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ABSTRACTS

Submission of an abstract for participation in the MedCLIVAR Workshop entitled *"Scenarios of Mediterranean Climate Change under increased radiative active gas concentration and the role of aerosols"*; to be held at the ICTP in Trieste, 23rd – 25th September 2010.

An analysis of chemical particles related to the sulfur cycle and the meteorological effects of sulfate aerosols over Europe and the Mediterranean region

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ABSTRACT

The PRECIS (Providing REgional Climates for Impact Studies) Regional Climate Model was used for a control experiment for the period 1960-1990 and for a future B2 scenario (2070-2100) using the HadAM3P driving model. The study domain was defined over Europe and the Mediterranean region.

The PRECIS RCM . The analysis focuses on the direct and indirect effects of the presence of sulfate aerosol in the Aitken, accumulation and dissolved modes in the atmosphere over the study domain. The results obtained from the chosen model parameters seem to suggest that there is an over-prediction in the sulfate parameters and also of the parameters studied. This can either be due to an over-estimation of the natural sulfate emissions, or due to overestimating the chemical conversion of SO_2 to SO_4^{2-}. To bring more insight towards the problem of sulfate overestimation an analysis of the chemical components that relate to the sulfur cycle within the model, namely, DMS, H_2O_2, natural SO_2, OH, HO_2, and ozone was performed and will be presented.

Influence of NAO and clouds on dimming and brightening in Europe

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This study is an analysis of the seasonal all-sky surface solar radiation variability in Europe during 1970-2000 using surface observations from the Global Energy Balance Archive (GEBA). Based on the annual means period 1970-1985, there is a statistically significant decline of -3.0% decade^{-1} (-3.8 Wm^{-2} decade^{-1}) followed by a non-significant rise of 0.3% decade^{-1} (0.4 Wm^{-2} decade^{-1}) during 1985-2000. The behavior of the solar radiation for spring is similar to the annual series and has the strongest increase of 1.6% decade^{-1} (2.5 Wm^{-2} decade^{-1}) during 1985-2000. In summer a similar evolution to the annual and spring time series is shown but has a stronger decline of -3.2% decade^{-1} (-6.8 Wm^{-2} decade^{-1}) during 1970-1985. A small positive non-significant trend is reported for the winter means time series while a statistically significant negative trend of -2.5% decade^{-1} (-2.1 Wm^{-2} decade^{-1}) was found in autumn during 1970-2000. By comparing variations in all-sky solar radiation with changes in cloud cover and NAO, we attribute the winter and autumn trends mainly to the NAO through the modification of mid- to low-cloud cover in Southern Europe and the spring and summer trends to mid- to low-cloud cover in Northern Europe. However, because the cloud cover and solar radiation relationship weakens in the low-frequency variability, it suggests that other effects such as aerosols may also play a role. In addition, aerosols could be interfering with the relationship between solar radiation and NAO contributing to a strengthening of their correlation in the low-frequency variability during winter and autumn.

Measurements of Mediterranean aerosol radiative forcing and the intense Saharan dust event of March 25-26, 2010, at Lampedusa.

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The Mediterranean region is characterized by a high variability in aerosol origin, composition, optical properties, and radiative effects. At Lampedusa (35.5°N, 12.6°E, central Mediterranean) the ENEA maintains the Station for Climate Observations, where measurements of radiative fluxes, aerosol optical properties, sky conditions, meteorological parameters, and greenhouse gases are continuously performed since 1999.

