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Conference proceedings

Gerd Schädler, Hendrik Feldmann, Hans Schipper (eds.)

INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH
SOUTH GERMAN CLIMATE OFFICE

Climate Limited-area
Modelling Community

KIT – The Research University in the Helmholtz Association

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From September 18 to 21, the 13th General Assembly of the CLM community (https://www.clm-community.eu/) took place at Campus South of the Karlsruhe Institute of Technology. Nearly 60 international participants learned over these four days about the latest results and developments of the COSMO-CLM and ICON model systems in 23 plenary lectures and 21 posters. The premises in building 10.81 ("altes Ingenieursgebäude") also offered the opportunity to engage in parallel sessions in in-depth discussions in the individual working groups of the CLM community.

The present conference proceedings hold all the abstracts of the oral and poster presentations during the assembly and gives a good insight in the broad work and applications of the CLM Community.

Herewith, the organizing team would like to sincerely thank

- the participants of the conference,
- the CLM working group leaders,
- the scientific advisory board,
- the catering service,
- the janitors of building 10.81,
- the student assistants, and
- all others involved in organizing the assembly.

Local organizing team

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Atmosphere, Ice and Ocean

Activities with COSMO-CLM and NEMO for the North and Baltic seas at DWD

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Activities with COSMO-CLM and NEMO for the North and Baltic seas at DWD By coupling atmosphere and ocean, processes and interactions between those two realms can be represented more realistically in climate models. Especially in northern Europe, where North- and Baltic Sea have a great impact on the local climate, the consideration of an active ocean is very important. In the projects 'ProWaS' and 'NOCO' we therefore use the regional coupled climate model ROAM 1.0, which consists of COSMO-CLM (CCLM) coupled to the ocean-model NEMO-Nordic via OASIS3-MCT. The aim of 'NOCO' was to find an optimal configuration for ROAM 1.0 as a precondition for a 20-year reanalysis simulation, which was analysed with the help of satellite data. Different coupling time steps from five minutes up to six hours were tested, but no computational difference between the time-steps were found. In the pilot project ‚ProWaS' (Projektionsdienst für Wasserstraßen und Schifffahrt) several federal german agencies cooperate to determine the effects of climate change on waterways and shipping in the region of the German Bight and the rivers Elbe and Rhine. We will provide an evaluation simulation and a climate projection simulation with ROAM1.0, which will be further refined by impact models of the partner agencies to get small scale climate change information. The data will be distributed via the ESGF-node, which is installed at DWD in ProWaS.

Improvement in the simulation of fine-scale atmospheric moisture through Data Assimilation and sub-kilometer grid-refinement during a Heavy Precipitation case study. The HyMeX-IOP6

Alberto Caldas-Alvarez, Samiro Khodayar

Karlsruhe Institute of Technology (KIT), Germany

An accurate representation of Heavy Precipitation Events (HPEs) by current numerical weather and climate prediction models will be of most importance over regions especially vulnerable to Climate Change such as the Mediterranean basin. Previous studies have highlighted the large sensitivity of heavy precipitation forecasts to errors in the representation of the spatio-temporal distribution of atmospheric moisture. Indeed, changes of only 1g/kg in a time scale of minutes at the boundary layer, have been shown to make the difference between very intense convection and its complete suppression. The presented research work aims at gaining knowledge on how an improved spatio-temporal distribution of water vapour impacts Deep Moist Convection (DMC) representation during an HPE of the Hydrological Cycle in the Mediterranean Experiment (HyMeX), the IOP6. Two approaches are used to improve the fine-scale representation of water-vapour. We employ Data Assimilation of GPS-IWV measurements from a data set, specially homogenized for the western Mediterranean countries with a frequency of 10 minutes and high-resolution radiosondes. And we assimilate these data in three-day runs COSMO simulations on three different horizontal resolutions (~7 km, ~2.8 km and ~500m).

High-resolution modelling of the Greenland climate with the regional climate model COSMO-CLM

Melanie Karremann, Gerd Schädler
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Observations show that recent Arctic temperatures increases faster than global average. This has consequences for the Greenland ice sheet, which receded in recent decades. Given that these changes can have a high impact on the global sea level as well as atmospheric and oceanic circulation, it is of crucial importance to examine in more detail temporal and spatial behaviour of factors contributing to the ice sheet. With this aim, we simulate the Greenland climate with the non-hydrostatic regional climate model COSMO-CLM for the CORDEX-Arctic region for recent decades (1995–2015), using ERA-Interim as boundary conditions and considering different spatial resolutions (0.44°, 0.22°, 0.0625°). Comparisons of simulated temperature, precipitation and surface mass balances with observations show good qualitative and quantitative agreement, with higher skill for temperature and lower for surface mass balance. The skill is often higher with increasing model resolution. For example, positive skill is found for 0.0625° at more than 90 % of stations compared to 0.22°. The spatial pattern of mass balance estimates generally agrees with satellite products for 2005 to 2014, indicating negative mass balance near Greenland coasts and an increased loss in recent years. These encouraging results enable the usage of this model for other climate periods, for example the Midholocene or the last glacial maximum.

A long-term hindcast simulation with COSMO-CLM over Antarctica

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Given the large potential contribution of the Antarctic ice sheet to future sea level rise, understanding the climate system in the region is of high importance. To tackle this challenge, the regional climate modeling approach is a crucial tool, due to the scarcity and low spatial coverage of observations over Antarctica. In this study, we use COSMO-CLM 5.0 coupled to the Community Land Model (CLM4.5) and adapt it to Antarctic conditions. ERA-Interim is used as initial and lateral boundaries for a time period of 30 year (1986–2016; excluding 3 years of spin-up time) at a resolution of 0.22° over the whole Antarctic continent. Lackings in the model representation of basic climatic variables such as temperature and wind speed were tackled by adapting the turbulence scheme, implementing a two-moment cloud microphysics parametrization, as well as several modifications to the Community Land Model (e.g. snow metamorphosis, wind dependent compaction,...). We present an evaluation of this long-term COSMO-CLM simulation adapted for Antarctica. Results are compared to observations from satellites, automatic weather stations, field campaigns and radiosondes, over both the continent and the surrounding oceans. A particular focus is given to clouds and precipitation, as these atmospheric elements are generally not well represented in models over the Antarctic region, but play a crucial role in the surface energy budget.

