Climate Limited-area Modelling Community

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Newsletter

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Content

See YOU at the

Assembly 2020

14 – 18 September 2020

Virtual Meeting

Announcement:

ICCARUS 2021

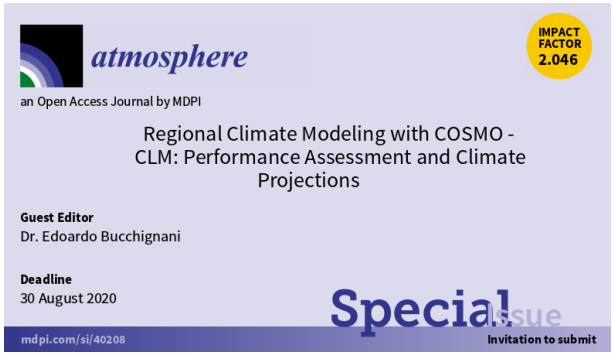
15 – 19 March 2021

Offenbach, Germany

Dear colleagues,

Welcome to the 15th CLM-Community Newsletter. We hope you and your families are fine and you are doing well in these difficult times.

This issue starts with an advertisement for the special issue "Regional Climate Modeling with COSMO-CLM: Performance Assessment and Climate Projections" in Atmosphere organized by our colleague Edoardo Bucchignani (CMCC), for which contributions are still welcome.



COSMO-CLM has been used for simulations on time scales up to centuries and spatial resolutions between 1 and 50 km. In the last ten years, it was used for downscaling for many regions of the world and for many of the global climate simulations available, in particular in the framework of the various CORDEX activities, in order to provide a core set of comprehensive and homogeneous projections across almost all CORDEX domains. COSMO-CLM is an important dynamical downscaling tool for providing the information needed for assessing climate change impacts, and a powerful model for improving our understanding of regional climate processes.

The main aim of the Special Issue is to summarize the recent progress achieved with COSMO-CLM. The following four important segments should be at least included:

- Investigation of the capabilities of COSMO-CLM at very high resolution (convection resolving) to describe the mesoscale features of climate in a recent-past period for selected areas.

- Assessment of the effects of increasing resolution on the quality of results. Such an analysis could be useful to stimulate in the future the scientific community to consider that, at least in some areas, high-resolution simulations could provide good earnings.
- Climate projections over targeted regions by employing the IPCC RCP scenarios, widening the range of projections already available in the literature but with higher resolution.
- Assessment of the model's ability to (realistically) represent the extreme weather events in the present climate as a preliminary and fundamental step to assess changes regarding extreme weather events expected under anthropogenic climate change.

If you are interested in contributing to the special issues or if you are looking for further information, please visit the following webpage: https://www.mdpi.com/journal/atmosphere/special_issues/climate_modeling_cosmo_clm

Furthermore, this issue includes more interesting information on recent activities of the CLM-Community members and again two research notes: one on sub-hourly rainfall in convection-permitting simulations and one on emissions of ozone investigated with the MECO(n) system. Enjoy reading!

Yours sincerely,

Christian Steger, Susanne Brienen and Anja Thomas

Five questions to …
Ingo Kirchner
Freie Universität Berlin

Photo by I. Kirchner

Ingo Kirchner is a senior scientist at the Freie Universität Berlin. He studied Meteorology at the Humboldt University of Berlin in the 1980ies and started working as forecaster. In 1990 he moved to the Max Planck-Institute for Meteorology (MPI-M) in Hamburg and received a PhD degree from the University of Hamburg in 1994. During his PostDoc time at MPI-M he was in the developer team of ECHAM. In 2003 he returned to Berlin and started teaching in software and model applications at the Institute of Meteorology.

1. ***Ingo, you work at the Institute of Meteorology at Freie Universität Berlin. Can you please tell us something about the institute and your tasks there?***

Freie Universität Berlin has been identified as one of Germany's "Universities of Excellence" by the national excellence board, with its focus on international networking. The Institute for Meteorology is an internationally renowned research and teaching facility, focusing in its research on the evaluation of observational data and output from global and regional models for the understanding of key weather and climate processes at a range of temporal and spatial scales. As scientist in the group of Prof. Stephan Pfahl I am involved in different scientific projects of the institute, responsible for the information technology tasks, coordination of our institutional IT infrastructure, organizing the scientific data management and train the students in model applications and software development. As a qualified meteorologist my scientific focus is directed in a better understanding of weather and climate processes. Together with my students, we are applying models from global to regional and from simple to complex in the VAST laboratory, https://vast.klimod.de, one of my e-learning projects.

2. ***You are a long-term member of the CLM-Community. What are, in your opinion the strengths and the weaknesses of the CLM-Community?***

The community, as a platform for sharing ideas and build up smaller groups, which are working in the same

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direction and find together the best way to achieve a goal, has a lot of potential. This can be very successful. The organization of such processes can be motivational, but too much borderlines, rules or bureaucracy can slow down the progress. I see a potential for more efficiency, but it is also a learning process with all involved persons. The clear and realistic definition of the objectives can help to form a small leading team, which represents the main vision of the community. This makes it easier for the members to be an active part or leave. Every member should him-/herself identify with the vision and then the chance to become an active member is higher. The community should be open for changes and our best students have to be motivated for a career in the field of model application and development.