In this study, ground-based measurements of aerosol optical properties and surface shortwave irradiance obtained at Lampedusa during 2004-2007 are combined with co-located simultaneous observations of the outgoing shortwave flux at the top of atmosphere (TOA) derived from Clouds and the Earth's Radiant Energy System (CERES) to derive estimates of the shortwave aerosol radiative forcing (RF). Three different particle classes are discriminated on the basis of their optical properties: desert dust (DD), urban/industrial-biomass burning aerosols (UI-BB), and mixed aerosols (MA). The shortwave RF at the surface, the top of the atmosphere (TOA) and in the atmosphere is calculated separately for each class. A detailed analyses of the dependence of the RF on the single scattering albedo, which is a crucial parameter in determining the radiative effect of aerosols, is also performed.
This methodology has been applied and extended in order to analyze the radiative effects in both the shortwave and longwave spectral range, of the intense Saharan dust event observed on 25-26 March 2010 at Lampedusa, when daily average aerosol optical depths larger than 1.1, and peaks as large as 1.6, were observed. Only two other events of similar intensity have been detected throughout the 10-year long optical depth record at Lampedusa.

Aerosol distribution and radiative effects in the Mediterranean, and the project ChArMEx

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The quantification of the radiative impact of tropospheric aerosols and subsequent forcing of the regional climate in the Mediterranean is far from completed. We present a compilation of results (mainly based on remote sensing data) on Mediterranean natural and anthropogenic aerosol distribution and optical properties, and illustrate their high temporal and geographical variability. Results show the strong accumulation of aerosol during the dry Mediterranean season, and the major role of continental sources of particles over the basin, especially desert dust. We illustrate the closed link between climate (e.g. North Atlantic Oscillation, precipitation) and aerosol variability. Available computations of the aerosol radiative impact yields very significant values and show the need to take them into account into regional climate model simulations. Finally, we describe the Chemistry-Aerosol Mediterranean Experiment (ChArMEx; http://charmex.lsce.ipsl.fr), an integrated project that, among other objectives, aims at a better understanding of the coupling between the Mediterranean aerosol and climate, combining background observatories and monitoring stations, intensive campaigns including airborne means, and regional transport and climate models.

<u>Cyclone intensity changes and risk of tropical cyclone development over the Mediterranean Sea in climate change scenario simulations</u>

Miguel Angel Gaertner

The possibility of tropical cyclones developing over the Mediterranean Sea under future climate change conditions has been raised in a study by Gaertner et al. (2007). The analysis of regional climate model simulations from the european project PRUDENCE has shown that several models show an increase in the intensity of late summer cyclones. Using an objective method for analyzing the cyclone structure, it has been found that the most intense cyclones simulated for climate change scenarios for the last decades of the 21st century show a warm-core, thermally symmetric structure, characteristic of tropical cyclones. The uncertainty of this result is large, as found by analyzing simulations of different models and of one model with different parameterizations. Several additional sources of uncertainty are addressed with the more recent simulations of the european project ENSEMBLES, where higher resolution regional climate models have been nested in several different global climate model simulations. This multi-model ensemble also allows to explore cyclone intensity changes for the first decades of the present century.

African monsoon and Mediterranean climate: the role of mineral dust aerosol from Saharan desert

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A relationship exists between the African monsoon and the Mediterranean region during the Boreal summer. Warm SST anomalies in the eastern Mediterranean basin positively affect the precipitation over the Sahel, through the enhancement of a northerly low-level flow that brings moisture across the Sahara and reinforces the monsoonal front. The mid-tropospheric Saharan high connects Tropical and sub-Tropical circulation features, maintaining the African Easterly Jet and driving the southerly flow into the western Mediterranean basin. In this picture, the active and passive role of the mineral dust aerosol is considered: the Saharan dust is injected into the atmosphere and transported by the circulation over Africa and Mediterranean, with consequences on radiative forcing, cloud dynamics and thus precipitation.