Chemistry, Clouds, Aerosols and Radiation

Comparison of MECO(n) simulated NO_2 vertical and slant column densities with TROPOMI and MAX-DOAS observations over Rhineland-Palatinate

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The evolution of trace gas detection techniques from space-borne instruments at a fine spatial resolution with daily global coverage, demands the need of a regional chemistry-climate model at a similar spatial resolution. TROPOMI instrument onboard Sentinal-5P was launched in October 2017 and measures tropospheric pollutants (e.g. NO2, HCHO, SO_2 and CO) at an unprecedented spatial resolution of 7 km × 3.5 km. A 1-way nested MECO(2) system was set-up for Germany, with the inner-most domain at 0.0625° (~7 km × 7 km) spatial resolution and 40 vertical levels which extend up to ~24 km. Anthropogenic and biomass burning emissions were taken from the RCP 8.5 scenario. NO_2 tropospheric vertical columns were derived from the model simulated NO2 profile by taking into account averaging kernels, tropopause level and apriori profiles from TROPOMI data products. Tropospheric vertical columns from MECO(2) and TROPOMI were compared on a daily basis for the month of November 2017. A 1-way nested MECO(3) system was also set up for Rheinland-pfalz region with the inner-most domain at a finer ~2 km × 2 km spatial resolution for comparison with ground-based NO2 slant column density (SCD) measurements from a 4-azimuth MAX-DOAS instrument operated at MPIC Mainz. Height-resolved 2-D boxed airmass factors were calculated using McArtim (Monte Carlo Atmospheric radiative transfer model) for different measurement elevation angles which were then used to determine SCDs from the modelled NO_2 profiles.

Improvement of the planetary boundary layer height based on COSMO-CLM simulation data

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The UBASOAP project aims to improve the model performance for particulate matter episodes with easterly wind directions by improving the modelling of the mixing layer height and by improving the emission information over the area of Germany/Poland. For this purpose the meteorological input data for LOTOS-EUROS has to be dynamical downscaled using the COSMO-CLM model. The planetary boundary layer diagnostics of COSMO-CLM will be evaluated and improved by using sensitivity simulations depending on turbulence closure and the surface transfer scheme. Two spatial resolutions are obtained with 7 km and 2.8 km using a double nesting approach. As boundary conditions the ERA-Interim reanalysis data-set is used. The mixing layer height is compared with sounding stations by using the bulk Richardson method. First results suggest that downscaling of the ERA-Interim reanalysis data-set leads to a cooling in the model domain but the representation of extremes is not improved, effecting particularly the lower atmosphere near the surface where increased resolutions and small-scale parameterizations improve the planetary boundary layer. The mixing layer height can significantly be improved and the COSMO-CLM simulation is well reflecting the temporal behavior. In case of downscaling to 2.8 km no added value of the mixing layer height is recognizable. The COSMO-CLM overestimates the mixing layer height at all. Results regarding the sensitivity simulations will be presented at the assembly.

Climate Projections and RCM Applications

Mesoscale resolving high-resolution simulation of wind farms in COSMO-CLM 5

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The rapid development of offshore wind farms has raised concerns about the local environment and ecosystem. Wind farms influence the local meteorology by extracting kinetic energy from the wind field and by generating a large wake. The North Sea is one of the main regions of the world where the growth of offshore wind farms is rapidly increasing. In this study, we analyze the impact of large-scale offshore wind farms in the North Sea on local meteorology using regional climate model COSMO-CLM. For this purpose, the parametrization for wind turbine driven by Fitch et al. (2012) and Blahak et al. (2010), previously implemented in COSMO-CLM v4.8 at KU-Leuven (Chatterjee et al. 2016), has been implemented in the latest version 5 of COSMO-CLM. Here we present the first results of COSMO-CLM long-term simulations with and without wind farms using mesoscale resolving high-resolution horizontal atmospheric grid spacing (~ 1 km).

Conditional Evaluation of Regional Hindcasts from the MiKlip Decadal Climate Prediction System

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We present results of conditional evaluations of retrospective forecasts from the MiKlip decadal climate prediction system. This system is a development within the framework of the German national research project "Mittelfristige Klimaprognosen" (MiKlip), funded by the Federal Ministry of Education and Research in Germany. The global prediction system, which will be fully operational at DWD by the end of 2019, is build around the coupled Max-Planck-Institute Earth System Model (MPI-ESM, high resolution (HR) version) as a core. For our study, we use higher resolved regional data of the European domain, obtained with a dynamical downscaling of the global MiKlip ensemble ("preop-GCM") with COSMO-CLM. The 2 m-temperature fields from the resulting regional MiKlip ensemble ("preop-RCM") are classified with respect to the North Atlantic Oscillation teleconnection pattern (NAO) and the Root Mean Square Error (RMSE) of ensemble members and reanalysis data. Forecast skill and forecast precision of the ensemble mean are then validated depending on lead time and data class.

High-resolution projection of climate change over Israel with COSMO-CLM

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Climate projections over Israel at 0.0715° resolution have been obtained with the regional model COSMO-CLM, nested into the CORDEX-MENA simulations at 0.22°. In a previous work, it was shown that increasing the spatial resolution improves the representation of climate extreme due to the better representation of topography, especially with respect to station data. In the present work, the model output is validated against E-OBS and APHRODITE data sets. Projections are presented in terms of average properties and using a subset of extreme temperature and precipitation ETCCDI indices for the period 2041–2070 with respect to 1981–2010, under the IPCC RCP4.5 scenario.. A general increase in seasonal mean temperature is projected, with peaks of about 2.5 °C, especially in winter and autumn. All temperature indices project a significant growth, with larger increase in the minimum temperatures. Regarding total seasonal precipitation, decreases were found in the north and central climate parts of Israel, with reductions reaching 40 %, and increases in the most southern arid parts during winter and spring. Precipitation amounts are different between the northern and the southern climate. A projected tendency towards drier conditions is in agreement with low-resolution projections. This spatial pattern probably results from an increase in convective activity in the south and from a decrease in cyclones' occurrences, which mainly influences the northern and central parts of Israel.

Climate variability and predictability of heavy precipitation events potentially causing floods

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Large floods are one of the major natural hazards affecting Europe, with enormous risk potential for buildings, infrastructure and fatalities. Such events are primarily driven by heavy precipitation over a large area, partly with secondary contributions from snow melt. In this study the predictability and climate variability of extreme precipitation events associated with floods for Central Europe are analyzed using regional climate hindcasts from CCLM. To identify such extreme-events a heuristic percentile index, based on mean precipitation over a catchment, is been developed. To study the multi-decadal variability and the relations between extreme events in Europe and large-scale teleconnection patterns in particular, a downscaling of 20th century reanalysis data has been performed within the German MiKlip project. Two approaches have been applied: First, dynamical downscaling using CCLM, and second, a statistical method based on analogues. These simulations will be used to evaluate under which conditions, one can expect predictive skill in terms of extreme precipitation events on a decadal timescale. Besides this, a methodological comparison will be conducted to examine the systematic differences between the dynamical downscaling approach and the computational less demanding statistical approach.

