The Abdus Salam
International Centre
for Theoretical Physics

3rd Workshop on Cloud Organisation and Precipitation Extremes - WCO3 | (SMR 3870)

04 Sep 2023 - 08 Sep 2023
ICTP, Trieste, Italy

P01 - ALINAGHI Pouriya

Dependence of Shallow Cumulus Cold Pools on External and Internal Variability

P02 - BASHIRU Yahaya

Tropical extreme precipitation-temperature scaling in different climate regimes in West Africa

P03 - BASSFORD Thomas James

Lagged cross-correlations of rainfall extremes during the West African Monsoon.

P04 - BOEING Steven Jonathan

Essentially Lagrangian simulation of cloud ensembles

P05 - CARNEIRO RODRIGUES P PONTES Daniela

Evaluation of the seasonal forecasts of the Eta model in the characterization of the beginning of the dry season in Alto São Francisco

P06 - CHARINTI Giousef Alexandros

Intensification mechanisms and cyclogenesis of tropical cyclones

P07 - CHENG Meiling

An interpretable digital twin to represent aerosol-cloud interactions

P08 - CHEN Jinghua

A Simulation Study of Effects of the Indian Summer Monsoon on the Inter-seasonal and Diurnal Characteristics of the Cloud Systems over the Eastern Tibetan Plateau

P09 - DRITSCHEL Gregory

Basic State Analysis of the Rainy-Bénard model

P10 - ENGELBRECHT Edward

Impact of Inland Deforestation on Rainfall Extremes: Amplifying the Role of Cold Pool Interactions in Organizing Convection

P11 - FEGER Guillaume Yves Francois

Understanding Aerosol Effects on Convective Aggregation during CADDIWA

P12 - GLASSMEIER Franziska

Aerosol-stratocumulus interactions as data-driven dynamical system

P13 - HAERTER Jan Olaf Mirko

A proposed high spatio-temporal-resolution pilot station network in the West African climatological hotspot region

P14 - HERNANDEZ Benjamin

Stratocumulus bistability and entropy production

P15 - KRUSE Irene Livia Livia

Tipping to an aggregated state by mesoscale convective systems

P16 - MAURY Nicolas

Role of mesoscale circulations in the organization of coherent structures in shallow convection

P17 - MAYBEE Ben

Sensitivity of model MCSs to land-surface variability

P18 - NOWAKOWSKA Kasia Teresa

Nowcasting using Simplified Models for Atmospheric Convection

P19 - TIKENG SONGWE Stella

ANALYSIS OF MESOSCALE CONVECTIVE SYSTEMS OVER YAOUNDE

P20 - URIBE CORTES Alejandro

Observed and modeled CMIP6 internal variability feedbacks and their potential to constrain forced climate feedbacks

P01

Dependence of Shallow Cumulus Cold Pools on External and Internal Variability

When cold pools (CPs) exist in trade cumulus cloud fields, these fields display increased cloud cover values. This relationship opens the possibility that shallow mesoscale CPs actively influence the cloud radiative effect (CRE) of fields of trade cumuli, and their feedback on warming. Here, we therefore seek to deepen our understanding of the relationships between CPs, the large-scale environment and trade-cumulus clouds. As a stride towards this, we utilize an ensemble of 103 idealized large-eddy simulations of shallow cumulus cloud fields (Cloud Botany). These simulations are initialized with a range of initial conditions extracted from ERA5 reanalysis data of trade cumuli. First, we analyze how CPs respond to large-scale cloud-controlling factors. Second, we explore the behavior of CPs in the absence of the diurnal cycle. Third, we demonstrate how CP fractions are related to cloud pattern metrics. Finally, we investigate the extent to which CPs influence CRE and how the relationship between CPs and CRE is modulated by large-scale cloud-controlling factors.