Based on the observed Mediterranean-monsoon relationship, three case studies are selected: summer 1986, 1987 and 1988. These seasons are characterized by warm SST anomalies in the eastern Mediterranean, enhanced northerly airflow across the Sahara, and normal, weak and strong precipitation in the Sahel, respectively. The aim of the study is the determination of the circulation effects on the dust transport and its potential relationship with the observed rainfall anomalies. This analysis is carried on using a comprehensive modeling system simulating the entire mineral dust cycle in the atmosphere. It consists of two major physical mechanisms: firstly, a wind stress lifting mechanism which is able to raise up dust particles from some type of bare soil surfaces; then, a long range transport mechanism with a high degree of spatial coherence. The modeling system is based on three different modules: the atmospheric, dust emission and transport/deposition models. The Regional Atmospheric Modeling System (RAMS), forced by the Reanalysis2 dataset, provides input data for the other modules. The dust emission model (DUSTEM) simulates the emission of four particle categories, based on the content of clay, small-sit, large-silt and sand from the Saharan desert. The dispersion model (Comprehensive Air quality Model with extensions; CAMx), takes the meteorological inputs from RAMS and the emission amount from DUSTEM.

The modeling system domain is 16E-60W, 4.7S-77N, with 30 km horizontal resolution over the selected summer periods (April to October). The higher horizontal and vertical resolution of the three-dimensional modeling system improves, with respect to global datasets, the description of dynamical features linking Tropics and sub-Tropics within the Afro-Mediterranean region. Results clarify the aerosol transport dynamics and its potential role in the African monsoon system.

Change of Mediterranean extreme events under increased greenhouse warming conditions

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Despite considerable advances regarding the physical realism and the spatial resolution of atmosphere- ocean general circulation models (AOGCMs), regionalization techniques are still of major importance to obtain climate change information on a regional scale. For a region like the Mediterranean area, characterized by a complex topography and a high climatic variability, downscaling of AOGCM output is particularly important for assessing regional climate change. In the scope of regionalization techniques two different types, namely dynamical approaches and statistical downscaling, can be distinguished.

The present work concentrates on statistical assessments of extreme events in the Mediterranean area. The statistical downscaling approach is based on statistical relationships linking a set of large-scale atmospheric variables to regional climate extremes. In this context percentile-based indices of extreme events have been defined based on station data of the Mediterranean area as well as on high resolution precipitation and temperature data (0.25° x 0.25° grid for terrestrial areas of Europe, Haylock et al. 2006). As large-scale predictors for extreme events in the Mediterranean area sea level pressure, geopotential heights, thickness of the 1000hPa/500hPa layer, specific humidity, and relative vorticity are primarily considered. Then statistical downscaling is established by relating the Mediterranean extreme events to the large-scale atmospheric circulation. This is done through the application of transfer functions (multiple regression analysis and canonical correlation analysis) as well as through a synoptical downscaling approach (cluster analysis).

To test the stability of the models and to account for non-stationarities in the circulation-climate- relationships the analyses are realised for different calibration periods and corresponding verification periods. Model performance in the verification periods is assessed by means of the correlation coefficients between modelled and observed extremes indices. Additionally the reduction of variance is calculated, being similar to the root mean squared skill score. Subsequently output of different AOGCMs under A1B- and B1- scenario assumptions is used to assess changes of extreme temperature and precipitation under enhanced greenhouse warming conditions.

The results indicate that the downscaling assessments vary considerably depending on the particular predictor used for the statistical assessment, whereas the application of different AOGCMs and different scenarios causes only a relatively small spread of the results. Thus special attention should be given to the different factors influencing extreme conditions in the Mediterranean area and they should be incorporated in a combined manner within downscaling models.

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XXI CENTURY MARINE CLIMATE SCENARIOS FOR THE MEDITERRANEAN SEA

The knowledge of marine climate is of great importance for environmental managers, scientific research or long-term infrastructures planning. Therefore, the identification of future changes in the marine climate produced by future greenhouse gases (GHG) emission scenarios is crucial for all those activities. At global scale, models used in the framework of the IPCC (Intergovernmental Panel for Climate Change) can provide an answer for expected mean changes. However, they can hardly account for regional scale variability. This is especially true in the Mediterranean Sea, where the complex coastlines, the basin shapes and the Gibraltar Strait require high resolution modelling. In that context, the VANIMEDAT-2 project and the ESCENARIOS project aim to produce regional projections of surface waves, storm surge, hydrodynamics and sea level for the Mediterranean and a sector of the NE Atlantic Ocean. In this presentation we will show the first results obtained in the framework of those projects.