The IPCC 6th assessment report: brief overview and opportunities for the CLM community

Alessandro Dosio
European Commission Joint Research Centre

The activities of the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WGI: the physical science basis) for the preparation of the 6th Assessment Report (AR6) will start officially with the First Lead Author meeting (LAM1) in June. Contrary to previous assessment reports, and as specifically requested by the IPCC following the outcome of a previous workshop (IPCC Workshop on Regional Climate Projections and their Use in Impacts and Risk Analysis Studies, 2015) AR6 will specifically focus on regional climate change information, with 3 chapters (10–12) specifically dedicated to the assessment of processes of global to regional climate change, weather and climate extremes in a changing climate, and climate change information for regional impact and risk assessment. In particular, the report should facilitate the integration and consistency of the assessment across the WGs (the 'hand shake') of regional impacts, vulnerability and risk (specifically undertaken by WGII). A regional atlas is also proposed as an annex of the WGI report. This talk will provide an overview of the AR6 cycle, with focus being on the challenges and opportunities for regional climate community such as the CLMcom.

Regional Decadal Climate Predictability and Variability – A Résumé of the MiKlip Project

Hendrik Feldmann and the MiKlip Module-C Team
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The BMBF project MiKlip has developed a decadal climate prediction system, which is intended to go operational at DWD by end of 2019. A regionalization module is part of the project, which for the first time offers systematic downscaling on the decadal time-scale. The core model for the downscaling is CCLM. In addition a "multi-RCM"-approach including REMO has been applied as well as a statistical-dynamical approach. Large ensembles of initializes decadal hindcast simulations have been generated. They offer about 20.000 simulation years covering the period 1960–2027. There are additional simulations covering the whole 20th century. This study gives an overview about the steps toward an operational climate prediction as well as the main results regarding the predictability of mean and extreme climate indicators as well as on their decadal variability and teleconnections.

Quantitative wind climatology for wind energy applications at heights above 100 m

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The increasing hub height of wind turbines results in optimizing the wind energy yield at one location and offers the possibility to provide new areas for wind power, for example forests. Furthermore, inhomogeneous environmental conditions of locations for wind turbines cause challenges for the wind power assessment. Thus, daily and seasonal periodic interactions between the airflow and other meteorological fields, e.g. the variable thermal stratification of the atmosphere, have to be realistically modelled. To specify the wind field at hub heights of modern wind turbines (100 m to 200 m) in a consistent way, a high-resolution wind climatology for Germany will be generated within the project QuWind100 (QUantitative WIND climatology for wind energy applications at heights above 100 m). For this purpose, a chain of non-hydrostatic models consisting of the mesoscale COSMO CLM in climate mode and the microscale model HIRVAC2D (HIgh Resolution Vegetation Atmosphere Coupler 2D) is applied. The concept of this methodology resulting in a new wind atlas for current and future conditions of climate and land use is presented.

COSMO-CLM in SOCLIMPACT

Anika Obermann-Hellhund, Bodo Ahrens
IAU, Goethe-Universität Frankfurt

Islands are vulnerable to climate change consequences and at the same time can be used as living labs with a high replicability potential to asses the climate change associated costs, benefits, and risks in other coastal regions. The SOCLIMPACT project aims at modeling the climate change impact on EU islands, including the Mediterranean and Baltic islands, the Azores, Canaries, Madeira, and the French West Indies. It focuses on the impact of climate change on environmental, social, and economic factors during 2030 to 2100 using impact chains. COSMO-CLM and several other regional climate models are used to provide the input for the subsequent environmental, social and economic modeling. We show how these regional climate models contribute to the impact chains and the SOCLIMPACT approach to estimate climate change impacts on islands.

The effect of coupled marginal seas on precipitation extremes and heat waves in 20th century CCLM simulation

Cristina Primo, Fanni Dora Kelemen, Anika Obermann, Bodo Ahrens
Goethe-University Frankfurt

Regional atmosphere-only (CCLM) and coupled ocean-atmosphere (CCLM-NEMO) model simulations are analysed together with the driving global data and observations to investigate the added value of regionalisation and coupling. Two analyses are carried out: The first focuses on the multi-decadal variability of precipitation extremes in the 20th century. For this, the Standardized Precipitation Index (SPI) is calculated and compared between the simulations and observations. The second focuses on the detection of heat waves. For this, maximum temperature coming from model simulations is compared to daily data provided by some DWD-stations during a period of 100 years.

Sensitivity studies for the CORDEX Central Asia domain with the COSMO-CLM 5.0

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The ability of climate models to reproduce past observations is welll acknowledged as a necessary prerequisite for the projection of future climate. Configuring a model in such a way that a certain measure of the model output agreement with selected observations is maximized, is indeed a fundamental step prior to any climate simulation. With the goal of determining the “best“ model configuration to be used in the new CORDEX-CORE initiative, we present here the results of a series of sensitivity tests conducted for the Central Asia CORDEX domain with the COSMO-CLM model version 5.0 driven by reanalysis data, at a spatial resolution of 0.22 longitude degrees. The study consists of a series of 15-year long simulations, covering the period 1991–2005 and performed using different physical parameterizations. The CORDEX Central Asia domain is one of the largest domains of the CORDEX action, including almost the entire continental Asia and presenting particularly heterogenoeus climatological conditions. For this reason, it offers a unique opportunity for the study of model sensitivity, allowing to deduce important insights on climate mechanisms and model uncertainties. Results suggest that, for the area, parameters related to the treatment of albedo and soil processes have the largest effects on a set of near surface variables such as temperature and precipitation and can sensibly improve model results when compared to observations.