3. In which context do you use COSMO-CLM?

In the exercises of our master courses in climate modelling, the regional model is a topic during the summer term. The students work on own sensitivity studies, setup the experiments, execute the model, analyze the results and discuss the outcome of the experiments. They cannot do all the tasks of a model developer, therefore they work with our web based e-learning environment VAST.

4. You are one of the ICON-CLM gatekeepers and also involved in the development process of ICON-CLM. Please tell us something about these tasks.

Well, the gatekeeper has a lot of responsibility for a stable and up-to-date codebase. It is a good possibility for me, to transfer my experiences in software engineering and model development into the development of the ICON model system. For me it's also an intensive learning process about how the technical implementation has changed since the 1990ies, as I started in climate modelling with ECHAM on a CRAY-2 in Hamburg.

5. The next CLM-Community Assembly will be hosted by Freie Universtität Berlin and you are the main organizer (Thank you very much!). Can you please give us some insights in the organization process?

Besides the global problems with the human healths we will welcome the CLM-Community in September in Berlin. Together with the Berlin members of the community I will make the assembly as best as possible.*

* The interview was done before the decision was taken that the Assembly 2020 will be organized as virtual meeting.

Thank you very much for the interview!

IPCC activities

IPCC: outline of the Synthesis Report of the 6th Assessment Report approved

by Andrew Ferrone, Ministry of Agriculture, Viticulture and rural Development
Administration of agricultural technical services
Meteorological service
Luxembourg

The IPCC met from 24-28 February 2020 In Paris for its 52nd session. One of the main outcomes of the session was an agreed outline of the 6th Assessment Report's (AR6) Synthesis Report (SYR), which will be the last product of the AR6 to be published probably in June-September 2022 (see below).

The outline gives the authors the mandate to produce a rather short and well understandable SYR that contains a stage-setting introduction and three sections: Current Status and Trends, Long-term Climate and Development Futures and Near-term Responses in a Changing Climate. Each section is accompanied by a series of indicative bullet points and by a note capturing the Panel discussions for additional consideration by the SYR authors (see Annex 1, p. 25 of https://www.ipcc.ch/site/assets/uploads/2019/12/IPCC-52_decisions-adopted-by-the-Panel.pdf)

The Panel furthermore agreed to progress its work on the regular Review Principles Governing IPCC Work at the next session based on recommendations from the Bureau. Issues to be addressed will include the process for establishing reports as well as governance and management issues. This offers some possibility for ensuring a more efficient transition to the IPCC 7th cycle, possible allowing for ensuring the availability of the IPCC products with the 2nd Global Stocktake under the Paris Agreement.

The Panel also agreed on the IPCC Gender Policy and Implementation Plan, which establishes a Gender Action Team to oversee and monitor implementation of the plan and develop and implement a process for addressing complaints.

Impact of COVID-19 crisis on IPCC 6th Assessment Report:

Following the declaration of the global pandemic by the World Health Organization (WHO),

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the IPCC Secretariat switched to home office working mode, while trying to maintain all its operations. All meetings that were planned so far, both authors meetings to prepare the AR6, as well as the 58th session of the IPCC Bureau, were held in a virtual format.

With these measures in place, a certain delay of the publication of the AR6 cannot be avoided. At the 58th session of the IPCC Bureau, the following indicative dates of the publication of the IPCC reports were communicated, but are still subject to change:

- WG I Report - Last week of July 2021
- WG III Report - Last week of October 2021
- WG II Report – 2nd week of February 2022
- Synthesis Report June - September 2022

The dates for the expert reviews, as well as the literature cut-off dates will also need to be adapted. The website of the IPCC www.ipcc.ch will be updated accordingly when final decisions are taken.

UNFCCC: no negotiations in 2020, but important to keep the momentum

Due to the COVID-19 global pandemic, it was decided, to postpone COP26, which was scheduled to be held this year in November in Glasgow, by a complete year, to 1st to 12th November 2021, still in Glasgow, United Kingdom. In addition, the 52nd sessions of the Subsidiary Bodies, which should have met from 1st to 11th June 2020 in Bonn, Germany, were postponed to next year, but the dates still have to be confirmed.

Despite the need to postpone the formal negotiations, in order to guarantee that all Parties can safely participate, the Chilean COP Presidency as well as the incoming UK COP Presidency have shown their commitment in these crucial years to keep the momentum for action against climate change up.

In this spirit a virtual event, the "June Momentum of climate change" was held from 1st to 10th June (https://unfccc.int/process-and-meetings/conferences/june-momentum-for-climate-change). This event included a series of online exchanges, including adaptation, mitigation, science, finance, technology, capacity building, transparency, gender, Action on Climate Empowerment and the preparation and submission of nationally determined contributions. The recordings of the events can be found online. Further virtual events might happen in the course of this year and at the beginning of next year and will be announced on the website of the UNFCCC: https://unfccc.int

CORDEX activities

Status CMIP6 downscaling

Christian Steger (DWD), Hendrik Feldmann (KIT), Silje Sørland (ETH)

The Coupled Model Intercomparison Project is currently in the sixth phase (CMIP6) and many of the global modelling groups have already published their historical and ScenarioMIP simulations on the ESGF. The CORDEX community is currently preparing a recommendation how the downscaling of the CMIP6 simulations can be organized. This article provides an update for the CLM-Community members and gives a summary of the current status from the perspective of EURO-CORDEX.

