Climate Limited-area Modelling Community

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Newsletter

No. 22

Content

See YOU at the

ICCARUS 2024

04 – 08 March 2024

Offenbach, Germany (hybrid)

Announcement:

CLM Assembly 2024

22 – 25 October 2024
Oberpfaffenhofen, Germany

Dear colleagues,

Welcome to the 22nd CLM-Community Newsletter!

Almost exactly four years after the last in-person CLM Community Assembly took place in Paestum, Italy, the community members were finally able to meet again. The Assembly 2023 was organized by Nicole van Lipzig and her team in the beautiful city of Leuven. Beside the scientific talks in the plenary sessions and the working group meetings, the assembly brought some important innovations. The CMCC Foundation from Italy was elected as a new core institution of the community and COSMO 6.0 became the new recommended version of the COSMO model for the CLM Community. Read more about last year's Assembly in the review report.

This issue of the Newsletter contains also an interview with Hendrik Feldmann from KIT, reports about the UDAG project and the International Conference on Regional Climate (ICRC)-CORDEX, an outlook to ICCARUS 2024 and two research notes. The first one by C. Beier and colleagues from BTU Cottbus-Senftenberg, Hereon and KIT provides an overview of the NUKLEUS simulation ensemble: a first look on evaluation and regional climate change. The second one by H. Truhetz and A.N. Mishra from the Wegner Center in Graz discusses soil moisture feedbacks in the Eastern European Alpine region in convection-permitting climate simulations.

Enjoy reading!

Yours sincerely,
Susanne Brienen, Anja Thomas and Christian Steger

Five questions to….
Hendrik Feldmann

Karlsruhe Institute of Technology (KIT)

Hendrik Feldmann is a senior scientist in the working group "regional climate and weather hazards" at the IMK-TRO at KIT Karlsruhe. He studied Geophyics in the 80s at the University of Cologne and worked 15 years in the field of regional chemistry transport modelling and atmospheric dynamics in the EURAD group within the "Rhenish Institute of Environmental Research (RIU)" before he went to Karlsruhe in 2007, working on regional climate modelling and topics like extreme events, climate ensembles and decadal predictions.

1. *Hendrik, you work at the Karlsruhe Institute of Technology in the Institute of Meteorology and Climate Research. Can you please tell us something about the institute, the work of the group and your tasks there?*

IMK-TRO is a large institute with more than 100 people, covering multiple topics from integrated observation systems (KIT-Cube) over atmospheric dynamics, cloud physics to atmospheric aerosols and trace gases (e.g., main developers of ICON ART). My own working-group led by Joaquim Pinto is dedicated to regional climate and weather hazards. The group grew fast in the last years and is quite international. Currently, we are more than 20 people and still looking for additional team members. I am involved with my colleagues in many projects, like e.g., Climate extremes and weather events (ClimXtreme) where we investigate how climate change has already or will in the future change weather extremes. In the projects NUKLEUS and ISAP, we aim to provide communal praxis partners useable information for climate change adaptation. I am also involved in the new project UDAG (see point 5). There are other projects as well, e.g. on paleoclimate, the story-line approach or the dynamics of extratropical cyclones and more. As the most senior member of our group, I have several coordination tasks and am PI in several projects. Furthermore, I am the representative for most of our regional climate ensemble activities and kind of the go to-guy for related information here.

2. *You are a member of the CLM Community for more than 15 years. What are in your opinion the strengths and weaknesses of the community and which changes did you recognize over time?*

I joined the CLM Community in 2007. So, not a first-generation member, but say second generation. I enjoyed all the meetings: the Assemblies or ICCARUS very much (not just for work and science). I learned a lot about the model, it's strength and weaknesses and about how interesting regional climate modelling is. It was inspiring to work with the long-term pillars of the community like Burkhardt Rockel, Klaus Keuler, Andreas Will and others and for me especially my IMK colleague Hans-Jürgen Panitz. Now they are retired, and we will have to carry on. I am optimistic that we will manage and I am willing to contribute. The motto of the community "If you want to go fast, go alone. If you want to go far, go together" is still very true. We achieved a lot over the time without significant funding of the community efforts. Sometimes, it is frustrating that often things progress slower than we would like. However, community efforts like currently the COPAT2 initiative shows what we can achieve when we work together. My impression is that we still have a good team and good organization. We are able to adapt to necessary changes due to the transition from CCLM to ICON-CLM including the shift in the organizational environment surrounding this. In my view a weakness of the community is currently that too few of the younger colleagues, at the PhD or early PostDoc level, are really integrated in the community tasks and the meetings. I know that it's gotten more difficult to dedicate time for that. However, I think it is possible and worthwhile for the younger ones to join and take over some tasks. Just try it!

