. With regard to interannual variation, the ensemble showed the highest skill in representing the series of precipitation anomalies at regional scales for all subregions. Improvement was also evident in the spatial patterns of the dominant precipitation variability modes and the corresponding temporal variations. For extreme precipitation, several indices were selected, and the ensemble was better able to capture the main features with higher spatial pattern correlations and closer magnitudes. The advantages of the ensemble are due to its appropriate regime specific weights derived from the Kain–Fritsch and Grell schemes.

A2-P-08

Effects of the regional-local circulation on precipitation development in the tropical Andes (Rio Santa Basin)

Abstract:

The Cordillera Blanca (central Andes of Peru) represents the largest concentration of tropical glaciers in the world although the atmospheric processes are still little studied in this region. The main objective of this study is to understand the atmospheric processes of interaction between local and regional scales controlling the diurnal precipitation cycle over the Santa River basin between the Cordillera Blanca and the Cordillera Negra. The rainy season (DJFM) of 2012-2013 is chosen to perform simulations with the WRF (Weather Research and Forecasting) model, with two domains at 6 km (WRF-6km) and 2 km (WRF-2km) of horizontal resolution, forced by ERA5. WRF-2km precipitation outputs show a clear improvement over WRF-6km in terms of the diurnal cycle compared to in situ observations. Three hours of the afternoon (13 LT, 16 LT, and 19 LT) are identified as associated with the triggering precipitation processes over the Santa basin. In addition, WRF-2km shows that the moisture from the Pacific Ocean is a crucial process modulating the diurnal cycle of precipitation over the Santa basin in interaction with moisture fluxes from the Amazon basin.

A2-P-09

ANALYSIS OF THE ADDED VALUE OF INCREASED SPATIAL RESOLUTION IN A REGION OF COMPLEX OROGRAPHY: A COMPARISON WITH CORDEX SIMULATIONS

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The increased resolution in regional climate simulations is expected to benefit the representation of climatic characteristics in orographically complex regions. In this framework, this study examines the benefit of increasing the spatial resolution to simulate regional climate in a high mountain region of special interest in southern Iberian Peninsula (IP), Sierra Nevada (SN). The SN, home of the highest peak in IP, is a mountainous region highly vulnerable to climate change, where mitigation and adaptation measures are critical for the species that inhabit it.

To do that, the Weather Research and Forecasting (WRF) model version 4.3.3 was used as a convection permitting model (CPM) to complete a 20-year simulation over the IP. This simulation was carried out using 2 one-way nested domains, with the coarser domain, d01, covering the Iberian Peninsula at a spatial resolution of 5 km. The nested domain, d02, was centered on SN in a domain with 1 km spatial resolution.

To analyze the added, reference databases from different sources were compared with the precipitation and temperature from both the d01 and d02 domains. In addition, the results obtained with WRF are compared with an ensemble from the Euro-CORDEX initiative for the study region for the spatial resolution of 0.11º in order to further study the effect of spatial resolution on the representation of precipitation and temperature.

The results of this analysis could be very useful for understanding convective processes in high mountain regions of special interest such as SN, which is a high mountain region of a semi-arid region.

Keywords: Sierra Nevada, precipitation, WRF, convection permitting model, added value.

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A2-P-10

A pan-European km-scale setup of the regional climate system model TSMP to study the impact of human interventions on the terrestrial water cycle

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The goal of the German Research Foundation Collaborative Research Centre project DETECT is to explore and understand observed patterns of hydrological change, that are related to persistent modifications of the coupled water and energy cycles of land and atmosphere, which are – aside from greenhouse gas forcing and natural variability – impacted by decades of human-induced land-use change, and intensified water use and management, contributing considerably to observed water storage trends at the regional scale. To investigate the associated terrestrial water cycle interactions and feedbacks, we use a fully coupled regional climate system model, TSMP (www.terrsysmp.org) that simulates the coupled groundwater-land surface-atmosphere system in a continuum approach. In its current implementation, TSMP consists of the COSMO atmospheric model, the Community Land Model, and the integrated hydrological model ParFlow, linked with each other through the OASIS3-MCT coupler. It has been shown previously, that TSMP can simulate the closed terrestrial water cycle, including anthropogenic water redistribution through pumping and irrigation. As part of the DETECT experiments, TSMP is used in a convection-permitting (3km) setup and configuration for a pan-European model domain. With a few pre-production-run ERA5-driven sensitivity study-simulations for short seasonal time spans, we try to explore the benefit of combining the added value of the convection-permitting resolution in combination with the 3D subsurface hydrodynamics simulation at the continental scale. Runs with human water use are compared to standard reference runs without human water use and an additional simulation with simplified 1D hydrodynamics. The altered (re-)distribution of surface and subsurface water impacts the subsurface-land-atmosphere coupling and soil water storage and eventually also atmospheric water budgets.

A2-P-11

Terrain-influences on the regionality of future increases in Japan's summertime extremely high temperatures and the projection uncertainty

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Anthropogenic climate change has been shown to impact present-day extremely high temperatures during summertime in Japan through event attribution studies, and concerns have arisen regarding the severity of extremely high temperatures in the future. To investigate future changes in extremely high temperatures without extreme statistical measures, we conducted large-ensemble simulations using GCM and RCM operated by the Meteorological Research Institute (MRI), Japan. We obtained a 360-year climate dataset with a 5-km resolution over Japan for each historical climate condition and for 2-K and 4-K warmer climates than the pre-industrial level. Extremely high temperature is defined as the top 10% of daily maximum temperature anomalies from the climatological mean in June - September, namely > 4000 events at a site. An increase in high temperatures is projected to be larger on the Pacific side of Japan compared to mean temperatures, while being smaller on the Sea of Japan side. This contrast is caused by differences in surface pressure changes that impact the wind blowing from the mountain behind, likely relating to the Foehn phenomena. For instance, the change in surface wind by a strengthened subtropical high in the south of Japan increases the high temperatures on the Pacific side via the Foehn. The robustness of the projected strengthening of the subtropical high is important for the large increases on the Pacific side, and thus comparisons are made between the projections from the GCM, MRI, and CMIP5/6 models. The CMIP5 projection shows large uncertainty in the future change of the subtropical high, but the uncertainty decreases in the CMIP6 projection. Additionally, the averaged projection over the CMIP6 models is close to that from the GCM, MRI. Therefore, extremely high temperatures are more serious on the Pacific side of Japan, and the projections are robust from multiple GCM projections.

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A2-P-12

Identifying future changes of extreme precipitation in Japan using 720-year 5-km-grid regional climate experiments

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Extreme precipitation is likely to trigger inland flooding, river flooding, and geohazards, which can easily cause destructive infrastructure damage and catastrophic casualties in both mountainous areas and floodplains. Japan is located at the east of the Eurasian continent and has experienced heavy precipitation many times in the past. To evaluate impacts of global warming on local-scale extreme precipitation in Japan, 720-year regional climate experiments are conducted by the non-hydrostatic regional climate model (NHRCM) [1] with 5 km grid spacing under the 2 K and 4 K warming climates relative to the preindustrial period. Our experiments are based on the large ensemble global and regional climate dataset, called database for Policy Decision making for Future climate change (d4PDF).

Annual maximum daily and hourly precipitation are enhanced over Japan due to global warming. The increasing rates depend on the region. The rate of annual maximum daily precipitation is larger over the Pacific Ocean coasts in eastern and western Japan and the northern parts of Japan. The periods when the extreme daily precipitation increases in each region depend on the progress of the Baiu stationary front and the number of typhoons from June to September. The maximum 24-hour land precipitation within 500 km of the typhoon center shows that the 50-year return value of the 5 km experiment is larger by 1.87 times than that of the 20 km experiment. The rates of future increase in 50-year return value related to typhoons are 1.30 relative to the present values for the 5 km experiments, respectively. The local-scale quasi-stationary band-shaped precipitation systems, which is called senjo-kousuitai [2], sometimes bring local-scale heavy precipitation to Japan. Based on the detection method of senjo-kousuitai [3], the 5 km experiments well reproduce the senjo-kousuitai and show increases in frequency and intensity of senjo-kousuitai under the 4K warming condition. We also introduce the application of our 5 km experiments to hydrological fields, such as future changes in river-basin scale precipitation.

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A2-P-13

CMIP6-Based Convection-Permitting Future Climate Simulation over the Black Sea Basin

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The Black Sea Basin is an area encompassing the coastal regions of the Black Sea and a broad part of the Anatolian Peninsula, which is highly vulnerable to the impacts of climate change. The region is characterized by complex topographical features and strong air-sea interactions, making it a climate change hot-spot. Previous studies have focused on regional climate modelling of this area, with horizontal resolutions on the order of 10 km. However, recent technological advances have enabled climate models to be run at 4 km or smaller grid spacings, known as the convection-permitting scale, over different regions worldwide. Such studies have highlighted the benefits of convection-permitting simulations, particularly in representing daily and sub-daily precipitation over complex terrain. In this study, we performed 10-years-long convection-permitting climate simulations at 3 km horizontal resolution for the reference and future periods (2005-2014 and 2061-2070) based on the SSP3-7.0 greenhouse gas emission scenario over the Black Sea Basin. To achieve this, we downscaled the CMIP6-based MPI-ESM1.2-HR outputs using the WRF model. The results indicate that the total precipitation decreases in spring and summer over the Black Sea Basin compared to the 2005-2014 reference period. On the other hand, it significantly increases by about 40% in winter over the Eastern Black Sea. The increase in the winter can be explained by the intensified low-level moisture flux, which increases by about 20%, enhanced by the increased evaporation due to higher SSTs. Regarding extreme precipitation, the maximum daily precipitation amount reaches 350 mm over the northeast of Türkiye and the Caucasus. The intensification of daily precipitation is most pronounced in the coastal subregions of the Black Sea Basin. Furthermore, the results highlight the intensification of sub-daily precipitation in these regions. In particular, afternoon precipitation intensifies in autumn over the coastal regions of Türkiye.

In terms of temperature, there is a significant increase in daily 2m maximum air temperatures in the spring, summer, and autumn, with an increase of about 3°C over the study area. Notably, the warming rates exceed 4.5°C in March and April. Analyses show that the northerly flow weakens around 1 m/s in March, both in the driving MPI-ESM1.2-HR and WRF over the simulation domain, resulting in warming. Moreover, the snow cover shrinks over the high-elevated regions of Eastern Anatolia in these months, and surface albedo decreases, further accelerating the temperature increase. This study emphasizes the urgent need for proactive measures to mitigate and adapt to the impacts of climate change in the Black Sea Basin, given its susceptibility to strong air-sea interactions and complex topographical features.

A2-P-14

Testing of Non-hydrostatic Core and Microphysics over the Carpathians

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This study involves the testing of non-hydrostatic core and microphysics over the Carpathians using the fifth-generation regional climate modeling system **RegCM5.** The domain size 80 x 108 x 18 was selected which include the Carpathians in the two basic regions i.e., Hungary and Slovakia regions. The domain center falls 47.5 N, 17.5 E. The ERA5 dataset was used for precipitation and temperature datasets for the years 1999-2015. The Kain-Fritsch cumulus convective scheme was used to evaluate the non-hydrostatic core and microphysics in the region in the 1st setup whereas it was kept off in the 2nd setup. The results of both setups were compared to see the differences and performance of the model run. The results of the model were validated against the observation. The model performance was better over the Slovakia region as compared to Hungarian region. The average daily temperature over the region produced results quite closer to that of observation. However, the results for precipitation were underestimated when compared to the observation. Similarly, the Cu-microphysics produced results quite closer to that of observation for daily temperature and precipitation whereas the model run without the convective scheme underestimated the results over the region. The results show that the Kain-Fritsch scheme in RegCM5 performs better over the Carpathian region. The simulations for longer time span may produce improved results for the region.

Keywords: Carpathian, Kain-Fritsch, convective scheme, model run, RegCM5

A2-P-15

Producing local climate information to help Western Australians adapt to our changing climate

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Climate projections are critical for informing decision-making for various sectors in Western Australia. Established in 2021, the Climate Science Initiative is being led by the Western Australian Government Department of Water and Environmental Regulation (DWER) in partnership with Murdoch University, the Pawsey Supercomputer Research Centre and the New South Wales Government Department of Planning and Environment to produce climate change projections extending 75 years into the future (https://www.wa.gov.au/climate-science-initiative).

We will be presenting the evaluation results for the Western Australia climate projections using ERA5 and Coordinated Regional Climate Downscaling Experiment (CORDEX) protocol. We have used ERA5 data to develop a historical climatology for Western Australia and have validated our results against observations from Bureau of Meteorology datasets. For the next phase, we will use the five selected CMIP6 Global Climate Model (GCM) data to project future climate conditions for the region under different emissions scenarios, i.e. SSP1.26 and SSP3.70 [1].

Our work has important implications for policymakers and stakeholders in the region, as it provides critical information for planning and decision-making in the face of a changing climate. We anticipate that our results will be of significant interest to a wide range of stakeholders, including government agencies, industry groups, and community organisations.

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A2-P-16

County-scale Climate Projections over Minnesota for the 21st Century

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Global warming has its largest amplitude in the higher latitude regions of the Northern Hemisphere [1]. This is especially the case during winter months when reduced reflectivity from diminished snow cover leads to higher average temperatures. This process has led to warming at twice the rate as the rest of the planet [2, 3]. In addition to accelerated warming from local snow melt, this Arctic warming is contributing to strong warming over Minnesota, especially during winter, when Minnesota is one of the states that is warming the strongest within the contiguous United States. We have previously emphasized this strong warming in our study on high-resolution climate projections over Minnesota [4], and we are now producing an updated dataset with higher spatial resolution.

Here, we use ensemble climate simulations over Minnesota with the Weather Research and Forecasting (WRF) [5] model coupled to input from six CMIP6 global climate models (GCMs). With WRF, we compute downscaled versions of the comprehensive global climate projections for the 20-year periods 2040-2059, 2060-2079, and 2080-2099. We also perform model integrations over the historical period of 1995-2014 in order to assess any systematic model uncertainties.

These projections build on our previous results at 10-km resolution, but now we use a higher 4-km horizontal resolution over Minnesota nested in a 20-km grid over the contiguous USA and southern Canada with 38 vertical levels in the atmosphere and a sophisticated representation of the many lakes that exist in Minnesota.

Our final results will show a more detailed representation of the ongoing warming for individual counties in Minnesota in all seasons, especially in winter. We expect conditions near the end of the 21st century that are significantly different from current climate. Our results will influence regional decision-making related to agriculture, infrastructure, water resources, and other sectors.

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A2-P-17

Performance of CMIP6 GCMs ensemble in the coupling zone for the RCM simulations in the PERUN project

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Global climate models (GCMs) are important tools for studying the climate system dynamics, evolution of past climates and climate change projections. However, due to their coarse spatial resolution, downscaling is necessary to assess climate features on regional and local scales, with dynamical downscaling using regional climate models (RCMs) being a common solution for this issue [1, 2]. Nevertheless, outputs of RCMs are influenced by the boundary conditions provided by GCMs at the lateral boundaries of the integration domain. The magnitude of this influence is subject of ongoing research and depends on various aspects including the geographical region, temporal scale, climatic variable, etc. Previous studies proved that an analysis of boundary conditions is needed for proper RCM evaluation, especially with regard to potential error propagation [3]. In the present study, we evaluate the simulation of CNRM-ESM2-1 [4], one of the GCMs from the Coupled Model Intercomparison Project phase 6 (CMIP6), and compare it to other CMIP6 ensemble members. The CNRM-ESM2-1 is being used as a driving model for convection-permitting simulation of Aladin-CLIMATE RCM within the Czech national project Prediction, Evaluation and Research for Understanding National sensitivity and impacts of drought and climate change for Czechia (PERUN) aimed at creation of updated climate change scenarios for the Czech Republic (https://www.perun-klima.cz/indexENG.html). The analysis is conducted over the boundaries of the RCM simulations integration domain, which covers Central Europe. The meteorological variables for analysis are temperature, relative humidity, u and v wind components and geopotential height in four pressure levels. We first evaluate CFSR and ERA5 reanalyses over the boundaries for further use as reference to evaluate the GCM simulations in the historical period of 1990-2014.

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A2-P-18

NUMERICAL SIMULATION OF THUNDERSTORM INDICES AND LIGHTNING OVER ODISHA, INDIA WITH WRF-ELEC

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Lightning-related dangers are a global hazard since they can strike at any time and in nearly any location on the planet. The scientific community has placed a greater emphasis in the last two decades on developing lightning forecasting systems using cutting-edge numerical weather prediction models. This study aims to evaluate the Weather Research & Forecasting (WRF) Model's ability to replicate the key aspects of convective storms for four lightning outbreak cases over Odisha, India. Furthermore, we investigate the impact of the horizontal grid resolution for simulating thunderstorm events. The model captures key properties of convective clouds, updrafts and downdrafts over Balasore, more correctly using 3 km than 9 km horizontal grid resolution. The model simulated Maximum Convective Available Potential Energy (J/kg) is showing values greater than 3500 in Northern Odisha which is more than sufficient for the development of a mesoscale convective event. The relative humidity profile is showing very high values of 80-90% which suggests the environment is very suitable for thunderstorm electrification. Moreover, this study focuses on the prediction of lightning with WRF-Elec and its overall performance over the WRF-ARW prediction technique with Lightning Potential Index (LPI). Overall, the simulated spatial pattern of lightning intensity aligned well with the Indian Institute of Tropical Meteorology (IITM) ground based observational data. The simulated Flash Origin Density and Flash Density shows maximum 180-190 flashes per column. The total charge density highlights that at 0 to -20 °C temperature contours there is negative charge accumulation but in the upward layers, containing the anvil of the cloud, an accumulation of positive charges can be seen. The WRF-ARW results reveal temporal and spatial displacement errors in some cases, as well as spurious echoes and lightning. The current study suggests that, on average, the simulated lightning fields for all four cases align reasonably well with the existing IITM Ground based observational lightning data. In all four scenarios, WRF-ELEC simulations outperform LPI-based predictions.

Key Words: WRF-ELEC, FOD, LPI, Flash Density, Charge Separation.

A2-P-19

Influence of small-scale ocean structures on surface wind variability over the Western Mediterranean region.

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The relevance of air-sea interactions on climate variability has been thoroughly analyzed for decades. At large scale the importance of those interactions is clear, but up to what extent small scale interactions play a role in the regional climate is still under debate. Some studies have addressed this question through sensitivity experiments using different spatial resolutions for the sea surface temperature (SST), going from ~100 km to ~30 km. However, observational and theoretical studies suggest that interactions at finer scales (< 10km) may be important. Although there are some studies addressing the effects of these high-resolution spatial SST structures on convective-driven high-precipitation events at meteorological timescales [1, 2], the analysis on climate timescales has not yet been addressed. In order to tackle this issue, a joint study of the MedCORDEX Flagship Pilot Studies on air-sea interactions and on atmospheric convection is being conducted. In particular, the sensitivity of the regional climate to the small-scale ocean structures will be assessed by means of an ensemble of convection permitting regional climate model simulations [3]. Due to the complexity and computational burden of this experiment, a preliminary step was required. First, a careful analysis of several high-resolution SST products has been carried out to characterize the small-scale SST structures and to evaluate the uncertainties associated to those products. Then, the influence of small-scale ocean structures on air-sea interactions has been analytically estimated. A decomposition of the surface turbulent fluxes has been done to assess the mechanisms controlling the surface winds and the response of the marine atmospheric boundary layer to the small-scale SST forcing structures.

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A2-P-20

Abstract for https: https://icrc-cordex2023.cordex.org/

Session:

- A2. Convection permitting modeling

Why was the 2019-2021 drought event in La Plata Basin so persistent and extreme?

J. Milovac, J. Fernandez, S. Solman, M. L. Bettolli, R. P. da Rocha, E. Coppola, F. Raffaele, J. Blazquez, A. Prein

Drought events are often supported by land–atmosphere (LA) feedbacks, and it has been shown that scarcity of soil moisture in combination with atmospheric aridity may prolong and exacerbate the event. Recently, one of the most severe droughts in the past 60 years occurred during the period of 2019-2021 in the La Plata Basin (LPB) in Southeastern South America (SESA). Given that this region has been recognised as a hotspot for LA feedbacks, in this work we investigate the importance of those feedbacks on the persistence of the drought event during these 3 years.

To do so, we use an ensemble of convection-permitting regional climate simulations (CPRCM) produced within the frame of the second phase of the CORDEX Flagship Pilot Study (FPS) over SESA. It is a collaborative work of various American and European institutes which carried out the coordinated simulations over a 3-year period, covering the drought event, with the WRF and RegCM5 CPRCMs at a 4 km horizontal resolution. We also included the convection-permitting simulation from the NCAR South America Affinity Group, which covers the entire South America during the analyzed event.

We focus our analysis on the LA feedback metrics, which are based on the correlation between surface state and atmospheric state variables. In this presentation we demonstrate the results from the CPRCM ensemble. Furthemore, the modeling results are compared to the ERA5 reanalysis and available ground/satellite observational datasets.

A2-P-21

Impact of increasing model resolution on added values in regional climate simulation of heavy precipitation

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This study explores the Added Values (AVs) of high-resolution regional climate models for precipitation, a topic that has been of great interest with the increase in computing resources. Previous studies had mainly examined AVs qualitatively by comparing the results of models with different resolutions. However, this study attempted to quantitatively investigate the AVs by analyzing the distribution of kinetic energy according to different wavelengths at two different resolutions (36km and 4km). The results of this study show that the high-resolution models simulated amplified precipitation intensity, especially for extreme precipitation and mesoscale or smaller scale weather/climate events. Furthermore, the use of more detailed topography models showed AVs for increasing spatial variability of precipitation, especially in mountainous regions. These findings have important implications for improving climate models and disaster management efforts. The study identified AVs related to kinetic energy with wavelengths at the meso-beta or smaller scale, but kinetic energy above the meso-alpha or larger scale did not show significant correlation with the AV of precipitation. These findings are significant because they provide a quantitative understanding of the AVs of high-resolution models for precipitation and can be used to improve the accuracy of climate models and disaster management efforts. Overall, this study highlights the importance of examining the AVs of climate models, as they can provide valuable insights into the accuracy and reliability of such models. In particular, the use of high-resolution models can result in more accurate simulations of precipitation intensity, which is critical for disaster management efforts.

A2-P-22

Abstract ICRC-CORDEX

Flux exchange over heterogeneous land surfaces

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Contrary to the atmosphere, where horizontal diffusion effectively reduces small scale fluctuations, land surfaces exhibit significant variability at very small scales. Surface processes need to be considered with a finer spatial resolution than atmospheric processes. In land surface models, flux aggregation techniques, such as tile or mosaic approaches, subdivide the land surface into patches for one atmospheric grid box to address for subgrid scale variability. The tile approach subdivides the surface based on a specific criterion, such as land use, as opposed to the mosaic approach, which uses an explicit, geographical sub-grid. Since fewer patches are employed in the tile approach, less computing time is needed and it is now commonly used in Earth system models. However, because it considers multivariate heterogeneity, the mosaic technique is more flexible and precise.

In this study, we use the scale-consistent, highly modular, physics-based, massively parallel, and fully integrated groundwater-vegetation-atmosphere regional Earth system modeling framework Terrestrial Systems Modeling Platform (TSMP, https://www.terrsysmp.org) to examine the effect of different flux aggregation methods on regional climate. TSMP is composed of the atmospheric models ICON or COSMO, the land surface model Community Land Model (CLM), and the ParFlow subsurface-surface hydrological model, coupled using OASIS3-MCT. We present the impact of flux aggregation techniques on atmospheric and land surface states, and outline further strategies for tackling heterogeneous land surfaces in regional climate modeling.

A2-P-23

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Assessment of homogeneous groups climatology simulated by RegCM-CP over southeastern South America

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In the context of the CORDEX-Flagship Pilot Studies over southeastern South America, this work aims to evaluate the annual cycles of precipitation, 2-m air temperature, and 10-m wind intensity simulated by convection-permitting Regional Climate Model (RegCM) using the convection-permitting (CP) version. RegCM-CP was forced by ERA5 reanalysis and integrated with a horizontal resolution of 4 km from June 2018 to December 2021 (3.5 years), in a domain covering the center-southeast (~ 15º to 35ºS) of South America. The simulation's performance was evaluated by comparing it with ERA5 and local station data in Argentina, Brazil, Paraguay, and Uruguay. Initially, the mean monthly observed precipitation was used in a cluster analysis to identify groups of stations with similar annual cycles, resulting in five clusters. The next step was to compute the mean annual cycle for the five clusters of the three variables under study from simulation, ERA5, and stations. Regarding precipitation over southeastern South America, RegCM-CP performed better than ERA5 in one cluster, while both datasets had similar performance in the other three clusters. Similar results were obtained for air temperature. However, despite the good performance of RegCM-CP in the mentioned variables, it presented an overestimation of wind intensity, which was higher than that of ERA5 in all clusters. In summary, RegCM-CP can reproduce the phase of the annual cycle of precipitation and air temperature with small biases, but presents a greater overestimation of wind intensity. The interannual variability in the clusters is also very well captured by RegCM-CP. These results are encouraging, as previous simulations for the studied region did not perform well in terms of annual cycle and interannual variability, not only in RegCM but also in other regional climate models.

Sensitivity of an unusual cyclone in southeast South America to convective parameterization schemes in the new ICTP RCM (RegCM5)

Raoni storm (2021) was a remarkable and unusual cyclone that developed on the Atlantic coast of southern South America. This winter extratropical cyclone underwent rapid intensification and transitioned to a subtropical cyclone when an upper-level cut-off low coupled with the surface low, inducing gale-forced winds. This study evaluates the performance of different parameterization schemes in simulating the evolution of Raoni. We carry out a set of sensitivity experiments using the latest and non-hydrostatic version of the limited area model originally developed by Giorgi et al. (1993), namely RegCM5. Multiple convective schemes are evaluated using the following mixed schemes: 1) Grell scheme over land and Emanuel scheme over ocean (Grell); Emanuel scheme over land and Grell scheme over ocean (Emanuel); and Tiedtke scheme over land and Kain-Fritsch scheme over ocean (Tiedtke). All the experiments employ the Biosphere-Atmosphere Transfer Scheme (BATS) to represent land surface processes. The results were validated against the ERA5 reanalysis. Results show that Tiedtke convective scheme has the best performance in representing the evolution of the cyclone in terms of position, intensity and duration, though the maximum intensities are underestimated with respect to reanalysis. The cyclone growth and its initial propagation are fairly well represented by the Emanuel scheme, but the cyclone dissipates too early. In contrary, the Grell scheme shows a low fidelity simulation as the cyclone moved southeastward and then a new cyclone developed along the coast of southern Brazil. The failure in the cyclone evolution simulated with Grell scheme is attributed to the erroneous upper-level structure that prevented the decrease of vertical wind shear which is an important factor to the development of a low-level warm core. In terms of precipitation, all the convective schemes show the increased precipitation during the initial stages of the cyclone, followed by a rapid decrease. These findings would be helpful in choosing the more appropriate cumulus parameterization schemes for cyclone simulations over South America, and in improving model predictions given the existence of model bias derived by imperfections in physical parameterizations.

Key-words: Raoni; subtropical transition; model simulations; RegCM5.