Floods in small and medium sized catchments in the Eastern Alps simulated by RCMs from the hydrostatic to the convection-permitting scale

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Small scale floods are a consequence of high precipitation rates in small areas that can occur along frontal activity and convective storms. In the extended Basin of Graz, located in the south-eastern part of the Alps, frequent small scale thunderstorms are leading to heterogeneous rainfall distributions that are causing very local flash flood events. Since the last years, the hydrological model KAMPUS is being operationally used to forecast the development of flood events in this region. In this work, we integrate KAMPUS into a climate modelling framework that consists of multiple long-term (1989 to 2010) ERA-Interim based hindcasts with CCLM and WRF operated with 50 km, 12.5 km, and 3 km grid spacing. Comparisons between modelled and observed flood events in a variety of catchments (ranging from 75 km^2 to 1103 km^2) provide detailed insights in RCM error characteristics (and their dependency from grid spacing) and the effects of a recently developed bias correction technique (Scale Distribution Mapping; SDM). This allows the formulation of requirements for both, RCMs and bias correction, when climate change effects on flood events shall be investigated by means of this modelling framework. The study was funded by the Austrian Climate Research Programme (ACRP, proj.id KR13AC6K11102 – CHC-FloodS) by the Austrian Climate and Energy Funds (KLI:EN).

Convection resolving climate simulations

Comparison of 2.8 and 12 km CCLM simulations for Germany

Susanne Brienen, Susanne Brienen, Michael Haller, Barbara Früh
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In the context of the German research project "Network of Experts - Adapting transport and infrastructure to climate change and extreme weather events", we ran simulations with the COSMO-CLM at 2.8 km for the time period 1971–2100. The focus of the project is the provision of high-resolution climate information in order to make the national transport infrastructure resilient to extreme weather and climate change. Temperature, precipitation and wind are key parameters. The COSMO-CLM simulations at convection-resolving resolution (2.8 km) were nested in 12 km EURO-CORDEX runs with COSMO-CLM driven by ERA40/ERA-Interim and MIROC5 (RCP8.5 scenario). We would like to present here a first analysis of these high-resolution simulations with a focus on the added value compared to the forcing simulations at lower resolution. The analysis is conducted over Germany and we use the HYRAS observational data sets, which are further developed in another part of the project, for evaluation. In another contribution, Michael Haller shows the statistical downscaling part of the research, which is intended to enhance the ensemble size in order to be able to quantify also uncertainties.

On the application of statistical downscaling for a convection-permitting climate projection ensemble for Germany

Michael Haller, S. Krähenmann, S. Brienen, B. Früh
Deutscher Wetterdienst

The knowledge about frequencies and intensities of extreme events, triggered by climate change is one of the key issues in the project “Network of experts - Adapting transport infrastructure to climate change and extreme weather events”, launched in 2016 by the German Federal Ministry of Transport and Digital Infrastructure. The vulnerability of traffic infrastructure has many different factors. One of these factors is the weather and climate impact. For the assessment of the vulnerability and possible adaptation strategies for transport infrastructure on a local scale, climate information is needed on the same scale. Thus, we perform high-resolution climate projections with COSMO-CLM on 2.8 km grid width for time periods of more than 30 years using the RCP 8.5 scenario, dynamically downscaled two-fold from MIROC5 global model data. In order to estimate the robustness of our climate projections we aim at developing a convection-permitting climate multi-model ensemble using a combination of statistical and dynamical downscaling. Thus, we apply a statistical downscaling technique for EURO-CORDEX ensemble members by linking high-resolution dynamical simulation at 2.8 km grid width to the simulations at 12 km grid width. For this procedure we use the principal component analysis (PCA) method. It has been tested for a 30 year period of climate projections driven with MIROC5. Results of the tests will be shown as well as a description of the method itself.

A multi-model evaluation and climate projection of extreme precipitation for Belgium. A micro-ensemble based on three convective-permitting models

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[1]KU Leuven, Belgium; [2]Ghent University, Belgium; [3]Royal Meteorological Institute of Belgium

A first multi-model evaluation and climate projection of summer extreme precipitation is presented for Belgium for the end of this century based on three convective-permitting models from the CORDEX.be project (http://www.euro-cordex.be/. It was found that the present-day extreme precipitation distributions were captured much better at convective-permitting scale, which can be attributed to the shift from parameterized to explicitly resolved convection. The ensemble of future climate projections showed a robust trend and revealed that at convective-permitting scale the number of hourly summer extreme precipitation events is expected to increase. It was found that the climate change signal mainly depends on three factors: the climate model, the region, and the precipitation intensity. This study further shows that the sensitivity of the climate change signal for hourly extreme precipitation depends both on the scale and on the topography.

Clouds in decade-long convection-resolving climate simulations over Europe

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Although crucial for climate, clouds are poorly represented in current models which operate at too coarse grid resolutions and rely on parameterizations. Advances in high performance computing and the use of a COSMO model version running entirely on GPUs allows performing kilometer-scale convection-resolving climate simulations with finer representation of topography and cloud processes, and without parametrization for convection, known as major source of uncertainties. We present a study based on decade-long convection-resolving climate simulations at 2.2 km horizontal grid resolution over a domain with 1536x1536x60 grid points covering Europe. Simulations driven by ERA-interim reanalysis show that biases in the mean summertime cloudiness and in the top-of-the-atmosphere radiation budget are reduced when convection is resolved compared to simulations at 12 km resolution. Especially, the typically underestimated mid-tropospheric cloud layer is enhanced, thanks to stronger mixing. Future climate simulations conducted using Pseudo-Global Warming experiments for an RCP8.5 scenario show reductions in low- and mid-tropospheric cloud cover fractions over mid-Europe. As unraveled by analyzing cloud profiles, these changes are due to an upward shift of clouds in the convection-resolving approach, whereas reductions of the cloud liquid water are dominating when convection is parameterized. The resulting surplus of incoming solar radiation indicates a positive cloud feedback.

Mountain Volume Control on Deep-Convective Rain Amount

Adel Imamovic, Linda Schlemmer, Christoph Schär
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Thermally driven upslope flows at mountains provide favorable conditions for ubiquitous summertime deep moist convection in mountainous areas. The present study investigates the response of deep convection to different length and height scales of orography using ensembles of idealized convection-resolving simulations with full physics parameterizations. In order to cover a wide range of scales we run simulations with height scales between 250 m and 1500 m and width scales between 5 km and 30 km. While we find a strong impact of mountain slope on upslope wind speed, deep convective timing, vigor and rain intensity, the rain amount over the mountain scales nearly linearly with the mountain volume. Tests with alternative mountain geometries and large scale flow suggest that the linear scaling holds over a surprisingly large portion of the parameter space: the scaling does not depend on the details of the mountain geometry or even the presence of multiple small scale peaks. For mountains of up to 750 m in height, the linear scaling even prevails if large-scale flow is present. For taller mountains the mountaintop heat anomaly is substantially vented away and the rain amount is reduced. The existence of the simple volume scaling over such a wide range of configurations suggests that deep-convective rain amount in many mountainous areas is disproportionally dominated by the large horizontal scales of orography.