The first global CMIP6 simulations became available on the ESGF-nodes mid of 2019, and meanwhile nearly all global modelling groups published large parts of their contribution to CMIP6. This is the first precondition for potential downscaling activities based on CMIP6 simulations. In addition to the input data from the GCMs, the regional modelling groups also need detailed information about the regional simulations that should be performed. This includes amongst others, information about the location of the domains, domain sizes, grid spacing, output variables and data standards. These information are summarized in an experiment design document.

The draft of the CORDEX experiment design document has been provided by the CORDEX Science Advisory Team (CORDEX SAT) in June and the modelling groups were able to make comments and suggestions for changes until 19 June. The document is currently in revision and we expect the publication of the final version in the near future.

As soon as the final version of the experiment design protocol becomes available, the different CORDEX domains can prepare the guidelines for their particular domain. The guidelines for each domain are based on the overall recommendations of the CORDEX SAT and provide further, more detailed and maybe specific information for each domain. For EURO-CORDEX, a group has been established for this task at the last General Assembly in January. The group will work on the details of the experiment design for EURO-CORDEX as soon as possible and according to the schedule the information should become available by the end of summer.

Furthermore, a second group has been established within EURO-CORDEX. This group should analyze the available CMIP6 historical and ScenarioMIP simulations and make recommendation for the GCMs that should be used as input data for the downscaling. Results of the work of the GCM group are also expected by the end of summer. The CLM-Community participates in the discussion of both groups. If you have any suggestions or questions about the experiment design and or the GCM selection, please contact the coordination office.

As soon as the experiment design document and the recommendations for the driving GCMs become available, the regional modelling groups can start their activities. The CLM-Community will certainly contribute to the second phase of CORDEX and some groups have already detailed plans (see report about RegIKlim/NUKLEUS in this issue). The contribution of the CLM-Community will be discussed and coordinated in working group CP. Please join the working group or get in contact with the WG coordinator (Hendrik Feldmann, KIT) if you plan to contribute to the downscaling of CMIP6 simulations or if you are interested in the topic.

CORDEX-FPS ELVIC: Climate extremes in the Lake Victoria basin

by Jonas van de Walle, KU Leuven, Department of Earth and Environmental Sciences, Belgium

Extreme weather events, like heavy precipitation, heat waves, droughts and windstorms, have detrimental impacts on East African societies. The Lake Victoria Basin is especially vulnerable, since nightly storms on the lake catch fishermen by surprise. The death toll is high. The International Red Cross estimates that each year 3000-5000 fishermen perish on the lake due to nightly storms. In addition, urban dwellers suffer from direct (flash) flood impacts on infrastructure and human settlements as well as from secondary effects such as outbreaks of diseases and disease vectors. Moreover, heavy precipitation events are shown to correlate with high landslide occurrences in mountainous areas embedding the Lake Victoria basin. As the frequency and intensity of climate extremes is projected to globally increase with climate change, so do the risks, with potentially major consequences for livelihoods and policy in the region.

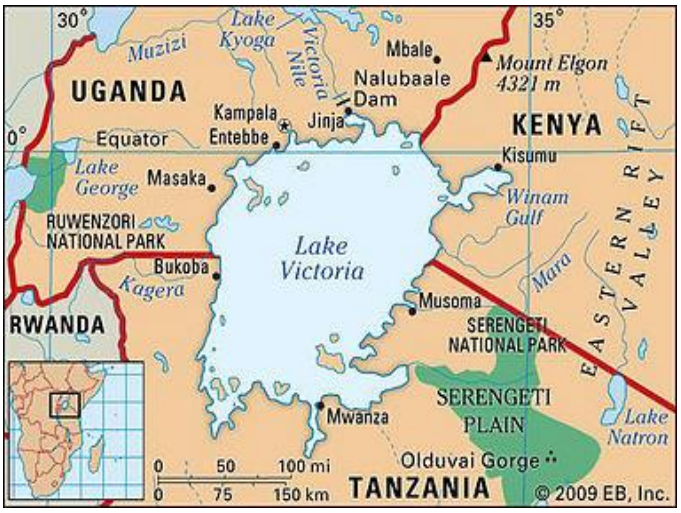

Fig. 1. Region surrounding Lake Victoria, East Africa: one of world's convectively most active regions often exposed to heavy precipitation, heat waves, severe droughts and windstorms.