A2-P-25

Dynamical downscaling experiments for a tropical region.

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Abstract

The tropical atmosphere is characterized by weak thermal gradient and intense convective activity, the release of latent heat is the main source of energy in the circulations of the region. In the southeastern Mexico the orographic and oceanic influence in the atmospheric processes modulate convection and precipitation, contributing to the spatial variability of the regional climate.

Earth System Models (ESMs) are a useful tool for understanding global circulation, generating climate change scenarios for the following decades. The resolution of these models is adequate to describe global circulation patterns, but it is insufficient to describe the important subcontinental processes in North America, such as the effects of their abrupt orography or atmospheric processes at scales smaller than 10 km. This gap is filled up by performing dynamical downscaling which requires regional models with the potential to increase spatial resolutions.

In this study, dynamical downscaling experiments were tested using the regional model WRF in the “convection permitting” mode. In a first step, the simulations were performed for a short period (April 22-30, 2014: during which an extreme precipitation event was registered) and in a second one, for a longer period: from May to June 2010, in both cases using ERA5 database to force the WRF model evaluating their capabilities. The regional model was running under medium resolution (15 km) and high-resolutions (3km, 4 km, 5 km, 6 km and 10 km) nesting grids, covering a domain over a group of river basins located in the tropical zone of Mexico: northern Veracruz. The numerical simulations were evaluated analyzing the spatial distribution of precipitation and surface temperature through comparisons between CHIRPS and ERA5 databases.

Comparisons were also made between the 15 km coarse grid and the high-resolution grids, analyzing the performance of the model, identifying the best combination of physical process parameterizations in combination with the convection permitting option for high resolution grids.

The implications of the improvement of the model's capacities to reproduce low and high frequency processes, including the “convection permitting” option are analyzed to understand the main local processes and mechanisms at different scales and their relationship, considering the role of ocean contrasts and the contribution of abrupt orography in tropical areas to the local and regional climate variability.

A2-P-26

On the ability of convection permitting models for capturing the urban-rural contrasts over selected cities in South America

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Cites are particularly vulnerable to climate change. Considering that a large part of the population lives in cities, there is an urgent need for building useful climate information for adaptation needs. In this work we demonstrate that regional climate models operating at convection permitting resolutions are a powerful tool for capturing the urban-rural contrasts of temperature, humidity and winds over large cities in South America. A set of coordinated convection permitting simulations operating at 4km horizontal resolution centered over subtropical South America was used to simulate a 3-year period to assess city footprints in three major South American cities: Buenos Aires and Córdoba in Argentina and Porto Alegre in Brazil. Differences between the urban and rural surrounding environment have been computed for identifying the city signal on temperature, referred to the urban heat island (UHI), relative humidity and wind intensity. The analysis also includes the response of the urban environment to extreme conditions such as heat waves. Simulated data has been compared against observed hourly station data. For the three cities evaluated, the convection permitting simulations reproduce the UHI signal in terms of both timing and magnitude, with the largest UHI signal occurring during nighttime hours and with a magnitude of around $2^{O}C$. These differences are larger for summer than for winter. Generally, dryer nighttime conditions (up to 10%) over the cities are well captured by the models, probably associated with the UHI, though models tend to overestimate the cities' drying effect. The intensity of the wind is weaker over cities and models reproduce this effect, though the magnitude of the difference is overestimated. During heat waves, the convection-permitting simulations capture the exacerbated warming and drying effect of cities, particularly in Buenos Aires and Cordoba. These results show that convection permitting simulations are useful tools to produce reliable information of the cities' fingerprints.

A2-P-27

BARPA: Advancing the Australian regional climate information for decision making

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The Australian Climate Service (ACS) is developing new climate and hazard information, which will enhance our ability to prepare for, respond to, and recover from the impacts of natural hazards under a changing climate for Australia. The ACS program is drawing upon the breadth of data available from the sixth phase of the Coupled Model Inter-comparison Project (CMIP6) and has commissioned the Bureau of Meteorology (Bureau) and CSIRO to produce a multi-model regional climate modelling ensemble for the CORDEX Australasian domain (under CORDEX2 protocol), and targeted convective-scale simulations for the Australian region. In particular, the Bureau is producing moderate-resolution climate projections based on the Australian Community Climate and Earth-System Simulator (ACCESS) for seven CMIP6 models, and a convective permitting km-scale modelling system is being tested. A higher resolution reanalysis is also being produced to support the evaluation and calibration of these new projections. A new national climate ensemble will be created by combining these new simulations with work done by universities and modelling groups funded by the Australian State and Territory governments, and international contributions to CORDEX Australasia. This is guided by the National Partnership for Climate Projections to ensure national alignment and integration with other existing programs and initiatives that support Australian climate projections science.
There are many challenges and considerations when designing, producing, and delivering climate change projections information. Here we outline our modelling framework for the Bureau's contributions to ACS: Bureau of Meteorology Atmospheric Regional Projections for Australia (BARPA). An overview is given of various stages of the production from global climate modelling scale to convective permitting scale, and different levels of assessments. More details on our convective-permitting modelling system will be presented in a companion submission by Howard et al.

A2-P-28

An Open-Source Python Package for Computing the Effective Resolution of Regional Climate Models: Development, Validation, and Implications for the Climate Modeling Community

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The effective resolution of regional climate models (RCMs) is crucial for understanding and interpreting their ability to reproduce the observed spatial patterns of climate variables. This work presents the development and validation of a new open-source Python package that computes the effective resolution of RCMs based on the kinetic energy (KE) spectra analysis.

The motivation for computing the effective resolution stems from the need to better understand the performance of RCMs and to provide guidance for future model development and application. To achieve this, we first compute the KE spectra at 500 and 200 hPa for the instantaneous horizontal wind components at 6-hour frequency, overcoming the aperiodic structure of atmospheric fields in limited area models using the 2D-DCT (Discrete Cosine Transform) technique [1].

By examining the KE spectra, we can observe its behavior in comparison to an observed spectrum and determine when it deviates, which allows us to establish the effective resolution [2]. In line with previous studies [3,4], we find that KE spectra decrease with scale. A k^-3 dependence is observed in the synoptic range, dominated by rotational modes, and transitions to a shallower k^-5/3 dependence in meso to smaller scales dominated by divergent modes, with the transition between the two modes being gradual.

To validate the Python package, we computed the effective resolution of 9 state-of-the-art RCMs and contacted the corresponding modeling groups to compare our results with their own perceptions and analyses of their model's effective resolution. This collaboration led to the confirmation of our results and demonstrated the utility of the package for the regional climate modeling community.

The developed Python package offers significant benefits to the climate modeling community by providing an accessible tool to assess the effective resolution of RCMs, which is essential for interpreting model outputs and driving advancements in model development. The package's open-source nature encourages collaboration and further improvements, ultimately contributing to better-informed climate projections and improved understanding of regional climate dynamics.

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A2-P-29

The design of the CORDEX.be II ensemble: selecting CMIP6 GCMs to downscale based on their spread of extreme weather at future warming levels.

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The Belgian CORDEX.be II project aims to close the gap between regional climate model information and local impacts for climate services in support of adaptation and mitigation with a focus on extreme events. The project addresses the growing needs of stakeholders from the policy, private and academic sector for detailed spatial and temporal climate information regarding extreme weather events. To achieve this, the project will create a convection-permitting model (CPM) ensemble by downscaling CMIP6 global climate models (GCMs) over Belgium. The ensemble will provide robust climate statistics, enable exploration of low-likelihood high-impact events, and will be used to force impact models.

To design such an ensemble careful forethought and interaction with the stakeholders is required to optimize its stakeholder usefulness given the practical limitations on the CPM ensemble size. The CORDEX.be II ensemble will consider two global warming levels (GWLs) as opposed to fixed future periods. The ensemble will consist of three CPMs (ALARO, MAR and COSMO-CLIM), each coupled to multiple GCMs.

The selection of GCMs that will be used to dynamically downscale was guided by the CORDEX white paper [1] principles with an emphasis on the GCM spread. In particular, the spread of available and plausible GCMs was assessed for extreme weather indices and weather classification types. The analysis of the model spread was used to include GCMs in the CORDEX.be II ensemble that are expected to enable physically consistent low-likelihood, high-impact events when downscaled. In addition, the analysis also provided a CMIP6 GWL climate signal for extreme events.

In this study, we describe the ensemble design, critically justify the choices for the modelling setup with a focus on the spread of extreme weather represented by the selected CMIP6 GCMs.

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A2-P-30

Soil moisture-atmosphere interactions during the 2020 European Heatwave using RegCM5

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The annual recurrence of the European heatwave has brought renewed attention to the role of climate change in extreme weather events. The development of extreme heatwave is often linked to the emergence of local high pressure, that decreases cloud cover which enhances the shortwave solar radiation at the surface as well as adiabatic subsidence, that leads to anomalous high temperature [1,2]. In this study, the *state-of-the-art* Regional Climate Model version 5 [3] (RegCM5) has been dynamical downscaled over EURO-CORDEX domain (12 km horizontal resolution) with 3 hourly initial and boundary condition from the ERA5 to replicate the dynamical features of extreme heatwave event that occurred in Europe between August 7-13, 2020. This study investigates the sensitivity experiments and coherence in the combination of different dynamical cores (MM5 and MOLOCH) and moisture schemes (SUBEX, Nogherotto-Tompkin and WSM5), with specific focus on role of soil moisture in modulating synoptic pattern and spatio-temporal evolution of extreme heatwave event in the model simulation. Under the objectives of FOCI project (https://www.project-foci.eu/) our best fit model output will be further utilized to investigate mitigation and adaptation policies over Europe. A comprehensive assessment of model validation and verification is performed with help of pattern skill score and Taylor diagrams to identify the best fit model combination. Further, examination of the role of sea surface temperature, soil moisture, relative humidity, geopotential height, surface temperature, wind in developing major heat wave events will be analyzed. Finding of this paper suggest model is capable in simulating the combined effect of high-pressure and drought condition results in more significant evaporation losses, leading to declining soil moisture creating *positive feedback*, affects the surface energy balance by altering the partitioning between sensible and latent heat fluxes, resulting in above normal surface air temperature [5].

Keywords: Regional climate model, Heatwave, Soil-moisture-atmosphere feedback, Moisture scheme sensitivity, RegCM5

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A2-P-31

Improvement of land-atmosphere exchange coefficient parameterization in regional numerical simulations

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Land-atmosphere energy and moisture exchange can strongly influence local and regional climate changes. However, high uncertainties exist in the representation of land-atmosphere interactions in numerical models and the coupling strength between land and atmosphere is largely overestimated, in which the determination of surface exchange coefficient is one of the main problems. Here, we show the improvements from a dynamic vegetation-type-dependent exchange scheme in the offline Noah land surface model with multi-parameterization options and the Weather Research and Forecasting model when applied to China. Compared to the default schemes, the dynamic exchange scheme significantly reduces land-atmosphere coupling strength overestimations, and comparisons to flux tower observations reveal its capability to better match observed surface energy and water variations. In particular, the above remarkable improvements produced by the dynamic exchange scheme primarily occur in areas covered with short vegetation. The improved version benefits from the treatment of the roughness length for heat. Further, land-surface processes play significant roles in cloud formation and precipitation generation by affecting local planetary boundary layer profiles. The dynamical exchange scheme could narrow the positive discrepancies in the simulated precipitation. Using 3-km-resolution convection-permitting models for three heavy precipitation cases, the dynamic coupling simulations could achieve the closest agreement with the field observations, especially the intensity and location of the heaviest rainfall during the precipitation process. Overall, our findings highlight the applicability of the dynamic scheme as a better physical alternative to the current treatment of surface exchange processes in atmosphere coupling models and could help achieve more accurate simulations.

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A3-P-01

Preparation and downscaling of High-Resolution Climate Data for Bangladesh, Nepal and Pakistan

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Abstract

This study is part of the APN project titled "Towards Robust Projections of Climate Extremes and Adaptation Plans over South Asia", which aims to prepare local-scale (5 km) reference data and future (CMIP6) data for Pakistan, Bangladesh, and Nepal. The aim of this project is to generate localized data on extreme climate events and to identify regions that are particularly vulnerable to such events.

In the first step of the project both objective and subjective techniques are used to perform quality control on the observed station data. The observation data was then used to bias-correct the ERA5 data. ERA5 bias-corrected and observed data combined interpolated using kriging. ERA5 data excluded the form those areas where observation stations were available due to higher weightage. For temperature, we calculated the average Lapse Rate of Temperature (LRT) in mountainous regions, with adjustments made for topography using data from the Global 30 Arc-Second Elevation (GTOPO30) provided by the U.S. Geological Survey (USGS).

In the second step, we validated 40 CMIP6 models and selected the best 5 models. We then statistically downscaled/bias-corrected the models using spatial disaggregation quantile delta mapping (SDQDM). This method overcomes the problem of stationarity in data and preserves the trend in future climate signals.

Keywords: 5km Climate Data, CMIP6, Pakistan, Bangladesh, Nepal, Reference data, Himalayan mountains and Lapse Rate of Temperature

A3-P-02

Investigating the interaction between tropical convection and Atmospheric Gravity Waves over West Africa

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Abstract

Gravity waves is an important feature that transport energy and momentum from the lower atmosphere to the upper atmosphere causing convection in the atmosphere. Convection is a vital process which helps to redistribute energy away from hotter areas to cooler areas of the Earth aiding temperature circulation and reducing sharp temperature differences. Using temperature and wind profiles obtained from COSMIC-2 experifrom 2019-2023, we have extracted temperature and wind perturbations that define the interactions of tropical convection and gravity waves for evaluation of the models. Tropical convection and Atmospheric Gravity Waves interaction as represented in CORDEX regional climate models is assessed at the seasonal time scale. Analysis for the interaction between tropical convection and Atmospheric Gravity Waves is achieved by finding the free Hamiltonian and the interaction Hamiltonian of the dynamical system in the interaction picture, expressing temperature and wind datasets in terms of potential and kinetic energies respectively. The regional distribution of gravity waves activity is determined.

A3-P-03

Testing convolutional neural networks as a downscaling tool over southern South America in a climate change scenario: the case of daily extreme temperatures

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Climate change is expected to have a notable influence in southern South America (SSA) as depicted by the General Circulation Models (GCMs). In this context, the generation of regional-to-local information is critical to develop optimal adaptation and mitigation policies. This kind of information can be obtained by performing downscaling procedures over GCM outputs, increasing the resolution of the climate projections. Current state-of-the-art statistical downscaling approaches in the region (e.g., Generalised Linear Models (GLMs)) need to undergo "human-guided" feature selection approaches, which is one of the primary sources of uncertainty. This study explores the advantages and limitations of using Convolutional Neural Networks (CNNs) in SSA to downscale daily minimum and maximum temperatures. The CNNs' performance was evaluated in 3 different experiments: a cross-validation (CV) phase in the present climate; downscaling the historical and RCP8.5 scenarios of the EC-Earth; a pseudo-reality experiment to measure the extrapolation skill. Results show no remarkable differences between the CNNs and the benchmark GLMs in the CV experiment. However, we use eXplainable Artificial Intelligence (XAI) to prove that co-linearities over the regions of complex topography are better handled by the CNNs than by GLMs, which translates into a better performance when switching from the reanalysis to the GCMs space. The pseudo-reality experiment shows a good extrapolation skill of CNNs giving reliability to the CNN-downscaled EC-Earth projections. Overall, the automatic skill of CNNs to extract relevant spatial features from predictor data —against conventional approaches— together with the plausible climate change projections obtained —as verified with the pseudo-reality experiment— enforce the idea of incorporating CNN into the battery of statistical downscaling techniques over SSA with prospects to be utilised in climate change studies.

A3-P-04

A deep learning framework to emulate the convection permitting dynamical models for extreme precipitation

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Disaster risk forecasting highly depends on the ability to correctly quantify the phenomena related hazards. As for the precipitation phenomenon, the classical method of deriving precipitation distribution from simulations of dynamical models is computationally too expensive when it comes to high resolution. The proposed data-driven framework represents a first attempt in emulating the convection permitting dynamical models, with the aim of improving the projection of climatic impact-drivers relevant for risk assessment, in a much more efficient way. The predictors are ERA5 reanalysis data, with hourly values for temperature, specific humidity, eastward/northward wind components and geopotential, on a regular grid of approximately 25 km, at multiple levels of altitude. In a supervised perspective, the target is represented by hourly precipitation observations, on a high-resolution grid of 3 km over land only. The framework is based on different deep learning architectures. Convolutional and recurrent neural networks are adopted to capture the spatial and temporal dependencies in the atmospheric data and produce a low-dimensional encoding of the input. Graph neural networks are used to effectively model the irregular output grid as a graph, where each node represents a point in the spatial domain and the edges can encapsulate information regarding the relationships between nodes. A local approach is adopted, where the training examples consist of subgraphs of reduced size representing different areas in space, to tackle the huge missing data in the target dataset, as long as avoiding excessive demand for RAM memory. The output of the framework are hourly precipitation values for each node in the spatial graph, from which average and cumulative precipitation maps can be derived. Results are promising both in annual and seasonal terms and in representing extreme events.

A3-P-05

In regions of the world where topography varies significantly with distance, most global climate models (GCMs) generally have difficulty simulating the key meteorological variables that are influenced by topography such as clouds, precipitation, and surface temperatures. One way to address this challenge is to run climate models of sufficiently high resolution over those topographically complex regions. While such model simulations provide far greater detail of the atmospheric processes than ever before, it remains computationally expensive to run models at such high resolutions compared to other models of lower resolution. Currently, it is unknown whether the added benefits of increasing spatial resolution in model simulations outweigh its associated increases in computational costs. Additionally, because regionally refined and high resolution climate models are relatively new, few datasets and frameworks exist to guide the development and evaluation of those types of climate models.

As such, we propose a new framework for quantifying the added value of high spatial resolution in simulating precipitation over the contiguous United States region (CONUS). To determine its viability, we applied the framework to two model simulations and an observational dataset, all of which have different spatial resolutions. We first remapped all the data into Hierarchical Equal-Area Iso-Latitude Pixelization (HEALPix) pixels. These pixels have several mathematical properties that allow for seamless evaluation of climate models across different spatial resolutions including its equal-area and partitioning properties. The remapped HEALPix-based data is then used to assess via several metrics how the spatial variability of both observed and simulated precipitation changes with resolution increases.

This study demonstrates that realistic and accurate simulations of spatial patterns in precipitation over CONUS require the allocation of more computational resources to run E3SM at higher temporal and spatial resolutions. In terms of the framework, we find that HEALPix is a viable method for evaluating both observed and simulated precipitation simulations of varying spatial resolution. We then promote the general usage of this framework for simulations of other climate variables, datasets, and disciplines where comparing datasets of different spatial resolutions is necessary.

A3-P-06

Testing the stationary assumption of statistical downscaling using dynamical downscaling model output as pseudo observation

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Statistical downscaling methods require fewer resources to transform the present-day simulation and future climate projection from the coarse resolution global climate model to regional and local scales that are often needed for climate impact and adaptation studies. Many different techniques are used in statistical downscaling methods to remove the model bias and retain the spatial details using high-resolution observation from the current climate. However, whether this transfer function based on present-day climate remains stationary when applied to the projected future climate is often questioned, especially for the large forcing case (i.e. end of 21st century under RCP8.5 scenario).

Our study explored the stationarity assumption with two "perfect model" experiment designs. Using a very high-resolution 5-km resolution regional model for dynamical downscaling from a high-resolution 25km global climate model, we created a pseudo-observation to test the assumption on the specific statistical downscaling methods we used. The first perfect model experimental design uses a 5-km regional model output as both "observation" and "model". By simply coarsening the 5-km model present climate simulation and future projection, one can examine the violation of the stationarity assumption with specific statistical downscaling methods by comparing the statistically downscaled future climate projection with dynamical downscaled pseudo observation. Again, the second perfect model experiment design uses the 5-km regional model output as "observation", but uses the high-resolution 25km global climate model as "model". This directly compares the future climate projection from dynamical downscaling and statistical downscaling. How the degree of violation of stationarity changes with the seasonality and variables selected are discussed. Interestingly, the study area over Taiwan and the surrounding ocean featured high topography and extended coastal region with the influences of large-scale monsoonal flow, heavy rainfall from the stationary Mei-Yu frontal system, and tropical cyclones.

A3-P-07

Emulating a Complete GCM-RCM Euro-CORDEX Matrix

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The first Euro-CORDEX ensemble based on CMIP5 is the largest GCM-RCM ensemble produced, and may remain so for a long time. But how close is it to a hypothetical full matrix, given that still only 66% of possible GCM-RCM combinations in the matrix have been simulated?

With a method developed during the PRINCIPLES project[1,2] we analyse this question. An ANOVA technique with scenario period, GCM, and RCM choices as dimensions of variation is used to fill the matrix holes, and a comparison is made of various quantities between a direct ensemble mean and a "democratic" mean with equal weight to all GCMs and to all RCMs over a filled matrix.

Initially, the technique has been developed and analysed for a complete sub-matrix of 4 GCMs and 5 RCMs. Differences between average fields are quite small compared to spatial variation. However, the emulated full-ensemble averages are much closer to the full-ensemble average than the direct non-emulated average. We now apply the technique to the 8x11 complete RCP8.5 ensemble. Results seem improved with the emulated matrix, particularly over se, where the choice of GCM plays a much larger role compared to the choice of RCM. The emulated values for winter temperature are roughly 5 times closer to this target than a direct average over sea and around 1.2 times better over land.

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A3-P-08

Assessment of the interannual variability of precipitation and surface air temperature over Europe from a continental-scale high resolution machine learning based downscaled data

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We evaluate the performance of MLDown, a new downscaling method, for reproducing interannual variability of precipitation and temperature over Scandinavia, the Mediterranean and Central Eastern Europe. MLDown employs a machine learning algorithm and utilizes several dynamical and thermodynamical variables from ERA5 reanalysis, including data at different pressure levels, to generate daily scale output at a resolution of 5.5 km. The accuracy of the MLDown method is assessed by comparing the results with precipitation and surface temperature from the CERRA reanalysis.

In addition, the performance of MLDown is compared with a dynamical regional climate model that operates at a resolution of 3 km. Both MLDown and the dynamical model are capable of reproducing the interannual variability of precipitation and temperature, but MLDown performs better with a higher Pearson correlation (mean $r>0.8$) with the CERRA reanalysis across all domains. However, MLDown underestimates the mean seasonal precipitation compared to CERRA and the regional model. Notably, the performance of both models is better during the winter season than during the summer season. Areas of low skill for reproducing the interannual variability are also found in larger regions during the summer season.

A3-P-09

Evaluating the multivariate structure of bias-corrected climate variables - Measuring joint extremity with vine copulas

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Climate model large ensembles are an important research tool to analyse and quantify natural climate variability and provide reliable information for rare extreme events. However, the models produce instances of reality via simulation and therefore contain biases. The research field of bias adjustment includes methods that correct these errors in model data using information from observed data while preserving the specific pattern of the model.

For a reliable correction, spatial, temporal and inter-variable dependencies in the data require multiple variables to be corrected jointly [1, 2]. The choice of method and design will determine the quality of the correction [3]. For example, univariate correction methods can not account for multivariate relationships. In order to assess the capabilities and limitations of the corrected data, it is crucial to validate the bias-corrected results in terms of their marginal distributions and (nonlinear) correlation structures.

Therefore, we propose vine copulas to evaluate and further explain the results of bias-corrected data. The class of vine copulas provides a flexible but powerful approach to modelling complex inter-variable, spatial and temporal dependencies of climate data in a graph composed of bivariate building blocks [4]. By evaluating the likelihood of the corrected data for the estimated vine copula of the measured data, the quality of the bias correction can be quantified. The bivariate building blocks explain the relationship between pairs of variables and return a tail dependence measure that expresses their degree of joint extremity. Monitoring with vine copulas allows assessment measures to be tailored to the true distributional shape of the variables, thereby giving further explanations about the data and its extremes.

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A3-P-10

Optimizing climate data analysis workflows: Strategies and lessons learned from two case studies

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Computational requirements for climate data analysis workflows have been dramatically increasing in recent years. This has occurred in proportion to increases in both spatial and temporal resolution and particularly in the context of climate models, the number of datasets being used in the analysis as well. Much emphasis on the tooling that has been developed to meet this need has been in the form of big data frameworks and parallel computing to perform analyses at scale. However, the use of such tools also has some important drawbacks such as creating additional complexity in the analysis codes (and therefore more prone to bugs) as well as potentially being very expensive. In practice, we have found that in many cases, climate data analysis codes are poorly optimized and so greater benefits can be gained simply from writing more performant code without immediately resorting to parallelism. Here we will describe examples of how to optimize publicly available codes for two algorithms that are highly relevant in recent climate modeling studies. These will include calculations for wet bulb temperature (Davies-Jones 2008) and extended heat index (Lu and Romps, 2022). We will demonstrate how our optimizations were able to improve the running times of both use-cases by two orders of magnitude.

A3-P-11

High resolution statistical downscaling for the European continent using fully-convolutional neural networks

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High resolution climate data is often needed in applications such as climate change impact studies, agricultural and hydrological modeling, and risk assessment. Current methods to produce such data consist of either dynamical or statistical downscaling of global data. However, dynamical downscaling is slow and very resource intensive, and is likely to introduce additional biases into the system. On the other hand, current dynamical downscaling methods are either of relatively low resolution, or limited to small regions.

We present a new machine learning-based downscaling methodology that provides climate data at high resolution (5.5 km) for the entire European continent. We use two fully-convolutional neural networks to downscale climate data by predicting high resolution ground temperature and precipitation, respectively, given five climate variables on four different pressure levels at low resolution. The input data to our model is ERA-5, a global 0.25 degree resolution dataset, while the ground truth data, which our model aims to predict, is CERRA, a regional 5.5 km resolution dataset covering the European continent.

Besides evaluating the performance of our method against CERRA, we also evaluate it against HCLIM, an even higher-resolution regional climate model (3 km) divided into three European subregions (the Nordic countries, Central and Eastern Europe, and the Mediterranean). By plotting histograms of the target variables, we observe slightly higher frequencies of extreme temperatures in our predictions compared with CERRA, but about the same frequencies of extreme precipitation, while both temperature and precipitation tend to have higher frequencies of extreme values in HCLIM compared with CERRA, as well as greater maximum values, and lower minimum values value for the temperature. This could be partly due to the lower resolution of CERRA compared with HCLIM, which may act as a form of spatial low pass filter and make extreme values less extreme. We also calculate five different indices of the temperature and precipitation for our predictions, CERRA, and HCLIM, where the difference between our predictions and CERRA is significantly lower than the difference between CERRA and HCLIM.

Thus a new, fast and inexpensive machine learning-based tool can be used to produce high-resolution climate data for the European continent, with performance comparable to a higher-resolution regional climate model like HCLIM.

A3-P-12

An interactive web interface to compare the LOcalized Constructed Analogs 2 (LOCA2) with its precursor and CMIP6

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The Localized Constructed Analogs2 (LOCA2)[1] is a statistically downscaled numerical model projection that provides a high-resolution dataset of daily precipitation and maximum/minimum temperatures over North America for the historical period of 1950-2014 and the future period of 2015-2100 under three scenarios. LOCA2 will be one of the two statistically downscaled techniques used to support the Fifth United States National Climate Assessment (NCA5) report, which aims to provide a scientific resource for understanding climate change in the United States and assessing its impacts crucial for economic and political decision-making.