The wind wave runs have been performed with the WAM model (1/6º of spatial resolution), while the storm surge runs have been carried out with the HAMSOM model (1/6º x 1/4º). Both models have been forced with outputs of the atmospheric model ARPEGE (~50km/6 h, MétéoFrance) for three scenarios of GHG emissions (A1b, A2 and B1). The 3D baroclinic runs aimed to get the evolution of temperature, salinity, circulation and total sea level have been performed with the NEMO model (1/8º). This model has also been forced by ARPEGE fields but only for the A2 scenario. The results show, for the end of XXI century, a 10-20% reduction in mean wave height under all scenarios in the western Mediterranean and a slight increase in the extreme events. The atmospheric component of sea level would decrease by 4 cm in winter and increase by 2 cm in summer on average in all the basin; however, extreme storm surge events would also increase everywhere except in the Adriatic and Aegean seas. Finally, the 3D model results suggest an increase of 2.5º in the mean surface temperature and an increase of 0.6 psu in salinity. These changes would imply a reduction of about 2 cm in the steric component of sea level.

S. Krichak

Title: Role of teleconnections in extreme precipitation climate events in the Mediterranean

Abstract

Lasting from several days to weeks, time periods with increased frequency of above-normal daily precipitation (extreme precipitation climate events, EPCEs) characterize the Mediterranean region (MR). The role of global teleconnections in influencing the characteristics of the EPCEs is analyzed with gridded data from the multiyear NCAR-NCEP Reanalysis (NNRP) data archive. Time series with monthly data for several teleconnection indices and gridded data from the NNRP are used in this investigation. To evaluate the role of dry and moist atmospheric dynamical processes, two variables are considered - dynamic tropopause pressure and column integrated water vapor content (precipitable water). Linear correlations are calculated between the time series of the frequency of days with above normal values for the above variables and indices representing the amplitude, of four teleconnection patterns. The results demonstrate that the teleconnection patterns have a large impact in the development of the EPCEs in the MR.

Estimating recurrence probabilities of severe heat waves in a changing climate

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Europe has recently been affected by several long-lasting and severe heat waves, particularly in July-August 2003, June-July 2006, and July 2007. The heat waves influenced various sectors of human activities, with enormous socio-economic impacts. With an estimated death toll exceeding 50000 over Europe, the August 2003 heat wave was the worst natural disaster in Europe during the last 50 years, yielding an example of how seriously may also high-income countries be affected by climate change.
The study deals with long-term variability of heat waves in central Europe and their recurrence probabilities under future climate change scenarios. We focus on analogs of the 2006 heat wave which lasted 33 consecutive days in Prague and was the longest and most severe heat wave since the beginning of temperature measurements in 1775. First-order autoregressive (AR) model with a deterministic component, incorporating the seasonal cycle and the long-term trend, is applied to generate artificial daily temperature series and estimate probabilities of long and severe heat waves. The model is validated with respect to the simulation of heat waves in present climate (1961-2006) and subsequently run under several assumptions reflecting various rates of summer warming over the 21st century, based on climate model projections.
The return period of a heat wave reaching or exceeding the length of the 2006 heat wave is estimated to be around 120 years in 2006. Due to an increase in mean summer temperatures, probabilities of very long heat waves have already risen by an order of magnitude over the recent 25 years, and they are likely to increase by another order of magnitude by around 2040 under the summer warming rate assumed by the mid-scenario. Even the lower-bound scenario yields a considerable decline of return periods associated with intense heat waves. Although positive socio-economic development, life-style changes and improvements in medical service have resulted in reduced mortality impacts during 'average' heat waves recently, adaptation measures and a better preparedness to heat-related risks are needed in order to mitigate impacts of severe heat waves in the near future. The methodology for estimating probabilities of heat waves may easily be transferred to other regions in which temporal structure of daily temperature series is approximated by an autoregressive model, including the Mediterranean region.