The ELVIC project is an internationally COordinated Regional climate Downscaling EXperiment (CORDEX) - Flagship Pilot Study (FPS) initiative, bringing together different research groups with the same goal: unraveling the complex regional climate near Lake Victoria, East Africa. Insights are gained from both observational and model perspectives. At the current stage, present-day simulations are performed with multiple high-resolution, convection-permitting regional climate models, including COSMO-CLM, RegCM, HCLIM-AROME, WRF and MO-UM. These convection-permitting models are compared against their convection parametrized benchmarks and evaluated against different remote sensing products. This evaluation is the first step of ELVIC to investigate the complex regional climate and its evolution in a warming climate, with a strong focus on extreme events. As such, the project aims at providing improved probabilistic information to the impact community.

Currently, the CLM-Community contributes to the ELVIC initiative with two evaluation runs for the period 2006-2016, both downscaled from the recent ERA 5 reanalysis. The coarse resolution (~12 km) simulation as well as the convection-permitting (~2.8 km) simulation are coupled to the lake surface parametrization scheme and include the two-moment microphysical scheme, strongly improving the cloud representation and precipitation results in the region. Future projections, driven with CMIP6 general circulation models are planned as the next step.

For more information about ELVIC, please visit our website https://ees.kuleuven.be/elvic and do not hesitate to contact Nicole van Lipzig and Jonas Van de Walle (KU Leuven).

CLM-Community issues

CLM-Community Assembly 2020 – Virtual meeting

Dear CLM-Community members, we invite all of you to attend the 15th CLM-Community Assembly, which will take place from 14th to 18th of September 2020. Due to COVID-19, we will unfortunately not be able to meet in person in Berlin this year as originally planned. However, we will organize a virtual meeting with several online sessions for talks, poster session, working group meetings and the community meeting. Even if we will not have an on-site meeting this year, we hope that the CLM-Community members can present their work and discuss scientific questions and important topics related to model development and organization of the CLM-Community as usual.

All relevant information including a detailed program is available on the CLM-Community webpage: https://wiki.coast.hzg.de/clmcom/assembly-98599085.html.

We would like to thank the colleagues from Freie Universität Berlin (Ingo Kirchner, Uwe Ulbrich) who already started to organize the on-site meeting and helped a lot to rearrange everything for the virtual meeting. Furthermore, Freie Universität Berlin also agreed to host the Assembly (again) in 2021. Thank you very much!

ICCARUS and Numerical Model Training 2020

The restrictions due to the COVID-19 pandemic started at the beginning of March, including the interdiction of hosting meetings with a large number of participants. Thus, the ICCARUS meeting, which should have taken place from 2 to 6 March 2020, has unfortunately been cancelled. As the decision was quite short notice, some of the talks and posters had already been prepared and are available at the web page:
https://download.dwd.de/pub/DWD/Forschung_und_Entwicklung/ICCARUS2020

Some of the working group meetings, which should have taken place during ICCARUS in Offenbach, have been organized as video conferences in the following weeks. Although this is not as efficient for advancing the tasks of the CLM-Community than a week-long face-to-face meeting, it is certainly better than nothing and the most important steps for the next months had been discussed. For the minutes of these meetings, have a look at the working group pages in the RedC or contact the working group coordinators.

The Numerical Model Training 2020 was scheduled for the week 30 March to 3 April 2020 and had to be cancelled as well. At the moment, the organization team investigates if at least an online course with a reduced program can be provided in autumn for the already registered participants.

We all hope that the meetings can take place again as usual face-to-face meetings in the next year. Currently, the intended dates are: 15-19 March 2021 for ICCARUS and 19-23 April 2021 for the Numerical Model Training (to be confirmed).

Useful local climate information for Germany (NUKLEUS)

Hendrik Feldmann (KIT), Klaus Keuler (BTU), Burkhardt Rockel (HZG)

The joint project NUKLEUS (German: “Nutzbare Lokale Klimainformationen für Deutschland “) represents a cross-cutting activity of the German RegIKlim project (Regional Information for Climate Action). Its goal is to meet the demands for high-resolution actionable climate information, which are required for the decision processes regarding climate change adaptation in communal areas in Germany. Eight German climate research institutes contribute to NUKLEUS – namely HZG Geesthacht with GERICS and the Institute of Coastal Research, KIT Karlsruhe, the German Climate Computing Center DKRZ, the University of Würzburg, the BTU Cottbus, the Justus-Liebig University Gießen and the Technical University Dresden.

In phase 1, a prototype of an unprecedented ensemble of high-resolution dynamical climate simulations will be developed, and complemented by statistical and statistical-dynamical downscaling methods towards a better estimation of the range of climate information.

These data are provided for six selected "Study Areas" in RegIKlim Module A, where different stakeholders from administration and economy develop decision support methods and procedures with respect to climate change. This includes urban climate-, impact- and integrated modelling, for which NUKLEUS will provide the climate information input.