3. *You are the coordinator of the working group Climate projections. What are the main topics in this working group and your tasks as coordinator?*

In 2023 we had to rethink the core tasks of the working groups CP (Climate Projections) and CRCS (Convection Resolving Climate Projections) and getting three out of four new (co-)coordinators for both groups. I am happy that Marianna Adinolfi from CMCC joint the CP coordination. The core focus of WG CP is and always was the coordinated generation of regional climate ensembles.

This includes the coordination within the Community as well as the representation of the Community within the international consortia like EURO CORDEX or the CORDEX FPS. In the last years the focus of many activities shifted from the continental scale efforts to CPM resolutions. We decided that the grid resolution is not a core point to assign the task either to CP or CRCS, but more the kind of work, which is required. CP will focus on ensembles and topic like climate change, whereas CRCS is more process oriented.

The primary challenge of CP these days is the establishment of a solid contribution of the CLM Community to CORDEX CMIP6 "balanced ensemble matrix" activity. Several members of the Community are willing to contribute either with CCLM or ICON-CLM simulations. The CORDEX simulation protocol is now ready. We had to adapt our models to include transient aerosols, which became a "last minute" requirement in the protocol. While ICON-CLM includes an option to use the MACv2-SP aerosol data, thanks to Ha Hagemann, I think we have a solution for CCLM as well, soon. For CCLM we will use the new recommended version of CCLM6 as the setup, which was provided by WG EVAL in the COPAT2 initiative. Hopefully, we will soon have an optimized version for ICON-CLM as well, which can be used for the CMIP6 downscaling.

4. *You participated in the CORDEX Flagship Pilot Study (FPS) Convection. This FPS is now over and data is (or will soon be published) on the ESGF. Can you give us a very short summary of the activities in the FPS and the outcome?*

The FPS Convection was able to provide the first of its kind coordinated multi-CPM/multi-GCM ensemble for the greater Alpine area. The projected ended end of 2022 and we are now in the process of publishing the data via the ESGF. The team produced a large set of studies based on the ensemble, which analyse the possibilities and challenges of CPM modelling. This brought great progress in this field of research. There are many studies on topics like extreme and mean precipitation, temperature and heat waves, on wind and local wind systems. The added value of CPM simulations was the overarching topic. The results did not always improve when going to higher resolutions. However, many of the problems were not model or simulation specific but appeared to some degree in most simulations. There is definitively a demand for further research.

5. *Currently you are involved in the NUKLEUS and UDAG projects. Can you give us some general information about the projects and the tasks of KIT?*

NUKLEUS is part of the German research program RegIKlim (for regional information for climate adaptation). We generated an ensemble of downscaling three CMIP6 GCMs with three RCMs – namely CCLM6, ICON-CLM and REMO – first to the EURO CORDEX EUR-11 grid and afterwards further to 3 km grid spacing for Germany. For EUR-11 the simulations are transient from 1950 to 2099 using the historical period and the ssp370 scenario. For the CPM simulations we used three 30-year time slices each, representing the historical period (1961-1990) and the global warming levels +2°C and +3°C. Our results show that especially the ICON-CLM performs very well. As mentioned before, RegIKlim aims to provide climate change information as well as methods to develop climate adaptation strategies for municipalities from them.

UDAG has just started and will build on the experience from NUKLEUS. There, we will perform a larger set of CORDEX CMIP6 simulations including different scenarios, but focussing just on ICON-CLM. Again, in a first nesting steps we target the EURO CORDEX grid. In a second nesting step we perform at CPM resolution for a domain covering Germany, Switzerland, Austria and its surroundings and aim for transient simulations even at high resolution.

Thank you very much for the interview!