To validate the LOCA2 dataset, we have introduced a web-based visual interface that allows scientists and end-users of NCA5 to visualize and compare the U.S. Climate Extremes Index (CEI) from LOCA, LOCA2, CMIP6, and observations. The interactive web service provides multiple visualizations optimized for NCA5, including map plots of North America, time series and bar charts for NCA regions, and user interactions to explore analysis results.

This web service will assist in the validation of LOCA2 and provide a key resource for addressing adaptation and mitigation questions related to regional climate change impacts. The ability to reproduce key plots and analyses shown in the NCA5 report will also be added in the future. We believe that this web-based visual interface will be an invaluable tool for researchers and decision-makers alike, as they work to address the critical issue of climate change.

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A3-P-13

Identification of the frequency of extreme precipitation events in southeastern South America

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Southeastern South America (SESA), delimited between 38°S–25°S and 64°W–51°W, is characterized as one of the regions in the world with the highest frequency of occurrence of intense storms associated with deep convection, mainly during the spring and summer months (Zipser et al., 2006). These convective storm systems induce extreme precipitation events and produce most of the rain in the warm season (Rasmussen and Houze, 2016), causing significant damage (floods, intense winds, hail) resulting in a high impact on economic and social activities. Considering that the occurrence of extreme precipitation events in SESA is associated with specific synoptic patterns (SP), the objective of this work was to detect the frequency of extreme precipitation events from the occurrence of certain SP, in spring (October to December, OND) and summer (January to March, JFM) in two regional climate models (RCMs)

Daily data from the CORDEX-CORE models available in the South American domain (REMO 2015 and RegCM 4.7 driven by three GCMs) in the period 1979-2005 was used.

To detect the frequency of occurrence of extreme precipitation events in the RCMs, an analogue method was applied based on SP precursors of extreme events.

This methodology made it possible to determine the mechanisms that lead to situations associated with the occurrence of a higher or lower number of extreme precipitation events. In addition, it is an input that could be used in future work to assess changes in the frequency of extreme events for future climate change scenarios.

A3-P-14

Evaluation of rainfall bias-corrected in high resolution CORDEX-SEA over Java Island, Indonesia

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This study assesses the performance of rainfall bias-corrected in high-resolution (5 km) simulation from Coordinated Regional Climate Downscaling Experiment-Southeast Asia (CORDEX-SEA) across Java Island, Indonesia. Historical data from three different forcing Global Climate Model (GCMs), including EC-Earth, HadGEM, and MPI, is corrected using observation data from CHIRPS with Quantile Delta Mapping (QDM) [1] technique. Rainfall bias-corrected shows an increase in accuracy in which correlations well improve especially in highland area and bias value significantly decreases from above 60% to below 20%. In general, bias-corrected Regional Climate Model (RCM)-5km of EC-Earth has the best improvement compared to other forcing GCMs. Future rainfall data of bias-corrected RCM-5km is expected to have a less steep decreasing annual rainfall trend than the uncorrected one. Decreasing rainfall of bias-corrected RCM-5km is about 4.17 mm/year for RCP 4.5 and 4.35 mm/year for RCP 8.5. A future decreasing seasonal precipitation trend is much steeper in SON, followed by DJF and JJA. MAM has almost no trend of precipitation changes. In the early century, some parts of Java will experience wetter conditions, particularly in DJF, MAM, JJA over mountain regions. At the mid and end of century, Java will experience drier conditions at the western and southern part of Java especially in RCP 8.5.

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A3-P-15

Enhancing Spatial Consistency in downscaled Fire Weather Index (FWI) Projections for Improved Wildfire Risk Management: A multi-site multi-gaussian CNN approach

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Accurate Fire Weather Index (FWI) projections are crucial for effective wildfire management and risk assessment. Statistical downscaling (SD) is commonly used to produce actionable regional-to-local climate change information, from coarse Global Climate Model outputs, following the perfect-prognosis approach, although some methodological limitations exist. For instance, analogs-based methods struggle with extrapolating to climate change regimes, generalized linear models (GLMs) have limitations in capturing the complexity between large and local scales, and single-site regression-based models fail to accurately reproduce the spatial distribution of extremes. This final aspect holds significant importance as extreme atmospheric conditions, characterized by the highest FWI values, contribute overwhelmingly to the total burned area in a given year.

In addition, by modeling the spatial consistency of the FWI extremes, fire management agencies can make more informed decisions about fire prevention and suppression across the entire region of interest.

Our study emphasizes the importance of spatial consistency of FWI predictions. We propose the Convolutional Neural Network Multi-Site Multi-Gaussian (CNN-MSMG) model to downscale the FWI over the Iberian Peninsula. This model establishes a non-linear relationship between large-scale atmospheric predictors and local FWI values by inferring daily multivariate gaussian distributions. The CNN-MSMG setup effectively combines the strengths of regression-based models (extrapolation ability) and analogs (spatial consistency and reproducibility of extremes) within a single model.

The CNN-MSMG structure offers a promising approach to downscale FWI values and enhance wildfire risk assessments within the CORDEX-ESD framework. Our study contributes to advancing machine learning techniques for regional climate modeling and downscaling, ultimately improving wildfire risk management and public safety.

A3-P-16

Harnessing machine learning for regional climate models: preparing ALADIN for EURO-CORDEX

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Physical parameterisations such as radiation or convection used in regional climate models (RCM) require approximations introducing a certain number of parameters, generally not directly observable and therefore difficult to constrain, thus generating large uncertainties. The adjustment of these parameters, called calibration or tuning, is a key step in climate modelling, aiming to build models more consistent with observations. The choices and compromises induced by this tuning can significantly affect the model results and the simulated climate projections, hence the need for an efficient, objective and transparent calibration.

Semi-automatic tuning approaches have recently been developed for global climate models, but the question of calibration is still rarely addressed in the regional climate modeling literature. The objective of the present study is to calibrate the CNRM-ALADIN RCM [1], using the High-Tune Explorer approach [2,3]. The latter is a statistical tool adapted to climate models, allowing the identification of the range of parameter values allowing the model to reproduce a climate compatible with reality, in the sense of a list of previously defined metrics. This tool includes a treatment of uncertainties and uses machine learning methods (Gaussian processes and history matching) to emulate the sensitivity of the model to its parameters, and thus explore the parameter space very efficiently.

In the presentation, we will first detail the High-Tune Explorer approach, and then present the results obtained for the ALADIN model over the EURO-CORDEX domain at a horizontal resolution of 12.5 km. The strength of the approach allows us to tune at the same time 42 model parameters using 248 control metrics by exploiting a total of 800 years of simulations. Finally, we will compare the new long hindcast simulations (ERA5-driven, 1979-2020) carried out with the tuned version against the existing CNRM-ALADIN63 version used in previous EURO-CORDEX simulations.

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A3-P-17

Intercomparison of statistical and dynamical downscaling in southeastern South America: future projections of extreme rainfall

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Session A3: Statistical Methods/Machine Learning techniques for RCM. 2000 caracteres.

High-resolution data of climate hazards such as extreme rainfall is of critical value particularly over areas like southeastern South America (SESA), where the observed and projected climate changes pose a substantial threat to the different socio-economic activities and the hydrological sector. In this work, future projections of extreme rainfall under the RCP 8.5 scenario were developed over SESA applying different empirical statistical downscaling (ESD) methods -analogs, stochastic and circulation-conditioned versions of regression-based models involving generalized linear models (GLM) and artificial neural networks- to a set of CMIP5 global climate models. These simulations were compared with the CORDEX-CORE RCM simulations available for the South American domain in terms of the sign and intensity of the changes. A general clear message was found among downscaled projections in terms of their agreement in increased mean precipitation and frequency of extreme events over the region. The ESD ensemble presented larger spread and more intense positive changes in mean precipitation than the CORDEX ensemble, especially during the warm season. For extreme indices, both downscaled sets agreed on the increase signal for extreme intensities by the end of the century. This agreement was consistent until the mid-21st century, when model spread -especially in the ESD simulations- started to increase. However, this spread was intensified due to the inclusion of specific GLM configurations, conditioned by a classification of weather-types that may not be accurate enough for the future period. Overall, our results evidence the complexity of performing a downscaling procedure over SESA and the assessment of possible future expectations, particularly when it comes to intense rainfall, which should be cautiously considered in the evaluation of plausible climate change scenarios.

A3-P-18

Use the data of the EURO-CORDEX ensemble of regional climate model simulations for probabilistic modeling of the maximum runoff of the spring flood on the rivers of the South of Ukraine

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For the South of Ukraine, which is characterized by the practical absence of systematic hydrological observations on small rivers, and often on medium ones, the most effective is regional probabilistic stochastic modeling, for example, based on the operator scheme for the river's maximum runoff formation [1]. If, at the stages of primary statistical processing, the presence of significant trends in the values of maximum water discharges is revealed, and the analysis shows that these trends are caused by modern climate changes, then the calculation method has the possibility of taking in account climate changes through the coefficient Kch. The calculation of the coefficient is carried out in the following order: 1) based on the data of global climate modeling, a model and scenario are selected, which will take into account the impact of climate change on the maximum runoff; 2) after that, the period for which forecast values will be used is determined; 3) for the calculation period and according to the coordinates of the geometric center of the water catchment, forecast values of the *average* annual mean temperature and precipitation are determined; 4) based on regional dependencies, forecast values of average multi-year maximum snow supplies and precipitation during spring flood are determined, which are compared with modern data

The research used the climate change projections for Europe based on an ensemble of regional climate model simulations provided by the EURO-CORDEX; ensemble average annual mean temperature and precipitation for the RCP4.5 and RCP8.5 scenarios.

According to the RCP4.5 scenario, in the South of Ukraine in the period 2021-2050, a significant decrease in the maximum runoff of spring floods is predicted. For example, a 75-80% decrease is predicted for the rivers of the Black Sea, the Southern Bug basin, and the Azov River; in the central part of the studied territory and the northeast - a decrease of spring flood by 65-70%.

The simulation results under the RCP8.5 scenario are somewhat different. The greatest decrease in maximum runoff is expected in the upper part of the Southern Bug and Azov river basins - up to 80%, in the rest of the territory by 2050, a decrease in spring flood by 65-70% is predicted.

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The Comparison of 25-km and 5-km resolution of CORDEX-SEA Simulation for Precipitation Over Java Island, Indonesia

[1]Ummu Ma'rufah, [1]Donaldi Sukma Permana, [1]Jose Rizal, [1]Danang Eko Nuryanto, [1]Ferdika Amsal Harapan, [1]Muhammad Arief Rahman, [1]Nurdeka Hidayanto, [2]Dodo Gunawan, [3]Ardhasena Sopaheluwakan, [1]Supriyanto Rohadi, [4]Dwikorita Karnawati

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Abstract

This preliminary study assesses the performance of high-resolution simulation from Coordinated Regional Climate Downscaling Experiment-SEA (CORDEX-SEA) in modeling precipitation with a resolution of 5 km compared to a resolution of 25 km across Java Island, Indonesia. Historical data from three different forcing Global Climate Models (GCMs), including EC-Earth, HadGEM, and MPI, is compared to observation data from CHIRPS from 1981 to 2005. The seasonal mean climatology of precipitation from model output showed a high wet bias compared to observation. The correlation between model output and observation is about 0.3 to 0.55. Downscaled from EC-Earth has better performance than the other forcing GCMs. However, it has the highest bias in SON, which is about 88%. Model outputs from HadGEM and MPI forcing GCMs have good performance in SON with a low bias of 21% and 38%, respectively. Spatially, precipitation from all forcing GCMs has a high wet bias in the eastern part of Java Island, especially during DJF. In contrast, wet bias occurred during JJA in the western part of Java Island. From annual climatology, precipitation from all forcing GCMs showed overestimation unless in the southern coastal line of Java Island, especially for HadGEM forcing GCMs (high dry bias). Overall, the model has not been able to simulate rainfall well for all forcing GCMs. Therefore, it needs to consider a parameterization scheme for a better result as well as the uncertainty of observation data.

Keyword: Seasonal mean climatology; forcing GCMs; parameterization scheme; uncertainty, Java Island.

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THE SOUTH AMERICAN MONSOON LIFECYCLE PROJECTED BY AN ENSEMBLE OF CMIP6-GCM STATISTICALLY DOWNSCALED

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The South American Monsoon (SAM) is a feature across a great part of South America associated with the concentration of precipitation during the austral summer months. Applying [1]'s methodology, the area from southern Amazonia to southeastern Brazil and Peru, Bolivia, Paraguay, and north of Argentina are regions with monsoon features. Knowing the timing of the rainy season each year is critical for economic sectors that depend on the climate conditions, such as agriculture and hydroelectric plants. But, projections of the monsoon lifecycle for the end of the century, under different climate scenarios, are also important for mitigation and adaptation strategies due to global climate change. Therefore, the main objective of this study is to describe the projected features of SAM under SSPs 2-4.5 and 5-8.5. Initially, we selected eight CMIP6-GCMs using [3]'s methodology with monthly historical simulations. But not all models indicated as outstanding in representing the South American climate had high-frequency precipitation data and/or future projections available when we started the study; so we followed the classification and used those models available in the ESGF platform. Once the models were selected, Quantile Delta Mapping statistical downscaling technique [2], with 50 km of horizontal resolution, was applied with two goals: bias correcting and improving the horizontal resolution of CMIP6-GCMs. The final step was to identify the monsoon lifecycle using [4]'s methodology. CMIP6-GCMs statistically downscaled delay the onset of the rainy season in central Brazil. This delay is greater than the demise, yielding an underestimated lifecycle compared to the reference dataset (CPC). On the other hand, in Paraguay and northern Argentina, it starts earlier and ends later, leading to a longer monsoon duration. In terms of climate projections, the SSP2-4.5 and SSP5-8.5 scenarios were analyzed in 4 timeslices (2020-2039, 2040-2059, 2060-2079, and 2080-2099). The study revealed that the onset of the monsoon may be delayed and the duration reduced, particularly in the SSP5-8.5 scenario and 2070-2099 period compared to the historical period (1995-2014). The authors would like to acknowledge ENGIE for the financial support.

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A3-P-21

Relation between maximum temperatures and weather types as a method for the statistical-dynamical downscaling of uncertainties in CMIP6 models

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Climate change projections are increasingly accounted for in national adaptation plans. Those plans include strategies against heat stress, which is exacerbated in cities. Kilometre-scale models have the required spatial resolution to investigate heat stress in cities and are driven by downscaled data from Global Climate Models (GCMs).

When considering how Belgian heat stress will evolve under different global warming levels (GWL), several uncertainties arise, in particular uncertainties related to changes in synoptic scale and mesoscales circulations. This, combined with the cost of downscaling, leads to limitations in the kilometer-scale projections used for national adaptation plans. Here, the correspondence between the Lamb Weather Types (LWT) and maximum temperatures was investigated with ERA5 reanalysis data, for 1960-2000. It was found that the Low Flow LWT is extremely relevant for heat stress. The predictive value of this Low Flow weather type was further optimised.

To quantify uncertainties related to flow conditions in the GCM projections, a statistical dynamical downscaling method is being developed, in which adequate GCM boundary conditions are selected that will subsequently be dynamically downscaled. Here, the recommended CORDEX evaluation [1] is further finetuned for a smaller region. As advocated in the CORDEX white paper, there is a need for regional scale evaluations, to which the developed method contributes. LWTs were calculated for the CMIP6 models and the ERA5 data for 1980-2010 for the region around Belgium. A clear division in performance was found for the different CMIP6 models, similar to the results of the white paper. These metrics of performance were used to select a subset of CMIP6 models. A further sub-selection of time slices from the GCMs is based on the GWL, the occurrence of weather types and the heat metrics. These selected time slices will be used to downscale GCM data to the kilometer-scale using COSMO-CLM.

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A3-P-22

"Tuning" CORDEX data to reduce uncertainty in climate projections for the Carpathian Region

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High-resolution EURO- and Med-CORDEX simulations can help to answer the following questions: "What are the consequences of climate change (warming)?" and "By when do we need to prepare for this level of climate change (warming)?". On the one hand, regional or local changes may not be consistent with global changes, as local processes may not be accurately interpreted by global climate models (GCMs) due to their relatively coarse resolution. On the other hand, the results of climate model simulations are prone to bias relative to observations, and climate projections can vary widely in modelling future temperature characteristics. In this context, while the magnitude of expected change described by a climate model may appear reasonable, the projected temperature conditions may not be realistic. More specifically, the standard procedure for assessing climate change can be illustrated by taking the mean for a future period (e.g. 2070-2099) and calculating the change relative to a reference period (e.g. 1976-2005). It should be noted that the expected changes based on these projections may be associated with a high degree of uncertainty, as simulations may show different mean temperature values for the same assessment periods, even within a range of a few degrees °C. When regional climate change is assessed on the basis of a given regional warming level (WL, e.g. 1.5 °C) added to the observed mean, the above range of uncertainty is reduced because the models (GCMs or regional climate models) are assessed with respect to the same 30-year mean temperature value. This can significantly reduce the uncertainty in the expected temperature changes, but at the same time an additional uncertainty factor may emerge: time, as climate models may reach this WL at different periods. Accordingly, we can provide information on relative changes with a specific uncertainty as a metric based on the time of reaching the assessed WL at regional scale.

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This work analyzes the relationships between lower tropospheric circulation types and precipitation patterns over the "South Central America" (SCA) sub-region of the Intergovernmental Panel on Climate Change (IPCC), as reported by [1]. This sub-region is a topographically complex narrow strip of land bounded by the Pacific ocean, the Caribbean sea, and the Gulf of Mexico. Central America has been identified as a hotspot for climate change [2] and, on its Pacific slopes, harbors the Central American Dry Corridor (CADC), as reported by [3]. The CADC is characterized by higher aridity than the rest of the SCA region and is particularly vulnerable to droughts and intense precipitation. The annual cycles of precipitation over the CADC exhibit significant seasonalities. Furthermore, droughts are expected to intensify in the CADC throughout the 21st century [4].

Defining one or more collections of circulation types that are linked to variations in the distribution of specific climate variables is a mean to characterize the regional atmospheric circulation, its temporal fluctuations, and its associations with other climate factors such as precipitation, as reported by [5] among others. The implementation of circulation types classifications has been carried out in the tropical Americas, revealing circulation patterns that are related with distinct precipitation patterns [6] (and references therein).

In this study, we used the kmeans++ clustering algorithm to define a collection of circulation types from ERA5 reanalisys wind fields at 925 hPa for a domain ranging from 106 to 70W and from 5.5 to 22.5N for the period 1979-2015. These circulation types were then projected onto the wind fields from historical and future simulations with RegCM4.7 from CORDEX-CORE [7] for the CAM domain. These simulations used lateral conditions from global climate models from phase 5 of the Climate Model Intercomparison Project (CMIP5; Taylor et al. 2012). Therefore, circulation types were also projected onto the wind fields from the downscaled simulations to assess the added value of the downscaling process.

The relationships between circulation types and precipitation were established by regressing monthly observed precipitation series onto a series of monthly frequencies of occurrence of the "observed" (ERA5) circulation types, using various methods. These regression models were then employed to predict monthly precipitation series for all the CORDEX-CORE and CMIP5 simulations mentioned above. This method serves as a bias-correction technique informed by the observed relationships between circulation types and precipitation, providing estimates of future precipitation with confidence intervals, which are vital for vulnerable regions such as the CADC. The key factor modulating the quality of the adjusted precipitation is the CMIP5 model, either pure or downscaled, from which the circulation types are regressed: better representations of the temporal characteristics of the circulation patterns produce better seasonal cycles of precipitation.

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B-P-01 - REMEDIO Armelle Reca Cabase

Projected climate change signals for hotspot regions in southern Africa using regional climate simulations

B-P-02 - SOMOT Samuel

Characterizing and understanding large-scale GCM-RCM inconsistencies in future projections : the European Summer case study

B-P-01

Projected climate change signals for hotspot regions in southern Africa using regional climate simulations

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The southern African climate change signal is projected to have a rapid warming compared to the global signal, with differential agreement on the regional patterns of rainfall change in different parts of the subcontinent, as recently described in the IPCC AR6 Report. The report also assessed that a decreasing trend in the observed mean precipitation can already be detected in most of southern Africa, with an increasing trend in heavy precipitation in eastern southern Africa. While some areas are experiencing increased rainfall and flood risks, others facing reduced rainfall and more frequent droughts (or regions are affected by both extreme events).These changes are projected to intensify in a warmer world, with significant impacts on water security, food security and biodiversity.

In this study we will assess the climate change signal for selected hotspot regions in southern Africa. In particular, we will analyze the temperature and precipitation changes from existing high resolution simulations (CORDEX, CORDEX-CORE, CCAM CMIP6 Simulations) for different time periods over case study regions in Namibia, Zambia, Botswana, and South Africa. These regional climate change signals will highlight the need for adaptation measures and sustainable development strategies to mitigate the impacts and enhance the resilience of communities and ecosystems in southern Africa, a region which is already water-stressed and with low adaptive capacity. This study is conducted within the “TIPPing points Explained by Climate Change (TIPPECC)” project embedded in the BMBF-funded SASSCAL 2.0 research program.

B-P-02

Characterizing and understanding large-scale GCM-RCM inconsistencies in future projections : the European Summer case study

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RCMs have demonstrated added value at small scales and for various extreme events. However, inconsistencies between GCMs and RCMs in future climate projections at larger scales (typically continental or sub-continental) raise fundamental questions for climate modelers and data users. Here we use the European Summertime climate change as a case study to illustrate this issue.

We first assess the level of inconsistency in future projections of near-surface temperature, precipitation and surface solar radiation in ensembles of GCM-RCM clean pairs. Our results show that, at large-scale, RCMs generally project less warming, less drying, and less brightening than their driving GCMs when projecting the future evolution of the European Summertime climate.

Next, we use both dedicated analyses of the 12-km EURO-CORDEX large ensemble and specific sensitivity studies to disentangle the origin of the identified inconsistencies and to better understand these inconsistencies. In particular, we investigate differences in resolution, external forcings, and model physics. Our findings have important implications for the development of RCM-based future climate projections in CORDEX and for their use in the service of society.

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ICTP

C1-P-01 - ADIBI Parya

Climatology and the dynamic mechanism of the Levar winds and dust events in eastern Iran: application of a regional climate model

C1-P-02 - AJAYI Vincent Olanrewaju

Potential Impact of Climate Change on Heat and Discomfort Indices Changes over Nigeria

C1-P-03 - ANDRADE GOMEZ Luisa

Present and future meteorological droughts in CORDEX-CAM with RegCM4.7

C1-P-04 - BETTOLLI Maria Laura

The FPS in Southeastern South America: actionable regional climate information for hydrological and agricultural sectors

C1-P-05 - BISKOP Sophie

Projected hydrological changes for agricultural risk assessment over southern Africa in a warmer world

C1-P-06 - BRHANE Ermias Sisay

SSP-RCP scenario-based future land use change projection over Ethiopia

C1-P-07 - BRHANE Ermias Sisay

Quantifying the Impacts of land cover change on hydrological responses under SSP-RCP Scenario

C1-P-08 - CAVAZOS PÉREZ María Tereza

Impact of climate change in Mexican winegrape regions

C1-P-09 - CAVAZOS PÉREZ María Tereza

Present and future meteorological droughts in CORDEX-CAM with RegCM4.7

C1-P-10 - CORRE Lola Marion

Storylines to synthetize the range of future plausible climates over France for hydrological studies

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Projected changes in precipitation, temperature and their extremes over tropical South America through the RegCM4

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Integrating regional climate models in flood modeling to quantify human health risks from contaminated urban floodwaters

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C1-P-01

Climatology and the dynamic mechanism of the Levar winds and dust events in eastern Iran: application of a regional climate model

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Dust storms in eastern Iran have a wide range of socioeconomic impacts, yet long-term numerical model analysis of the mechanism of strong winds and dust events in this region is limited. The regional climate model version 4 (RegCM4) coupled with a dust module is used to understand the climatology, climatic change, and the dynamic mechanism of the Levar wind and dust events in eastern Iran for the period 1991–2017. It is found that the strong Levar wind is the main driver of dust events in eastern Iran, particularly from June to September. Both model simulation and observations indicate that the Levar wind is strongest on the border between South Khorasan Province in Iran and Afghanistan. Our analysis indicates that the Levar wind is caused by the development of anomalous surface high pressure in Central Asia extending toward northeastern Iran and anomalous surface low pressure on the border between western Afghanistan and Pakistan. The strong pressure gradient force associated with these anomalous high- and low-pressure systems is responsible for the strong northerly Levar wind on the border between Iran and Afghanistan. Dust activity in eastern Iran exhibits a distinct seasonality. The highest dust emission occurs on the border between eastern South Khorasan Province in Iran and western Afghanistan from June to September, where near-surface winds are also the strongest. Relatively less dust emission occurs in the dry beds of Jazmourian from June to September, south of Saravan in May, and Rig-e Yalan in June. The removal of dust particles from the atmosphere is mainly by dry deposition in eastern Iran. The main sink of dust is located in the western parts of the Sistan Basin. Dust emission and burden in the main source of dust in eastern Iran have significantly decreased during the period 1991–2017, while near-surface wind speed has remained nearly unchanged.

C1-P-02

Potential Impact of Climate Change on Heat and Discomfort Indices Changes over Nigeria.

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Climate change is a global phenomenon that is affecting various regions of the world, including Nigeria. In recent years, there has been an increase in the frequency and intensity of extreme weather events, such as heat waves, in Nigeria. This study aims to assess the potential impact of climate change on heat and discomfort indices changes over Nigeria.

Ensemble of CORDEX-CORE data was used to simulate the present and project future heat and discomfort indices over Nigeria using the Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 scenarios. The projected changes in these indices and changes to heat stress and discomfort among the Nigerian population, particularly in urban areas is presented and discussed.

The study findings have important implications for climate change adaptation planning in Nigeria. There is a need for effective strategies to mitigate the potential impacts of climate change on heat stress and discomfort, including the development of heat warning systems and the implementation of measures to reduce urban heat island effects.

C1-P-03

Present and future meteorological droughts in CORDEX-CAM with RegCM4.7

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Historical and future meteorological droughts are analysed over the Coordinated Regional Downscaling Experiment-Central America, Caribbean, and Mexico (CORDEX-CAM) domain. We analyse the frequency and severity of the standardized precipitation index (SPI-12) and the standardized precipitation-evapotranspiration index (SPEI-12) to assess the skill of the regional climate model RegCM4 (version 7) at 25 km resolution driven by ERA-Interim (RegERA) during a historical period (1981-201) relative to observations (CRU, CHIRPS, and GPCP). RegCM4 forced by three global climate models (RegGCMs) are also analysed to obtain the possible changes of frequency and severity of SPI and SPEI at the end of the 21st century (2071-2010) relative to the historical period under the RCP8.5 and RCP2.6 emission scenarios. In general, RegERA and ERA5-Land capture the observed spatial patterns of the mean drought frequency and severity, but with some similar positive and negative biases. RegERA and RegHad adequately simulate the spatial patterns of the different drought metrics, with smaller bias in SPI-12 than SPEI-12. In contrast, RegMPI and RegGFDL overestimate the biases over northwest CAM, with the mean ensemble (RegGCMs) highlighting this overestimation. RegCM4 shows trends of increasing temperature and decreasing precipitation by the end of the 21st century over most of the CORDEX-CAM domain, higher with the RCP8.5 than RCP2.6. RegGCMs shows less frequent but longer and more severe droughts by the end of the 21st century under RCP8.5 over most of the CORDEX-CAM, especially with SPEI-12.