The project is organized in three work packages:

AP1 Modelling

The focus of this work package is the generation and provision of climate information with high spatial and temporal resolution, which shall be used to derive reliable statements on future regional and local climate developments in the six study areas mentioned above. It is planned to generate a multi-model ensemble with three different regional climate models (COSMO-CLM, REMO-NH and ICON-CLM), downscaling the results of three global CMIP6 simulations. The regional simulations will be performed on a convection permitting scale with a horizontal resolution in the kilometer range and cover the entire area of Germany. The common definition of a suitable simulation protocol is subject of the first project phase. This includes the selection of appropriate global simulations, which should capture the circulation patterns relevant for the Central European climate as good as possible, and investigations and definitions of nesting steps, nesting methods, domain sizes and resolutions, as well as a common initialization and simulation strategy. It is intended to replace the usual approach of selected scenarios with dedicated time slices by a new strategy in which the simulated periods are selected according to averaged temperature changes (+0.5°, +1.5°, +2°, +3°, +4°C) of the global simulation for Germany. The scenario simulations will be completed by an ERA5 driven evaluation run with each of the three regional models. Especially the use of the new ICON-CLM for regional climate simulations requires additional extensions and preparatory tests. The dynamically nested climate simulations will be complemented by a statistical-dynamic downscaling approach, which is based on a circulation type classification, and will use simulations of corresponding episodes by all three regional models.

AP2 Evaluation and Analysis

In order to be able to make reliable statements about the effects of climate change, it is necessary to evaluate the data used. This is done for the existing simulations. In addition, the selection of suitable initial and boundary data from CMIP5 and the future CMIP6 simulations as well as CORDEX is important for downscaling in AP1. The high-resolution simulations in AP1 carried out in the project, from which the data for the model regions are to be extracted, will also be evaluated. Due to the high resolution and the needs of the model regions for suitable indicators, this places high demands on the methodology and the reference and observation data. The model data should be bias-corrected in a consistent manner, as far as possible, in order to match the model regions and to be able to supply the best possible multivariate climate information.
Various quality-checked observation data (e.g. HYRAS, DWD radar climatology) and the high-resolution COSMO REA2 / 6 reanalyses by the Hans Ertel Center for Weather Research are taken into account. In order to analyze the high-resolution climate data, the spatial and temporal variations are examined. In particular, the added value of the higher resolution and the reliability are quantified. In addition, a process-oriented evaluation of various phenomena (e.g. heavy rain events, heat waves, storms) and their temporal and spatial variability is planned. In a final step, multivariate postprocessing and bias adjustment methods are used to provide usable input variables for impact modeling.

AP3 Interfaces

The goal of the work package is to establish and optimize the interfaces to impact models together with the partners from the RegIKlim model domains. NUKLEUS develops a data portal based on FREVA (Free University Berlin Evaluation System Framework) at the German Climate Computing Center DKRZ to provide local climate information. This information will be tailored according to the needs of the model domains with respect to the required parameters as well as the spatial and temporal scales.

Research notes

Subhourly rainfall in a convection-permitting model

Edmund P. Meredith, Uwe Ulbrich, Henning W. Rust,
Institut für Meteorologie, Freie Universität Berlin, Germany

More details can be found in:
Meredith, E.P., Ulbrich, U. & Rust, H.W. (2020). Subhourly rainfall in a convection-permitting model. Environ. Res. Lett. 15, 034031, DOI: 10.1088/1748-9326/ab6787

Introduction
The added value of convection-permitting models (Δx < 4 km; CPMs) for simulating subdaily and hourly precipitation is by now well established. This added value is highest for warm season intense precipitation, which tends to be convective. The most intense convective downpours, however, often occur at subhourly timescales. Less is known about how well models represent precipitation at subhourly timescales, and in particular if the added value shown by CPMs at the subdaily timescale also extends to subhourly resolutions. This knowledge gap results, in part, from a lack of sufficiently long observational time series at subhourly resolution. The good performance of CPMs in representing hourly precipitation need not necessarily extend to the subhourly timescale. The case of daily precipitation in coarse-resolution models is here instructive: to the extent to which coarse-resolution models produce "realistic" daily precipitation totals, it is known that this often results from an error-cancellation of insufficiently intense events which are too temporally persistent. It is thus not just desirable for models to produce realistic precipitation sums, but also to reasonably recreate the observed intermittency of precipitation, as this will have feedbacks on other hydrometeorological processes.

Method
Through the EU H2020 project BINGO (www.projectbingo.eu), we obtained access to a high-temporal-resolution gauge network for the city of Barcelona, Spain, including 19 tipping-bucket gauges dating back to at least 1996. We performed CPM simulations at 0.02° resolution for a regional domain (dimensions 241x241x60) centred on the city of Barcelona with CCLM version 5.00_clm9.

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Boundary conditions came from a 0.11° ERA-Interim forced CCLM run over the EURO-CORDEX domain, which is dry biased in our study region. To reduce computational expense, we performed 4-month time-slice simulations each year from July to October, with analyses focused on the months August – October, the 3 months for which climatologically the most intense subhourly precipitation falls. We compared the performance of CCLM in simulating precipitation at 5-, 15-, 30- and 60-minute resolution.