Assessment of climate change for the Mediterranean with a quadruple coupled model

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A quadruple coupled climate model is developed for the Mediterranean. It is composed of two atmospheric models and two oceanic models for both global and regional purposes. The global atmosphere is LMDZ-global, a coarse-resolution global atmospheric general circulation model. The regional atmosphere is LMDZ-Med, a regional model with spatial resolution of about 35 km over the Mediterranean. The global oceanic model is ORCA2, an oceanic general circulation model with a resolution of 2 degrees. And finally the regional oceanic model is NEMO-Med8, a Mediterranean sea general circulation model at 1/8 degree. These four models are interactively coupled together through the OASIS coupler. This quadruple coupled system is suitable for studies on the teleconnections between the Mediterranean climate and the global climate. The whole coupled system has been run with observed concentrations of main greenhouse gases from 1951 to 2000, and for IPCC-A1B scenario from 2001 to 2050. Diagnostics of the scenario will focus on the differences between the global model and the regional model covering both the Mediterranean basin, but with different spatial resolutions.

Accuracy and uncertainty in Climate Models : an intercomparison between regional climate models (RCMs) and global climate models (GCMs) for monthly precipitation and temperature fields over the Mediterranean region

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In this study we estimate the accuracy of the regional climate models (RCMs) with respect to that of the global climate models (GCMs) that have been used for driving them, by intercomparing the respective monthly precipitation and temperature fields. The analysis is based on the results of the ENSEMBLES and PRUDENCE projects. Specifically, for the ENSMBLES project the GCMs ECHAM5 and HADCM3Q0 have been compared to RegCM, HIRHAM, REMO, RACMO, RCA (driven by ECHAM5) and to PROMES, CLM, HadRMQ0, HIRHAM, RRCM (driven by HadCM3Q0); for the PRUDENCE project the GCM HADAM3H has been compared to RACMO, CLM, REMO, RegCM, PROMES, CHRM and HIRHAM. The analysis has been carried out over the Mediterranean region for the control period (1961-1990) and has used the CRU (Climate research Unit) monthly climatologies for validation over land, ERSST (Extended Reconstruction Sea Surface Temperature) and NOCS precipitation (National Oceanographic Center Southampton) for validation over sea. The results shows that the higher resolution of RCMs improves the representation of climate, in particular where there are significant regional influences, such as those produced by mountains and coastlines. The Kappa statistic has been used to quantitatively compare categorical data sets and show differences and similarities between models and observed climatologies. Improvements due to higher resolution are more significant for temperature than for precipitation. For precipitation, improvements are clear in the coastal zone and at high levels However, these improvements are partially compensated by positive biases introduced in other areas, especially in the period from november to january, and the overall score of RCMs though higher is similar to that of GCMs.

Impact of large-scale mid-latitude circulation on regional climate model trends in the Mediterranean area

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The research project KLIWEX-MED (Changes in weather and climate extremes in the Mediterranean Basin) aims to analyse the regional characteristics of climate change in the Mediterranean Basin with focus on temperature and precipitation means and extreme events like heavy precipitation, heat waves and droughts. For this investigation, simulations with the high-resolution (0.5°) regional climate model REMO nested in the coupled global climate model ECHAM5/MPI-OM are available for the time period 1961-2050. For 1961-2000 we consider observed GHG emissions and during 2001-2050 A1b and B1 emission scenarios as well as scenarios for anthropogenic land use change.