Towards advances in modelling of heavy precipitation by the synergetic use of convection-permitting simulations and state-of-the-art observations

Samiro Khodayar, Alberto Caldas-Alvarez, Sebastian Helgert, Johannes Hoerner

Karlsruhe Institute of Technology (KIT)

As a result of global warming, the type, frequency and intensity of extreme events are expected to rise. The physical impacts of the climate change will result in an increased number of fatal consequences. These changes will be more drastic in certain areas of the globe such as the Mediterranean regions. The scientific community thus faces a challenging task answering the question: Where, when and how intensely weather and climatic extremes will occur? The capability to predict such dramatic events is still a great challenge. Despite the significant progress made during recent years, many uncertainties remain. In this study, the synergy of state-of-the-art observations and high-resolution convection-permitting model simulations is used to explore the sensitivity of heavy precipitation to soil moisture conditions and atmospheric water vapour evolution. Several numerical experiments have been designed across scales and resolution to assess, (a) the relevance of soil conditions for the occurrence of extreme precipitation, (b) the impact of soil moisture initialization making use of high-resolution satellite-derived surface soil moisture observations, and (c) the relevance of an accurate representation of atmospheric water vapour distribution and evolution through assimilation of a state-of-the-art GPS-derived Integrated Water Vapour data set and radiosounding profile information. A local-to-regional approach and a process-understanding methodology are applied.

Temperature and Precipitation extremes in a very high resolution (0.025°) climate projection ensemble for Southern Germany

Natalie Laube, Gerd Schädler, Hans-Jürgen Panitz, Joaquim G. Pinto
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Previous studies have indicated heterogeneous climate change signals for areas characterized by complex topography. In order to obtain more reliable and robust projections on a high spatial scale, an ensemble of COSMO-CLM (CCLM) climate simulations was generated with a final resolution of 0.025° (about 2.8 km) and including three global climate models as forcing (used in the CORDEX initiative). One control (1971–2000) and two future periods based on the RCP 8.5 emission scenario are considered, one for the Near Future (NF, 2021–2050) and one for the Distant Future (DF, 2071–2100). To evaluate the CCLM simulations for the control period, the model results are compared to Eobs V14 [Haylock et al. 2008] and HYRAS observations [Rauthe et al. 2013]. Comparing the second nesting step (7 km) to the third (2.8 km) an added value of the higher resolution was identified for several variables. An overall cold and wet bias was found (with minor exceptions). With skill scores, the reliability of the ensemble was tested. Also, the characteristics of heat waves (HW) were investigated. Their climate change signal not only includes a strong increase of the HW temperatures (up to 5 °C in the DF), but also higher numbers on HWs per year with longer durations. The mean precipitation decreases slightly in both future periods, while for extreme precipitation events large spatial variations are identified.

Synoptic-scale conditions and convection-permitting hindcast experiments of a cold-season derecho on 3 January 2014 in Western Europe

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A major linear mesoscale convective system caused severe wind gusts in parts of Western Europe on 3 January 2014 and it can be classified as a cold-season derecho. While such derechos occasionally develop along the cold front of an extra-tropical cyclone, the investigated system formed in a postfrontal air mass along a baroclinic surface trough and profited from strong large-scale forcing for ascent. Additionally, the lower troposphere was characterized by weak latent instability and very strong vertical wind shear. Given the poor operational forecast of the storm, we analyse the role of the initial conditions to the development of the storm with a modelling approach. With this aim, convection-permitting simulations are performed with different datasets for initial and boundary conditions. While the storm is well reproduced with ERA5 reanalysis initial and boundary conditions, this is only partially the case with ERA-Interim reanalysis and not the case with the operational ECMWF analysis. Therefore, we conclude that this storm was predictable given the correct initial and boundary conditions. Moreover, very high model resolution (1.1-km grid spacing) enables a better representation of the observed derecho intensity. Thus, this case study indicates that convection-permitting ensemble simulations might be important to overcome the current shortcomings of forecasting cold-season convective storms, particularly for cases not associated with a cold front.

Bulk and structural convergence at convection-resolving scales in simulations of summertime moist convection in the light of model uncertainty

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Convection-resolving models are established as a solid framework to simulate moist convection in both numerical weather prediction and regional-scale climate projections. However, the truncation of the continuous energy cascade at scales of O(1 km) poses a challenge, as in kilometer-scale simulations the size and properties of the simulated convective cells are often determined by the horizontal grid spacing (Δx). This study investigates both the bulk convergence of the mean diurnal cycle and spatial distribution of precipitation, clouds and convective transport of mass, heat and water vapor, and structural convergence of statistics and scales of individual convective cells in idealized and real-case simulations of summertime moist convection over land at Δx ranging from 8.8 km to 500 m. Bulk convergence is discussed in the light of model uncertainty. Results reveal that bulk convergence is generally attained in idealized simulations. In real-case simulations the resolution sensitivity of bulk quantities generally decreases at smaller Δx over mountainous terrain. However, it is impracticable to assess whether bulk convergence is in fact achieved or not, since the resolution sensitivity is comparable with the model uncertainty. Structural convergence is not yet fully achieved at the kilometer scale, despite the evidence that the probability density functions of convective mass flux are insensitive to further refinements of the mesh grid beyond $\Delta x = 1.1$ km.

Evaluation of convective cell characteristics in COSMO-CLM

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So far few studies have investigated sub-hourly precipitation dynamics of convection permitting climate models despite the fact that convective cells typically have a life time of less than an hour. To tackle this issue, we apply a tracking algorithm to precipitation data from radar observations and from a regional climate model (COSMO-CLM) that have a temporal resolution of 5 min. This approach allows for the individual selection of convective cells and the monitoring of their development in time. The evaluation period covers the time from 2001 to 2016. We simulate single days within this period that are characterized by high convective activity using COSMO-CLM in a convection permitting setup (1 km grid spacing) over the domain of South-Western Germany. We evaluate statistics of heavy rain cell characteristics like maximum precipitation intensity, area and life time of convective cells. We show that COSMO-CLM can reproduce the observed frequency distributions of these quantities. We also investigate spatial patterns of convective activity in order to detect orographic effects. Furthermore, we investigate the degree of organization of the convective cells and relate it to surface temperature in order to investigate a potential Clausius-Clapeyron scaling of cell characteristics.