Results
In terms of general biases across the precipitation distribution, our subhourly results are in line with previous CPM evaluations at the hourly timescale. Moderate events are often insufficiently intense and thus contribute too low a fraction of total precipitation (Fig. 1). Extreme events, meanwhile, are more realistically represented and have lower biases in their actual and fractional contributions to mean precipitation, though still appear to contribute too high a fraction of total precipitation – a corollary of the negative fractional bias seen for moderate events. Importantly, the biases are consistent across temporal resolutions (5-, 15-, 30-, 60-minutes), suggesting that CPMs satisfactorily capture the observed intermittency of events, at least from an Eulerian perspective. The joint probability distribution functions (JPDFs) of wet-spell duration and intensity lead to similar conclusions (Fig. 2): the lowest statistically significant biases are for extremes of intensity, followed by duration, with stronger biases for non-extreme events. It is also important to keep the limitations of the measuring devices in mind. The strongest biases we find are for events of short duration and low intensity, exactly the conditions under which tipping-bucket gauges exhibit highest systematic errors. These CPM biases thus come with high uncertainty.

Conclusions
Our findings indicate that while subhourly precipitation in CPMs exhibits biases, these biases are no worse than those found at the hourly timescale. These results add confidence to projections of subhourly precipitation, particularly extremes, based on CPM model experiments and support the use of subhourly CPM precipitation in hydrological and impact modelling studies. Lagrangean studies of subhourly CPM precipitation also represent a valuable contribution to CPM validation (e.g. Purr et al. 2019) and will be employed in the BMBF ClimXtreme project.

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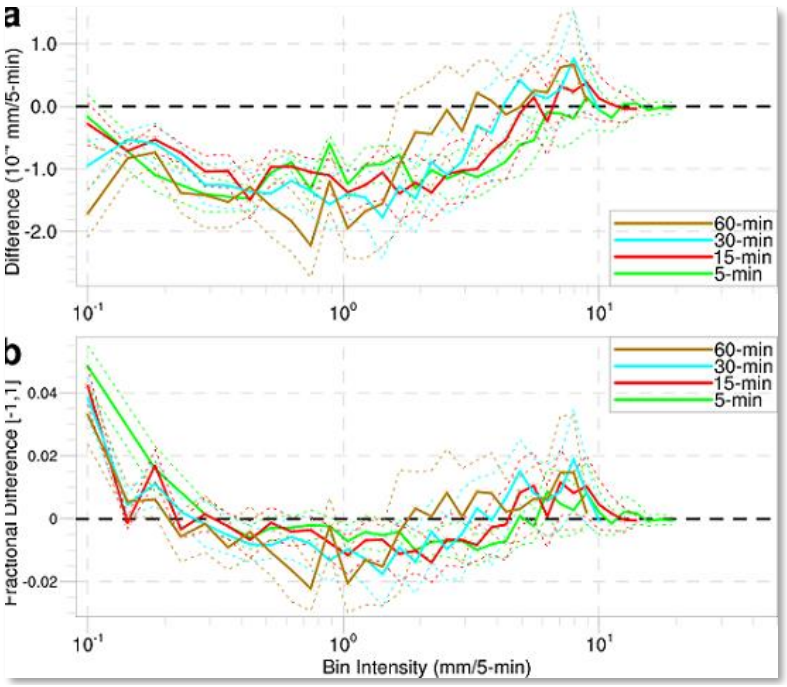

Figure 1. Biases in (a) contribution and (b) fractional contribution across precipitation distribution, for each aggregation time. For ease of comparison, all intensities are scaled to 5 min resolution. Computations are for discrete precipitation bins based on the ASoP method proposed in Klingaman et al (2017).