P02

Tropical extreme precipitation-temperature scaling in different climate regimes in West Africa

The West African Sahel, Savannah and Guinea Coast areas are known for heavy rainfall associated with organized meso-scale convective systems. During boreal summer, strong organized convection and squall lines move across the region and deliver rainfall with varying intensities at short durations which can result in flash floods posing risks to lives and infrastructure. Extreme convective precipitation is likely to intensify under global warming. The highly variable nature of convection makes it difficult to characterize on nearly all temporal and spatial scales. The atmosphere's saturation water vapor is expected to increase roughly exponentially with increasing near-surface temperature, according to the thermodynamics Clausius-Clapeyron relation. Using station observations, we here carry out a detailed investigation of the temperature dependence of extreme precipitation within the different climate zones of tropical Africa. Sub-daily (5-minute and hourly accumulations) as well as daily and event-based data are analyzed for 23 coastal and 10 inland stations in Ghana, as well as 2 buoys in the equatorial Atlantic. Various binning techniques(variable width bin, equal number of samples in a bin) were used to also confirm the sensitivity of the results to the methodology used. Sensitivity analysis of extreme precipitation was done using both temperature and dew point. The results show that the sub-daily precipitation intensity (5mins and 1 hour) increases with temperature for the higher percentiles(99.9 and 99)in all the climate zones. The hourly precipitation intensity for all the climate zones increased in the range of super Clasius Clapeyron(2xC-C). The sub-daily precipitation intensity

P03

Lagged cross-correlations of rainfall extremes during the West African Monsoon.

This study uses nine West African monsoon seasons of lagged cross-correlations (CC) to identify patterns in the intense rainfall surrounding the location of earlier intense rainfall in the Sahel. The results show a ringlike pattern of correlation around the position of the initial rainfall, with suppressed rainfall inside the ring. Similar patterns exist in both observations and in data from a convection-permitting climate model. Parameterized convection leads to a far weaker correlation and to the poor representation of the propagation of discrete regions of intense rainfall. To investigate the mechanism for the ring-like patterns, further CC were calculated between rainfall and anomalies in dynamical fields. Low-level temperature and horizontal wind CCs indicate the presence of a large area up to ~2 degrees in radius from the initial rain location that is affected by cold pools. There are also wave-like signals in vertical cross-sections of wind and omega CCs. Both these mechanisms have been shown to be potential sources of convective initiation and here the ring mechanisms are likely a combination of both given the statistical compositing.

P04

Essentially Lagrangian simulation of cloud ensembles

(Steven Boeing, Matthias Frey, David Dritschel) The Ellipsoidal Parcel-In-Cell (EPIC) model provides a novel approach to geophysical fluid dynamics, based entirely around Lagrangian parcels. The parcels in EPIC represent both the thermodynamic and the dynamical prognostic properties of the flow. An efficient grid-based solver calculates parcel advection velocities, but diffusive regridding operations are avoided. The Lagrangian nature of EPIC has a number of advantages that are particularly relevant to moist convection: thermodynamic/tracer properties and their correlations are naturally conserved, and the amount of mixing between parcels is explicitly controlled. We will demonstrate the first use of EPIC to simulate an ensemble of shallow cumulus clouds (based on the BOMEX intercomparison study), with an emphasis on the development of cloud size and spacing, mixing and vorticity dynamics during the simulation.

P05

Evaluation of the seasonal forecasts of the Eta model in the characterization of the beginning of the dry season in Alto São Francisco

Daniela C Rodrigues [1], Chou Sin Chan[1], Priscila Tavares[1], Jorge Gomes[1], Gustavo Sueiro[1] and Diego Chagas[1]