Simulations of radiative-convective equilibrium (RCE) using COSMO-CLM

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Radiative-convective equilibrium (RCE) is the statistical equilibrium that the atmosphere and surface reaches in the absence of lateral energy transport. It is determined by a balance between net radiative cooling and convective latent heating. It can be understood as an idealization of the tropical atmosphere. RCE has regained great attention recently, as spontaneous self-aggregation of convective clouds in simulations of RCE have been reported. This self-aggregation is of critical importance for the climate system, as in contrast to an atmosphere with randomly distributed deep-convective clouds, an atmosphere with aggregated clouds shows much more efficient longwave radiative cooling. Here we present idealized RCE simulations above a two-dimensional mixed-layer ocean using COSMO-CLM. First, the modifications necessary to the radiation code and the inclusion of a mixed-layer ocean are detailed. Second, simulations of RCE at sea-surface temperatures between 292.5 K and 307.5 K are presented. Hereby, the resulting equilibrium state and the emerging aggregation of clouds is discussed. Finally, the response of precipitation and convective mass flux to temperature is assessed. This is done both for simulations with explicitly simulated convection and also for simulations where convection is parameterized.

The COSMO-CLM contribution to ELVIC CORDEX-FPS

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Weather hazards in East Africa have a large impact on local societies. As extreme precipitation events frequently lead to urban flooding in African cities, they favor the spread of vector-borne diseases such as malaria. Moreover, every year, possibly more than 5000 fishermen lose their lives over Lake Victoria alone, mostly due to hazardous weather conditions. Yet several deficiencies remain in modeling and understanding the extremes. First, the diurnal cycle of extreme precipitation is badly represented in coarse resolution models. Secondly, complex orography and inland lakes induce strong mesoscale circulations that are not captured. Hence the need to enhance the understanding of the local climate. The ELVIC 'climate Extremes in the Lake VICtoria region' project, a CORDEX-FPS initiative, aims to provide an answer to this need. Present-day simulations and future projections are planned with different regional climate models, but the same resolution of 2.8 km. Such convection permitting simulations showed added value over European regions. Hence they are promising for this convectively active region. Here we present the CCLM contribution to ELVIC. The analysis of the high resolution simulations includes the extreme precipitation, mesoscale circulation and temperature patterns. The ultimate goal is to improve the understanding of the regional climate in the lake Victoria region and to provide a reliable member to the next-generation ensemble of climate simulations.

Dynamics and Numerics

COSMO 5 with non-dissipative dynamics and Two-Way Coupling: model development and its relevance at 0.11 grid resolution over Europe

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Recently, the new full 4th order and energy conserving horizontal discretisation scheme (S4p4) and the Two-Way Coupling (TWC) with MPIESM via OASIS3-MCT have been implemented in COSMO_5 and MPIESM. The scheme S4p4 allows long time simulation without any numerical horizontal diffusion (d0.00). As shown by Ogaja and Will (2016) this increases the effective model resolution by approximately a factor of two and enhances the dynamics in the atmospheric boundary layer. TWC reduces the boundary effect of downscaling. A combination of both developments has the potential to reduce two fundamental error sources in limited area modelling. We present the new model version cosmo_5_HOS-TWC and first results of the comparison between the reference simulation over Europe at 0.11 resolution with COSMO_5 (CEU11) using the reference dynamics C3p2 (upwind 3rd order and 2nd order fast waves /pressure solver), the Two-Way Coupled simulation (CEU11-TWC), the symmetric scheme simulation (CEU11-HOS) and the simulation (CEU11-TWC-HOS) combining both developments.

Evaluation

Reproducibility of regional climate simulations

Beate Geyer, Andrew Ferrone
Helmholtz-Zentrum Geesthacht

The reproducibility of our regional climate simulations with the COSMO-CLM across Europe is being investigated. The COPAT parameter test simulations for 1980–2000 with ERAinterim forcing were performed on various supercomputers to determine optimal parameter settings. In order to be able to estimate the influence of namelist parameter changes compared to technical deviations due to the use of different computer platforms and compilers, simulations with the same setup were performed on the computers of ETHZ, DWD, LRZ, KUL, LIST, CIRA, DKRZ-blizzard and DKRZ-mistral. The results of the platform dependency for the variables temperature, minimum temperature, maximum temperature at 2m altitude, precipitation, pressure at sea level, cloud coverage are presented. To classify the results found, the deviations from 6 realizations of this simulation on a single computer (ETHZ) with temporally offset initial conditions are determined. In addition to the technical reproducibility, the reproducibility of the findings is analysed, which is questioned by various underlying truths, the observation data. For this, the deviations found are related to the variability in the eObs data. When the first 7 simulations were performed in 2015, the eObs version 10.0 dataset was up-to-date and used as a measure, while a current assessment of the tested parameters would presuppose version 17.0 data as optimal. The differences between the 8 versions are discussed.

What can we learn from MSG?

Ronny Petrik, Beate Geyer, Burkhardt Rockel
Helmholtz-Zentrum Geesthacht

During the last years more and more observational datasets arise on the market using the data retrievals of the MSG-satellites. The bunch of products range from surface radiation (SARAH2) over radiation budget at TOA (MVIRI-SEVIRI) to cloud-related properties (CLAAS2) as well as parts of the TRY dataset. Such data have the potential to allow for insights into model's physical drawbacks. However, the data have to be treated with care. It is discussed how to prepare model output or online diagnosis in such a way that a proper evaluation can be done. Therefor, we also shortly address the data retrieval of relevant products of MSG and the associated shortcoming and limitations. The aforementioned data products are used to investigate the performance of most recent regional hindcasts on medium scale (6–12 km) and convective-permitting scale (2.8 km). In the presentation it is shown how well satellite-based radiation fits to ground-based measurements. The models are analyzed for their performance in correctly depicting the radiative daily cycle, which tends to be sensitive to tuning. Furthermore, the relationship between integrated radiation and the occurrence of clouds is investigated for the models and observations. It turns out that the quality of the simulated spatial fields and timeseries highly depends on the resolution and the level of assimilation. Finally, we add to our discussion global reanalysis data to put the regional simulations into context.