C1-P-04

The FPS in Southeastern South America: actionable regional climate information for hydrological and agricultural sectors

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With a focus on extreme rainfall events in Southeastern South America (SESA), the FPS-SESA initiative promotes inter-institutional collaboration and networking to tackle the following specific objectives: 1) to study multi-scale processes and interactions that result in extreme precipitation events; 2) to develop actionable climate information from statistical and dynamical downscaling based on co-production with the impact and user community. The FPS-SESA was extended to comprehensively address this second objective, for which new RCM and ESD simulations to support planned impact modeling and studies of the streamflow of the Uruguay river and crop yields in Southern Brazil. Targeted convection-permitting (CP) RCM and deep learning-based ESD simulations were performed covering 3 consecutive years from June 2018 to May 2021 in order to consider different important aspects (interannual variability) and variables for impact modeling. This period corresponds to unprecedented dry conditions that, combined with high temperatures, have led to widespread crop failures, wildfires and reduced water availability. In spite of that, many extreme and localized precipitation events occurred over SESA during this period, making it particularly challenging to simulate and to assess the impacts of these combined events on different productive systems in the area.

This work presents the main outcomes of the second phase of the FPS-SESA initiative where five CP modeling systems based on WRF and RegCM5 RCMs contributed, as well as different ESD models based on convolutional neural networks. These were used to drive the Variable Infiltration Capacity hydrologic model and the AgS crop growth model. Results evidenced the need to produce multi-model simulations to account for different uncertainty sources. Inter-institutional collaboration and coordinated science are key aspects to address these end-to-end studies.

C1-P-05

Projected hydrological changes for agricultural risk assessment over southern Africa in a warmer world

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Southern Africa was identified as a climate change hotspot by the IPCC SR1.5. The region is warm, dry and water-stressed, and under low mitigation scenarios is projected to become drastically warmer, and likely also drier. Such a change in the regional climate system will imply limited adaptation options, with potentially unprecedented impacts on agriculture. In this study we project hydrological changes in southern Africa and assess their potential impact on risks to food security. We calculate hydrological impact indices based on the regional climate model bias-adjusted projections of CORDEX under low mitigation. In particular, we analyze the seasonal changes in soil moisture, as approximated by the Keetch-Byram drought index and changes in climatic water balance, in order to detect changes in planting date, length of the growing season and length of the burning season in the summer rainfall region of southern Africa. These changes are of particular importance in southern Africa for rainfed maize production, known to be highly vulnerable to extreme temperature events occurring under limited water and soil-moisture availability. We undertake a further assessment of the water balance in a warmer world, making use of the hydrological modelling system JAMS (http://jams.uni-jena.de). Our analysis indicates that reductions in soil-moisture and water availability in southern Africa is a robust signal across the CORDEX ensemble, even in the near-term (2021-2040) and in models that project rainfall increases. This signal of drying strengthens over time and as a function of the regional level of warming and increasing evaporation. The growing season is projected to decrease due to reduced soil-moisture and water availability, and correspondingly the burning season is projected to become longer. The research is part of the SASSCAL 2.0 programme, project TIPPECC, which deals with the potential occurrence of regional climate change tipping points in southern Africa.

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SSP-RCP scenario-based future land use change projection over Ethiopia

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Abstract

Land use land cover (LULC) data are crucial for modeling a wide range of environmental conditions. So far, access to high-resolution LULC products at a global and regional scale for public use has been difficult, especially in developing countries/regions (Doelman et al., 2018). Land Use Land Cover (LULC) change simulation models are a powerful tool for analyzing the causes and effects of LULC dynamics under different scenarios. Scenario-based simulations of future land-use change can provide important information for evaluating the impacts of land strategies under different conditions. In this study, we project the future land use data at a 1-km resolution that comprises six land use types, adopting the latest integrated scenarios of the shared socioeconomic pathways and the representative concentration pathways (SSPs-RCPs) over Ethiopia. To generate this high-resolution land-use product, we use the FLUS model to simulate future land-use dynamics. The process of generating a future land dataset for Ethiopia can be divided into two parts. The first part is the estimation of the future area demands of different land use types under different SSP-RCP scenarios extracted from the LUH2 (Land-Use Harmonization 2) datasets which is available for free at http://luh.umd.edu/index.shtml. This dataset comprises a global projection of multiple land types for successive years from 2015 to 2100 under different SSP-RCP scenarios with a 0.25° resolution (approximately 25 km at the equator). The second part is conducting a 1-km spatial land simulation using the future land use simulation (FLUS) model under the macro constraints of the demands. We select a series of relevant spatial driving factors, such as socioeconomic (GDP, population), distance factors (urban center, roads, and rivers), and natural factors (climate, topography, and soil quality). On this basis, a new set of land use projections, with a temporal resolution of 10 years and a spatial resolution of 1km, in eight SSP-RCP scenarios, comprising six land use types in Ethiopia is produced. This dataset shows good performance compared to remotely sensed ESA CCI-LC data. The results show that our land use simulation yields a satisfactory accuracy (Kappa = 0.8, OA = 0.9, and FoM = 0.12). Because of the advantages of the fine resolution, recent scenarios, and multiple land types, our dataset provides powerful data support for environmental impact assessment and climate research, including but not limited to climate models.

Keywords: LULC, SSP-RCPs, FLUS, LUH2, ESA_CCI

I prefer: **ORAL**/ POSTER presentation

Quantifying the Impacts of land cover change on hydrological responses under SSP-RCP Scenario

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Abstract

Land use land cover (LULC) change induced by rapid anthropogenic activities is one of the major causes of change in hydrological and watershed processes. This study aims to assess the impacts of land cover change on the hydrological responses of the Upper Blue Nile (Abay) basin, the largest and most rich river basin in Ethiopia. Commonly, such assessments are accomplished by using distributed hydrological models in conjunction with different land use scenarios. To this end, a large-scale physically based distributed hydrological model, Soil and Water Assessment Tools (SWAT), and historical and future land cover scenarios from our previous study based on Land-Use Harmonization 2 (LUH2) were used to simulate the discharge and other hydrological components at daily timescales in the Upper Blue Nile basin. We use the FLUS (future land use simulation) model to simulate future land-use dynamics under eight SSP-RCP scenarios. For this study, three scenarios were considered for land use change projections: SSP1-1.9 as the low-emission scenario, SSP2-4.5 as the medium-emission scenario, and SSP5-8.5 as the representative high-emission scenario. Our land use based on the LUH2 dataset indicates a noticeable increase in the cropland (18 %) at the expense of forest (25.4 %) by the end of the year 2100 compared to the baseline year, 2015. As a response, simulation results indicate a median percent increase in the extreme flows and mean annual flows in the range of 1.8 % to 11.3 % across the sub-catchments. The direct conversion of forested areas to agriculture reduces the leaf area index, reducing evapotranspiration (ET) and increasing surface runoff. Further, the range of behavioral hydrological predictions indicated variation in the magnitudes of extreme flows simulated for the different land cover scenarios; for instance, uncertainty in the scenario labeled “Far Future” ranges from 15 to 180 $m^3 s^{-1}$ across sub-catchments. This study indicates that the recurrent flood events occurring in the upper Blue Nile River basin might be influenced by the changes in LULC at the catchment scale and suggests that model parameterization represents an uncertainty that should be accounted for in the land use change impact assessment.

Keywords: SWAT, FLUS, LUH2, SSP-RCP

I prefer: ORAL/ POSTER presentation

C1-P-08

Impact of climate change in Mexican winegrape regions

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We analyzed the current climate of seven wine-growing regions of Mexico and their possible changes during the 21st century. Various bioclimate indices were calculated over a wide domain that covers Mexico and the south and southwest United States with observations and simulations from two regional climate models (RegCM4.7 and RCA4) for historical (1981-2010), near future (NF: 2021-2050), and far future (FF: 2070-2099) periods under two emission scenarios (RCP2.6 and RCP8.5). Both models reproduced the main characteristics of the Mediterranean and semiarid climates typical of the winegrape regions with some biases. Despite the biases, the models suggest similar future changes during the growing season (GS: April-October) in winegrape regions. Increases in temperature (~ 1.2°C) are expected in the NF period, which could produce an early start of the growth (mid-March) and flowering seasons. More significant changes are expected in the FF under the RCP8.5 scenario; temperature during April-October may increase ~4.3°C, and growing degree days and minimum temperature could also increase (~ 800°C GDD and 4.5°C, respectively), especially in the northern Mexican high plateau region (HP), substantially reducing the suitable areas for viticulture. Moreover, annual precipitation may decrease ~200 mm in the central HP and the onset of the GS may start in early March in most viticulture regions in the FF. In the Mediterranean Californias, cool nights (< 12°C) could be reduced during the current harvest season (September) affecting the acidity and flavor. Thus, viticulture in Mexico could be significantly affected at the end of the 21st century under the RCP8.5 scenario, suggesting the need for early adaptation/mitigation measures to overcome these possible changes.

C1-P-09

Present and future meteorological droughts in CORDEX-CAM with RegCM4.7

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Historical and future meteorological droughts are analysed over the Coordinated Regional Downscaling Experiment-Central America, Caribbean, and Mexico (CORDEX-CAM) domain. We analyse the frequency and severity of the standardized precipitation index (SPI-12) and the standardized precipitation-evapotranspiration index (SPEI-12) to assess the skill of the regional climate model RegCM4 (version 7) at 25 km resolution driven by ERA-Interim (RegERA) during a historical period (1981-201) relative to observations (CRU, CHIRPS, and GPCP). RegCM4 forced by three global climate models (RegGCMs) are also analysed to obtain the possible changes of frequency and severity of SPI and SPEI at the end of the 21st century (2071-2010) relative to the historical period under the RCP8.5 and RCP2.6 emission scenarios. In general, RegERA and ERA5-Land capture the observed spatial patterns of the mean drought frequency and severity, but with some similar positive and negative biases. RegERA and RegHad adequately simulate the spatial patterns of the different drought metrics, with smaller bias in SPI-12 than SPEI-12. In contrast, RegMPI and RegGFDL overestimate the biases over northwest CAM, with the mean ensemble (RegGCMs) highlighting this overestimation. RegCM4 shows trends of increasing temperature and decreasing precipitation by the end of the 21st century over most of the CORDEX-CAM domain, higher with the RCP8.5 than RCP2.6. The RegGCMs shows less frequent but longer and more severe droughts by the end of the 21st century under RCP8.5 over most of the CORDEX-CAM, especially with SPEI-12.

C1-P-10

Storylines to synthetize the range of future plausible climates over France for hydrological studies

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The precipitation response to global warming over metropolitan France is highly model-dependent. Future changes show a meridional gradient over Europe with an increase in the northern regions and a decrease in the Mediterranean region. The location of the boundary between these two regions varies from one model to another, leading to large uncertainties in the latitude band where France is located. In order to capture the range of the possible futures, a large ensemble of projections should be considered with particular attention to synthetize uncertainties.

At the French national climate services, we work with a set of about twenty 12-km-resolution EURO-CORDEX scenario simulations that have been selected to conserve the range of changes in mean temperature and precipitation of the full EURO-CORDEX ensemble over metropolitan France. Simulations have been bias-corrected and are intended to be used for hydro-climatic projections.

Using this dataset, we compare two approaches to assess the climate future evolution over France: the conventional approach that describes the future changes using a probabilistic description of all available projections and a storyline approach, i.e. a small number of simulations selected to summarize the dispersion of all available projections. This alternative method, also called possibilistic, eases the usability of the projections for impact studies. For the storylines, two simulations selection procedures are compared: a subjective selection, consisting of four simulations illustrating the most contrasting futures possible, based on a co-construction work with users involved in hydrological impact studies and a semi-objective selection resulting from a hierarchical classification of mean temperature and precipitation changes over France. Both selections are used to force hydro-climatic projections which are analyzed in terms of water resource impacts.

C1-P-11

Projected changes in precipitation, temperature and their extremes over tropical South America through the RegCM4

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In recent decades, the frequency and intensity of extreme events induced by global warming have increased significantly, causing serious impacts on the development of society and ecosystems. Therefore, we use the regional climate model RegCM4 (horizontal resolution of 25 km), driven by the global circulation model HadGEM2-ES, to produce regionalized simulations and projections based on low (RCP2.6) and high (RCP8.5) greenhouse gas emissions scenarios. Therefore, this study focuses on evaluating the added value (AV) of RegCM4 in simulating (1986–2005) and projecting (2080–2099) spatiotemporal features, including mean and extreme climate, over tropical South America (TSA). The extreme climate indices based on daily precipitation and maximum and minimum temperature follow the definitions of the Expert Team on Climate Change Detection and Indices (ETCCDI). Mean climate was validated using the monthly dataset from the Climate Research Unit version ts4.05 (CRU). In turn, the daily dataset from the Climate Prediction Center (CPC) was used to validate the ETCCDI indices. The RegCM4's performance of the mean climate simulation is evaluated and the results indicate that it is capable of AV in the spatial distribution of precipitation and temperature over the Northeast region of Brazil and part of the Andes Mountains. However, it does not adequately represent precipitation over the Amazon Basin. The underestimation of precipitation in part of the Amazon Basin is a persistent feature of the regional model [1]. Results for future projections indicate that the RegCM4 simulation improves the projected changing patterns and modifies the precipitation signal in some cases. Both models project a higher magnitude temperature rise for RCP8.5. However, RegCM4 presents a more refined and realistic spatial distribution. Regarding the ETCCDI indices, RegCM4 adequately reproduces the spatial distribution of extreme precipitation and temperature indices and AV to HadGEM2-ES, especially for temperature-derived indices. The projection results showed that extreme indices indicate that drought events may advance until the end of the century, showing a pattern that precipitation will be gradually reduced in the Amazon Basin and in the Northeast region of Brazil. Despite the systematic biases of RegCM4, studies like this one help us understand how climate change can affect planning and regional development.

[1] da Silva, M. L., de Oliveira, C. P., Silva, C. M. S. E., de Oliveira, S. G., Correa, M. J. Analyzing Dynamical Downscaling over the Tropical South America Using RegCM4. Pure Appl. Geophys. **179**(10): 3859-3874 (2022).

C1-P-12

Integrating regional climate models in flood modeling to quantify human health risks from contaminated urban floodwaters

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Climate change poses a grave global threat, causing disruption to the entire water cycle, including altered precipitation patterns, rising temperatures, and sea level rise. As a result of these erratic changes, floods are becoming more frequent and severe in numerous regions across the world. The impacts of floods on society, the economy, and the environment have been well-documented. Nevertheless, the potentially grave risks posed by the spread of waterborne infectious diseases remain under-explored. In **Delhi**, India's capital city, urban flooding has caused extensive damage and numerous incidents. Factors such as the city's location along the **river Yamuna**, high population density, haphazard urbanization, inadequate drainage systems, and increasingly extreme rainfall due to climate change are the primary contributors to this dire situation. To combat the adverse effects of flooding, city planners and water experts have begun using flood inundation mapping to identify flood-prone areas as a first step. However, the **severe microbial contamination of floodwaters** remains an ongoing issue.

For the first time, this study primarily aims to quantify the risks to **human health associated with contaminated urban floodwaters in a flood-prone region of Delhi** adjoining the Yamuna River. By developing a framework that integrates **climate and socio-economic changes**, the study provides quantitative and qualitative information about flood and human-health risks, both present and in the anticipated future. Hourly and sub-hourly hydro-meteorological data are collected, including rainfall, streamflow, sewer flow, and various water quality parameters. Future rainfall projections from **CORDEX** under **RCPs 4.5 and 8.5** are statistically downscaled, while **SSPs 1 and 3 scenarios from the CMIP6 consortium** are considered to account for socio-economic scenarios. A set of flood inundation (depth, velocity, and inundated area) and hazard maps are derived from the **MIKE+ model**, an acclaimed 1D-2D coupled hydraulic model. The flood outputs from MIKE+ are fed to the **MIKE Eco-Lab** water quality model to map the water quality dynamics and the spread of Faecal Indicator Bacteria (FIB) in the domain. The human-health risk from FIBs is estimated based on the **β-Poisson dose-response model**. The proposed framework of fusing climate and socio-economic structures within a **hydraulic-cum-water quality** modeling environment is generic as it promises its demonstration for any other flood-prone region. Ultimately, the study aims to support the development of efficient resilience mechanisms that protect communities at risk and benefit developing and underdeveloped nations that face increasing flooding risks due to climate change and socio-economic changes.

Keywords: Climate change; CMIP6; CORDEX; Flood hazards; Human health risks; Urban floods.

C1-P-13

Title: - Hydrological and Land Suitability Analysis for Flood-based Productivity in Afar Region, Ethiopia

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One of the driest regions in Ethiopia is the Afar region. Much of the area is classified as arid- and semi-arid, with annual rainfall ranging from less than 144 mm near the desert's edge in Asiata and Dedal to just over 800 mm in Chifra and Dulecha. The region experiences more than 27.5 ^{0}C on average and fewer than 300 mm of rainfall on average (53% of the region). There are little to no water resources available from rainfall for most of the year that can be used beneficially.

The pastoral and Agro-pastoral ways of life are practiced by the people of Afar. Irrigation, spate, and river water abstraction are used in the area to produce crops. As a result, pastoralism is the primary farming strategy in the region, with sporadic crop farming techniques used in some locations. Flooding in the area could have disastrous effects if it coincides with the current vulnerable systems due to the changing climates and increased frequency of extreme events anticipated in the Ethiopian highlands. if floods are well managed, they can serve as a source of livelihood by recharging groundwater levels, improving soil fertility, and water availability for livestock drinking, agriculture, and household use. They can be also very important sources of much-needed water for growing crops.

In such a moisture-stressed location, the capacity to provide alternative water sources and install effective rainwater management systems is crucial for creating a productive system that will support sustained agricultural expansion, rural development, overall economic growth, and efficient utilization of the region’s land resources.

For this study, we applied the simplest approach using the surface runoff coefficient method. In this method, the surface runoff is a percentage of precipitation considering all the factors that affect runoff. We also used the rational formula to estimate the peak runoff for the watersheds contributing to floods that are potential to be used for spate irrigation. The isohyetal method was applied to get the areal average rainfall over the selected sites. soil samples are taken in different locations of the area for soil and land suitability analysis.
The result of this study based on samples of the districts mapped for site-level validation has proved the presence of potentials both in terms of floods and water. The hydrologic analysis resulted in the availability of an estimated 796 million m3/year that could be available for growing crops typical of the region, i.e., (Sorghum, maize, forage, and vegetables) using spate irrigation. Physical land suitability evaluation for irrigation was carried out for the region, following FAO methodology for general irrigation farming. Land suitability analysis resulted in 877,000 ha that can be used to grow crops. Implementation of flood-based irrigation developments could help to bring several economic and social benefits to the community. These include improved economic and environmental status through increased crop & forage production and increased production time.

Keywords: - Flood Area, Soil, and land Suitability

C1-P-14

Unprecedented compound hot and dry events in Europe under different emission scenarios

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Given the observed increase in the concurrence of summer heat waves and severe droughts, it is of extreme interest to investigate how the frequcny and spatial extension of compound hot and dry (CHD) events will evolve under projected global warming.
Here we employ a large ensemble of EURO-CORDEX high resolution (0.11 degree) Regional Climate Models (RCMs) to investigate the future occurrence of summer CHD events under three Representative Concentration Pathways, namely RCP2.6, RCP4.5 and ECP8.5.
RCMs daily temperature and precipitation are first bias-adjusted with a trend preserving, parametric quantile mapping, designed to robustly adjust biases in all percentiles [1].
CHD events are defined by means of the standardized precipitation index (SPI) and the Heat Wave Magnitude Index daily (HWMId) [2] designed to account for both the duration and the intensity of heat waves.
We first analyze the past (1981-2020) observed spatio-temporal evolution of CHD events and we evaluate the ability of the model ensmeble to reproduce the main distribution of heatwvaes, droughts and CHDs over the 1981-2010 period, used here as reference.
We then assess the change in the frequcney and spatial distribution of heatwaves, droughts and CHDs at the end of the 21st century (compared to the reference period) under the three RCPs. In particular, we assess how a projected warming under RCP2.6 (i.e. an emission scenario comaptible with a 2C global wamrting) reduces the frequancy of CHD events compared to higher emission scenarios (RCP4.5 and RCP8.5).
Finally we assess the projectd occurrence of record-breaking CHD, i.e those defined as having, at the same time, the lowest SPI and the highest HWMId recorded values.

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C1-P-15

Hydrological modeling of the Uruguay River with actionable climate information from statistical and dynamical downscaling

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The second objective of the Flagship Pilot Study in Southeastern South America (FPS-SESA) proposed to develop actionable climate information from statistical and dynamical downscaling based on co-production with the impact and user community. As a result, new RCM and ESD simulations were designed for the planned impact studies of streamflow modeling of the Uruguay river. A 3-year time period, June 2018 to May 2021, was selected to study the ability of convection-permitting (CP) RCM and deep learning-based ESD simulations outputs to reproduce the Uruguay River streamflows when used to feed the Variable Infiltration Capacity (VIC) hydrological model. During these 3 years extremely dry conditions developed and persisted over the basin with high impact on water resources in the region including very low streamflows. Nonetheless, extreme precipitation events were also observed during warm months, which makes this period particularly interesting to study extreme discharges through hydrological modeling. The outcomes of the second phase of the FPS-SESA initiative provide five CP simulations conducted with WRF and RegCM5 RCMs, as well as simulations with different ESD models based on convolutional neural networks which were used to drive the VIC model. Simulations with observations and ERA5 data were also performed and compared with observed discharges at 7 gauge stations distributed along the upper, middle and lower basin. Results evidenced the need to produce multi-model simulations to account for different uncertainty sources.

C1-P-16

Providing unbiased high resolution extremes precipitations for sectorial custumers: test of differents corrections methods

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For our client in insurance and energy sector mainly, we are providing debiaised climate data for their sectorial impact studies. We focus on extremes precipitations mainly over the southern part of France where very heavy precipitations events occurs in Autumn. Those heavy precipitations cause many dommage locally.

In the first part, we compared results of corrected data which have been produced for customers using different corrections methods. Different method using the quantil-quantil correction, CDFt method or gamma law are applied on the daily output from EURO-CORDEX RCMs (12 kms). The strength or weakness of each method are evaluated..

In the second part, following the results of the corrections with the EURO-CORDEX RCM, we apply corrections on the CP-RCM (Convection Permitting) at 2-3 kms resolution on an hourly basis.

Such corrected data are used for ours sectorial customers.

C1-P-17

Potential Impact of Climate Change on Cereal Suitability in West Africa using CORDEX-CORE Models

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The increase in global warming is projected will significantly affect agricultural production in West Africa with notable implication on suitable area for cereal cultivation which contribute largely to the economy of the region (FAO/OCED, 2016). The present study examines the impact of climate change on cereals (Maize, Sorghum, Pearl millet and Rice) suitability and planting season in West Africa owing to their economic importance to the region. The new CORDEX-CORE datasets, GCMs; CLM, GERICS-REMO2015 & ICTP-RegCM4.7 downscaled by three RCMs; MOHC-HadGEM2, MPI-ESM and NCC-NorESM1 under RCPs 2.6 and 8.5 for the historical (1979-2005) and end of century (2069-2095) study periods were used as input data into Ecocrop, a crop suitability model to investigate the impact of climate change at different RCPs on cereal suitability and planting season over West Africa (Ramirez et al., 2013). Our findings show all four crops are mainly suitable over the Guinea-Savanah zones with suitability index above 0.6 (60%) except in the Sahel zone (north of 14°N) over the historical period. In general, the impact of climate change leads to about 2-3% increase in suitable cropland for Maize, sorghum, and Rice under RCP2.6 relative to the historical period while no significant change was observed for Pearl millet. However, increased warming under RCP8.5 may lead to a 5-7% increase in unsuitable area for cereal cultivation notably for Rice and sorghum and about 3-5% decrease in suitable area for all the crops. In addition, no change in planting season is expected across the four crops under RCP2.6. However, a projected 1-2month early planting season is expected for all the crops and up to 3months for Rice along the south-west coast from Liberia to Sierra Leone under RCP8.5 while a 1-month delay in planting season is projected for Pearl millet under the same condition. The study will assist to improve our understanding on the impact climate change under different emission scenarios on cereal production in Africa. It will also help inform policy maker in their decision making and adaptation strategies to ensure food security and zero hunger in West Africa.

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C1-P-18

Climate scenarios for Angola from CORDEX AFR22 simulations

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This work uses Regional Climate Models (RCMs) simulations from the CORDEX-AFR22 programme to generate climate scenarios for Angola, with a specific interest in potential changes in extreme events such as droughts and floods.
Climate scenarios are based on CORDEX-AFR22 simulations, including REMO2015 [1], CCLM5-0-15 [2] and RegCM4-7 [1] for the historical period (1981-2010) and RCP8.5 (2040-2099), driven by CMIP5 Global Climate Models (GCMs) NorESM1-M, MPI-ESM-LR and HadGEM2-ES. Historical simulations have been evaluated using the CHIRPS dataset [3] for precipitation and the CRU dataset [4] for temperature. In the historical period we find: 1) for air temperature and maximum temperature, all simulations have negative bias in eastern Angola and positive in the west, being very pronounced in the drier southwest; for minimum temperature, all simulations have a positive bias; 2) for annual precipitation, REMO2015 has positive bias in the whole area; CCLM5-0-15 has positive bias mainly in the western region (near the coastal region), while in large part of the eastern region (inland), the bias is negative; RegCM4-7 shows positive bias in almost the whole area, except in some northern parts where, in all cases, the bias is negative. In all these cases, bias patterns are more dependent on the RCMs.
RCMs climate responses have been compared with each driving GCM response. Climate change responses show that: 1) RCMs match quite well GCM patterns of temperature change, with a good matching of interannual variability; 2) patterns of climate change for precipitation are more dependent on RCMs but with good anomaly correlation on interannual variability with their driving GCM aggregated over the whole country. RX1day shows similar patterns for each RCMs but with a climate change response dependent on the temperature response of the driving GCM. These results support the use of CORDEX-AFR22 for the generation of high-resolution climate scenarios for Angola.

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C1-P-19

Medium-term and long-term changes in the Extreme Precipitation Indices in Colombia, using the CORDEX-RCM SAM-20-CCCma-CanESM2-Eta

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Extreme precipitation events (EPE), including heavy rain and droughts, are becoming more frequent and intense in many parts of the world due to climate change [1, 2]. This increase in EPE can lead to more flooding and landslides, which can cause significant damage to infrastructure and communities [3]. At the same time, climate change can also lead to more frequent and severe droughts, particularly in regions that are already experiencing water scarcity [1]. Understanding the causes and impacts of EPE is essential for developing effective strategies for managing and adapting to climate change. This requires combining observational data, climate models, and statistical analyses [4]. Using these tools, the complex relationships between climate variability, climate change, and extreme precipitation events can be better understood.