[1] *National Institute for Space Research – INPE - Brazil*

The São Franscisco Hydrographic Region is the third largest basin in Brazil and plays a fundamental role in several socioeconomic sectors in the country. The study of precipitation predictability during the transition period from the rainy season to the dry season, as well as the duration of the dry season in the Upper SF sub-basin is valuable, as the rainfall regime in this region is crucial for water availability in other sub-basins. In this work, it was evaluated the seasonal precipitation simulations produced by the Eta regional model [1] nested within the Climate Forecast System (CFS), in characterizing the transition period from the rainy to dry season in the Alto SF basin - Brazil. The domain covers all South America with a horizontal resolution of 20 km. Rounds of 6.5 months were performed from February 15 of the years 2018 to 2022. To evaluate the performance of the Eta model, the simulated precipitation accumulated in pentads, that is every 5 days, over the Upper SF sub-basin area was compared with the observed precipitation product MSWEP. Preliminary results indicate that, although the models did not accurately simulate the magnitude of cumulative precipitation, they successfully captured seasonal precipitation trends. Most of the time, the Eta model tends to follow the monthly variability of the CFS, which led to an anticipation of the end of the dry period. The overestimation of the Eta model can be reduced through adjustments in the precipitation production schemes and through bias correction techniques.

[1] Chou, S.C. et al. 2018. From Subseasonal to Seasonal forecasts over South America using the Eta Model. Numerial Weather, Belgrado, p. 7, 2018.

P06

Intensification mechanisms and cyclogenesis of tropical cyclones

Giousef Alexandros Charinti[1], Andrea Polesello[1], Caroline Muller[1], Claudia Pasquero [2] and Agostino Meroni [2]

[1] *Department of Earth Science, Institute of Science and Technology Austria, Klosterneuburg, Austria*

[2] *Department of Environmental and Earth Science, University of Milan-Bicocca, Milan, Italy*

The feedback of wind induced surface heat fluxes exchange (WISHE) is considered to be the most prominent mechanism under which tropical cyclones intensify. Simulations using the high resolution cloud resolving model SAM with rotating radiative-convective equilibrium settings confirm the importance of this mechanism involving surface fluxes and additionally reveal a link between the re-intensification cycles of the cyclone and upper-level processes through their modulation of CAPE. Peaks in CAPE prelude the onset of an intensification which is followed by a decrease in CAPE, which occurs due to a warming of the upper troposphere through convective transport of MSE and reduction of radiative cooling due to cloud forcing. During intensification phases the cyclone gains energy through the surface heat fluxes, in accordance to the WISHE theory, but further simulations with different radiative forcings (fixed and homogenized radiation) show that radiation, as well as upper level circulation, also play a key role in modulating the magnitude of the wind velocity in re-intensification phases. Therefore, our results suggest a link between upper tropospheric processes and cyclone intensification phases.

[1] C. S. Bretherton, P. N. Blossey, M. F. Khairoutdinov, J. Atmos. Sci. **62**, 12 (2005).
[2] C. S. Bretherton, M. F. Khairoutdinov, J. Adv. Model. Earth Syst. **7**, 4 (2015).
[3] K. A. Emanuel, J. Atmos. Sci. **43**, 6 (1986).
[4] K. A. Emanuel, J. Atmos. Sci. **52**, 22 (1995).
[5] K. A. Emanuel et al., Annu. Rev. Earth Planet Sci. **31**, 1 (2003).
[6] C. J. Muller, D. M. Romps, PNAS **115**, 12 (2018).
[7] M. F. Khairoutdinov, D. A. Randall, J. Atmos. Sci. **60**, 4 (2003).
[8] A. A. Wing, K. A. Emanuel, J. Adv. Model. Earth Syst. **6**, 1 (2014).

P07

An interpretable digital twin to represent aerosol-cloud interactions

Meiling Cheng[1], **Franziska Glassmeier**[1]

[1] *Delft University of Technology, Delft, Netherlands*

Aerosol-cloud interactions (ACIs) are recognized as the most uncertain anthropogenic forcing in the climate system. Comprehending the influence of ACIs on climate remains challenging due to the intricate nature of interactions from micro to macro scales, and the difficulties in accurately representing them in climate models. While advanced machine learning techniques have been utilized in ACIs research to mitigate uncertainties and improve computational efficiency, these models lack interpretability, making it difficult to assess their reliability when extrapolating from present-day data to unseen anthropogenically-changed climate states in the future.