Performance evaluation of convection-permitting model CCLM with TERRA-URB parametrization to reproduce the heat waves of 2003 in Europe

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In the frame of the CORDEX project, the FPS-CPS (Flagship Pilot Studies – Convection Permitting Scales) aims to investigate convective-scale events, their processes and their changes in a few key regions of Europe and the Mediterranean, using convection-permitting Regional Climate Models. For this purpose, CMCC is carrying out a simulation with CCLM including TERRA-URB parametrization. This is a bulk parameterization scheme including prescribed Anthropogenic Heat Flux and Impervious Surface Area datasets, offering intrinsic representation of the urban physics with modifications of input data, soil module and land atmospheric interactions. According to the FPS protocol, the mandatory domain is centered on the Alpine region, at very high resolution of 0.0275° (3 km), adopting a nesting strategy based on EURO-CORDEX simulations with CCLM at 0.11° (12 km) . The evaluation experiment ranges in the period from 1999 to 2011. The goal of this study is to evaluate the performance of the CCLM with urban module in capturing the exceptionally long and severe summer heat waves of 2003 over Europe. These phenomena were responsible for a dramatic excess mortality: certainly more than 50 000 excess deaths for Europe in August 2003. This analysis focuses on the main urban areas of northern Italy to evaluate the impacts of the physical model (TERRA-URB) on the urban environment that represents a crucial challenge area in the evolution of climate.

ICON (project group)

Regional climate modelling with ICON

Vera Maurer, Christian Steger, Barbara Früh
Deutscher Wetterdienst

Within the project CMIP6-DICAD, we are exploring new pathways of regional climate modelling. The ICON-model provides a completely new infrastructure with the possibility for configurations with two-way nesting of model domains. For numerical weather prediction, ICON is running operationally at DWD in such a configuration with a global domain of a grid-point distance of about 13 km and a subdomain for Europe of about 6 km. However, the earth-system model configuration of ICON (ICON-ESM) uses different physics packages for the atmospheric part than the operational ICON-NWP. The atmospheric physics packages of ICON-ESM were adopted from ECHAM, which is the atmospheric part of MPI-ESM used for the production of climate projections within CMIP6-DICAD. The two-way nesting has not yet been fully implemented into the atmospheric part of ICON-ESM. We completed this and can use now the atmospheric part of the ICON-ESM for climate simulations with a simultaneous running global climate model and one or more regional subdomains. The new model version together with a running example will also be made available for other ICON users. In this presentation, we will outline advantages as well as drawbacks of such a model configuration for climate simulations and present first simulations with a regional CORDEX-domain.

Status of ICON-CLM development

Christian Steger, Trang Van Pham, Barbara Früh
Deutscher Wetterdienst

On the 20th of January 2015 ICON replaced GME as operational model for weather forecast at DWD and in December 2016 a domain with grid refinement for Europe (ICON-EU-Nest) within the global ICON replaced COSMO-EU for high-resolution forecasts on the European domain. In the second half of 2020 the Limited-Area-Mode of ICON (ICON-LAM) will replace the high resolution COSMO for the German domain and DWD will stop the operational use of the COSMO model after 15 years. In order to have a state of the art tool for climate applications for the upcoming years, the CLM-Community wants to adapt ICON-LAM for regional climate applications. DWD started the development of ICON-CLM (ICON Climate Limited area Mode) in the project ProWas (Projection Service for Waterways and Shipping) – a joint pilot program of several German Federal Agencies – to prepare a regular federal forecasting and projection service about the influence of climate change on coastal and waterway traffic. Here, we show results from a first test simulation of ICON-CLM and present the current status of the development as well as the future plans.

Soil and Vegetation

Urban climate modelling using Local Climate Zones and COSMO – TERRA_URB over a tropical city. The case of Kampala, Uganda

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Kampala, Uganda is one of the most populated cities in Subsaharan Africa. Yet, one major challenge for modelling its impact relies in the poor data availability for parameterization and evaluation of urban canopy model simulations. Thus, this study first makes use of the Local Climate Zones scheme (LCZ; Stewart and Oke, 2012) to extract physical and morphological parameters following the WUDAPT framework (Ching et al; 2018). Applying techniques of previous studies (Brousse et al., 2016; Wouters et al., 2016; Hammerberg et al., 2018), the derived urban canopy parameters are extracted and fed into the urban canopy model TERRA-URB, embedded in the COSMO-CLM model. It was considered the best candidate for modelling scarcely documented areas due to its simple representation of three-dimensional urban physics impact on the climate (Brousse et al., 2018; Wouters et al., 2016, 2017). Then, an evaluation is performed for 10 extreme clear sky days defined within an 11-year period (2005–2015) by comparing modelled outputs to earth observation datasets from MODIS and Landsat 8 in terms of land surface temperature and surface urban heat island intensity (SUHI). Finally, a detailed analysis of the modelled urban impact on air temperature, air humidity and wind regimes (lake – land breezes) in a tropical environment is performed. The simulation setup consists of a one-way nesting over two nested domains (12 km and 1 km) forced by the ERA-Interim reanalysis dataset.

The biogeophysical role of European forests: First results from the LUCAS FPS multi-model ensemble

Edouard Davin and the LUCAS team
ETH Zürich

The Land Use and Climate Across Scales (LUCAS) FPS is a coordinated effort to better integrate Land Use and Land Cover Change (LULCC) forcings in regional climate change projections. In the first phase of the project, idealized experiments over Europe have been performed in order to benchmark the RCMs' sensitivity to extreme LULCC. Namely, two experiments (FOREST and GRASS) have been performed with a set of 9 different RCMs. The FOREST experiment represents a maximally forested Europe, while in the GRASS experiment trees are entirely replaced by grassland. Comparing FOREST and GRASS therefore illustrates the theoretical effect of a full deforestation over Europe. We find a large inter-model spread in the simulated climate response to deforestation. A large part of this spread is attributed to the representation of land processes rather than atmospheric feedbacks. Indeed models sharing the same Land Surface Model (LSM) exhibit more similarity in their response compared to models sharing the same atmospheric model but different LSMs. We also find that, in winter, most of the inter-model spread can be explained by the magnitude of albedo change. In summer, model disagreement can be mostly linked to evaporative fraction. Based on these results, we will finally discuss the implications and prospect for the next phases of LUCAS.