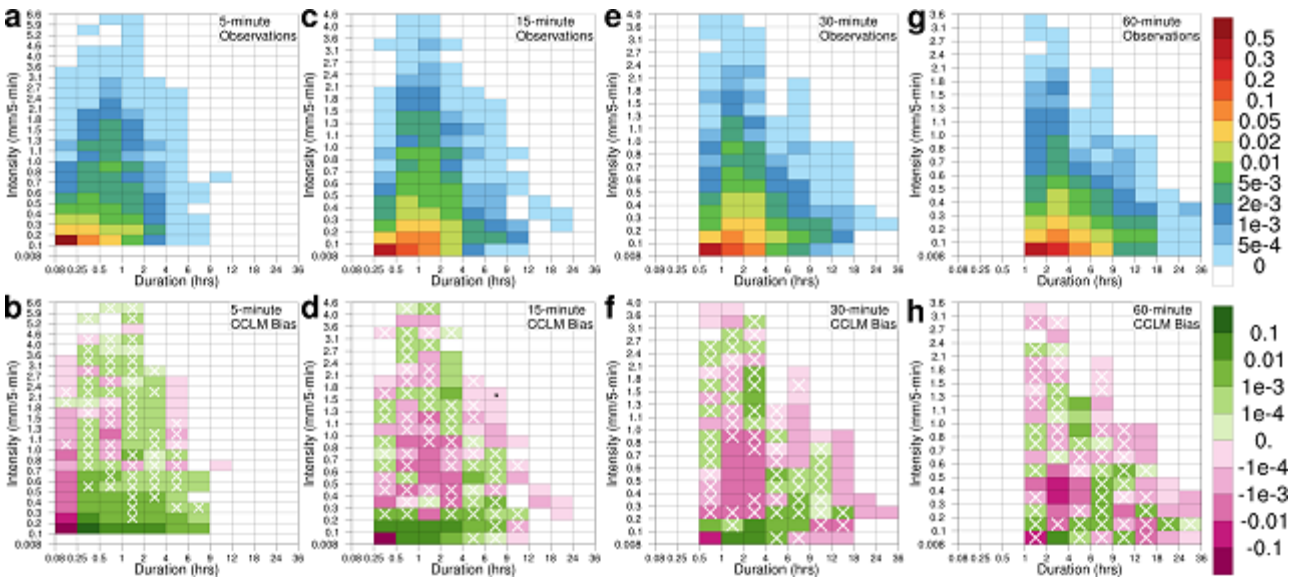

Figure 2. JPDF of wet-spell duration and intensity. **(a)**, **(c)**, **(e)**, **(g)** JPDFs for observations at 5, 15, 30 and 60 min resolution. **(b)**, **(d)**, **(f)**, **(h)** Bias of CCLM-02 with respect to observed JPDF. Biases which are not statistically significant at the 0.05 level with respect to interannual variability are crossed through in white. For ease of comparison, all precipitation intensities are scaled to 5 min resolution.

Simulation data and namelists are openly available from the DKRZ archive:
https://cera-www.dkrz.de/WDCC/ui/cerasearch/entry?acronym=DKRZ_LTA_961_ds00007

References

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Purr, C, Brisson, E, & Ahrens, B (2019). Convective Shower Characteristics Simulated with the Convection-Permitting Climate Model COSMO-CLM. Atmosphere, 10, 810, DOI: 10.3390/atmos10120810.

Are contributions of emissions to ozone a matter of scale? – a study using MECO(n) (MESSy v2.50)

Mariano Mertens, Institute of Atmospheric Physics, German Aerospace Center (DLR), Germany

More details and additional references can be found in:

Mertens, M., Kerkweg, A., Grewe, V., Jöckel, P., and Sausen, R.: Are contributions of emissions to ozone a matter of scale? – a study using MECO(n) (MESSy v2.50), Geosci. Model Dev., 13, 363–383, https://doi.org/10.5194/gmd-13-363-2020, 2020.

Introduction

Despite the strong reduction of emissions during the Covid-19 shutdown in March and April 2020, the ozone levels in some cities were larger as in previous years. This effect could be partly caused by meteorological effects and it could be partly caused by non-linear effects of the ozone chemistry. Generally, ozone in the troposphere is formed by photochemical reactions from different precursors, most important nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs). The non-linear effects can lead to a decrease of ozone during enhanced concentrations of NOx.

To better understand the reasons for changing ozone, such as for instance during the Covid-19 shutdown, we have implemented a method (called "tagging") which diagnoses the contribution of specific emission sources to this non-linear ozone formation. This method uses diagnostics tracers, which are labeled according to the emission source, e.g. NOx from lightning, VOCs from road traffic, etc. The chemical reaction of these additional tracers is tracked, such that the reaction products are labeled in the same way. For instance, a certain percentage of ozone as reaction product can be attributed to NOx from lightning. This information can help to understand specific processes and is of special importance when investigating potential effects of emission reductions in order to mitigate climate change and/or air quality problems. However, the results of this method are still a model based diagnostic and subject to specific uncertainties. One uncertainty, which is very important due to non-linearity of the ozone chemistry, is the model resolution. Therefore, we investigate the impact of the model resolution on contributions diagnosed with the tagging method.

Model description

We applied the MECO(n) model system, which couples the global-chemistry-climate model EMAC on-line with the regional chemistry-climate model COSMO-CLM/MESSy (Kerkweg & Jöckel, 2012a,b).

For this study we developed a MECO(2) set-up (Mertens et al., 2016), i.e. with 2 refinements, one over Europe (50 km), and one over Germany (12 km). The global model EMAC is applied in resolution T42L31ECMWF, i.e. with a spherical truncation of T42 (corresponding to a quadratic Gaussian grid of approx. 2.8°x2.8° in latitude and longitude, approx. 300 km) and 31 hybrid pressure levels in the vertical direction up to 10 hPa.

In all three model instances we apply the same chemical process descriptions, the same emissions and, most importantly, the same tagging method (Grewe et al., 2017). Therefore, we are able to compare the model results on all scales and investigate the impact of the model resolution on the diagnosed contributions. Analyzed are results from three years (2008-2010).

Results

Here, we focus on the results for Europe, comparing EMAC and COSMO-CLM/MESSy with 50 km resolution (from now on CM50). Figure 1 shows the absolute and relative contributions of different emission sources to the European ozone column up to 850 hPa as simulated by EMAC and CM50. Generally, the largest absolute and relative ozone contributors are the anthropogenic non-traffic and the biogenic categories, both with contributions of more than 1 DU, corresponding to more than 15 %. Both model instances simulate similar absolute ozone contributions from the categories anthropogenic non-traffic (≈ 1.0 DU), land transport (≈ 0.7 DU), shipping (≈ 0.5 DU), and biomass burning (≈ 0.4 DU). CM50 simulates larger absolute contributions compared to EMAC for the categories lightning and stratosphere, mainly caused by the more intensive vertical mixing in CM50 compared to EMAC.