In this study, we present a novel efficient and interpretable data-driven tool to capture the dynamics of ACIs. This tool combines the advantages of interpretable conceptual models, the precision of small-scale cloud models, and the efficiency of machine learning techniques by using a large ensemble of large-eddy simulations of stratocumulus. By employing a limited number of key variables, this tool not only encompasses the microphysical processes involved in ACIs but also uncovers potential governing principles in the form of differential equations on the mesoscale. To demonstrate its versatility, we will conduct different parameter settings in two conceptual models that describe aerosol–cloud–precipitation interactions as predator-prey relationships, and uncover the nonlinear sensitivity of our data-driven tool and unlock its potential for discovering the governing equations in complex dynamic systems.

P08

A Simulation Study of Effects of the Indian Summer Monsoon on the Inter-seasonal and Diurnal Characteristics of the Cloud Systems over the Eastern Tibetan Plateau

The Indian summer monsoon (ISM) can impose influences on the moisture transport to the Tibetan Plateau (TP) from the south and then affects the cloud and precipitation over the Tibetan Plateau (TP). The influnece of ISM on the cloud and precipitaiton over the Eastern TP are discussed via a cloud-resolving model. The outbreak of the ISM can stimulate moisture transport between the TP and the southern ocean in May, reaching the most active period in July. The simulation results show that, comparing with the normal ISM year, the moisture transport intensifies in pre-summer and weakens in a strong ISM year, leading to more pre-summer deep clouds and rainfall. However, a weak ISM year exhibits weak pre-summer moisture transport and active summer moisture transport. resulting in few pre-summer deep clouds and rainfall. The summer moderate cloud cells are reduced in the strong ISM year and are promoted in the weak ISM year, taking responsibity for the total summer precipitation variations. The ETP daily maximum precipitation appears at noon and increases after mid-April,reaching its maximum in summer. The nocturnal rainfall of the ETP is stimulated after mid-May and reaches its maximum in late June-early July. The DCC (deep convective cloud) precipitation at approximately noon increases from May-August and greatly contributes to noontime precipitation. The nocturnal DCC is stimulated in May and increases in summer, and is responsible for summer nocturnal precipitation. Compared with the normal ISM year, the increase of the non-DCC deep cloud in the weak ISM year is one possible

P09

Basics State Analysis of the Rainy-Bénard Model

Gregory Dritschel[1], Steven Tobias[1], Douglas Parker[1], and Lorenzo Tomassini[2]

[1] *University of Leeds, Leeds, United Kingdom*
[2] *Met Office, Exeter, United Kingdom*

The Rainy-Bénard model is a simple model of moist convection, and can be viewed as a moist extension of dry Rayleigh-Bénard convection. The analysis of the basic state solutions of this model is conducted for a particular set of boundary conditions relevant to the climate change problem. A simple radiative cooling profile is added to the model, and the behaviour of the basic state solution to changing radiation and surface temperature is studied.

[1] G. K. Vallis and D. J. Parker and S. M. Tobias, J. Fluid Dynamics, DOI. **10.1017/jfm.2018.954** (2019).

P10

Impact of Inland Deforestation on Rainfall Extremes: Amplifying the Role of Cold Pool Interactions in Organizing Convection

Edward H. Engelbrecht [1,2], **Jan O. Haerter**[1,2,3]

[1] *Complexity and Climate, Leibniz Centre for Tropical Marine Research, Bremen, Germany*
[2] *Physics and Earth Sciences, Constructor University, Bremen, Germany*
[3] *Niels Bohr Institute, University of Copenhagen, Denmark*

Under weak large-scale forcing, thermally induced mesoscale circulations are well known to focus moist convection along sharp gradients in land surface properties [1]. Anthropogenic deforestation changes these land surface properties, and although a number of previous studies found an average decrease in rainfall brought about by deforestation [2], questions regarding rainfall extremes over these areas and possible mechanisms resulting in the extremes remain largely unanswered.