Karlsruher Institut für Technologie

CORDEX activities

Report from the International Conference on Regional Climate-CORDEX 2023 (ICRC-CORDEX 2023)

By V. Maurer, M. Adinolfi, K. Görgen, B. Ahrens, S. Poll, M. Raffa, H. Hagemann

The ICRC-CORDEX 2023 conference (https://icrc-cordex2023.cordex.org/) took place from 25-29 September at the ICTP facilities in Trieste, Italy, and was jointly organized by ICTP, IITM (Indian Institute of Tropical Meteorology), SMHI, and WCRP. The conference was split over two locations: The main venue was Trieste, and a second one was in Pune, India. In Pune, also a number of separate sessions were held. Despite a remote option, most participants were on-site in Trieste.

Impressions from the ICRC-CORDEX 2023 (Source: Picture 1 CORDEX, Pictures 2 and 3 V. Maurer)

The conference was also an opportunity to honor the life's work of Filippo Giorgi, Head of the Earth System Physics Section at ICTP, who was one of the first scientists setting up regional climate model simulations at the end of the 1980s (Dickinson et al., 1989, https://doi.org/10.1007/BF00240465; Giorgi and Bates, 1989, https://doi.org/10.1175/1520-0493(1989)117<2325:TCSOAR>2.0.CO;2) and ever since then advancing the field. He will retire soon.

In the first block on the topic **"Advancing the regional climate science on decision making scales**", there were three larger sessions focusing on the modelling part: (1) **Earth System Modelling in a regional context**, co-chaired by Klaus Görgen (FZJ), (2) **Convection Permitting Modelling** (CPM), and (3) **Statistical Methods/Machine Learning techniques for regional climate modelling/downscaling.**

The keynote speaker of the regional ESM (RESM) session, Samuel Somot (Meteo France), pointed out that there is no clear definition of an RESM. For CORDEX, a minimum list of required model components should be defined, but models of different complexities could and should be mixed in one ensemble. Most commonly used additional model components are hydrology, vegetation, ocean, urban, and aerosols. The cryosphere part has received less attention up to now.

According to the keynote of the CPM session, given by Erika Coppola (ICTP), convection-permitting regional climate modelling has shown a lot of added value and is developing towards a new standard. However, the path towards CPM experiments and applications in a coordinated community setting is challenging. Future experiments should evolve towards larger model domains (even continental-scale domains in the long term) and longer, if possible transient simulations. Smaller sub-domains are highly suitable for specific process studies, but it is absolutely important to maintain multi-model, multi-institutional ensembles. Fragmenting into smaller domains bears the danger of weakening the ensemble approach and also the community itself.

The synergy of statistical and dynamical downscaling approaches was addressed in the session on Statistical Methods. Very promising results from RCM emulators were shown. Still, a much better coordination of the growing ESD community is necessary.

The block was wrapped up with a "Discussion on the future scientific developments and priorities". With respect to RESMs, adding more Earth system components does not only lead to a more complete process representation and understanding, it also allows for new feedback loops to evolve. Also, human interventions with the climate system can be included. At the same time, standardization is a key to make such model runs feasible. Upcoming ensembles will see an increasing number of coupled RESMs.

CPMs have established themselves, many processes are improved. Due to the high cost, even more coordination is needed. There is an ever-increasing gap of suitable observational data at these scales. With respect to Machine Learning and Deep Learning, well designed experiments can allow for the extraction of more information from existing data. With respect to standardization and new simulation protocols, work needs to be invested, as these are crucial for RESM, high-resolution, and also ML/DL enabled future experiments.

The problem of the large time lag between the CMIP and CORDEX cycles was discussed as well. Different opinions were given, ranging from "we should not care" to running RCM simulations "on the fly" on the same computing systems as the GCMs. On the one hand, a certain timeliness is considered important. CMIP5 projections, which are still widely used, start in the year 2006, which seems to be outdated today. At the same time, it became obvious that the CORDEX simulations are very difficult to be kept in sync with the GCM/CMIP cycles.

The second block was on the topic "**CORDEX interaction with Society"**. Some take-home messages from the general discussion were that the context in which information are to be used is the "king", and the co-creation is the key. If we better understand the context, we may provide more useful information. Sources of information may still be too diverse. WCRP Regional Information for Society (RIfS) may pave a way here.