Our recent focus lies on the investigation of the impact of interdecadal model variability on regional climate model trends in the Mediterranean, a region strongly influenced by large-scale circulation. We analyse if discrepancies in seasonal temperature and precipitation trends between REMO and the gridded observational dataset E-OBS Version 2.0 for 1961-1990 can be explained by differences in mid-latitude circulation. Thereby, we determine large-scale circulation from seasonal principal components of sea level pressure from the driving global climate model ECHAM5 and global NCEP/ NCAR reanalysis data. A cross-validated multiple regression analysis between large-scale circulation and regional temperature and precipitation is performed for both observational and model data. The impact of circulation is removed from the original temperature and precipitation time series and the trends of both the circulation-related and circulation-unrelated parts are compared between model and observations.
We find that most differences in winter temperature and precipitation trends are forced by different temporal evolutions of the North Atlantic Oscillation and the East Atlantic pattern. In general, model circulation shows weaker trends than observations. Several discrepancies in summer temperature trends can be explained by differences in large-scale circulation patterns as well. Summer precipitation is hardly influenced by circulation. We conclude that interdecadal model variability has a large impact on model results in regions strongly influenced by circulation and can highly disturb validation of regional climate model trends if interdecadal model variability does not fit the observed circulation changes.
Similar investigations of the influence of large-scale mid-latitude circulation on regional climate model trends of seasonal temperature and precipitation are performed for the whole time period 1961-2050 considering future scenarios of Mediterranean climate change under increased GHG emissions and anthropogenic land use change.

Detection of an anthropogenic climatic change over the Mediterranean area

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The detection and attribution of climatic change to different sources is challenging at the regional scale. The application of formal detection and attribution analyses has been recently attempted over the Mediterranean domain. An other study consists in checking the consistency between observed and simulated trends over the last decades. After a brief presentation of the methodologies, we will review the main results of these studies that generally converge in the detection of a climate change signal that is consistent with what is expected from anthropogenic influence on climate, as far as temperature is concerned. However, partly due to improper characterization of internal variability, incomplete observation sampling, or modelling uncertainties, these studies fail at detecting with a high level of confidence an anthropogenic influence on the observed precipitation changes.

Regional climate simulations of aerosol radiative impact over the Mediterranean basin.

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In this study, we are assessing the ability of a regional climate model (RegCM4) to study aerosol-climate interactions over the Mediterranean basin. Particularly we'll discuss the skill of the model to reproduce natural and anthropogenic aerosol variability and associated radiative forcing compared to observations. Simulated regional climatic responses to aerosol radiative forcing will be also presented , and sensitive issues to be notably addressed in future research program (e.g. MedCordex, ChArMEx) will be discussed.

Mediterranean Sea Heat Budget: observed estimates, present-climate model evaluation and climate change scenarios

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Considering the Mediterranean Sea surface Heat Budget (MSHB) multi-year mean, the Mediterranean basin loses heat by its surface with an excess of the net Long-Wave radiation LW, Sensible Heat flux SH and Latent Heat flux LH over the incoming net Short-Wave radiation SW. This surface budget is balanced by the net Gibraltar strait Heat Transport (GHT) and the variation of the Mediterranean Sea total Thermal Heat Content (THC). The MSHB partly drives the Mediterranean Sea surface temperature, its feedback to the regional climate and its impact on the characteristics of the water masses. The estimation of the MSHB becomes consequently a tipping point of the observation, modelling and understanding of the regional Mediterranean climate system. The complex regional physical characteristics of the Mediterranean basin (orography, complex coast line, strong land-sea contrast, air-sea coupling, regional winds, cloud-radiation interaction and aerosol-radiation interaction) strongly influence the various components of the MSHB and make this estimation task even more complicated.