We investigate the effect of inland deforestation on afternoon rainfall in a simplified way by employing a checkerboard pattern of alternating dry vs. wet soil moisture patches inside an idealized, relatively high-resolution, cloud resolving model, with patch sizes comparable to the deforestation found in Rondônia (~100km). In short, we find that convection first organizes along the edges of wet and dry soil moisture patches, followed by a migration towards the centre of the dry patches as the afternoon progresses, where localized extremes of rainfall are produced. Using 4 years of lighting flash data sourced from the GOES-16 satellite over Rondônia and conditioning the lightning on days dominated by warm, synoptically weak weather (using ERA5 reanalysis), similar lightning patterns emerge when compared to the convection patterns observed in the idealized simulations. By tracking cold pools, cold pool collisions and its association with moist convection in the model data, we hypothesize that specific deforestation patterns found in the Rondônia region of Brazil increase the probability for intense rainfall by amplifying the role of cold pools in organizing convection under weak large-scale forcing.

We conclude that human-made land cover changes could potentially affect extreme rainfall events at the mesoscale. Therefore, it is important to consider nearby metropolitan areas, or areas that are susceptible to erosion and flash flood damage when planning land use cover changes on scales larger than 50 x 50 km. This is especially crucial within the deforested region.

[1] R. Knox, G. Bisht, J. Wang, & R. Bras. Precipitation variability over the forest-to-nonforest transition in southwestern Amazonia. Journal of Climate, **24**, 2368 (2011).

[2] Silva Dias, M. A., & et al. Cloud and rain processes in a biosphere-atmosphere interaction context in the Amazon Region. Journal of Geophysical Research, 107, 8072 (2008)

P11

Understanding Aerosol Effects on Convective Aggregation during CADDIWA

Mesoscale convective systems (MCSs) have a significant influence on climate regulation and can cause severe disruptions to human activities. It is crucial that the scientific community take up the challenge of understanding how they form and evolve. The effects of aerosols on convective initiation and cloud microphysical properties of clouds are not yet well-understood, making this an ongoing area of research. Due to the presence of compensating effects, the role of aerosols on MCSs, and particularly in convective aggregation, is not easily discernible. In September 2021, the CADDIWA (Clouds-Atmospheric Dynamics-Dust Interactions in West Africa) airborne campaign was conducted in the tropical region near the Cape Verde Islands. Over a two-week period, two MCSs and their environment were observed. One of the objectives of this project is to evaluate how aerosols affect the atmospheric circulation by influencing convection. In this study, we utilize large-eddy simulations and sensitivity tests to better understand the impact of aerosols convective aggregation.

P12

Aerosol-stratocumulus interactions as data-driven dynamical system

Franziska Glassmeier[1], *F. Hoffmann*[2], *E. Gryspeerdt*[3], *Y. Chen*[4], *J. S. Johnson*[5], *T. Yamaguchi*[4], *R. J. Murray-Watson*[3], *K. S. Carslaw*[5], *G. Feingold*[6]

[1]TU Delft [2]LMU Munich [3]Imperial College [4]CIRES Boulder [5]U Leeds [6]NOAA Boulder

The evolution of stratocumulus cloud decks is governed by three timescales: the large-scale evolution of the boundary layer, the mesoscale evolution of liquid water path and cloud fraction, and the microscale processes of cloud microphysics and aerosol-cloud interactions. Our quantitative understanding of aerosol-cloud-climate cooling is especially challenged by the mesoscale response of stratocumulus decks to aerosol perturbations. We characterize this mesoscale response by capturing stratocumulus dynamics as a data-driven dynamical system. This description can be visualized as a flow field in a low-dimensional state space spanned by liquid water path and cloud droplet number. We demonstrate that such flow fields can be derived from initial-condition ensembles of large-eddy simulations as well as based on short-term tendencies of MODIS snapshots from Aqua as compared to Terra satellite overpasses. We illustrate the versatility of our dynamical-systems perspective by (i) quantifying liquid water path adjustments in response to aerosol perturbations, (ii) discussing the role of aerosol dynamics in shaping mesoscale cloud response, and (iii) exploring the modulation of liquid-water-path dynamics by the diurnal cycle.