The third block was on "**Impacts"**, with sessions on **Societal Impacts** and on **Natural Ecosystem** Impacts. An introduction was given by Bart van den Hurk, co-chair of IPCC WG-II. Before scenarios are built, we should talk to the stakeholders, who use the final data in the first place, and learn about the risks and the hazards they face.

On the third day, there were parallel sessions on:

- **CORDEX-Ocean: Towards a CORDEX framework for Ocean Regional Modelling.** Up to now, there has been no international coordination of ocean regional climate modelling (ORCM) activities. A good example of coordinated ORCMs is BALTEX, protocols could be used as a basis. It was decided to first set up a CORDEX-Ocean task force and to eventually establish an FPS later, if the task force proves useful.
- **Regional Climate Modelling in the Polar Regions**
- **Discussion session: Climate projections for islands**. It was decided to install a new FPS about this topic.
- **Concepts and identification of global warming levels (GWLs) for regional climate services**, organized jointly by the weather services of the DACH region
- **FPS LUCAS: Land Use & Climate Across Scales**
- **FPS URB-RCC Side Event at ICRC-CORDEX 2023**

Contributions from members of the CLM-Community:

M. Adinolfi et al.: Advances of CMCC climate simulations with transient land use (Talk during side event)

B. Ahrens and M. Hamouda: On convective enhancement of Vb-events in present and warmer climate (Poster)

K. Görgen: Coupled groundwater-to-atmosphere simulations with the regional climate system model TSMP as a contribution to the new European CORDEX-CMIP6 ensemble (Talk)

K. Görgen: A pan-European km-scale setup of the regional climate system model TSMP to study the impact of human interventions on the terrestrial water cycle (Poster)

H. Hagemann et al.: Regional Earth System Models for CMIP6 downscaling over the EURO-CORDEX domain (Poster)

V. Maurer et al.: Calibration of the new regional ocean-atmosphere model based on ICON and NEMO for the EURO-CORDEX domain (Poster)

S. Poll: Flux exchange over heterogeneous land surfaces (Poster)

M. Raffa et al.: Integration of LUCAS-LUC dataset in COSMO-CLM simulations with URBAN parameterization (Talk during side event)

The UDAG Project – Updating the data basis for adaptation to climate change in Germany

By C. Steger (Deutscher Wetterdienst)

The German adaptation strategy for climate change is largely based on climatological information from regional climate projections for Europe. It is therefore very important that up-to-date regional climate projections are available. The aim of UDAG is the provision of these up-to-date regional climate projections for the use in the German adaptation strategy. The regional climate projections currently used for taking adaptation measures are based on the global climate projections produced within the Coupled Model Intercomparison Project Phase 5 (CMIP5). These global climate projections have been updated in recent years in the framework of CMIP6. The Shared Socioeconomic Pathways (SSPs) newly introduced in CMIP6 and the further development of the climate models make an update of the regional climate projections for Germany necessary.

Group picture from the kick-off meeting on the roof deck of the DWD branch office in Hamburg (Source DWD)

Therefore, UDAG will provide a quality-checked ensemble of regional climate projections for Europe (at 12 km) and for 'hydrological Germany' (i.e., including the river basins draining into Germany at 2-3 km). For this purpose, the global climate projections are downscaled to 12 km for 6 global climate models using the regional climate model ICON-CLM for the SSP3-7.0 and SSP1-2.6 scenarios supplemented with some simulations for SSP5-8.5. The empirical-statistical method EPISODES downscales all CMIP6 ScenarioMIP projections that provide the necessary input data.

In a second step, the regional climate projections spanning the bandwidth of the 12 km ensemble are selected and further downscaled to 2-3 km using ICON-CLM. This creates an unprecedented ensemble of convection permitting climate projections for 'hydrological Germany' at high temporal and spatial resolution.

UDAG is funded by the German Ministry for Education and Research. It started in September 2023 and will run for 3 years. The project is a joint effort of some of the German member institutions of the CLM Community: Deutscher Wetterdienst (DWD, project coordination), Karlsruhe Institute of Technology (KIT), BTU Cottbus-Senftenberg, Helmholtz-Zentrum Hereon - Institute of Coastal Systems (Hereon) & Climate Service Center Germany (GERICS) and the German Climate Computing Center (DKRZ). More information can be found on the project webpage (in German only): www.dwd.de/udag.