State-of-the-art observation datasets over the period 1989-2001 are assessed for the different components of the MSHB using in-situ data, reanalysis-derived data and satellite products to reach a best estimate that full-fills the closure hypothesis. We specially take care about the grid, the land-sea mask and the resolution of each dataset during the computation. We then evaluate the components of the MSHB of Mediterranean-dedicated Regional Climate Models (RCM) in ocean-atmosphere coupled and non-coupled configurations from the ENSEMBLES, CIRCE, HyMeX and MedCORDEX projects against these best observed estimates. Finally climate change scenarios following the IPCC-A1B scenario are analysed for the 21st century.

Abrupt warming and salting of the Western Mediterranean Deep Water after 2005

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Recent studies suggest that the deep western Mediterranean is undergoing a drastic change, comparable to what happened in the eastern basin during the mid-‘80s and ‘90s, the Eastern Mediterranean Transient (EMT).

In the deep layers of the western basin, an almost constant trend towards higher salinity and temperature has been observed since the ‘50s. More recent observations evidenced an acceleration of this tendency, which has been related to the propagation of the EMT signature, from east to west. Since 2005, the data collected in the deep western basin have revealed an abrupt change, with the appearance and spreading in the whole western basin of a new deep water, significantly warmer and saltier than previously, which has substantially substituted the resident deep water. This new deep water has been formed during massive convection events, that took place during the winters 04/05 and 05/06 in the north-western Mediterranean (NW-MED), linked to extreme winter air-sea heat and freshwater forcing of the basin. The contributions of atmospheric forcing and lateral advection of anomalously warm, salty water to the convection region are discussed in order to determine their relative roles in causing massive renewal of Western Mediterranean Deep Water and its anomalous properties.

Extreme Mediterranean Cyclone and Wind Events under increasing GHG Climate Forcing

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Extreme cyclones and related extreme wind events are investigated, applying a methodology for the association to ERA40 and to GCM data for present day and future climate. Typical characteristics are evaluated, like the occurrence of particularly intense cyclones and wind events in present and future climate, and the typical distances between cyclone cores and the wind event centres. The model results show a reduction in the number of extreme wind events and associated cyclones in the Mediterranean region under scenario climate forcing. However, the variability of the strength of the events in terms of the standard deviation of a Storm Severity Index is higher in the future climate scenario integrations than in the present day climate simulations. The scenario integrations include a number of extreme wind events exceeding the strength of the most extreme events found in the corresponding present day climate simulations. This suggests that in spite of a future reduction in the number of extreme wind events in the Mediterranean region might be decreasing there is a potential for stronger events impacting the area.

Applying Analysis of Variance on a Multi-Model Ensemble of Global Climate Models in the Mediterranean Area

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The German KLIWEX-MED (Changes in weather and climate extremes in the Mediterranean Basin) project is concerned with the analysis of the regional characteristics and intensity of climate change in the Mediterranean Basin and with the quantification of the corresponding uncertainties. In further steps of research, the frequency and strength of extreme events like heat waves, droughts and heavy precipitation are investigated.

For this purpose, the ensemble simulations of different global climate models of the fourth IPCC asessment report are analyzed in a statistical and probabilistic sense based on the simulated monthly model means.

After interpolation on a common 3°x3° spatial model grid it is possible to compare temperature, precipitation and sea level pressure means, standard deviations and trends across several models in the Mediterranean Basin. The results of the 20c3m scenario for a present-day time slice (1961-2000) are compared with those of a future time slice (2001-2098) for different GHG emission scenarios A2, A1B, and B1. Particular attention is paid to highlighting the results both in a yearly analysis as well as in a seasonal context.

By means of 1-way and 2-way analysis of variance (ANOVA) it is possible to describe the model uncertainty in the multi-model ensemble simulations over the Mediterrranean Basin in a quantitative way. Here, the amount of climate variability that is common to all models and, thus, can be considered as a comparatively confirmed signal of climate change, is set into ratio to the internal variability inherent in each climate model and its typical specification like parametrizations and discretizations. Thus, it is proved if it will be possible to distinguish a multi-model trend imposed by radiative forcing and scenario against the background of model uncertainty developed by the internal model variability.