P13

A proposed high spatio-temporal-resolution pilot station network in the West African climatological hotspot region

The Sahel is a climatological hotspot: even small variations in the seasonal meridional ITCZ-migration under climate change can lead to dramatic hydroclimatic shifts, either towards more pronounced drought or higher flood risk - with severe implications for local populations. Dakar is frequently exposed to monsoonal floods. Limited adaptation capacity, especially within informal settlements, can amplify material damage and threats to lives. Large parts of sub-Saharan Africa are however still very data sparse. Paired with the difficulty of reliably predicting mesoscale convective systems (MCS), this hardly allows forecasts to outperform climatological statistics. For metropolitan areas short-term predictions using “nowcasting” at the lead time O(1h), are thus one promising option. Objectives: (I) A quasi linear station network of ~50km length in the meridional direction ~50km east of Dakar, will allow for improved nowcasting for Dakar when combined with satellite-based cloud top and precipitation fields. (II) This network will enable the detection of MCS-related cold pool gust fronts and their propagation during the monsoon. (III) As stations will be installed in educational institutions and data made available at near-real time to the public, the project has an educational dimension. Technically, we aim to deploy 15-25 robust, tested and widely-used meteorological stations, capable of measuring standard variables: e.g., wind speed, temperature, humidity, precipitation, and soil moisture at 1-5 minute temporal resolution. Stations will be made near-autonomous as they communicate directly through the local mobile network and deposit data at near real time in a publicly-available cloud storage.

P14

Stratocumulus bistability and entropy production

Benjamin Hernandez[1], **Pier Siebesma**[1], **and Franziska Glassmeier**[1]

[1] *Department of Geoscience & Remote Sensing, Delft University of Technology, Delft, The Netherlands*

Stratocumulus clouds exhibit two distinct states known as *open* and *closed cells*, with notable albedo differences between the two. This study aims to investigate the production of entropy in stratocumulus clouds and analyze its various contributions to gain valuable insights into the behaviour of this complex system at steady-state. This analysis, referred to as the *entropy budget* (e.g., [1]), has thus far been applied to the entire climate system with assumptions of radiative-convective equilibrium [2]. By applying this formalism, we hope to generalize the procedure and gain valuable insights into the properties of this bistable complex system. Additionally, we will discuss the validity and applicability of variational principles related to non-equilibrium state-selection scenarios, such as the controversial *maximum entropy production principle* proposed by [3, 4].

[1] M.S. Singh and M.E. O'Neill, Rev. Mod. Phys. 94, 015001 (2022).
[2] O. Pauluis and I.M. Held, J. Atmos. Sci. 59, 125-139 (2002).
[3] G.W. Paltridge, Q. J. R. Meteorol. Soc. 101(429), 475 (1975).
[4] R.C. Dewar, C.H. Lineweaver, R.K. Niven, K. Regenauer-Lieb, Understanding Complex Systems (2014).

P15

Tipping to an aggregated state by mesoscale convective systems

Key forcing conditions influencing tropical deep convection include diurnally varying land surface temperatures, near-constant sea surface temperatures, and prevailing easterly flow. Implementing such conditions into cloud-resolving numerical simulations, we investigate the formation of multi-day persistent dry areas over land, a process we attribute to mesoscale convective systems (MCSs). Under wind shear or without, we show that, if sufficiently developed, such persistence prevails indefinitely when switching to oceanic conditions. When incompletely developed, the atmosphere re-establishes homogeneous characteristics. We mimic this bistable switching by a simple discrete reaction-diffusion-type toy model. Our results imply that MCS can induce a tipping from a homogeneous to aggregation like state under typical tropical conditions.