UDAG
Updating the Data basis for Adaptation to climate change in Germany

UDAG Logo (Source Hereon)

CLM-Community issues

Review CLM Community Assembly 2023

By S. Brienen (Deutscher Wetterdienst)

It was a great pleasure to meet again in person for the 2023 CLM Community Assembly! The meeting was organized by the colleagues of the KU Leuven and took place from 18-22 September 2023 with more than 30 participants in a nice university building in the city center of Leuven, Belgium.

The structure of the sessions was as usual, with a mixture of plenary talks, working group meetings and the CLM Community meeting. The very interesting invited talk was given by Hugues Goosse from the Université catholique de Louvain on "Modelling atmosphere-ice-ocean interactions in the Southern Ocean in a regional coupled model".

One of the major community topics was the completion of the evaluation procedure (COPAT2) for the COSMO-CLM 6.0 version. It was decided that COSMO6.0 with the configuration "C2C316" is now the recommended version of the CLM Community. No further community work will be done on the COSMO-CLM including source code administration. Any new developments are in the responsibility of the developer alone. The development of ICON-CLM is now the focus and it is organized now through the working group MODEV in cooperation with the ICON community.

The CMCC was elected as a new core institution. Finally, there was a long discussion about the format of future assemblies, e.g. regarding length, hybrid meetings and possibilities to make it more attractive also for PhD students. Details are still to be discussed, involving also the SAB. As a first test, the 2024 assembly is planned to be hold for 3 days only.

Many new results have been presented in the oral presentations and a lot of interesting scientific discussions took place after the talks, in the coffee breaks and in the working group meetings. The highlights and other important discussion points in the working groups are summarized here: https://www.clm-community.eu/events/clmcommunity-assembly-2023/programme/83/uploads/4f1c0228-9ff0-497f-bfa0-586b4488d24d?next=/events/clmcommunity-assembly-2023/programme

A very nice social program with joint dinners and a guided tour through Leuven completed the successful week.

Conference Dinner and retirement ceremony of Klaus (Source: S. Brienen)

Finally, we had to say Good-bye to another day-1 community member: Klaus Keuler (BTU Cottbus) has retired at the end of 2023. He was in the team starting the development of the CLM as regional climate model and was a very active and valuable community member through all the years, especially as our "Evaluation master" and lately pushing forward the usability of ICON-CLM. The community says "Thank you very much!" for all the contributions and the good collaboration!

All material of the assembly (program, abstracts, working group minutes, etc.) can be accessed as usual through the CLM community website: https://www.clm-community.eu/events/clmcommunity-assembly-2023/.

Next years meeting is planned to be held at DLR in Oberpfaffenhofen, Germany, in October 2024.

We hope to see again many of you there!

KU LEUVEN

Outlook ICCARUS 2024

By C. Steger (Deutscher Wetterdienst)

The ICCARUS (**I**CON/**C**OSMO/**C**LM/**A**RT **U**SER **S**EMINAR) 2024 will be organized as hybrid conference from 04 – 08 March 2024. The on-site participants will meet at the DWD Headquarters in Offenbach, Germany. An online poster session will take place on Monday, 11 March in Gather.town.

ICCARUS 2024 will include plenary sessions from Monday, 04 March to Wednesday, 06 March and working group meetings on Thursday and Friday in the same week. As usual, the plenary sessions will be the place for scientific presentations of the participants and keynote presentations that cover different main aspects of the ICON modelling framework. The following keynote presentation are planned for this year: Ali Hoshyaripour (KIT) about the general ICON Strategy and ICON-ART, Günther Zängl (DWD) about the plans for ICON NWP, Oliver Fuhrer (MeteoSwiss) about COSMO/ICON activities and Wolfgang Müller (MPI-M) about ICON Seamless. An invited talk will be given by Thibaut Montmerle from Météo-France. He will present the PIAF project, which aims for a better integration of nowcasting and NWP and could be seen as an equivalent to the SINFONY project at DWD.