Colombia is a country characterized by complex topography and diverse climatic conditions. The study by [5] analyzed the ENSO-driven variability and long-term changes in extreme precipitation indices in Colombia, using satellite rainfall estimates (CHIRPS). The authors found that extreme precipitation events in Colombia have become more frequent and intense in recent years, with significant variations depending on the region. For instance, the study found that in the Andean region of Colombia (the most populated of the country), EPE have become more frequent and intense during the La Niña phase of ENSO, while in the Pacific and Caribbean regions, extreme precipitation events have become more frequent and intense during both El Niño and La Niña phases (depending on the specific area). These findings highlight the need for region-specific strategies for managing and adapting to EPE in Colombia. The impacts of EPE in Colombia can be severe, with flooding and landslides causing significant damage to infrastructure and communities. For example, in 2017, Colombia experienced one of the deadliest landslides in its history, which killed more than 300 people and caused extensive damage to the town of Mocoa (southern part of the country, in the Amazonian region of Colombia; [6]).

This work uses precipitation data from the CORDEX Regional Climate Model (RCM) CCCma-CanESM2-Eta for computing the Extreme Precipitation Index (EPI) in Colombia between 1960-2099 (in the same way as in [5]). The selected RCM has 0.2° spatial resolution (South America's SAM-20 domain) and daily time resolution. The RCM maps were cropped between 5°S-15°N and 80°W-65°W to fit the Colombian territory. Three periods (1979-2009, 2024-2054, and 2069-2099) were selected to assess the near and far future EPI relative change. The Mann-Whitney-Wilcoxon test was used to evaluate the significance of the estimated changes (i.e., $EPI_{1979-2009}$ vs. $EPI_{2024-2054}$, and $EPI_{1979-2009}$ vs $EPI_{2069-2099}$).

Preliminary results show that, in general, there is a tendency for the EPIs to become drier (i.e., fewer days with heavy rain, lower intensity of extreme events, longer dry spells, shorter wet spells, etc.) for both scenarios (changes with larger negative/positive magnitudes for the RCP85 scenario). However, as in the work of [5], the trends highly depend on the selected region. For example, Fig. 1 shows the RCP45 results for the EPI *Rx1day* in the two future windows considered; positive changes were observed in the Andean region of Colombia (these changes will be more accentuated in the distant future). Still, the observed difference is scattered in the remaining Colombian regions. Fig. 2 shows the results obtained for the RCP85; a scattered behavior of the trends can be observed for the near future, but unambiguous positive (Andean region) or negative changes (Orinoco river plain of Colombia and Venezuela) for the far future.

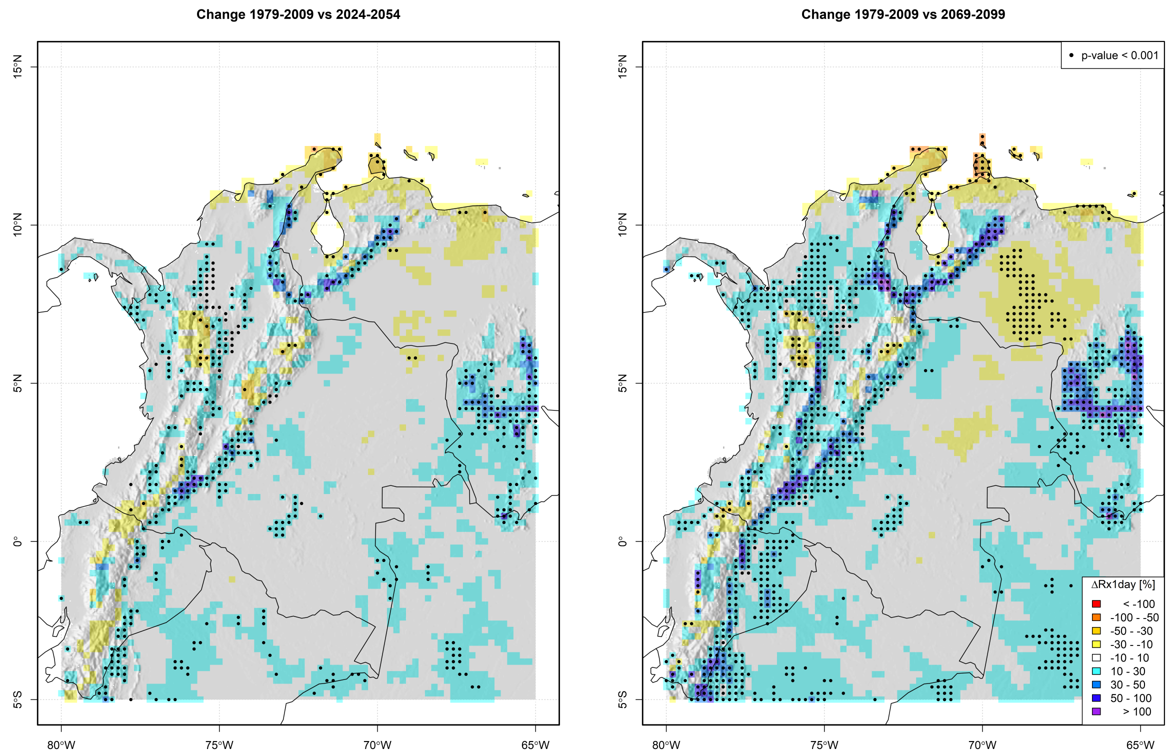

Figure 1: Relative changes in the EPI *Rx1day* for RCP45 (computed as $\Delta EPI = 100 \cdot (\overline{EPI}_{scen} - \overline{EPI}_{hist})/\overline{EPI}_{hist}$; *hist* is the *historical period* 1979-2019; *scen* can be the two *future periods* 2024-2054 -left panel, near future- or 2069-2099 -right panel, far future-).

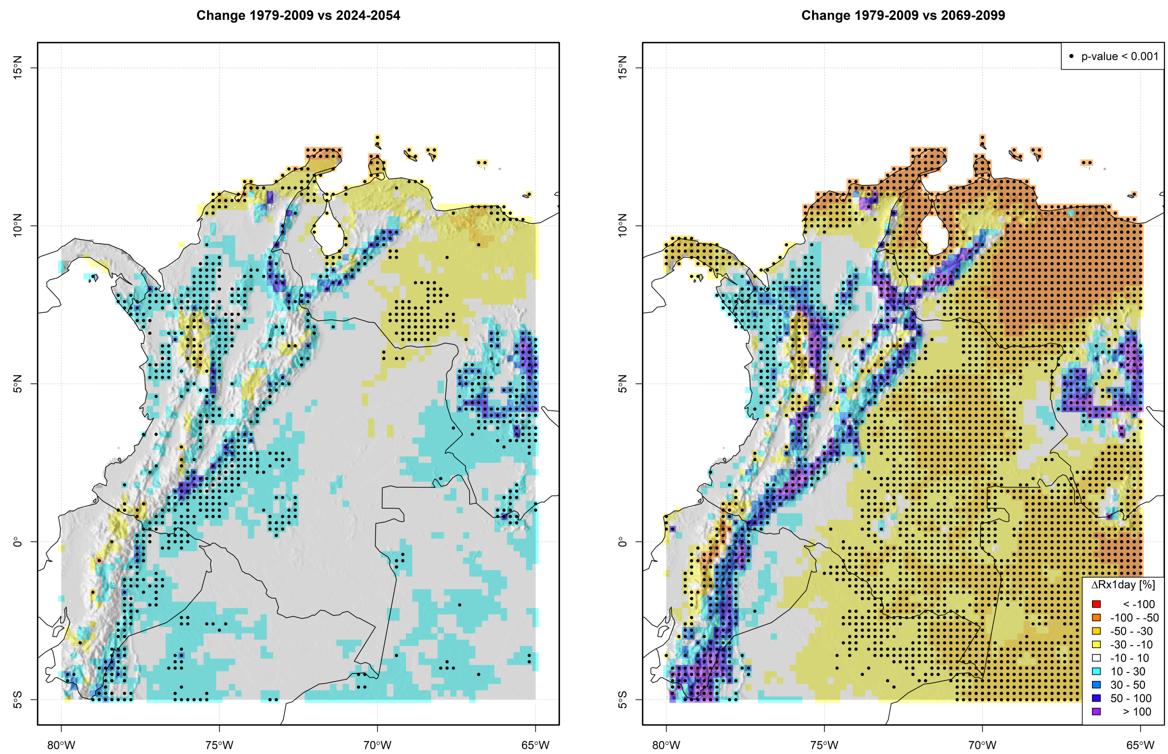

Figure 2: The same as Fig. 1, but fo RCP85.

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C1-P-20

Impact of Climate Change on solar resource: a review of projections comparing global and regional climate models

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The increase in global deployment of photovoltaic (PV) technology and its projections for the near future requires an accurate solar resource assessment for the industry. While historically that assessment was made with satellite or in-situ observations, studies using climate models have shown that climate projections are necessary to account for climate variability and is impacts in the near or mid-future. In recent years, many studies have been conducted analyzing climate projections of solar resource, utilizing either global and/or regional climate models, considering different time horizons and emission scenarios worldwide. Some studies have used a single regional climate model for a specific area, while others have adopted a multi-model approach, incorporating simulations from coordinated experiments. In certain cases, disparities between global and regional model projections have been reported, with corresponding analyses published.

The objective of this study is to conduct a comprehensive review of solar resource projections worldwide. The analysis will be based on distinct regions based roughly on the main CORDEX domains, and the results will summarize the projected changes in solar resource and differences between global and regional models, as well as the main sources of uncertainty reported in the literature for each region. This work aims to synthesize the most up-to-date knowledge on solar resource assessment for photovoltaic energy using climate models to assess climate change impact on future photovoltaic systems.

C1-P-21

Project FOCI - Non-CO2 Forcers and Their Climate, Weather, Air Quality and Health Impacts

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While overall the global warming with the causes and global processes connected to well-mixed CO_2, and its impacts on global to continental scales are well understood with a high level of confidence, there are knowledge gaps concerning the impact of many other non-CO_2radiative forcers leading to low confidence in the conclusions. This relates mainly to specific anthropogenic and natural precursor emissions of short-lived GHGs and aerosols and their precursors. These gaps and uncertainties also exist in their subsequent effects on atmospheric chemistry and climate, through direct emissions dependent on changes in e.g., agriculture production and technologies based on scenarios for future development as well as feedbacks of global warming on emissions, e.g., permafrost thaw.

The main goal of the EC Horizon Europe project FOCI, is to assess the impact of key radiative forcers, where and how they arise, the processes of their impact on the climate system, to find and test an efficient implementation of these processes into global Earth System Models and into Regional Climate Models, eventually coupled with CTMs, and finally to use the tools developed to investigate mitigation and/or adaptation policies incorporated in selected scenarios of future development targeted at Europe and other regions of the world. We will develop new regionally tuned scenarios based on improved emissions to assess the effects of non-CO_2 forcers. Mutual interactions of the results and climate services producers and other end-users will provide feedbacks for the specific scenarios preparation and potential application to support the decision making, including climate policy.

C1-P-22

Machine learning models reveal reductions in land surface temperature associated with forest management in Fennoscandia

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Forests affect the local climate through a variety of biophysical mechanisms. Observational and modelling studies have investigated the effects of forested vs. non-forested areas, but the influence of forest management on surface temperature has received far less attention owing to the inherent challenges to adapt climate models to cope with forest dynamics. Further, climate models are complex and highly parameterized, and the time and resource intensity of their use limit applications. The availability of simple yet reliable statistical models based on high resolution maps of forest attributes at various development stages can link individual forest management practices to local temperature changes, and ultimately support the design of improved strategies. In this study, we investigate how forest management influences local surface temperature (LST) in Fennoscandia through a set of machine learning algorithms. We find that more developed forests are typically associated with higher LST than young or undeveloped forests. The mean multi-model estimates from our statistical system can accurately reproduce the observed LST. Relative to the present state of Fennoscandian forests, an ideal scenario with fully developed forests is found to induce an annual mean warming of 0.26 °C (0.03/0.69 °C as 5th/95th percentile), and an average cooling effect in the summer daytime from -0.85 to -0.23 °C (depending on the model). On the contrary, a scenario with undeveloped forests induces an annual average cooling of -0.29 °C (-0.61/-0.01 °C), but daytime warming in the summer that can be higher than 1 °C. A weak annual mean cooling of -0.01 °C is attributed to historical forest harvest that occurred between 2015 and 2018, with an increased daytime temperature in summer of about 0.04 °C. Overall, this approach is a flexible option to study effects of forest management on LST that can be applied at various scales and for alternative management scenarios, thereby helping to improve local management strategies with consideration of effects on local climate.

- Using a machine learning-based system to predict the effects of forest management.
- The system can accurately reproduce the observed temperature in Fennoscandia.
- More developed forests are associated with a higher temperature than young forest.
- Historical forest management had a mean annual cooling, but warming in the summer.

- The approach is flexible and can be applied to different management scenarios.

Keywords
Forest management, climate change, surface temperature, machine learning, statistical model

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Expected climate changes in Croatia by the middle of the 21st century

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According to the latest IPCC report, the wider Mediterranean area is projected to experience a continued rise in air temperature and an increase in the frequency of warm extremes, accompanied by a decrease in annual precipitation. These changes are expected to lead to more frequent agronomic and ecological droughts. In order to gain a deeper understanding of these anticipated changes and their spatial variability specifically over the wider Croatia and Adriatic area, our analysis focuses on examining both mean temperature and precipitation changes, as well as a wide range of extreme temperature and precipitation indices.

To estimate the climate change signal for the middle of the 21st century (2041-2070) compared to the historical period (1981-2010), we employ the "moderate" greenhouse gas concentration scenario RCP4.5. Our ensemble consists of 12 EURO-CORDEX simulations conducted at a horizontal spatial resolution of 12.5 km. Notably, three regional climate models (RegCM, RCA4, and CCLM4) are driven by four global climate models (CNRM-CM5, EC-EARTH, MPI-ESM, and HadGEM2).

In our analysis, we focus on assessing the mean annual and seasonal changes in temperature and precipitation indices. By utilizing this comprehensive approach, we aim to quantitatively evaluate the projected shifts in climate conditions over the wider Croatia and Adriatic areas. Overall, our study seeks to provide valuable insights into the complex dynamics of climate change in this region, aiding policymakers and stakeholders in formulating effective adaptation strategies and mitigating the impacts of these projected changes.

C1-P-24

Uncertainties in the projections of the extreme precipitation events over East Asia

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Changes in the extreme precipitation in the recent decades have been observed globally. According to Intergovernmental Panel on Climate Change (IPCC), East Asia especially, is at an increased risk of intensification of heavy precipitation, intensified tropical cyclones and droughts. Previous research, such as Park et al, 2021 [1] and Kim et al., 2021[2], has already shown that under RCP4.5 and RCP8.5 scenarios, the precipitation extremes are projected to increase over parts of East Asia.
However, the predictions of future climate are subject to uncertainty. The uncertainty of climate projections has several sources. First source of uncertainty is climate system's own internal variability. The second source of uncertainty is the scenario uncertainty, which refers to uncertainties in the developments of the future economies and societies, leading to uncertainties of the future radiative forcing. Finally, as different models simulate different changes for the same radiative forcing, there is model uncertainty.
While the mean values of precipitation have been previously studied for their uncertainties, research on precipitation extremes is lacking. Considering the greater impact of precipitation extremes, it is important to address the uncertainties in their projections. Therefore, this study analyses the uncertainties of several precipitation indices using bias-corrected 3-hourly and daily values across the CORDEX East Asia domain. The precipitation indices analysed include maximum 3-hour, maximum 6-hour and maximum daily precipitation.
For the majority of the East Asia domain, the model uncertainty plays the largest role for all indices, followed by the internal uncertainty. The scenario uncertainty seems to play a relatively small role in the total uncertainty as compared to model and internal uncertainties.

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C1-P-25

Development of agro-climatic indicators and services over Europe in the framework of the STARGATE project

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In this work we present a set of agroclimatic indicators calculated over Europe from 1986 to 2055 under different scenarios using EURO-CORDEX data and examine their trends over different European biogeographic areas (Czech Republic, Israel and Spain). We also examine the effects of agricultural practices (irrigation and tillage) during selected heat wave events, using the WRF model in a very-high resolution configuration (1 Km).

The behaviour of agro-climatic indicators depends on region and scenario, cconsistent appears the increase of mean, max, min temperature (1.5-3^{o}C / 70 years). With respect to irrigation, the analysis showed that it has a clear cooling effect on surface and near-surface air temperatures over irrigated lands, however the strength of the signal differs in each pilot use case under examination. Irrigation adds available moisture to the soil, which mostly influences the sensible and latent heat fluxes, albedo, incoming shortwave by changing the low cloud cover and longwave radiation at surface. The turbulent fluxes partitioning appears to be the key-factor contributing other changes in surface temperature. It is found that over the Czech pilot, irrigation has the smallest impact on surface temperatures compared to the other pilots. Regarding tillage management, it is shown that conventional tillage affects both surface albedo and leaf area index. Depending on soil properties (e.g., resistance, heat capacity, porosity) conventional tillage alters the emitted heat fluxes (sensible and latent). The numerical experiments revealed that the Czech pilot is the most affected region in terms of the induced changes on surface temperature with respect to tillage management.

This work has been performed in the framework of the EU project Stargate (resilienT fARminG by Aaptive microclimaTe managEment, Grant Agreement No 818187).

C1-P-26

Future Projection of Precipitation over the Korean Peninsula under Global Warming Levels of 1.5 °C and 2.0 °C, Using Large Ensemble of RCMs in CORDEX-East Asia Phase 2

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This study investigated future projection of extreme precipitation (PR) over the Korean Peninsula under global warming levels of 1.5 °C and 2.0 °C (GWL 1.5 °C and 2.0 °C). The bias-corrected large ensemble of the Regional Climate Model (RCM) in the Coordinated Regional Climate Downscaling Experiment-East Asia Phase 2 was used. Under GWL 1.5 °C, the RCM multi-model ensemble (MME) projected mean PR to increase by 4.69% and extreme PR to increase by 10.14%. There was regional difference in the projection, which is a larger increase over the northern KP (NKP) and southern KP (SKP) than central KP. Accordingly, the distribution of extreme PR was expected to shift with the right, and extreme events with reoccurrence of 20 years over the SKP and NKP were expected to change to the events once every 12.56 years and 10.04 years, respectively. The mechanism of extreme PR was investigated for cases from June to September. The RCM MME predicted increase in extreme PR per warming over SKP and NKP to be 5.64 % $°C^{-1}$ and 8.37 % $°C^{-1}$, respectively, which was close to the Clausius-Clapeyron scale (7.7% $°C^{-1}$). This implies that increased moisture capability from the warming will affect the change in extreme PR. Other possible factors were investigated and the RCM MME predicted vertical instability over East Asia to continue. And moisture flux and convergence around the KP to be strengthened. Meanwhile, under GWL 2.0 °C, extreme PR was expected to increased more than under GWL 1.5°C. This precipitation enhancement was projected to be related to the strengthening of the mechanism.

C1-P-27

Future Changes in Extreme Heatwaves over the CORDEX-East Asia Phase 2 Domain under RCP and SCP Scenarios

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As the frequency and intensity of heatwaves have been increasing worldwide (Zhao et al 2019, Perkins-Kirkpatrick and Lewis 2020, IPCC 2021), East Asia has also experienced unprecedented heatwaves in recent years. This study focuses on the future changes in an extreme heatwave, in terms of intensity and duration, over the CORDEX-East Asia phase 2 domain. An extreme heatwave is defined as one in which the heatwave magnitude (HWM), which is the accumulated daily intensity of a heatwave during the heatwave period, is higher than the 95th percentile of the HWM for the reference period. In Historical simulations (1981–2005), heatwaves have occurred mainly from April to June in India, in April and May in Indochina, from June to August in China and Mongolia, and in July and August in the Korean Peninsula and Japan. Most heatwaves in East Asia last three to four days, but long-lasting and intense heatwaves occur more often in India and Indochina than elsewhere. In the end of the 21st century (2071-2100), heatwave intensity will increase, the average duration of heatwaves will be approximately two to three weeks, and the heatwave season will be lengthened. Therefore, extreme heatwaves will occur more frequently and strongly. Under two representative concentration pathway scenarios (RCP2.6 and RCP8.5) and two shared socioeconomic pathway scenarios (SSP1-2.6 and SSP5-8.5), the proportion of extreme heatwaves to all heatwave events will increase from 5.0% (historical) to 8.0%, 20.8%, 19.3%, and 36.3%, and the HWM of the extreme heatwave will be 1.4, 3.5, 3.0, and 9.0 times stronger, respectively. The main reason for the increase in the HWM of extreme heatwaves is the increased duration rather than the daily intensity of the heatwaves. In East Asia, the temporal and regional disparities of heatwave damages will be much more pronounced, as extreme heatwaves become stronger and more frequent in the regions and during the periods that are more affected by heatwaves in the present day.

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C1-P-28

Heat in cities across the globe: what can the CORDEX-CORE regional climate model ensemble tell?

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Cities worldwide are under pressure due to climate change impacts, particularly heat extremes. Climate change and related extreme events are projected to intensify during the course of this century, putting further strain on urban areas and its populations.
The CORDEX-CORE regional climate model ensemble covers the major inhabited areas across the globe. The ensemble consists of two main members REMO and RegCM, which downscaled three global climate models each. The CORDEX-CORE output provides regional climate model data on a 0.22° spatial resolution for the RCP2.6 and RCP8.5 scenario, for the time period 1970-2100. The CORDEX-CORE dataset offers the possibility to analyse big cities across the globe under long-term climate change conditions, and to investigate urban-rural contrasts. As part of our research, a land surface analysis shows how the CORDEX-CORE models represent urban areas worldwide through their respective urban fractions and land surface schemes. In order to understand if the models are able to capture the main mean temperature trends, as well as the temperature difference between the city and its surroundings, an evaluation of the reanalysis driven model simulations is conducted for a subset of cities for which observational records are available in and outside the city. Furthermore, CORDEX-CORE model projections for RCP8.5 are investigated to understand future trends in mean temperatures, as well as extreme heat episodes for around 30 big cities and their surroundings across the globe in different climate zones. The study gives insights into the capabilities of the CORDEX-CORE multi-model ensemble to capture mean temperature trends and heat extremes for large urban areas across the globe under climate change.

C1-P-29

Three-dimensional characteristics of heat waves in CORDEX RCMs

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Heat waves are recognized as one of the greatest hazards in relation to climate change. They are characterized as prolonged periods of abnormally hot weather in summer and have severe impacts on various sectors, including agriculture, livestock, forestry, and infrastructure. They are also associated with excess human mortality, decreased mental health, and other negative societal impacts [1]. Heat waves has been a major topic in climate change research – 8,011 papers are listed in Web of Science from 1990 to 2020 and their number has been doubling approximately every five years since 2003 [2]. That year was characterized by an unprecedented heat wave over Western Europe [3], prompting an intense investigation of these events.

Pioneering works using one-dimensional station data have been gradually supplemented by studies using more advanced two-dimensional products, i.e. station data interpolated into regular grid, which allow for a more comprehensive investigation of the physical processes that govern heat waves [4]. However, the effects of individual drivers are not additive, indicating their complex relations through feedback loops between atmospheric circulation and land–atmospheric coupling in a relatively high vertical tropospheric column [5]. Therefore, we aim to advance in understanding of heat waves mechanisms by analysing them as *three-dimensional (3D)* phenomena.

In this study, we evaluate the capability of 9 CORDEX regional climate models (RCMs; higher resolution EUR-11 versions) driven by the reanalysis in terms of reproducing the 3D characteristics of heat waves. Firstly, we evaluate the simulations of summertime temperatures in 850, 500, and 200 hPa pressure levels over Europe against the ERA5 reanalysis [6], focusing on extreme values and their links to surface temperatures.

Based on the observed and RCM-simulated relationships between temperatures in the free atmosphere and near-surface temperatures, we propose a definition of a heat wave in 3D space. We evaluate the simulated characteristics and interannual variability of those '3D heat waves'separately in several European regions for the 1989–2008 period (common for all RCMs used) in order to assess the performance of the RCMs in various climatic zones. This study will serve as a springboard for more in-depth analyses focusing on the governing mechanisms of heat waves in 3D space.

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C1-P-30

Attribution of Extreme Precipitation Events in The Mediterranean Region Using High-Resolution COREX Ensemble

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Detection and attribution of anthropogenic influence on extreme events has always been one of the focuses of climate research. Among assorted methods, the risk-based approach has been widely applied for attributing extreme events of various types over the globe. One of the major challenges faced by event-based attribution is the short observational record, particularly under non-stationary conditions where the extremity of the event is so high that the statistical model suggests a near-zero probability of occurrence. Utilizing such an insufficient record under changing climate conditions can lead to an underestimation of the return level and an overestimation of the return period [1]. In this study, the long-term simulations of the high-resolution (0.11°) COREX ensemble over the Mediterranean region are employed to tackle this issue. Specifically, a set of three floods/extreme precipitation events that occurred in Italy was considered. Precipitation records in the three locations are used to bias correct the historical simulations from CORDEX. The obtained precipitation series are separated into two periods, with the first half representing the past climate (counterfactual world) and the second half representing the present climate (factual world). The ensemble members are aggregated to extend the length of the time series, to which the risk-based approach is then applied.

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C1-P-31

A reference set of bias-corrected regional projections for hydrological impact studies over France

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The Explore2 project aims to update knowledge on the impact of climate change on hydrology and also support stakeholders in understanding and using the results for adapting their water resources management strategies. The project will offer publicly accessible state-of-the-art climate data and hydrological indices for the French territory on the DRIAS web portal [1,2].

We present how we use EURO-CORDEX simulations to produce atmospheric forcings for hydro-climatic projections and hydrological impact studies over France.

A meaningful set of simulations is selected from the EURO-CORDEX ensemble. Their biases is assessed and reduced by applying two established bias-correction methods [3,4]. A set of climate change indices relevant for hydrology is then calculated, with a focus on air temperature, precipitation, water deficit and their extremes.

For the selected ensemble we present a synthesis of those indices, which are estimated over several time horizons, different emissions scenarios and allow a comparison of the effects of the bias-correction methods.

In the continuation of the Explore2 project, the bias-corrected simulations are then used to force a set of hydrological models which assess the impacts on water resources.

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C1-P-32

PROJECTED CHANGES IN EXTREME RIVER-FLOW IN THE UPPER MISSISSIPPI RIVER BASIN

Modified from a manuscript to be submitted to
Science of the Total Environment

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Abstract:

The Mississippi River basin is a very important source of water for civilian and agricultural usage. It is also very sensitive to climatological changes such as shifts in precipitation patterns that drive the streamflow of the entire system including the Upper Mississippi River Basin (UMRB). In this study, the MPI and GFDL GCMs were dynamically downscaled by Reg-CM4 under RCP 8.5 and bias corrected as part of the NA-CORDEX program. Output from those simulations (Daily Precipitation, T min and T max) was then fed into the Soil and Water Assessment Tool (SWAT) model to simulate streamflow for UMRB high water marks at Grafton, IL, for contemporary (1981-2010) and future scenario (2041-2070) climates. The growing seasons (May-Aug) of each period were also specifically analyzed. Both MPI-RegCM4 and GFDL-RegCM4 produced similar results for streamflow during the contemporary period. When the future projections were analyzed, GFDL-RegCM4 gave higher streamflow with greater exceedance of 90th,95th, 98th percentiles than MPI-RegCM4, especially during the growing season. The MPI-RegCM4 tended to simulate a dryer and hotter future scenario than GFDL-RegCM4 with greater potential evapotranspiration, less precipitation, and therefore lower evapotranspiration, water yield, and basin-wide snowmelt. Both models, however, projected greater inter-annual variability in the future scenario with higher standard

deviations than their contemporary simulations. An important implication is that this projected increase in inter-annual variability could drive streamflow to greater extremes on both the dry and wet ends of the spectrum.