P16

Role of mesoscale circulations in the organization of coherent structures in shallow convection

Cumulus clouds are ubiquitous in subtropical regions and tend to organize at the mesoscale to form distinct cloud patterns that depend on environmental conditions (Stevens et al. 2020, Bony et al. 2020). The data collected during the EUREC4A field campaign, conducted in Jan-Feb 2020 over the Western tropical Atlantic (Stevens et al. 2021), identified the 2nd of February 2020 as a ‘Golden case’ of transition from a quasi-homogeneous cloud organization to a more clustered one. LES simulations of this Golden case suggest that this transition is associated with the development of a shallow mesoscale circulation (Narentipak et al. 2021). To understand how the geometry and organization of clouds vary with mesoscale circulations, we analyze these LES simulations further and explore how the transition, and mesoscale circulations, affect the cloud size distribution and the cloudy thermal population in the subcloud layer. Our study shows that as cumulus clouds, the thermals organize at the mesoscale during the transition. We also show that it is associated with significant changes in the number, width and clustering of thermals, but little changes in the vertical extent or thermodynamic properties of the thermals.

P17

Sensitivity of model MCSs to scales of land–surface variability

Ben Maybee[1], John H. Marsham[1], Helen Burns[1], Douglas J. Parker[1,2,3], Emma J. Barton[4], Cornelia Klein[4] and Christopher M. Taylor[4]

[1] *School of Earth and Environment, University of Leeds, Leeds, UK*
[2] *National Centre for Atmospheric Science (NCAS), University of Leeds, Leeds, UK*
[3] *NORCE Norwegian Research Centre AS, Bergen, Norway*
[4] *UK Centre for Ecology and Hydrology (CEH), Wallingford, UK*

Improving our understanding of the dynamics of Mesoscale Convective Systems (MCSs) is an essential step towards reducing uncertainties in future projections of tropical rainfall. A crucial mesoscale interaction observed to influence both developing and mature MCSs is that with the land–surface. Local surface variability can influence the entire MCS lifecycle via daytime fluxes of heat and moisture: observations from the Sahel show that convective initiation is twice as likely over strong gradients in soil–moisture [1], while dry soil patches at scales of over 200km can intensify mature MCSs [2].

The LMCS project is investigating the impact of land–atmosphere interactions on MCS dynamics using global observational datasets and convection–permitting regional models. Here we present preliminary results investigating the sensitivity of MCS dynamics to land–surface structures on different length scales. To test this sensitivity we use multiple new simulations from the Met Office Unified Model, run at 1.5km resolution over the Sahel, in which we spectrally–filter spun up soil–moisture states for a range of length scales up to an MCS scale of 500km. We also investigate the ability of our control model simulation to replicate observed features of the land–MCS coupling and storm response to environmental variables such as wind shear, and begin to explore how well theoretical descriptions of MCS dynamics explain the influence of the land surface state on MCSs.

[1] C. M. Taylor et al., Nat. Geosci. **4** 7, 430–433 (2011).
[2] C. Klein and C. M. Taylor, Proc. Natl. Acad. Sci. U.S.A, **117** 35, 21132 (2020).

P18

Nowcasting using Simplified Models for Atmospheric Convection

Kasia Nowakowska [1], **Douglas Parker** [2], **Steven Tobias** [3] **and Lorenzo Tomassini** [4]

[1] *CDT in Fluid Dynamics, University of Leeds, UK*
[2] *School of Earth and Environment, University of Leeds, UK*
[3] *School of Mathematics, University of Leeds, UK*
[4] *Met Office, Exeter, UK*

Nowcasting describes the current state of the weather and provides forecasts for the next few hours, typically within the 0-6 hour time range. Prediction of convective storms within this timeframe is challenging, and while traditional nowcasting methods track the movement of convective cells effectively, predicting the initiation and decay of cells has proven more difficult [1]. In this study, we explore the fundamentals of short-term prediction by employing a simplified model for moist convection known as the Rainy-Bénard model, which extends the classical Rayleigh-Bénard convection [2]. Our main objective is to investigate secondary convective initiation driven by gravity waves. We will focus our analysis on exploring the underlying processes that trigger plume initiation and determining the specific locations and patterns where these plumes form. Initial results indicate that plume initiation in the model is associated with gravity wave convergence, low convective inhibition, high convective available potential energy, and high kinetic energy. To predict the initiation of these plumes, we intend to use a specific type of machine learning known as Echo State Networks [3]. By employing this technique, we aim to deepen our understanding of gravity wave initiation and enhance our ability to make accurate predictions, with the potential to inform real-world nowcasting tools.