Especially due to the increased contributions of lightning and stratosphere, CM50 simulates larger ozone values in the boundary layer compared to EMAC. This leads to overall slightly lower relative contributions of the categories land transport, anthropogenic non-traffic, shipping, and biomass burning, for which EMAC simulates around 0.1 to 1 percentage point larger relative contributions compared to CM50. These differences are only partly due to the coarser model resolution of EMAC, but also due to individual model biases. However, the results show, that in general ozone contributions of anthropogenic emissions averaged on the continental scale are hardly influenced by the model resolution. Hence, results of global models are robust on the continental scale.

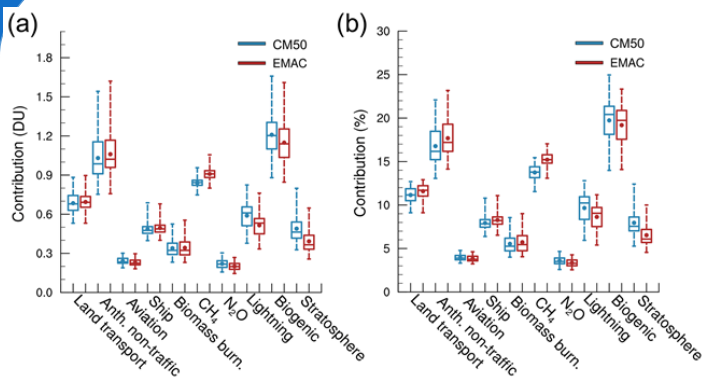

Figure 1: *Box-and-whisker plot for (a) the absolute (in Dobson units) and (b) relative (in percent) contributions to the ozone column up to 850 hPa. The values are area averaged over the CM50 domain. The lower and upper ends of the boxes indicate the 25th and 75th percentiles, the middle bars represent the medians, the dots represent the average, and the whiskers represent the ranges of the time series for the JJA values from 2008 to 2010.*

On the regional scale, however, results from global and regional models diverge strongly. As an example, Fig. 2 shows the relative contribution of land transport emissions to ground level ozone. In general, both model instances simulate a comparable distribution, with slightly lower values for CM50 compared to EMAC. Most importantly, however, the maxima are completely shifted and lead to differences of up to 4 %-points. While CM50 simulates a maximum contribution in the Po Valley, EMAC simulates a maximum contribution around Naples and Sicily. As our analyses show, this displacement of the maxima in EMAC compared to CM50 is an artifact of the low resolution of EMAC. This low resolution leads to land transport emissions into grid-boxes, which are over sea in a finer grid. The hot-spot over the Po Valley, on the other hand, is caused by stagnant weather conditions, large ozone production rates and strong land transport emissions.

Conclusion

Besides model-specific differences and biases that we discuss in detail, our results have important implications for other modelling studies and modelers applying source apportionment methods. First, contributions from anthropogenic emissions averaged over the continental scale are quite robust with respect to the model, model resolution, and emission inventory resolution.

Second, differences on the regional scale caused by different models and model resolutions can be quite large, and regional models are indispensable for source apportionment studies on the subcontinental scale.

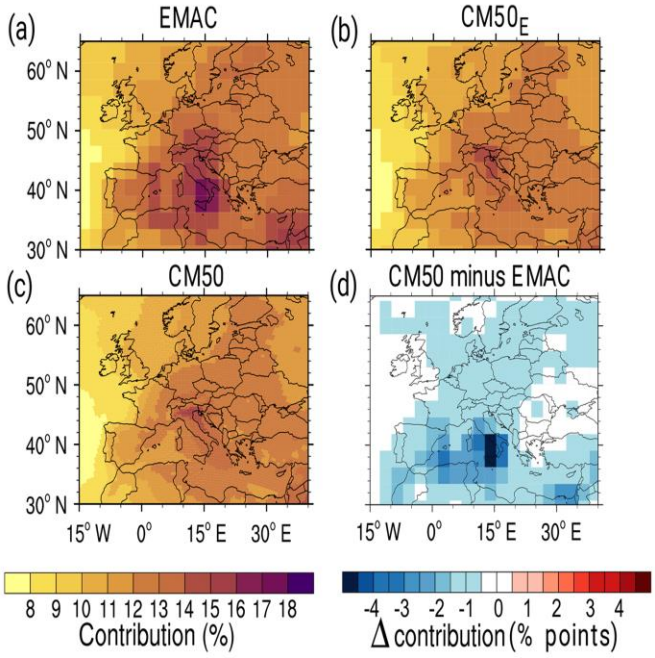

Figure 2: *Comparison of the JJA average (2008--2010) relative contribution of ozone due to land transport emission to ground-level O3 (in percent) of EMAC and CM50: (a) results of EMAC, (b) results of CM50 transformed to the EMAC grid, (c) results of CM50 on the original grid, and (d) difference ("CM50 minus EMAC" in percentage points) on the coarse grid. The comparisons in (a–c) use the same scale.*

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Recent publications

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Upcoming events 2021

2021

March 15 – 19	ICCARUS, Offenbach, Germany
June 07 – 11	ICAM 2021, St. Gallen, Switzerland

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