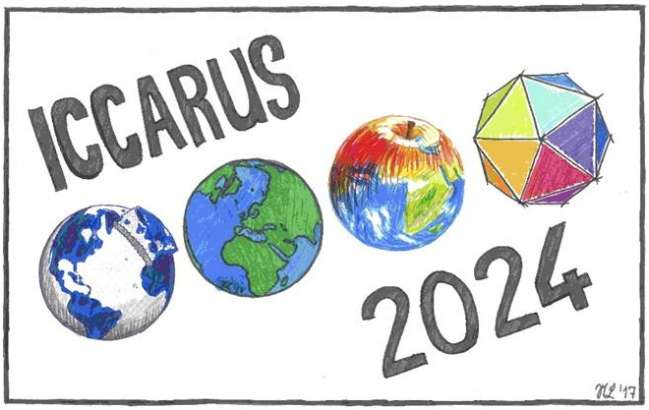
All working group meetings at ICCARUS 2024 will be joint sessions of members from COSMO, CLM and ICON communities. This should bring the developers of the different communities closer together and foster the collaboration of people working on the same topics. The ICCARUS organization team has identified several overarching topics and contacted people from the different communities for the organization of the joint sessions. The following working group meetings are planned for ICCARUS 2024.

- Data Assimilation *(Organized by C. Schraff)*
- Ensemble *(C. Marsigli)*
- Support Framework *(B. Maco, A. Kerkweg)*
- ICON-C / ICON-GPU *(X. Lapillonne)*
- Gatekeeper Meeting *(D. Rieger)*
- ICON AI *(R. Potthast, S. Hollborn, J. Keller)*
- Soil, Vegetation & Land Surface *(J.-P. Schulz, L. Schlemmer)*
- Climate Forecasts *(P. Mercogliano, C. Steger)*
- ICON Upper Atmosphere *(t.b.d)*
- Model Dynamics *(M. Baldauf)*

The format of the meetings (on-site, online or hybrid) will be defined by the session organisers. The time schedule for the working group meetings and contact information of the organizers will be distribute with the ICCARUS program. Please contributed to the sessions on your topics of interest.

The registration (online participation) and abstract submission for posters for ICCARUS 2024 is still open. For further information, please visit www.dwd.de/iccarus.

We are looking forward to ICCARUS 2024 and hope that many of you will come to Offenbach or participate online in the conference, the poster session and the working group meetings.



ICCARUS Logo (Source N. Leps (DWD))

Research notes

The NUKLEUS simulation ensemble: a first look on evaluation and regional climate change

Christian Beier, Klaus Keuler, Michael Woldt (BTU Cottbus-Senftenberg), Beate Geyer, Ronny Petrik, Burkhardt Rockel, Kevin Sieck, Lars Buntemeyer (Hereon), Hendrik Feldmann, Marie Hundhausen, Christoph Braun (Karlsruhe Institute of Technology)

The main objective of the joint project NUKLEUS (Nutzbare Lokale Klimainformationen für Deutschland, funded by the BMBF) is to provide regional climate information for pilot regions in Germany in order to develop appropriate measures for climate adaptation. For this purpose, the first multi-decadal and multi-climate model ensemble on a convection-permitting scale for Germany will be created with simulations from three regional climate models (RCMs: COSMO-CLM 6.0, ICON-CLM 2.6.5 RC and REMO2020). The ensemble consists of 51 simulations (30 convection-permitting): six hindcast simulations (driven by ERA5), 18 historical simulations and 27 scenario simulations (driven by global CMIP6 climate simulations with the models MPI-ESM1-2-HR, EC-Earth3-veg and MIROC6) for the scenario SSP3-7.0. The model domain covers Central Europe (CEU-3) and the horizontal resolution of the simulations is around 3 km. An intermediate nesting step is required. These simulations have been run transiently (historical: 1950-2014, scenario: 2015-2099) for the EURO-CORDEX domain (EUR-11) with a resolution of approximately 12 km. In contrast, the CEU-3 simulations (CPM) were conducted in separate 30-year time slices covering the historical period 1961-1990 and the scenarios were defined on the basis of the average global warming in the respective global climate simulation of +2K and +3K (Global Warming Levels) compared to the pre-industrial levels. For example, for EC-Earth, which exhibits the highest climate sensitivity of the three global climate models (GCMs), the time-slices cover the periods 2024 to 2053 (+2K) and 2047-2076 (+3K).