[1] Ravuri, S., Lenc, K., Willson, M. *et al.* Skilful precipitation nowcasting using deep generative models of radar. *Nature* **597**, 672–677 (2021).
[2] Vallis, G. K., Parker, D. J. and Tobias, S. M. A simple system for moist convection: the Rainy–Bénard model. 2019. *Journal of Fluid Mechanics, Cambridge University Press* **862**, 162–199 (2018).
[3] Lukoševičius, M. A Practical Guide to Applying Echo State Networks. In: Montavon, G., Orr, G.B., Müller, KR. (eds) Neural Networks: *Tricks of the Trade. Lecture Notes in Computer Science*, **7700**. Springer, Berlin, Heidelberg, (2012).

P19

ANALYSIS OF MESOSCALE CONVECTIVE SYSTEMS OVER YAOUNDE

Stella Songwe Tikeng[1] , Wilfried Mba Pokam[1,2] , and Richard Washington[3]

[1]*Laboratory for Environmental Modelling and Atmospheric Physics (LEMAP), University of Yaounde 1, Yaounde, Cameroon*
[2]*Department of Physics, Higher Teacher Training College, University of Yaounde 1, Yaounde, Cameroon*
[3] School of Geography and the Environment, University of Oxford, Oxford, UK

ABSTRACT

This study examines mesoscale convective systems (MCSs) in relation to one-minute automatic weather station data for two years over the city of Yaounde. The focus is on determining annual and seasonal diurnal cycles of occurrence frequencies and percentages of rainfall, relative humidity, dew point temperature, solar radiation, temperature and wind speed for days with and without MCSs. The link between MCSs activity and regional-scale circulation and atmospheric instability is investigated. The diurnal cycle of the number of MCSs shows a maximum in the afternoon (between 1500–2100 UTC, i.e., 1600–2200 LT), a morning minimum (around 0600–1200 UTC, i.e., 0700–1300 LT), and substantial activity during the night. Surface relative humidity is 5% lower on no MCS days, surface dew point 2% higher on MCS days between 0700 and 1800 hours, and solar radiation higher on MCS days between 0500 and 1000 hours. The first rainfall season has a higher frequency of occurrence of MCSs and more precipitation due to MCSs than the second season, while the second season therefore has the highest rate of annual precipitation not due to MCSs. MCSs activity is associated with instability in the lower troposphere, which is more pronounced during the March–May season than during the September–November season. This convective instability is maximal during the peak of the MCSs activity.

KEYWORDS: MCSs, Yaounde, diurnal cycle, rainfall

P20

Observed and modeled CMIP6 internal variability feedbacks and their potential to constrain forced climate feedbacks

Inter model variations in global temperature response to increasing atmospheric carbon dioxide stem mostly from uncertainties in modeled climate feedbacks. To study potential reductions in model feedback uncertainties, we estimate observed feedbacks in response to internal variability using changes in Top Of the Atmosphere energy balance with temperature. We compare those observations with internal variability feedbacks from historical simulations of coupled and atmosphere-only experiments from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) to identify that simulated feedbacks exhibit biases in the tropics, subtropics, and the Southern Ocean. Furthermore, we find a relation between simulated longwave and shortwave internal variability feedbacks and those where atmospheric carbon dioxide is abruptly quadrupled. For longwave and shortwave feedbacks, such relationships emerge earlier (14 years) than for the net feedback. This allows for using CERES satellite observations and ERA5 reanalysis to identify that models with moderate negative longwave and moderate positive shortwave internal variability feedbacks are more consistent with observations. The relationship for the net feedback requires a longer time to emerge, about 60 years. In light of these findings, continuous satellite records are needed for at least 24 more years before estimates of observed net internal variability feedback can be used to constrain net forced climate feedback, and thereby climate sensitivity.