C1-P-33

Novel tools for model evaluation from the Big Data and Climate FRONTIER project

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Climate information is becoming increasingly important for effective planning, adaptation and mitigation to future costs and disruptions arising from climate variability and change. However, this increasing demand for climate information is driving an explosive increase in the volume of climate data. This creates obstacles for users who need to access this data. Accessing such a large volume of climate data will require highly specialised skills and tools which can be unaffordable for many users. FRONTIER aims to address this challenge through the key issues of data production and data analysis. As part of this process, we have developed new tools and metrics that can benefit the wider community of regional climate modelling. In particular, we will present a novel feature tracking tool called the Multi-Objective Analysis of Atmospheric Phenomena (MOAPP). MOAAP tracks extratropical cyclones, fronts, atmospheric rivers, high-pressure systems, mesoscale convective systems, tropical cyclones, and is used to understand their relationship to extreme precipitation. We will also present a new framework and composite metric called the Bergen Metric which summarises the overall performance of climate models and aims to ease interpretation of results from multiple error metrics.

C1-P-34

Quantifying the climate change and its impacts on wheat productivity for decision-making support in Egypt

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Climate change is one of the main challenging issues worldwide, with the Middle East and North Africa (MENA) region considered as one of the most susceptible to it. Egypt, located in the MENA region, is expected to suffer from several negative impacts of climate change, with increased temperature and reduced rainfall being among the worst potential perils [1]. The agriculture sector is thought to be vulnerable to the consequences of the climate change. In this study, we aimed at quantifying the climate change over a part of Egypt, with a focus on a rural area. Temperature and precipitation trends were analysed as indicators of climate change. The CORDEX data were used to project the future climate of the study area, until 2050, using the RCP4.5 and RCP8.5 scenarios. Moreover, to assess the possible impacts on the agricultural sector, the wheat crop was chosen as a strategic crop in Egypt to study the possible effects of climate change on it. Expected wheat productivity was predicted for 5-year intervals during the period between 2025-2050 using the World Food Studies Simulation Model (WOFOST) and by applying the future CORDEX data with the two scenarios (RCP4.5 and RCP8.5). The results pointed out an expected increase in temperature and a reduction in the precipitation rate, with the RCP8.5 scenario exhibiting more pronounced changes. The wheat crop was shown to manifest the impact of climate change, indicating remarkable changes in its productivity and harvest index. These results can be useful for decision-making support process in agriculture strategy for cereal productivity.

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C1-P-35

Projected changes in the frequency of compound events over tropical Brazil in CORDEX-CORE simulations

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In the past decade, extreme weather events have become increasingly frequent due to global warming, and their frequency is expected to rise with every increment in temperature. In particular, the potential increase in compound drought and heat events could profoundly impact societies, ecosystems, and economies, leading to crop failures, wildfires, and water scarcity, especially in Brazil, which is vulnerable to recent extreme climate events.
To investigate changes in compound events in response to changes in radiative forcing and their impact on extreme climate events such as drought and extreme heat, we assessed an ensemble of CORDEX-CORE simulations over Tropical Brazil. The simulations were conducted at a 25 km horizontal grid spacing using lateral and lower boundary forcing from three Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models, each covering the period from 1980 to 2100 under two Radiative Concentration Pathways (RCP2.6 and RCP8.5) in the 21st century projections period. We evaluated the simulations using observed data from the Brazilian Daily Weather Gridded Data (BR-DWGD). In addition, we performed a quantitative assessment of the areas affected by these compound events during the present day.
Our projections for the near term (2021-2040) indicate that the number of compound events could increase by up to 100% in the majority of the domain, with a band in Central Brazil, another in the Northeast, and a region in the extreme North experiencing a rise of between 150 and 400% in the number of events. The number of events increased significantly along the time slices for the RCP2.6 scenario, while the perceptual number of compound events increased substantially for the RCP8.5 scenario. In the long term (2081-2100) time slice, the RCP8.5 scenario shows an increase of between 300 and 700% in most parts of North-Central and Northeast Brazil and an increase of up to 900% in the extreme North.

Analysis of Climate Indices in Climate Change Scenarios Applying Spatial Data Correction, the case of Guayas Province, Ecuador

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Abstract

Climate change amplifies the impacts of extreme events, including heatwaves, floods, and intense rainfall, which surpass the normal range of climatic variation. These changes pose significant threats to societies and the environment. The Sixth Assessment Report (AR6) by the Intergovernmental Panel on Climate Change (IPCC) highlights the escalating frequency and intensity of extreme weather events, and underscores the need for developing local studies, particularly in highly vulnerable regions. The Guayas province, situated on the coast of Ecuador, has been affected by extreme weather events, especially rain-induced floods that endanger the lives of the inhabitants. To assess the potential effects of climate change in this area, the AR5 Representative Concentration Pathways (RCP) scenarios were evaluated using climate indices trends from the 'climdex' R library. The data used was spatially corrected using Variational Merging (VARMER) and a statistical downscaling to improve the zoning of impacts in this highly populated province. The results highlighted the usefulness of the methodology and indicated increasing frequency and intensity of extreme events in the study area under both RCP scenarios (4.5 and 8.5). Revealing that the RCP 4.5 scenario projects a higher number of extreme precipitation events (95th percentile), while the RCP 8.5 scenario projects higher temperatures reaching an increase of 2 ºC by 2050. This study develops climate indices useful for the assessment of climate change impacts at the local level. It is also emphasized that there is an urgent need for robust data collection that is critical for climate change and weather events research, and would strengthen the proposed methodology.

C1-P-37

High-resolution climate projections to support adaptation planning in the Mashreq region

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Climate change information at regional and local scale is highly demanded by a wide range of stakeholders worldwide for impact modelling and adaptation planning. However, high-resolution (HR) climate projections that are the basis for regional climate information are still missing or not easily accessible in many regions. An integrated approach to provide HR regional climate projections and related products for stakeholders in the Mashreq region was developed within the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR, riccar.org). The Mashreq Domain covers a region of Western Asia and Northeast Africa that includes coastal urbanised landscapes and mountainous areas. At the first step, an ensemble of climate projections for the Mashreq region was generated by a regional climate model - HCLIM-ALADIN at 10km resolution. The ensemble consists of 12 members driven by six global climate models under the SSP2-4.5 and 5-8.5 scenarios for the period 1961-2070. The second step is an advanced bias adjustment for most requested variables: daily mean/maximum/minimum temperature and precipitation. At the third step, a number of temperature- and precipitation-based extreme event indices relevant for the Mashreq region is calculated. Other indices, such as proxies for dust emission (e.g. Dust Uplift Potential), are under development in order to fill remaining regional knowledge gaps on how climate change may affect sand and dust storms. The ensemble of the 10km bias-adjusted climate projections for the Mashreq region provides a unique package of HR climate data that has already been used for impact studies and adaptation planning in the Mashreq region. A subset of daily variables is available from the RICCAR website. It is also planned to make a more complete archive, including sub-daily output, available through the Earth System Grid Federation (ESGF).

C1-P-38

Heat Wave Increase Based on EURO-CORDEX Scenario Simulations in Metropolitan Cities of Türkiye

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Heat wave events enhanced by human-induced climate change have recently caused thousands of dead in the Euro-Mediterranean region. We have calculated heat wave events over the western Türkiye based on simulations of the EURO-CORDEX project which are produced by five different regional climate models that forced four GCMs. The definition of heat waves has been made by the EuroHEAT project as days in which the maximal apparent temperature (Tappmax) exceeds the threshold (90th percentile of Tappmax for each month) and the minimum temperature (Tmin) exceeds its threshold (90th percentile of Tmin for each month) for at least two days. The calculation period for heat waves is only limited to the summer months. The heat wave analyses in three different periods have been conducted with 16 metropolitan cities in western Türkiye for the RCP4.5 and RCP8.5 scenarios. The total population of these 16 metropolitan cities is over 47 million and constitutes 55% of the entire population of Türkiye. In terms of the RCP8.5 scenario, the heat wave events increased nearly five times in Istanbul in the 2021-2050 period compared to the reference period (1976-2005), while it increased 12 times in the 2051-2080 period. For İzmir, a tourism city located near the Aegean Sea, the increases in the same periods were 4.5 times and 10 times (corresponding to 52 days), respectively. For the RCP4.5 scenario, on the other hand, the number of heat wave days in the same periods is reduced by almost half in all metropolitan cities. The number of heat wave days for the future in other metropolitan cities also indicates similar change rates to those in Istanbul and Izmir.

C1-P-39

Future changes in extreme rainfall events on the Caribbean slope of Costa Rica, Central America, based on CORDEX-CORE models.

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Regional Climate Models (RCMs) better simulate local changes in atmospheric circulation in areas with complex orography such as Central America [1]. CORDEX-CORE models [2] provide a comparable set of high-resolution projections, which is approximately 22km for Central America and the Caribbean (CAM-22). In this research, 3 RCMs (RegCM4-7, REMO2015 and CRCM5) driven by 3 different Global Climate Models (GCM) each were used for rainfall in the Caribbean slope of Costa Rica. The selection of these RCMs is supported by previous research indicating that these models have shown improvements in the representation of key circulation patterns in the Central American region [1]. Monthly and extreme monthly rainfall (25^{th} and 75^{th} percentile) in the historical experiment (1985-2005) and the RCP8.5 scenario for 2-time horizons: 2040-2069 and 2070-2099 were analysed. The study area was delimited to the Caribbean slope of Costa Rica and the outputs were interpolated to a common 0.25° by 0.25° grid. Validation was performed using quality database of 28 weather stations. This research is focused in 2 months that presented opposite and significant behaviours in the trend analysis: September (negative) and December (positive) [3].

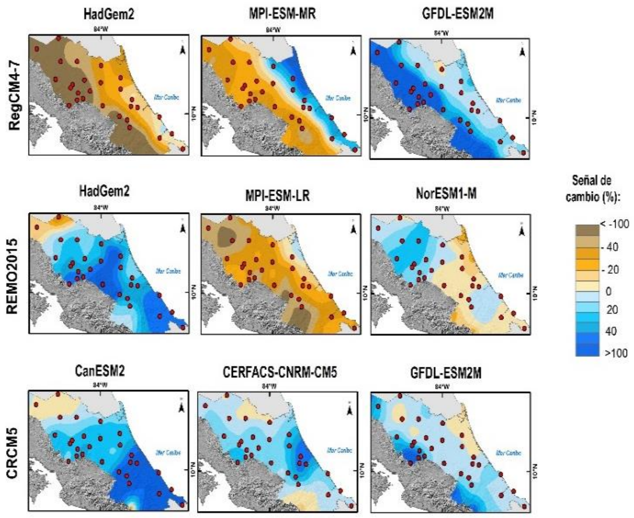

Fig. 1. Signal of change, 25th percentile in September, 2040-2069.

The validation results for September (December) show, in general, an overestimation (underestimation) of monthly rainfall. Regarding extreme rainfall, the 25th (75th) percentile in September (December) exacerbates the error found in the mean value. For both September and December, most of the models project increases of mean rainfall to the east-southeast whereas more inter-model variability is presented to the west-northwest for the near future period. In general, for September, the increases or decreases deepen, while for December, the decrease deepens in most models (5) for the second horizon with respect to the first. In September, near future changes of the 25th percentile (Fig 1) is positive in almost all the study region according to 5 RCMs, negative for 2 RCMs and spatial heterogeneous for the rest. The signal changes in sign in 5 of the 9 RCMs in the second horizon with respect to the first one. In December, near future changes for the 75th percentile is negative according to most of the RCMs, which present deepening of the decrease in rainfall in the second horizon. Finally, the signal of future change is lower than the bias analysed during the validation stage, indicating the high uncertainty involved in the projections.

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C1-P-41

Construction of regionalized scenarios for simulations of the urban area and buildings: present and future climate in the RCP8.5 scenario

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The present study evaluates climate projections in high horizontal resolution (20 km) for the metropolitan region of São Paulo (RMSP), in order to build typical meteorological years (TMYs) to be used in simulations of the urban area and buildings, seeking strategies for mitigation of climate change. Three climate simulations were performed with the RegCM4 regional model, one reference run forced by the ERA-Interim reanalysis, and two forced by the CMIP5 global models (HadGEM2-ES and MPI-ESM-MR (named, respectively, RegErai, RegHad and RegMpi) for the RCP8.5 scenario. Each climate projection is evaluated in the historical period (1980-2014), near future (2026-2060) and distant future (2064-2098). The evaluation of the present climate (1980-2014) carried out comparisons of the temperature (T) and capture (Pr) time series of the RegErai experiment and local observations and reanalyses. The simulation captured local climate factors, with good performance in simulating the characteristics of the annual cycles (Pr and T) observed in the RMSP: maximums of Pr and T in the summer months, and minimums in the winter, although there is an overestimation of Pr and an underestimation of T. RegMpi underestimates and RegHad overestimates Pr in relation to RegErai in the present period. For the future, RegHad projects a drier climate between February-March and June-September, while RegMpi indicates an increase in Pr mainly in February and September-November, but with a sharp decrease in August. Both experiments project a progressive T increase in the near and distant future, with RegHad indicating an increase of up to 4°C. Modern methods of building TMY filter data bring them closer to climatology, so, here we propose a method of hourly climatology where hourly values of each day of the year are grouped and hourly averages are calculated. The annual bias of each simulation varies, as well as its distribution over the year. Thus, a technique was developed to correct the simulations considering the average monthly diurnal cycle of local observations. In this way, the biases (difference between the simulated and observed psychological average diurnal cycles) are removed from the simulations on the hourly scale for each TMY day. The bias correction has a direct impact on the TMY result, providing curves for variable densities such as T, relative humidity, wind direction and speed much closer to those observed than before the correction. A similar technique is being applied to trends in order to contemplate the visual projections in the RMSP.

C1-P-42

Future Projections of extreme events over Central Asia in CORDEX-CORE Simulations

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Abstract:

Under the framework of the recently funded European Union project "WATER EFFICIENT ALLOCATION IN A CENTRAL ASIAN TRANSBOUNDARY RIVER BASIN (WE-ACT)", we evaluate the performance of CORDEX-CORE regional climate model (RCM) simulations over Central Asia (CORDEX-CAS) during the past and under different greenhouse gas scenarios. The WE-ACT project is a major step towards the development of a decision support system to facilitate efficient water allocation using hydrological models driven by bias-corrected input variables (e.g., precipitation, temperature, wind speed, etc.) from the RCMs.

The evaluation of the RCMs' performance is done using various statistical metrics such as mean bias, skill score, and Taylor diagrams. We find that there are biases in the model-simulated mean climatology that vary across the domain. We also compute and assess the models in terms of extreme precipitation and temperature indices such as consecutive dry days (CDD), the representation of heavy precipitation events (R95p), extreme warm days (tx90p), as well as the heat wave duration index (HWDI). We'll present first findings of this work which is important as Central Asia is underrepresented by current studies compared to the expected climate change impacts of the region. Therefore, we further aim to employ an appropriate bias-correction methodology to alleviate the biases associated with them before forcing the hydrological simulations over the Central Asia domain.

Keywords: CORDEX-CORE, Central Asia, extreme events, climate change, bias-correction

C1-P-43

Biophysical impacts of land use changes on the local and regional climate – Results and lessons learnt from the CORDEX Flagship Pilot Study LUCAS

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The CORDEX Flagship Pilot Study "LUCAS" (Land Use and Climate Across Scales) investigates biophysical impacts of land use changes on the local and regional climate. In FPS LUCAS, for the first time an ensemble of RCMs is used in coordinated downscaling experiments including land use changes. In LUCAS phase 1, idealized experiments with maximized forest/grass cover have been performed for the European continent in order to investigate model sensitivities to extreme land use change forcing. Simulations from more than 10 different regional climate model - land surface model combinations and configurations are available for the EURO-CORDEX domain at 0.44° horizontal resolution. In addition, modelling groups from North America joined LUCAS and applied the LUCAS phase 1 experiment protocol in the CORDEX-NA domain. The results reveal significant biophysical effects of re-/afforestation versus grassland on seasonal near surface air temperatures within the range of -2 to +2 °C, depending on the region and season. The large range of model sensitivities to extreme land use changes indicate that fundamental modelling uncertainties remain.

In preparation for LUCAS phase 2, a new high-resolution land use land cover change dataset for use in RCM experiments has been generated. Annual plant functional type maps are provided on a 10 km target resolution, for the past period 1950-2015 and for the future period 2015-2100 for different SSPs/RCPs, based on land use transitions compliant with CMIP6. The newly developed land use translator can be transferred to other world regions. The new “LUCAS LUC” datasets provide the land use forcing for LUCAS phase 2 experiments which are currently performed over Europe and North America.

We will present selected results from the CORDEX FPS LUCAS and share some lessons learnt and future perspectives.

C1-P-44

Uncertain water resources under global change – Assessing water use-climate feedbacks in the UWaRes project

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The sufficient availability of freshwater is vital to humans, economies, and ecosystems. The global population is rapidly growing while living standards and economic development widely increase. This results in evergrowing water use per capita, and the increasing food demand can often only be met through massive increases in irrigation activities. The high water demand from households, agriculture, and industries often leads to water scarcity and prevents a fair share of the available resources at the expense of the environment. In addition, anticipated climate change alters regional hydroclimatological conditions and impacts the occurrence and intensity of extreme events (e.g., droughts). However, when planning future water use under global change, water managers are often confronted with insufficient and inaccessible data and models, high uncertainties, and vague scenarios.

How can climate science and hydrology effectively assist future water planning? In the UWaRes project, we address this question by combining process-focused climate and impact-focused water resources modeling, guided by the practical challenges experienced by end-users and water managers. To improve assessments of the water use-climate feedback we couple a water use model to the regional climate model REMO with a special focus on irrigation. The water use model provides the amount of water required and available for irrigation, which is then applied to the crops in REMO. Such a coupled model setup will allow us to study the climate impacts of different water management strategies.

C1-P-45

The extreme future of soil moisture in a Mediterranean country: the Portuguese case

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Climate change constitutes a major threat for all the Mediterranean countries due to the combination of large precipitation reductions and temperature increases and the higher frequency of climate extremes, especially driving water scarcity and all the derived multi-sectoral impacts. Portugal, as most of the Mediterranean countries, already endures larger frequencies of droughts and deficits in soil moisture and water storage. In the current study, the future projections of soil moisture are examined using a multi-model EURO-CORDEX regional climate ensemble, in agreement with three future emission scenarios (RCP2.6, 4.5 and 8.5). As expected, the projections show a clear reduction of soil moisture through the entire annual cycle, in response to the large decrease in precipitation and temperature increase, via a massive growth of potential evapotranspiration. The overall total soil moisture decreases ranges from −5% for the RCP2.6 to −20% (-10%) for the RCP8.5 (RCP4.5), w.r.t. the present climate. In the historical period, soil moisture deficits rarely reach values 3x over the standard deviation, but projections reveal that for the RCP4.5 (RCP8.5) for the mid-century deficits up to 5x (6x) are projected to occur, and for the end-of-century even 7x for the RCP8.5. The annual cycle of soil moisture is in present and future climate determined by precipitation and potential evapotranspiration, and deficit is both enhanced and covers a wider monthly window in the future, especially for the RCP8.5. The surface humidity also decreases importantly, up to −4% and −8% in spring and summer in the end-of-the-century, in agreement with RCP4.5 and RCP8.5, respectively. Resulting from the projected changes the typical semi-arid climate, which in present climate is confined to a small south-eastern region of Portugal, is expected to cover almost 2/3 of the mainland in the case of RCP8.5.

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C1-P-46

How the risk of heat waves will change in the future decades in Croatian cities?

Lidija Srnec, Vjeran Magjarević

After the well-known Western European heat wave during August 2003 that caused as many as 70000 excess deaths, many countries started to build heatwave early warning systems. In Croatia, the system is operational since 2012, and it warns about the level of possible risk for eight main regions in the country. Monitoring of the past 20 years regarding issued warnings, but also heat wave risk estimated by measured temperatures clearly indicates that the level of risk is increasing.

The aim of this work is to analyse what can we expect, regarding the intensity of heat waves in Croatia, in the future. For that purpose, we will use regional climate simulations from EURO-CORDEX data set. Simulations will cover a set of projections on 12.5 km horizontal resolution, taking into account several RCP scenarios. The future climate will be considered for three 20-year time slices.

The operational criteria used in the Croatian heat wave early warning system will be applied to the projected daily minimum and maximum temperatures. Historical climate risk simulated by models will be compared with issued warnings in order to evaluate simulations. The difference between projected and historical climate risk will be analysed by the level of risk, its duration and spatial distribution.

C1-P-47

Regional Climate Data for Use in Advancing Successful and Equitable Decarbonization of the US Electric Power and Residential Sectors

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Successfully decarbonizing the United States requires deep decarbonization of electric power and residential sectors. To expedite equitable decarbonization, we will answer the following research questions: How will residential decarbonization and climate change interactions affect (1) the future value of residential and power sector decarbonization strategies and (2) household energy burdens? We are developing a framework for analyzing decarbonization strategies and energy burdens given near-term (e.g., up to 2035) climate change that will couple climate data with innovations in power and building modeling.

To capture near-term threats of climate change that can be assessed within this framework, we analyze historical and future weather variables across CONUS from (1) a large ensemble of multiple members from one climate model (the NCAR Community Earth System Model version 2 Large Ensemble Project; CESM2-LE [25]), and (2) dynamically downscaled simulations from the CORDEX North America project. The CESM2-LE simulations have multiple realizations (100 members) of climate around the globe for the historical and future period for the Shared Socioeconomic Pathway (SSP) 3-7.0 at a global 1° resolution. From CESM2-LE, we will obtain overlapping sets of climate variables across CONUS for building modeling and power system modeling. Because urban areas are crucial study regions to understand household decarbonization and energy burdens, we will also include dynamically downscaled simulations from the CORDEX experiment. Climate variables needed for building modeling include temperature, incoming longwave and shortwave solar radiation, relative humidity, air pressure, and winds all at surface level, temporally disaggregated from 3- hourly, 6-hourly, and daily values to hourly values. Power system modeling also requires higher level (e.g., 100 m) wind speed to calculate wind power. We will compare and contrast these global large ensemble simulations with CORDEX simulations to explore the impacts of the urban heat island effect and spatial distributions of air temperatures on residential decarbonization and energy burdens.

C1-P-48

The frequency of extreme temperatures and summer heat waves in Belarus

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Climate changes have caused temperatures to rise in recent decades in all seasons of the year in Belarus. The average growth rate of the average annual temperature starting from the late 90s of the XX century was 0.4°C/10 years, which exceeds the average value around the globe. The most intense temperature increase is observed in winter – by 0.6°C, in spring and summer – by 0.5°C, in autumn – by 0.3°C.

This study analyzes the frequency of extreme high temperatures in Belarus in the period from May to September (the warm period of the year) and heat waves in the summer season of 2003-2022 using data on the maximum air temperature calculated from the daily temperature fields of the EURO-CORDEX project (Copernicus Climate Data Store) and averaged across regions of the country.

The meteo service of Belarus has adopted the following criteria for extreme high temperatures: orange hazard level (+25...+34°C) and red (highest) (+35°C and above). A heat wave was defined as a period when the maximum daily air temperature for five or more consecutive days exceeded the average maximum temperature for a given day for the base period (1961-1990) by more than 5°C.

The analysis of the total number of extremely warm days in Belarus showed that there was a significant increase of them in all regions during the study period. A total of 5,903 extremely warm days were recorded in all regions of the country, the number of days when the temperature reached the orange danger level was 5842, red – 61 (1% of the total number of days). The maximum number of extremely warm days was observed in the southern regions of the country (Gomel – 1270, Brest – 1125), the minimum – in the north-west of the country – Grodno (814 days). In the annual distribution, the largest total number of days with extreme temperatures was observed in 2018 – 451, the minimum – in 2009 (183), in other years the number of days ranged from 223 to 346. The number of extreme warm days has been increasing since May, reaching a maximum in July (1963 days), the minimum was in September (331 days). The hottest in the history of meteorological observations was the warm season of 2010, the record of the absolute maximum temperature was broken in August at meteorological station Gomel (+38.9°C).

The number of heat waves, their duration and intensity increased in all regions of the country during the study period. The analysis of the frequency of heat waves showed that their number was 131, the maximum was observed in the central region (Minsk) – 27, the minimum – in Mogilev region (17). The average duration of heat waves in the country was 8 days, the longest waves were observed in June 2019 in Gomel region (23 days) and Mogilev (19 days). The frequency of heat waves at the end of the study period has tripled compared to the beginning, reaching an average 9 cases per year.

Over the past decades, direct and insured losses from disasters that are associated with extreme heat have increased significantly both at the global and regional levels. The observed climate change puts people, society, economic sectors and ecosystems at risk.

C1-P-49

Fidelity of RCMs in Quantification of Climate Change Impacts on Flood Risk- An exhaustive approach over severely flood-prone coastal catchment

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Flood is a hydro-climatological disaster experienced by several nations worldwide. In the recent past, climate change has significantly influenced the pattern, thereby increasing the severity and frequency of floods. Although General Circulation Models (GCMs) have improved our understanding of atmospheric phenomena, using them for flood mapping at regional scales has been challenging due to their coarse resolution. Past studies have commonly relied on GCMs and their downscaled versions to incorporate hydro-climatological data, but these models often produce significant anomalies in capturing flood statistics at the regional level. Under such circumstances, high-resolution Regional Climate Models (RCMs) are a fitting option, but their suitability in capturing flood hazard transformations is not well understood. The system complexity becomes precarious in flood-prone coastal catchments that witness interplay of multiple flood drivers like extreme rainfall, storm-tide, and riverine flows. To addressing this research gap, the present study utilizes rainfall from a set of RCMs (RegCM4.7, COSMO & REMO2015) from the Coordinated regional climate downscaling experiment (CORDEX) Consortium. The distributed rainfall values are segregated into Scenario 1 (1980-2000) and Scenario 2 (2000-2020), and design rainfalls are estimated for 1 in 100-yr return periods using a set of probability distributions. MIKE+ 1D-2D model is set up to simulate 1 in 100-yr flood hazards while considering design rainfalls, along with Digital Elevation Model, land use land cover, design discharge and design storm-tides. For vulnerability assessment, a set of socio-economic and infrastructure indicators are considered within Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) framework. Hazard and vulnerability values are combined together to derive flood risk for both scenarios. The study is demonstrated over Jagatsinghpur, a severely flood-prone catchment of the Lower Mahanadi River basin of Odisha, India. While accounting the decadal transformation, we find a noticeable rise in flood hazards over the coastal stretches that amplifies the overall flood risk. Later, flood hazards are simulated for the near future (2020-2060) and far future (2060-2100) by considering the rainfall projections under RCPs 4.5 and 8.5. A conspicuous rise in flood hazards is noticed in the future periods. The study helps in locating those regions that face serious flood risk (high hazard and vulnerability) in the historical period and high flood hazards in the future periods. It recommends suitable climate resilient adaptation measures to reduce vulnerability for the future periods that will eventually lower risk.