Impact of soil moisture initialization on the convection-permitting COSMO representation of heavy precipitation over the Iberian Peninsula

Sebastian Helgert, Samiro Khodayar
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Soil moisture(SM) has a long memory in forcing atmospheric processes and therefore acts at both weather and climate timescales. Missing knowledge about the initial status of SM in weather and climate models has been identified as a source of uncertainty in the prediction of extreme events. A novel satellite-derived SMOS 1km-SM downscaled product(SMOS-L4) offers great opportunities for realistic model initialization in convection-permitting resolution. Our aim is to prove the potential of high-resolution SMOS initialization for the improvement of the model representation of heavy precipitation events in convection-permitting resolutions. We have developed an initialization strategy for the model implementation of SMOS data. First, we select the SMOS-L4 swath product, which has shown the best agreement with three available in situ SM networks. Then, we correct the bias between SMOS and the model by applying a CDF-matching technique and we estimate the root-zone soil moisture using an exponential filter method. The obtained SM profile product shows very good agreement with observations. Verification with the SAL method exhibited an improvement in amplitude and location of precipitation simulations after realistic initialization with SMOS-L4. The SMOS initialization simulations reveal a modification of wind circulation, moisture stratification and advection. These lead to additional triggering mechanisms which improve the simulation of precipitation compared to control simulation.

High Resolution Urban Climate Modelling

Johann Züger
Austrian Institute of Technology, Austria

Regional Climate Models usually work at resolutions of app. 10 km. This is insufficient for addressing the micro-scale effects generated in urban environments. For that reason high resolution model runs based on results from the project reclip:century were carried out at the Austrian Institute of Technology. This was achieved with 4 nesting steps at 50 km, 10 km, 4 km, and 1 km horizontal resolution. The first 3 runs were performed with the standard Regional Climate Model COSMO-CLM (cosmo_4.8_19), for the 1km run special urban extensions provided by Hendrik Wouters were applied. Therefor two additional input fields are needed: the urban fraction (URBAN) and annual-averaged anthropogenic heat (AHF, AHE). The high resolution model domain represents a 100x100 km^2 square of the Greater Vienna Region. The model was evaluated by 13 measurement stations in and around Vienna using ERA40/ERAInterim forcing data from 1960 to 2015. Model runs for the future climate are based on data from the Global Climate Model HadCM3 using the IPCC SRES scenario A1B. Although the Regional Climate Model Cosmo-CLM has a distinct cold bias the temperature profiles are significantly enhanced and very close to measurements. Compared to the 4 km run results show a gain in accuracy especially in representing urban heat island effects. Further on a few sensitivity tests have been carried out using different anthropogenic heat emission sources and changing the soil sealing in very dens populated areas.

Support and Technical Issues

Namelist driven, tailor-made on-line diagnostic and output control for COSMO-CLM using the Modular Earth Submodel System (MESSy)

Astrid Kerkweg[1], Mariano Mertens[2], Patrick Jöckel[2] and Christiane Hofmann[1]
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Long-term and/or high resolution simulations with geoscientific models become more and more limited by storage space. Therefore, on-line diagnostic tools calculating the target variables directly during the model simulation become increasingly important. The CLM working groups SUPTECH and CLM-CO realized this need as well. One option is to use COSMO-CLM/MESSy which was developed within the CLM-community expanding COSMO-CLM by a huge range of on-line diagnostic tools, e.g. (1) simple statistics w.r.t. time, such as monthly mean, standard deviation, minimum, maximum or event counting, (2) the output on distinct surfaces (e.g., pressure levels, PV iso-surfaces), (3) output of data along sun-synchronous satellite orbits or radiosonde tracks, (4) the renaming of variables, as e.g. required by the CMOR standard, (5) redirection of a set of variables into specific output files, etc., (6) diagnostics for tracers (e.g. hydrological variables). Due to the modular MESSy infrastructure, additional tailormade on-line diagnostics can be integrated into the model without modifying the COSMO-CLM code itself. At the ICCARUS meeting 2018, it was decided by the working groups SUPTECH and CLM-CO that, in addition to the official COSMO-CLM release, a version of COSMO-CLM/MESSy will be provided to the CLM-community members. In our presentation we will provide a general overview of the features of the namelist driven diagnostic capabilities of COSMO-CLM/MESSy.

News from COSMO and ICON

Daniel Rieger, Ulrich Schättler, Günther Zängl
Deutscher Wetterdienst

The presentation will provide a broad overview on the most important changes, development and research activities with the COSMO and ICON community. A particular focus is set on new developments and code changes in the COSMO model and int2lm. Furthermore, development and research activities in the scope of COSMO priority projects and priority tasks are summarized. With the new priority project C2I (Transition of COSMO to ICON) experience with the new ICON model in its limited area mode (ICON-LAM) will be gathered jointly by COSMO and CLM members. A brief outline of the scope of the priority project and recent developments in ICON will be presented.

COSMO-CLM on its way to the next reunification

Burkhardt Rockel
Helmholtz-Zentrum Geesthacht

The COSMO-CLM and INT2LM versions have not been changed for quite a while. The recommended versions are COSMO_131108_5.00_clm10 (at the assembly in Graz 2017 it was COSMO_131108_5.00_clm9) and int-2lm2.0_131101_clm4 (same as it was in September 2017 and 2016), respectively. On the other hand there are major efforts in the COSMO consortium in developing COSMO model version 5.x and INT2LM 2.x. The COSMO model 5.x versions are intermediate steps to the next unified version 6.0. The roadmap as is was in September 2017 had a milestone for version 6.0 in September 2018. Unfortunately this deadline cannot be kept. In this presentation the status of COSMO-CLM and INT2LM and the latest roadmap will be presented.

Post-processing tools for generating project compliant climate model output

Fabian Wachsmann, Martin Schupfner, Stephanie Legutke
Deutsches Klimarechenzentrum

Projects like CORDEX define data standards in order to facilitate data analysis across results from different models. Since the format of raw climate model output may violate the requested standard, post-processing is often needed to convert it into the standard format. The German Federal Ministry of Education and Research (BMBF) supports the German modeling groups in the production of quality-assured standard-compliant CMIP6/CORDEX data. As one activity, the DKRZ supplies the modeling groups with a web GUI including five tools for the generation of post-processing components. 1. A custom data request (DReq) generator and a 2. volume estimator based on Martin Juckes' DreqPy API. 3. The user may specify how to convert raw data variables into target variables of the DReq including diagnostic algorithms in a data base called mapping table. 4. Two Post-processing script fragments built from the mapping table content are provided. The script fragments apply the CDO tool kit developed at the Max-Planck-Institut for Meteorology. The rewriting part uses the cmor operator recently developed at DKRZ and based on the CMOR libraries (Climate Model Output Rewriter). 5. A meta data table needed for the cmor operator can be created with the help of a Web GUI based on the project controlled vocabulary (CV).

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