Keywords: Flood Risk; CORDEX; MIKE+; TOPSIS; Decadal transformation; Jagatsinghpur

C1-P-50

Forcasting atmospheric variables with RegCM4.7 for the optimal operation of uruguayan energy system

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Uruguay is one of the leading countries in the world in terms of wind energy production, together with Denmark, Ireland, and Germany, with more than a third of its electricity coming from wind farms. In fact, Uruguay has the higher per capita wind energy in Latin America [1]. In the last decade, efforts have been put into the energy sector, and nowadays, 97% of the country's energy generation is renewable [2]. Although renewable energy has a lot of advantages, it has to be considered that it is highly variable, depending on atmospheric conditions [4]. Then, it is vital to get precise forecasts.

For the optimal operation of the electrical power generation system, Uruguay uses SimSEE [3] (electricity system simulator). Based on atmospheric forecasts, this model is able to forecast energy generation and demand. Historically, the input atmospheric forecast used is not specifically calibrated for the region.

To get a more precise energy generation and demand forecast, we have started to initialize SimSEE with RegCM's output. Firstly, we validated the regional climate model for Uruguay, dividing it into rainfall and non-rainfall days in each season. At this point, it is essential to consider atmospheric dynamics to understand the ability to forecast each variable. For example, it is important to understand if errors are due to a wrong location of a specific phenomenon or if the intensity or the pattern are not well simulated. Secondly, we predicted energy demand and generation with the atmospheric variables that resulted from RegCM. Finally, we compared energy forecasts initialized with RegCM's outputs, with the model that has been historically used and with global climate models. The results show that RegCM adds value to the SimSEE, and more experiments are being analyzed.

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C1-P-51

Past and future precipitable water vapor and extreme precipitation over Ethiopia based on CORDEX

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Precipitable Water Vapor (PWV) and extreme rainfall are strongly related and this is of prominent importance in the context of climate change. Normally these are investigated in mid-latitudes and for flat terrain. Ethiopia is located in the tropics and has a complex orography, both of which may severely affect these relations. We investigate PWV and extreme precipitation over Ethiopia by use of Regional Climate Models (RCMs) from the Coordinated Regional Climate Downscaling Experiment (CORDEX). We first evaluate the RCMs by comparing their annual PWV cycles with the ones obtained from Global Positioning System observations and reanalysis in the past. Additionally, we focus on the behaviour of PWV before and after a heavy-rainfall event. It is found that there are two characteristic timescales, both for the build-up and for the decline around the event of the heavy precipitation: a timescale of about 2 days and a longer timescale that extends beyond ten days which seems unreported in the literature. The RCMs are capable of reproducing the PWV annual cycle and the spatial variability. However, there is a predominantly dry bias that strongly increases with elevations. The RCMs reproduce well the spatial differences of the PWV anomaly peak during a heavy-rainfall event but overestimate the timescales of build-up and decline. Future PWV-changes scale linearly with the near-surface temperature changes at a rate of 7.7% per degree warming and locally increase up to 40% for the end-of-the-century RCP8.5 scenario. Changes in rainfall extremes, on the other hand, do not follow this trend especially in north-western Ethiopia, potentially caused by an overall decrease in rainfall in that region.

C1-P-52

Provision of climate change information on rainy season indicators for the agricultural sector in Burkina Faso

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Food security in Burkina Faso is strongly linked to its agricultural sector and it is estimated by the United States Agency for International Development (USAID) that roughly 20 percent of Burkina Faso's population are considered to be food insecure [1]. Furthermore, West Africa is particularly vulnerable to the effects of possible future climate change on agriculture, which will also have consequences for food security in Burkina Faso. It is therefore important to develop land management strategies to increase the resilience of the agricultural sector to the negative impacts of climate change in the country. These strategies can only be developed by taking the needs of farmers into account and tailoring climate change information adequately.

In the WASCAL WRAP 2.0 LANDSURF project, demand driven climate change information with focus on the agricultural sector is being generated and will be provided by the newly developed Decision Support System (DSS) for West Africa. Stakeholders and decision-makers, e.g. farmers, consulting companies, and regional and national administrative authorities from several countries, including Burkina Faso, have identified rainy season parameters such as onset and cessation as key climate information to be included in the DSS.

We will present the projected changes and their uncertainties in rainy season indicators for Burkina Faso under a low and a high emission scenario for the end of the century (2071-2100). The indicators are calculated from the CORDEX-CORE Africa ensemble, which provides information at a spatial resolution of about 25 km. This data set consists of nine regional climate projections generated by three different regional climate models (RCMs) forced by projections from three different global Earth System Models (ESMs). To represent the range of potential future emissions, the Representative Concentration Pathways (RCPs) 2.6 and 8.5 are used.

[1] USAID, Burkina Faso – Agriculture & Food Security Factsheet (2022). https://www.usaid.gov/sites/default/files/2022-12/Burkina%20Faso%20AG_Food%20Sec%20Fact%20Sheet%20English%20May%202022_1.pdf

C1-P-53

Evaluation of the Impacts of Climate Change on Irrigation Requirements of Maize by CROPWAT Model

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In the presented study, the eventual effects of climate change on maize farming under Mediterranean climatic conditions were investigated by CROPWAT Model. Irrigation scheduling and determining water requirements are of great importance in adapting the climate change. The CROPWAT model is a software used to calculate the response of crop water requirements to different climatic conditions and irrigation strategies. The reference (1961-1990) and the future (2070-2099) climate data determined by the ICTP's Regional Climate Model system version 3 (RegCM3) were used as climate data in the study. According to the results, the mean reference evapotranspiration of growing season in the study site will be 0.49 mm day^{-1} higher on average in the future. In the period of 2070-2099, irrigation water requirements for maize will be 7.37% more on average than they were from 1961 to 1990. For the periods of 1961-1990 and 2070-2099, average crop evapotranspiration was calculated to be 480.1 mm and 513.4 mm, respectively. These simulation results revealed that irrigation scheduling in maize farming in Mediterranean climatic zones should be adjusted to the climate change.

C1-P-54

Hot Spots of Global Temperature of Emergence of several Climatic Impact-Drivers (CIDs) for the CORDEX regions

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The time of emergence (ToE) of a specific climatic impact-driver (CID) in a particular region is crucial information for stakeholders. ToE represents the moment when a distinct signal emerges from natural variability, serving as an indicator of the magnitude of climate change and playing a significant role in a risk framework for mitigation purposes.

There is no single metric for determining the time of emergence. It relies on user-driven choices of variables, spatial and temporal scales, the baseline relative to which changes are measured, and the threshold at which emergence is defined. In the present study, after testing different metrics, we chose the one based on the existing literature. In addition to ToE, we also calculated the Global Temperature of Emergence (GToE), where time is replaced with the global mean temperature. This approach eliminates dependence on model differences and emission pathways.

The GToE is thus defined on the basis of thresholds of temperature, the Global Warming Levels (GWL), expressed as changes in surface global temperature relative to the period 1850-1900. The probability of reaching a specific GWL threshold is then estimated for each CID and each region of interest.

In this study, we use GWL 1.0, 1.5, 2.0, 3.0 and 4.0 as thresholds and we evaluated the probability of crossing them for several CIDs related to extreme temperature and wet and dry indices. We analyze all the CORDEX simulations available for the CORDEX domains, the corresponding CMIP5 drivers and CMIP6 Global Climate Models outputs, in line with the IPCC WGI Interactive Atlas. Moreover, different observational datasets are included in the analysis in order to identify the presence of existing trends.

As expected, the probability of surpassing a specific threshold increases with the increase of GWLs. There are regions where high probability is shown even at lower GWLs and those indicate "CID hot spots" in the different domains. Depending on the analyzed domain, some CIDs are more relevant than others.

C2-P-01 - ALI Endris Mohammed

TinyML-Based Flood Disaster Prediction and Early Warning System for Awash River Basin

C2-P-02 - DOKO Hailemariam Mengistu

Climate Change Impact and its Mitigation Assessment the Case of Afar Water Spreading Weirs, Ethiopia

C2-P-03 - JAISANKAR Bharath

Influence of climate forcing agents on the regional hydrological cycle trends in a changing climate

C2-P-04 - STRUGLIA Maria Vittoria

DYNAMICAL DOWNSCALING OF CMIP6 MODELS OVER THE MED-CORDEX REGION: AN APPLICATION OF ENEA-REG 2.0 TO THE ASSESSMENT OF EXPECTED CLIMATE CHANGHE IMPACTS

C2-P-05 - TAYLOR Graham Patrick

Future conditions of wind and rain associated with fall wildfire conditions in CMIP6 models over western North America

C2-P-01

TinyML-Based Flood Disaster Prediction and Early Warning System for Awash River Basin

Endris M. Ali[1], **Mebatsion Sahile** [1]

[1]*(Computer Science Engineering, SoEEC, Adama Science and Technology University, ASTU, Ethiopia*

Recently. TinyML has become an emerging environment to predict flood disasters and early-warning systems in low-resourced contexts. Floods are a type of natural disaster that typically occur during the summer months (June-August) in the Ethiopian calendar. These floods can result in devastating and dangerous events, causing extensive damage to infrastructure, property, and human lives. Therefore, to mitigate the impact of the flood a TinyMl-based flood prediction and early-warning systems play a crucial role to alarm all stakeholders. As floods are seasonal disasters, they fall under the category of time-series applications, where time-series data can be used to develop models and algorithms that can forecast floods and provide early warning to vulnerable areas. Our case study examines the floods caused by the Awash River in the basin, which have been found to result in extensive damage to the regions of Afar and Oromia. The objectives of this study is to design a TinyMl-based model to measure the streamflow magnitude of the river and notify with alarm to stakeholders for minimizing flood risks. The model consists of five main layers: (i) sensor layer for data collection from selected basin areas, (ii) data processing layer for data cleaning, normalization, feature extraction, and other data preparation techniques, (iii) ML layer for processing extracted features and making predictions or decisions, (iv) inference engine layer for deploying the trained model to the edge device for real-time predictions, and (v) deployment layer for deploying the model and inference engine to edge devices or embedded systems like microcontrollers or microprocessors where the TinyML system runs. In this case, hydrological data is used to simulate and predict the behavior of water systems such as streamflow speed, water pressure, and surface area. Plus, meteorological data such as temperature, precipitation, humidity, wind speed and direction, air pressure, and cloud covers are used to understand the flooding context. For this model, the topography of the study area is defined, and collect ten (10) years of historical hydrological and meteorological data for training prediction model from the Ethiopian Water and Energy Minster(MoWE). Our data set comprises both categorical and numerical variables, with linear and non-linear relationships between them. To model this complex data, Random Forest, and Gaussian Process Regression (GPR), along with ensemble ML techniques, are employed on the edge-Impulse platform. These models are utilized to extract features from continuous time-series data, enabling accurate and reliable predictions for effective flood disaster management. We assessed the performance of our models using Root Mean-Square Error (RMSE) and F1-score as evaluation metrics. The results showed that the ensemble and Random Forest model outperformed the GPR approaches in terms of prediction accuracy, as evidenced by lower RMSE values and higher F1 scores.

[1] Costa, Daniel G., et al. "A survey of emergencies management systems in smart cities." IEEE Access (2022).

[2] Kyrkou, Christos, et al. "Machine Learning for Emergency Management: A Survey and Future Outlook." Proceedings of the IEEE (2022).

C2-P-02

Title: **Climate Change Impact and its Mitigation Assessment the Case of Afar Water Spreading Weirs, Ethiopia**

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Most Ethiopians (78 percent) are estimated to reside in rural areas, with more than a fourth of them living in the lowlands, according to the Central Statistical Agency's (CSA) forecast for 2021. The region's wide variations in rainfall frequently cause droughts and flooding, endangering both agricultural output and the survival of animal herds crucial to sustaining human livelihoods. Flooding in the Afar region may bring further catastrophic damages to the already vulnerable environment due to land degradation, with changing climates and more frequent extreme events projected in the Ethiopian highlands. German International Cooperation's (GIZ SDR) introduction of Water Spreading Weirs (WSW) in several districts of the Afar Region as a response to the existing issues by raising productivity, rehabilitating the environment, and improving livelihoods. These systems are used to spread flood out of the concentrated flow into the plain to reduce the velocity and distribute flood to the wider plains and create an opportunity to grow forage/crops while preventing the potentially disastrous effects of the flood on soils, vegetation, and livelihoods.

This study assesses the impact of the WSWs, starting by delineating potential rehabilitated areas then the Water Productivity Open-access Portal (WaPOR) data analysis was conducted over the identified areas. To estimate the potential rehabilitated area, the 30m spatial resolution of Landsat 8 images was pan-sharpened to 15m spatial resolution. The average value of the NDVI before and after the WSW construction was investigated. All values greater than the mean would be identified as rehabilitated areas. The method for the delineation of the potential rehabilitated areas was adopted from Strunck Alexander (GIZ). After the potential rehabilitated areas were identified, the decadal values of Net Primary Production (NPP) and Actual Evapotranspiration and Interception (AETI) were acquired from the WaPOR portal and converted to seasonal values for these areas. This computation was done directly through the WaPOR portal which takes the mean value of all pixels within the delineated shapefile. In addition to the seasonal values, the average seasonal values of NPP and AETI before and after construction of the WSW have been calculated at all water-spreading areas for both seasons. Results from the WaPOR analysis of AETI and NPP showed an increasing trend in all water-spreading weir intervention areas after the year 2016 and rehabilitated 17280 ha. On the other hand, the value of seasonal rainfall increased at all water-spreading weirs after the year 2016.

Keywords: Flood. Water spreading weir (WSW), WaPOR

C2-P-03

Influence of climate forcing agents on the regional hydrological cycle trends in a changing climate

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In recent decades, the global hydrological cycle is severely affected by Green-House Gases (GHG), Anthropogenic Aerosols (AA), LULC, etc. in addition to climate variability. The northern hemispheric monsoon precipitation trends are reported to have a strong connection to the GHGs and AAs. In this work, we attempted to carefully investigate the trends of regional precipitation globally, by examining the connection of downward solar radiation with evapotranspiration using the CMIP6 General circulation models historical simulations along with the individual experiments of GHGs, AA, and Natural forcings for the study period 1850 to 2014. The regional trends of downward solar radiation showed that India and East China have undergone a substantial decline from the 1960s onwards. We focus on these regions to report the changes in the hydrological cycle. The trend analysis of evapotranspiration and precipitation over south and east Asia from the 1950s to 2010s showed a drying trend in Eastern China, while India had an increase in annual total evapotranspiration and rainfall in the same period. These opposing responses in these two regions are due to, more so than the greenhouse gas effect, AA emissions have considerable control over Eastern China's precipitation. In contrast, the greenhouse effect has strong controls on the Indian land region's hydrological cycle exceeding the forcing brought on by the AA emissions.

Keywords: Climate change, Climate modelling, Anthropogenic aerosols, GHG, Hydrological cycle.

C2-P-04

DYNAMICAL DOWNSCALING OF CMIP6 MODELS OVER THE MED-CORDEX REGION: AN APPLICATION OF ENEA-REG 2.0 TO THE ASSESSMENT OF EXPECTED CLIMATE CHANGHE IMPACTS

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[2] *ICSC-Super Computing Centro Nazionale di Ricerca in High Performance Computing, Big Data e Quantum Computing*

We present recent results obtained with the latest version of the regional Earth System Models ENEA-REG designed to downscale, over the Mediterranean basin, the models used in the Coupled Model Intercomparison Project (CMIP6).
A hindcast simulation has been performed, driven by the ERA5 reanalysis and using ORAS5 as boundary conditions at the Atlantic open boundary, and a historical simulation forced with the MPI-ESM1-2-HR model. Comparing the two simulations and the observed values allows us to make an initial assessment of the effect of dynamic downscaling in evaluating the impacts of climate change.
In particular, among the various observables we will select those that can be most affected by a better numerical representation of air-sea interactions: marine heat waves, changes in sea level, and occurrence of locally developed cyclones.
Simulations were also run for different scenarios using the MPI model as the driver again, and analyses of climate change impacts will be presented in analogy with the analyses done for the present climate, for some regions of greatest interest within the simulation domain.

C2-P-05

Future conditions of wind and rain associated with Fall wildfire conditions in CMIP6 models over western North America

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This study uses a large ensemble of CMIP6 models, as well as a suite of dynamically downscaled CMIP6 models, to investigate the impact of global warming on the timing of fall wind and rain over western North America, which is highly impactful for wildfire severity. The basic ingredients of fire weather are dry conditions and strong wind. Specific to the Pacific Northwest (PNW), exceptionally strong wind bringing dry air into the region, often warmed by descending the cascades, has been linked to some of the PNW's largest fires. The timing of this wind is crucial. The onset of the PNW wet season, typically in September or October, generally marks the end of active wildfires in the region. Simultaneously, the likelihood of amplified atmospheric circulation patterns leading to strong winds is increased from summer. The occurrence of such wind events before the onset of wetting rain can lead to explosive fire growth. Particularly catastrophic fires in western Oregon, such as the 2020 Labor Day fires, have been linked to compound extreme events in which strong easterly wind speeds and dry conditions coincided to produce wildfires that burned the most acreage in recent Oregon history. Using a simple metric of cooccurrence of strong wind and short term drought, the results will have important implications for wildfire climatology in western North America under a warming climate.

D3-P-01 - AMADOU MALAM LACHO Almoustapha

Impacts of ocean-atmosphere coupling on precipitation in small islands: a case study of the Cape Verde archipelago.

D3-P-02 - ANDRADE UZIEDA Marko Jorge

Ensemble of numerical models for rainfall and temperature estimation in Bolivia using RegCM 4.7

D3-P-01

Impacts of ocean-atmosphere coupling on precipitation in small islands: a case study of the Cape Verde archipelago. ICRC-CORDEX 2023 to be held in Trieste, Italy between 25 - 29 September 2023

Almoustapha Amadou Malam Lacho[1], Torsten Weber[2], William Cabos[3], Dmitry V. Sein[4], Armelle Remedio[2], Nilton Évora do Rosário [5]

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Understanding and predicting the climate as well as its variability over small islands are crucial for planning and adaptation for future changes. Using high-resolution simulations of 0.22 x 0.22 degree from a regionally coupled ocean-atmosphere modeling system called GERICS-AWI REMO-OASIS-MPIOM (ROM), we analyzed the precipitation characteristics as well as its interannual variability over the Cape Verde Islands. A 10-island archipelago located off West Africa's Atlantic coast, Cape Verde precipitation presents high interannual variability mainly driven by the strength and duration of the West African Monsoon. Comparing the coupled and uncoupled ocean-atmosphere simulations of ROM with the satellite-based observational dataset from CHIRPS and local rain gauges network during the ERA-Interim period from 1981 to 2010, the precipitation biases from the coupled simulation were lower than the uncoupled simulation. The regions where the added value of the coupled simulation was also identified. This reduction of the bias could be due to the improved representation of localized processes, such as coastal upwelling, air-sea heat fluxes, and feedback mechanisms specific to coastal regions.

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[2] Sein, D. V., Gröger, M., Cabos, W., Alvarez-Garcia, F. J., Hagemann, S., Pinto, J. G., Izquierdo, A., de la Vara, A., Koldunov, N. V., Dvornikov, A. Y., Limareva, N., Alekseeva, E., Martinez-Lopez, B., & Jacob, D. (2020). Regionally Coupled Atmosphere-Ocean-Marine Biogeochemistry Model ROM: 2. Studying the Climate Change Signal in the North Atlantic and Europe. Journal of Advances in Modeling Earth Systems, 12(8). https://doi.org/10.1029/2019MS001646

D3-P-02

Ensemble of numerical models for rainfall and temperature estimation in Bolivia using RegCM 4.7

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An ensemble of numerical models for the estimation of rainfall and temperature in Bolivia has been generated under different configurations in RegCM v4.7. The work is based on a previous calibration that was carried out in the Center for only 1 year of simulation. On this occasion, however, the simulation period was extended to 10 years, taking advantage of the implementation of the HPC-UMSS cluster (High Performance Computational Cluster) that allows simulations of high computational cost.

The assembly has been formed considering the following alternatives: Two boundary layer configurations of the atmosphere (Holtslag and UW), two cloud microphysics setups (SUBEX and Nogherotto), four convective scheme configurations both, land and ocean (Grell, Emmanuel, Tiedtke and Kain-Fritsch), and three spatial resolutions (30km, 10km and 5km). The models have been implemented in the cluster after the installation of RegCM for parallel HPC architecture. Each of the models was compared with ground-based and reanalysis data. A comparison between models was made using Taylor diagrams and thus the best configuration of the assembly could be chosen.

D4-P-01 - OVCHARUK Valeriya

Development of Multilevel Local, Nation- and Regionwide Education and Training in Climate Services in Ukraine

D4-P-02 - SCHUCHNÉ BÁN Beatrix

EURO-CORDEX data in the climate services of the Hungarian Meteorological Service

D4-P-01

Development of Multilevel Local, Nation- and Regionwide Education and Training in Climate Services in Ukraine

Valeriya Ovcharuk [1], **Inna Khomenko**[1], **Sergiy Stepanenko**[1], **Oleg Shabliy**[1]

[1]*Odessa State Environmental University*

As declared by WMO in 2009, in a period of unprecedented and inevitable climate change, there is an urgent need to establish national climate services to adapt countries to the on-going climate change. Unfortunately, in Ukraine, despite having an extensive and powerful meteorological service, climate services are extremely poorly developed due to several economic and political reasons.

In this regard, an international consortium comprising the University of Helsinki (Grant Coordinator of the Project), University of Rovira i Virgili (Spain), Estonian University of Life Sciences, six Ukrainian universities: Odessa State Environmental University (National Project Coordinator), Kyiv National University of Construction and Architecture, O.M. Beketov National University of Urban Economy in Kharkiv, Lviv Polytechnic National University, Bila Tserkva National Agrarian University, Odessa National Medical University, and two ministries – Ministry of Education and Science of Ukraine and Ministry of Energy and Environment Protection of Ukraine initiated the European educational project of 'Multilevel Local, Nation- and Regionwide Education and Training in Climate Services, Climate Change Adaptation and Mitigation – ClimEd', 619285-EPP-1-2020-1-FI-EPPKA2-CBHE-JP. This project received European Union support and implementation was launched by the consortium at the end of 2020.

The implementation of this project involves the establishment of climate services in Ukraine through a full-scale deployment of works on the organization of climate education, which, with the close cooperation of specialized universities in Ukraine and the support of leading European partners and stakeholders, will help to build the a multi-level education system in the field of climate services that meet international standards. Unfortunately, due to active hostilities in Ukraine, in 2022, work on the project was suspended until September 2023. We hope that by this time all participants from Ukraine will be able to resume work in total, and the implementation of the project will contribute to the achievement of sustainable development goals in the post-war period.

D4-P-02

EURO-CORDEX data in the climate services of the Hungarian Meteorological Service

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OMSZ currently provides projection data for climate change impact studies from two sources: (1) The KLIMADAT information system contains temperature and precipitation climate indicators over Hungary based on in-house simulations conducted with ALADIN-Climate and REMO regional climate models (RCM), all driven by RCP4.5 and RCP8.5 scenarios. The data are available in form of annual, seasonal or monthly means for 30-year periods covering 1971–2100 with 10-year shifts. The climate indicators can be displayed and retrieved as grid point values with 0.1-degree resolution and as averages for NUT3 and LAU1 regions.
(2) Additional information can be supplied on request from a EURO-CORDEX ensemble consisting of 12 simulations achieved by multiple RCMs, driven by different GCMs, RCP4.5 and RCP8.5 scenarios. This set of simulations was selected and processed several years ago. Its advantage is the better representation of projection uncertainties due to the large variety of applied models and it is especially recommended when extra climate indicators are requested for a specific area and/or time period.
To provide the best possible quality of climate projection data for users from different sectors, we regularly review and update this database. Recently, we have scrutinized the available EURO-CORDEX simulations and selected an updated set of experiments. The aspect of the selection was the availability of daily data for the historical period and with the RCP2.6, RCP4.5 and RCP8.5 scenarios. The aim is to extend the KLIMADAT with the selected EURO-CORDEX simulations and with more indicators requested by the users. The extension also helps to describe more properly the uncertainty of climate change, especially the precipitation tendencies which are largely uncertain based on the results of the current 4 in-house simulations [1].
On this poster, we would like to present the validation of the new EURO-CORDEX selection for Hungary in addition to our current climate service practices.

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D6-P-01 - BASTIN Sophie Francoise

Sensitivity of WRF simulation of PBL dynamics and UHI characteristics to the choice of physics, urban schemes and land surface database during two heat waves of summer 2022 over Paris area: comparison with PANAME* observations

D6-P-02 - CASTRO GARRO Dante Tomas

Decomposition of the future changes in UTCI using regional climate projections for German cities

D6-P-03 - FERNANDEZ FERNANDEZ Jesus

Representation of the Urban Heat Island in CORDEX-CORE: A global multi-city analysis from the CORDEX FPS URB-RCC

D6-P-04 - KIM Jinuk

Projection of photovoltaic potential based on high-resolution SSP scenarios over South Korea

D6-P-05 - LE ROY Benjamin

Evaluation framework for high-resolution regional climate simulations for urban studies

D6-P-06 - NGUYEN Ngoc Kim

Development of a High-Resolution Gridded Climate Dataset for Vietnam by blending ERA5-Land and in-situ data in the period 1981-2019

D6-P-07 - SOARES Pedro Miguel Matos

Towards an improved representation of the urban climate: an application of artificial intelligence

D6-P-01

Sensitivity of WRF simulation of PBL dynamics and UHI characteristics to the choice of physics, urban schemes and land surface database during two heat waves of summer 2022 over Paris area: comparison with PANAME* observations

Sophie Bastin [1] , Simone Kotthaus [2] , Morgane Lalonde [1,3], Lluis Fita[4], and Martial Haeffelin[2]

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The Paris region (France) is increasingly the focus of urban atmospheric research. Numerous national and international research projects have chosen Europe's largest metropolitan region as their study area to better understand and predict critical hazards (incl. heat, air pollution, thunderstorms) in the context of a changing climate. Located on rather flat terrain in continental, mid-latitude climates, the densely populated Paris region is very suitable for the evaluation of urban processes in numerical simulations at different scales. The FPS "Urban Environment and regional Climate Change" selected Paris as the core city for the evaluation of multi-model ensemble.
During summer 2022, Paris experienced several heat waves that were densely documented by different individual field campaigns. The PANAME initiative allows to facilitate the synergy of these different projects.
In this study, several simulations of a few days covering the heat wave of June 2022 and the one of July 2022 area evaluated against some of these observations. The ensemble of simulations allows to test the sensitivity of the WRF model to different physics options (including urban schemes) and land use data base.

* https://paname.aeris-data.fr/

D6-P-02

Decomposition of the future changes in UTCI using regional climate projections for German cities

Dante T. Castro Garro[1], Peter Hoffmann[1], Christine Nam[1], Lars Buntemeyer[1], Ludwig Lierhammer[1]

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Considering the current warming, the frequency, intensity, and duration of heat waves in Europe are expected to increase [1]. This in turn increases the risk of heat-related morbidity and mortality [2]. But the heat-related risk depends not only on extreme temperature but on the interaction with other environmental variables (e.g. humidity, radiation, and wind). Consequently, different environmental configurations could produce similar risk levels, each condition requiring specific adaptation and mitigation measures. In this context, aiming for a better representation of the human body's reaction to the environment, the UTCI was proposed as a thermal comfort measurement [3, 4]. UTCI has already been analyzed in future climate projections and it was found that heat stress events (like heat waves) increase significantly [5, 6]. An investigation regarding the degree to which different variables contribute to the future UTCI heat stress increase, however, has not yet been done.

This study aims to explore in depth the behavior of future UTCI projections in multiple German cities by analyzing changes in the meteorological components of UTCI. The projected data will be obtained from an ensemble of EURO-CORDEX projections based on the RCP8.5 scenario [6]. Furthermore, the significance and robustness of the projected changes in the individual variables will be addressed by taking advantage of the ensemble dataset [5].

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D6-P-03

Representation of the Urban Heat Island in CORDEX-CORE: A global multi-city analysis from the CORDEX FPS URB-RCC

Jesus Fernandez[1], **Javier Diez-Sierra**[1], **Gaby Langendijk**[2], **Matthias Demuzere**[3], **Lluís Fita**[4], **Louisa Bell**[5], **Michal Belda**[6], **Eleni Katragkou**[7], **Rafiq Hamdi**[8,9], **Tomas Halenka**[6], **Peter Hoffmann**[5], **Lin Pei**[10], **Diana Rechid**[5], **Jiacan Yuan**[11]

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Urban areas modify atmospheric processes at scales that can only be represented in detail by km-scale simulations, and even at this scale, their effects need to be parameterized. Such simulations are only available for short periods at very specific sites. The CORDEX Flagship Pilot Study on Urban environments and Regional Climate Change (FPS-URB-RCC) aims to coordinate next-generation km-scale simulations to understand the two-way effect between urban areas and regional climate. In the meantime, the highest resolution resource to explore globally and from a multi-model perspective the effect of climate change on cities is the CORDEX-CORE experiment, which provides Regional Climate Model (RCM) projections with 0.22º grid spacing for most inhabited areas in the world.

In this work, we evaluate the representation of cities within CORDEX-CORE. For this purpose, we compare the nocturnal urban heat island against daily observations for a selection of more than 30 cities in different CORDEX domains with varied climates, degrees of continentality, and elevation. At this coarse resolution, cities are represented by few model grid cells, making it challenging to discern urban effects from other regional climate forcings, such as nearby seashores or complex terrain. Moreover, we show that the representation of urban areas within the different models varies widely, adding extra challenges to define reference urban surrounding areas and to systematically compare the results across models.

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D6-P-04

Projection of photovoltaic potential based on high-resolution SSP scenarios over South Korea

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The study predicts the future photovoltaic power generation potential (PVpot) changes based on high-resolution climate change scenarios over South Korea. According to the Shared Socioeconomic Pathways (SSP) scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5), in the end of the 21st century (2070-2099), surface down-welling shortwave radiation, which has a major impact on PVpot, is expected to increase (by about +0.7～+3.5W/m^2) compared to the present-day. However, the increase or decrease of PVpot depends on the level of emissions in the future. In the low-emissions scenario (SSP1-2.6), PVpot is expected to increase (by about +1.3%), while in the high-emissions scenarios (SSP3-7.0 and SSP5-8.5), PVpot is expected to decrease (by about -0.7～-2.0%). Because as the temperature increases significantly, the temperature of the solar cell panels increase, and performance ratio of PVpot decreases. This means that even though the surface down-welling shortwave radiation increases, the increase in temperature may offset the positive impact on PVpot. Seasonally, PVpot is expected to increase (by about +2.3 ～ +4.0%) in summer and decrease (by about -3.6 ～ -7.1%) in winter. Overall, this study highlights the importance of considering the impact of climate change on renewable energy sources like solar energy. It also emphasizes the need to adopt low-emissions policies to mitigate the negative effects of climate change on renewable energy generation potential.

D6-P-05

D6-P-06

Development of a High-Resolution Gridded Climate Dataset for Vietnam by blending ERA5-Land and in-situ data in the period 1981-2019

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This study presents a new high-resolution gridded climate dataset for Vietnam, covering the period from 1981 to 2019, with a monthly and about 9km grid in native resolution. The dataset was created by applying the Cressman interpolation method to station data and the ERA5-Land reanalysis. The study introduces a seasonality index calculation to compare the new dataset with other regional datasets, and we evaluate the key influencing factors of the interpolation method, such as the number of observation stations and influence radius. The newly created dataset was evaluated using the Taylor diagram and compared with other regional datasets and global climate models. The results showed that the new high-resolution gridded climate dataset has significant potential and better improvement compared to other datasets. Overall, this study provides valuable insights into the process of building high-resolution climate datasets and improving their accuracy for future research and applications.

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D6-P-07

Towards an improved representation of the urban climate: an application of artificial intelligence

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Cities concentrate people, wealth, emissions, and infrastructure, thus representing a challenge and an opportunity for climate change mitigation and adaptation. This urgently demands for accurate urban climate projections to help organizations and individuals to make climate-smart decisions. However, most of the large ensembles of global and regional climate model simulations do not include sophisticated urban parameterizations and reveal caveats when comparing urban observations with model results (e.g., EURO-CORDEX; CMIP5/6). Here, we explore new artificial intelligence approaches to improve the local featuring of urban climate properties, namely focusing on the urban heat island (UHI) and the surface urban heat island (SUHI) effects, and on temperature extremes. Using the ERA-5 reanalysis (the latest generation reanalysis from the European Centre for Medium-Range Weather Forecasts) and the CMIP6 global models, we perform local downscaling a group of European cities, characterized by different large-scale, mesoscale circulations and local features, such as Lisbon, Madrid and Paris. These cities are considered as testbeds for the application of those new methodologies, and these are assessed evaluating their performance against ground based and remote sensing observations, in present climate. The remote sensing observations correspond to the LSA SAF (Satellite Application Facility on Land Surface Analysis) land surface temperature product. Our results show an overall improvement of temperature description for the considered cities, in what concerns to its mean values, the extreme tails and both the UHI and SUHI.

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GEN-P-01

Heat and Drought in Observational and Modelled Data for Africa

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For our project LANDSURF (WASCAL WRAP2.0), we are calculating different climatological and agrometeorological indices aiming to support stakeholders and farmers in adapting to climate change in Africa. This guidance is given by a decision support system (DSS) which is currently developed within the project and fed by selected indices. Some of these are presented in the current study.

Here, we are focussing on the number and duration of heatwaves as they represent a limiting factor for crop yield and, in consequence, food security in Africa. Additionally, we investigate the occurrence of droughts and relate them to heatwaves by comparing SPI and SPEI. As validation over the historical period, we use ERA5Land. The regional climate models (RCMs) (REMO2015, RegCM4-7, and CCLM5-0-15) are taken from CORDEX-CORE. Furthermore, we compare the performance of the evaluation run driven with ERA-Interim as well as of the respective driving GCMs over the historical period and examine its development for the near-, mid-, and long-term future until 2100 under the Representative Concentration Pathways (RCPs) 2.6 and 8.5.

GEN-P-02

Impact of Amazon Deforestation on Temperature and Precipitation in Southern Mexico, Central America, and the Caribbean through Regional Climate Simulations

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In this study, we will employ the Regional Climate Model (RegCM) to investigate the impacts of complete deforestation in the Amazon region on temperature and precipitation patterns, as well as changes in the frequency of wet days and warm days, in southern Mexico, Central America, and the Caribbean. Through a series of simulations spanning a 20-year, period from 1996 to 2016, driven by reanalysis datasets, we will utilize the RegCM model following the specifications outlined by the Coordinated Regional Downscaling Experiment (CORDEX) for the Central America region.

The initial simulation will serve as a control run, incorporating prescribed vegetation within the model. Subsequent simulations will involve replacing the existing forest cover in the Amazon region with C3 and C4 grasslands and bare soil, respectively. By examining changes in temperature, precipitation, as well as the frequency of wet days and warm days, we aim to comprehensively understand the impacts of deforestation on regional climate dynamics.

This study seeks to provide valuable insights into the future implications of Amazon deforestation on temperature and precipitation patterns, and the associated changes in the frequency of wet and warm days, in southern Mexico, Central America, and the Caribbean using the RegCM model. The findings will inform policymakers and stakeholders about the potential consequences of deforestation and guide decision-making processes for sustainable land management and climate adaptation strategies. Furthermore, it underscores the importance of considering multiple climate indicators in assessing the environmental consequences of land-use change.

GEN-P-03

Future climate projections of cyclones in RegCM4.7 over South America and South Atlantic Ocean

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Cyclones affect the weather and climate contributing to high precipitation accumulations and intense winds, and influence the climate system acting in the heat, momentum and water vapor transport between tropics and extratropics. Studies related to global warming have been increasing due to the importance of understanding and developing adequate strategies for mitigation and adaptation. The atmospheric systems affect humanity, economy, and ecology, therefore, understanding the physics of these phenomena are very crucial scientific questions. Accordingly, our main focus is to understand how global warming will affect cyclones tracking and variability by using the Regional Climate Model version 4.7 (RegCM4.7) climate projections. RegCM4.7 present (1979-2005) and future (2006-2060) projections were forced by two global climate models (HadGEM2-ES and MPI-ESM-ER) and by reanalysis (ERAInterim) for historical evaluation. We used ERA5 reanalysis to validate the historical period. The results presented here are part of the project Western South Atlantic Climate Experiment (WeSACEx). We evaluated the annual and seasonal frequency of cyclogenesis for the three main South American cyclogenetic regions (Argentina, Uruguay and southeast Brazil-SEBrazil). For present climate, RegCM4.7 simulations reproduce the ERA5 density pattern very well. At regional scale, RegCM4.7 has better ability to simulate cyclones frequency in Argentina and SEBrazil regions than in La Plata/Uruguay. In seasonal terms, the simulations have higher frequency of cyclogenesis in winter and spring in Uruguay, and summer and spring for SEBrazil, while in Argentina the differences are small.. For the future, both simulations (RegHad and RegMPI) in the two climate scenarios (RCP4.5 and RCP8.5) and two periods (2006-2030 and 2031-2060) project an increase in the cyclogenetic frequency in the Uruguay in autumn and decreases in summer, while for SEBrazil the projections indicate a decrease in winter. Previous works using old simulations also found a future increase of cyclones in winter in Uruguay/La Plata, but not in autumn as in this work.

GEN-P-04

A multi-scenario view of impacts on climate extremes and indices with a multi-variable ensemble of regional climate projections for Portugal

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Climate projections are a powerful tool that can help decision makers to timely prepare adaptation policies, which may then be efficiently implemented. Climate indices are developed to determine climate impacts on different socioeconomic sectors, providing a comprehensive communication of complex information arising from climate change assessments. These may be used by decision-makers to properly and timely implement climate change adaptation measures in different sectors of human activity, such as agriculture and crop selection, forest, and coastal management, among others. Here, a comprehensive analysis of how climate change may affect Portugal (located in a climate change hotspot) is conducted, providing the foundations to the first National Roadmap for Adaptation 2100. A multi-variable multi-model ensemble was built and tested, being the baseline for assessing future projections for three different emission scenarios (RCP2.6, RCP4.5, and RCP8.5) throughout the 21st century, accounting for the model's ability to simulate a set of variables. A warmer and drier future climate is projected for the mainland, being more severe in the interior regions. Even for the optimistic RCP2.6 scenario, results indicate increases in temperature between 1 and 2ºC in comparison with the historical period and can surpass 6 ºC in some regions for RCP8.5. Extreme hot events will be more frequent and severe, with maximum temperatures above 45ºC being more common throughout the 21st century. A decline in precipitation is expected mostly in summer and intermediate seasons, with losses above 40% for the end-of-century. However, an intensification of heavy short-term rainfall events is projected to increase in northern regions. A rising of maximum wind gusts is also expected in these regions. Aligned with warming and drying projected conditions, an increase in the number of summer days to very hot days is expected to become more frequent and intense, with more impact over interior regions. Tropical nights are projected to become more common, affecting the thermal comfort conditions and threatening future human health. Although the future projections show an overall reduction in the number of wet days, the amount of precipitation during short-time wet periods will increase leading to an intensification of moderate/heavy rainfall. These results corroborate that Portugal is in a climate change hotspot, calling for efficient policymaking by the relevant authorities. Indeed, such projections call for an urgent planning and development of adaptation measures to safeguard critical sectors of the Portuguese society, such as agriculture, forests, coastal management, among others.

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GEN-P-05

Land-atmosphere coupling during compound extreme heat events in the LUCAS experiment with extreme land use changes: a new coupling metric for climate extremes

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Land use/land cover changes (LUC) modify local land surface properties that control the land-atmosphere mass, energy, and momentum exchanges. The impact of these changes depends on the scale and nature of land cover modifications and is very difficult to quantify. The Flagship Pilot Study LUCAS (Land Use & Climate Across Scales) provides a coordinated effort to study LUC using an ensemble of regional climate models (RCMs). In the first phase of the project 3 experiments were performed for continental Europe: EVAL (current climate); FOREST (maximum re-/afforestation) and GRASS (forest replaced by grassland).

Heatwaves can be defined as extreme hot consecutive days and have a variety of direct, indirect, immediate, and delayed impacts, including higher water loss via evapotranspiration, lower yields of agricultural products, severe health problems, increased energy consumption and increase in the duration, size, and intensity of wildfires, causing economic losses and catastrophic environmental impacts. An analysis of the energy balance for the three experiments is performed, focusing on the relationship between the fluxes partitioning and heatwaves. We present results for different durations (3-, 5-, and 7-d heatwaves) and extreme maximum temperature thresholds (85th, 90th, and 95th percentiles) using the EVAL experiment as a reference. The impact of afforestation or deforestation is not consistent across models.

To better assess the link between extreme temperatures and soil moisture or evapotranspiration, a coupling metric for short time scales, the Latent Heat Flux-Temperature Coupling Magnitude (LETCM) is employed. This metric is computed for a specific period, considering either the positive temperature extremes and the negative latent heat flux extremes for areas where positive strong coupling is expected or positive temperature extremes and positive latent heat flux extremes for areas where weak coupling is expected.

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GEN-P-06

Abstract for ICRC-CORDEX 2023

Simulating extreme temperatures over Central Africa by RegCM4.4 regional climate model

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Nowadays, extreme temperatures are associated with global warming and cause great concerns worldwide, particularly in Africa because of low resilience, adaptation and mitigation strategies. The present study investigates the performance of RegCM4 climate model in reproducing extreme temperatures over Central Africa (CA) during 2002–2006 period. Apart of daily minimum and maximum temperatures, the study uses six extreme temperature indices based on the recommendations of Expert Team on Climate Change Detection and Indices. These include four intensity indices and two duration indices. Focus has been done in two sub-regions embedded over the study area for more specifc analysis. The frst sub-region named zone 1 is semi-arid while the second one named zone 2 is humid. We found that whatever the region or season over CA, RegCM4 displays fairly well the intensity indices associated to daily minimum temperatures, namely TNN and TNX, with underestimations not exceeding 4 ◦C. For intensity indices based on daily maximum temperatures, namely TXX and TXN, the warm bias can reach up to 10 ◦C. This model behavior is associated to its inability to depict surface downward solar and thermal fuxes as well as surface sensible heat fux. Regarding the duration indices, RegCM depicts the hot sequences with high biases, unlike the cold sequences. Statistical parameters used for evaluation show that despite the diferences between model and ERA5, RegCM4 can be used to investigate extreme temperatures over the study region mainly if indices of interest are based on daily minimum temperatures and cold sequences..

Keywords : RegCM4 · ERA · CRU · Intensity indices · Duration indices

[1] Demeko Yemih P., Komkoua Mbienda A. J., Guenang G. M., Matho Lontio S. L., Teka Kue G. A., Vondou D. A., Mbane Biouele C., "Simulating extreme temperatures over Central Africa by RegCM4.4 regional climate model", *Climate Dynamics*, **(2022)**.

GEN-P-07

Projection of the Future Changes in Tropical Cyclone Activity Affecting East Asia over the Western North Pacific Based on Multi-RegCM4 Simulations

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Future changes in tropical cyclone (TC) activity over the western North Pacific (WNP) under the representative concentration pathway RCP4.5 are investigated based on a set of 21st century climate change simulations over East Asia with the regional climate model RegCM4 driven by five global models. The RegCM4 reproduces the major features of the observed TC activity over the region in the present-day period of 1986−2005, although with the underestimation of the number of TC genesis and intensity. A low number of TCs making landfall over China is also simulated. By the end of the 21st century (2079−98), the annual mean frequency of TC genesis and occurrence is projected to increase over the WNP by 16% and 10%, respectively. The increase in frequency of TC occurrence is in good agreement among the simulations, with the largest increase over the ocean surrounding Taiwan Island and to the south of Japan. The TCs tend to be stronger in the future compared to the present-day period of 1986−2005, with a large increase in the frequency of strong TCs. In addition, more TCs landings are projected over most of the China coast, with an increase of ~18% over the whole Chinese territory.

GEN-P-08

Development of Dynamical Downscaling Method for Regional Weather/Dispersion Model near Nuclear Power Plants

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This study developed a new dynamical downscaling method for a high-resolution reginal weather/dispersion model near nuclear power plants. This method is developed based on the Weather Research and Forecasting (WRF) model version 3.6.1 for Kori and Wolsong NPPs located on the southeast coast of the Korean Peninsula, adjacent to the mountains. We suggested six considerations for a methodology creating high-resolution and three-dimensional local meteorological fields near the NPPs based on previous studies demonstrating the performance improvement of local meteorological field simulation over complex topography. For the multiscale dynamical downscaling, we then increased the spatial resolution by gradually reducing the size of the domain using the one-way (parasitic) nesting method. New subgrid-scale topographic drag parameterization has been implemented for a realistic representation of the atmospheric surface-layer momentum transfer. We also updated land-use and topography data to improve the model performance of local wind fields around the NPPs. We performed the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model using the improved meteorological fields simulated by the WRF model as input data. As a result, we obtained forward trajectory, concentration, and deposition data of Cs-137 released from NPPs sites during 2013-2016. The surrounding topography influenced the annual dispersion characteristics of NPPs. The seasonal characteristics showed the influence of the diffusion direction and speed related to the seasonal wind, which appeared predominantly on the Korean Peninsula.

GEN-P-09

Title: Boundary layer schemes in the regional climate model RegCM4.6 over Central Africa

Abstract

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This study examines the performance of two Planetary Boundary Layer (PBL) parameterizations in the RegCM4.6 regional climate model for the Central African domain. These are the Holtslag scheme and the University of Washington (UW) scheme. The evaluation is made by performing two experiments over 5 years (from January 1, 2002 to December 31, 2006) with a horizontal resolution of 0.35°×0.35°. The UW-PBL scheme only takes into account the gradients within adjacent vertical levels in the model whereas the Holtslag PBL scheme takes into account the vertical transport over a deeper layer covering several levels in the model. The analysis extends over December–January–February (DJF), March–April–May (MAM), June–July–August (JJA), and September–October–November (SON). For more specific analysis, the study domain is divided into five zones. The results show that the Holtslag scheme is favorable for simulating rainfall in Central Africa mostly during JJA season in zone 3. As far as the wind is concerned, both schemes have a more or less reasonable approach with the positioning of the jets and the observed monsoon flow but with a slight difference. The patterns show a much greater diversity in the way the turbulent mix is taken into account in PBL. The inclusion of evaporation in our analysis shows that it may be the origin of the absence of water vapor in clouds which considerably reduces the amount of rainfall at the ground surface. Results also show that the simulated total cloud cover can explain the better performance of UW PBL scheme than Holtslag scheme to reproduce surface temperature.

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GEN-P-10

Drought-related impacts and the role of Soil Moisture Feedback in Africa

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Water availability patterns have far-reaching ecological and social consequences, particularly in the context of climate change. This study investigates the interactions of soil moisture on precipitation-evapotranspiration feedback and how it affects wet-dry land conditions. A time-lag approach is used to assess the influence of soil moisture on precipitation evapotranspiration, while a Budyko framework is employed to identify the wet-dry land conditions that determine whether the feedback is positive or negative. Moisture convergence is analysed to determine the impact of climate dynamics on the soil moisture and precipitation-evapotranspiration relationship. The results of this study are expected to shed light on the mechanisms underlying drought-related impacts over Africa and provide valuable insights into the potential implications of climate change on the continent. By understanding the soil moisture-precipitation-evapotranspiration feedback loop, policymakers and scientists can better predict and prepare for the impact of climate change on water availability and mitigate its consequences.

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GEN-P-11

Climate change and precipitation extremes over South Asia

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The response of precipitation extremes to climate change has been the subject of extensive study because of the potential impacts on human society and ecosystems. It still is not clear how climate change will impact precipitation events over South Asia under different emission pathways. There has been an increase in extreme precipitation over most of South Asia in the past 120 years, with urbanization correlating to an increase in the intensity of these extreme events [1]. The Asian Monsoon shows a higher sensitivity to global warming when compared to other monsoon domains [2]. In this study we have used 13 Coupled Climate Models with various Shared socioeconomic pathways (SSP's) to understand present and future changes in precipitation extremes over the South Asia until the end of 21st century.

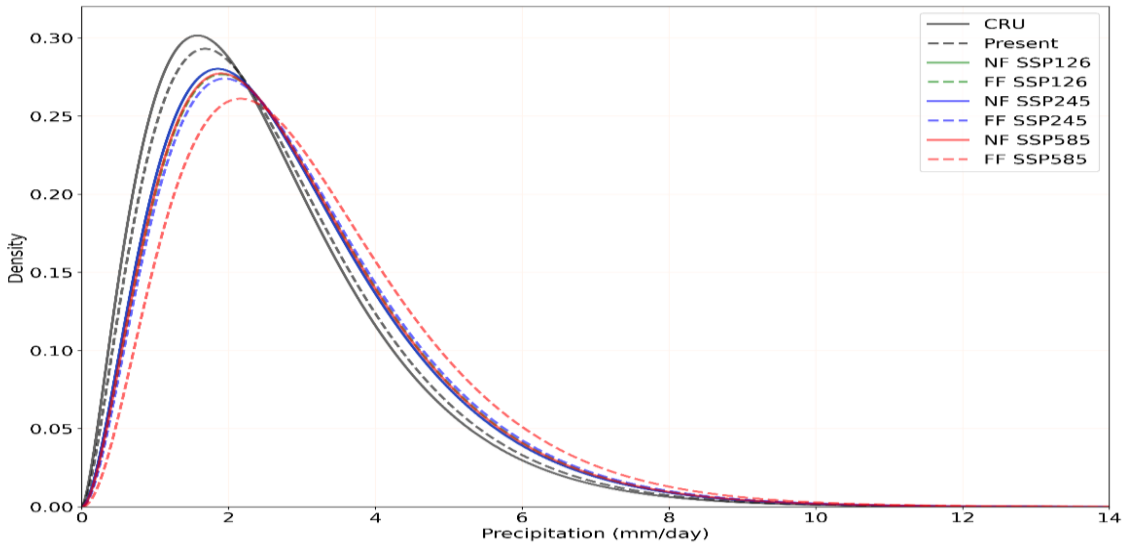

Fig. 1 – Mean precipitation over South Asia land mass. The solid grey line shows observed precipitation, and the dashed grey line shows the present ensemble mean precipitation for the historical period (1901-2014). The green, blue, and red lines represent SSP1-2.6, SSP2-4.5 and SSP5-8.5. For the SSPs a solid line represents the NF (2030-2060), and a dashed line represents the FF (2070-2100).

For the historical period the ensemble mean distribution slightly overestimates precipitation when compared to observed values. Far-future SSP5 shows the largest shift (0.48 mm/day) in precipitation and all other scenarios show a shift of around 0.23 mm/day when compared to present values. Our findings suggest that continuing fossil-fueled development will lead to an increase in precipitation during the South Asian monsoon by the end of the century.

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GEN-P-12

CLIMATE CHANGE IMPACTS ON GROWING RICE SEASON IN THE HIGHLAND OF MADAGASCAR

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Abstract
Madagascar is an island in the Southwest Indian Ocean. Trends analysis of climate change indices showed the effects of global warming on Madagascar's climate [1]. Its population activities are mainly in the agriculture sector which is most affected by climate change. Rainfed rice crops are mostly grown in the highland. They are classified following their vegetative cycles as short (105 days), medium (130 days), and long (145 days). This paper assesses the rainfed rice crops growing season by using CORDEX-AFRICA datasets following the two scenarios rcp45 and rcp85 over the period from 2030 to 2100. Most individual GCMs are used in the previous study on the detection and attribution of climate change in Madagascar [2]. The growing rice season onset date is defined as the first day after August 1st with more than 20mm of rain in 2 days and at least 2 days of rainy days within 5 days and no dry spell within the next 21 days exceeding 7 days. Its cessation date is the first day after March 1st when soil with a 150mm water holding capacity gets completely depleted, assuming a daily evapotranspiration rate of 5mm, and remains depleted for at least 5 consecutive days without recovering to maximum capacity in the next 15 days. The growing rice season length is the number of days between onset and cessation dates. A comparison of onset and cessation dates and length of growing rice season is done according to the two scenarios. Results show that the growing rice season onset and cessation dates will be more and more late and early respectively. Therefore, growing rice season length will be reduced. Only rice crops, which have short vegetative cycles, could be more resilient in the future.

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GEN-P-13

Sensitivity analysis of RegCM4.7 in simulating tropical cyclone characteristics over the CORDEX-Southeast Asia region

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In preparation for the downscaling simulations using CMIP6 GCM output, sensitivity experiments were conducted by the Southeast Asia Regional Climate Downscaling / Coordinated Regional Climate Downscaling Experiment – Southeast Asia (SEACLID/CORDEX-SEA) group using the Regional Climate Model version 4.7 (RegCM4.7) forced by the European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis version 5 (ERA5) data for the period 2011–2015. In this study the performance of 38 experiments with different parameterization schemes were evaluated in terms of simulating the characteristics of tropical cyclone (TC) climatology using statistical metrics—namely, root mean square errors (RMSE), mean bias errors (MBE) and spatial correlation (SCorr)—and by having an overall performance evaluation index (OPEI) to rank the experiments from best to worst. The results show that most of the experiments underestimate the total count of TCs while five of the experiments extremely overestimate it. Most of the experiments also underestimate the high intensity TCs (Categories 4–5) but overestimate the moderate intensity TCs (Categories 1–3). In terms of spatial distribution, the majority of the experiments have pattern correlation between 0.6–0.8. Furthermore, model skill greatly varies depending on the combination of parameterization schemes used. For example, the experiments that use GFS or UW as the planetary boundary layer scheme and SUBEX or WSM5 as the moisture scheme show relatively good skill in simulating the TC climatology compared with the other schemes. The three highest ranked experiments based on the OPEI have a combination of schemes of Grell/KF/Tiedke, GFS, and SUBEX.