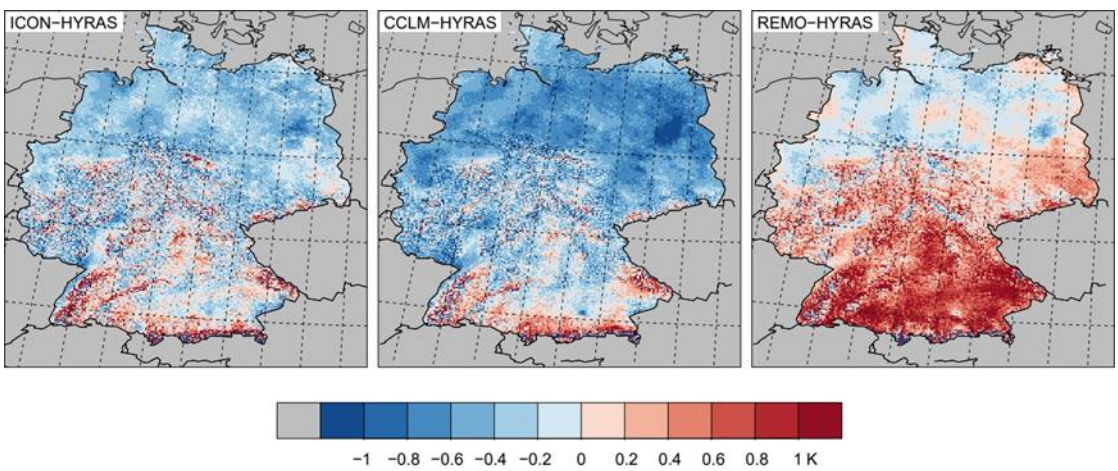


Figure 1: *Annual mean temperature bias for the three CPM ERA5-driven hindcast simulations with ICON-CLM, CCLM and REMO with respect to the HYRAS reference data (DWD) for the period 2005-2014.*

The evaluation of the hindcast simulations has demonstrated an overall good quality of the simulations. Comparison of the 2m temperature and precipitation with gridded (HYRAS) or station-based observations revealed smaller deviations with respect to older simulations such as EURO-CORDEX (Kotlarski et al., 2014). The temperature bias is mostly in the range of +/-1 K. ICON-CLM and CCLM are slightly too cold (CCLM more than ICON), especially in northern Germany. REMO is too warm in southern Germany (Figure 1). For precipitation the three regional models have a tendency to a wet bias. For ICON-CLM and CCLM, these differences become stronger towards the east and south, for REMO in the northern part of Germany and over areas with higher topography. The mean annual cycles for the pilot region of the East Frisian coast show a stronger cold bias from winter to spring, but they are mostly in the range of the station data. For precipitation, the maximum deviations of the monthly means are found in summer.

The historical simulations show similar trends and patterns as the evaluation runs, but the absolute values and temporal variations are mainly strongly dependent on the driving GCM. Spatial patterns, on the other hand, are more independent of the forcing data. Area averages over monthly means (mean annual cycles) are hardly affected by the improved resolution, even over small areas. The intensities of daily extreme events are not generally improved, CPMs mostly overestimate extreme precipitation at high percentiles, as do the hindcast simulations.

Temperature change signal, defined as the difference between the annual mean temperature in the scenario and the historical period, indicates that the regional warming for the 3K GWL is about 1 K greater than for the 2K GWL of global warming (Figure 2). However, the absolute intensity is dominated again by the driving GCM, while the spatial structure of the temperature increase is similar in all six ICON-CLM simulations. Considering the frequency distribution, the temperature change is not uniformly distributed, the strongest warming occurs in the lowest quantiles (up to P-values of 1%) with only small variations between the 3 km and 12 km resolutions.

In conclusion, the ranking of influences decreases from the GCM to the RCM and then to the resolution. This suggests that for the historical runs, the bias to the reference, and for the scenario runs, the climate change signal, are mainly affected by the choice of the GCM.

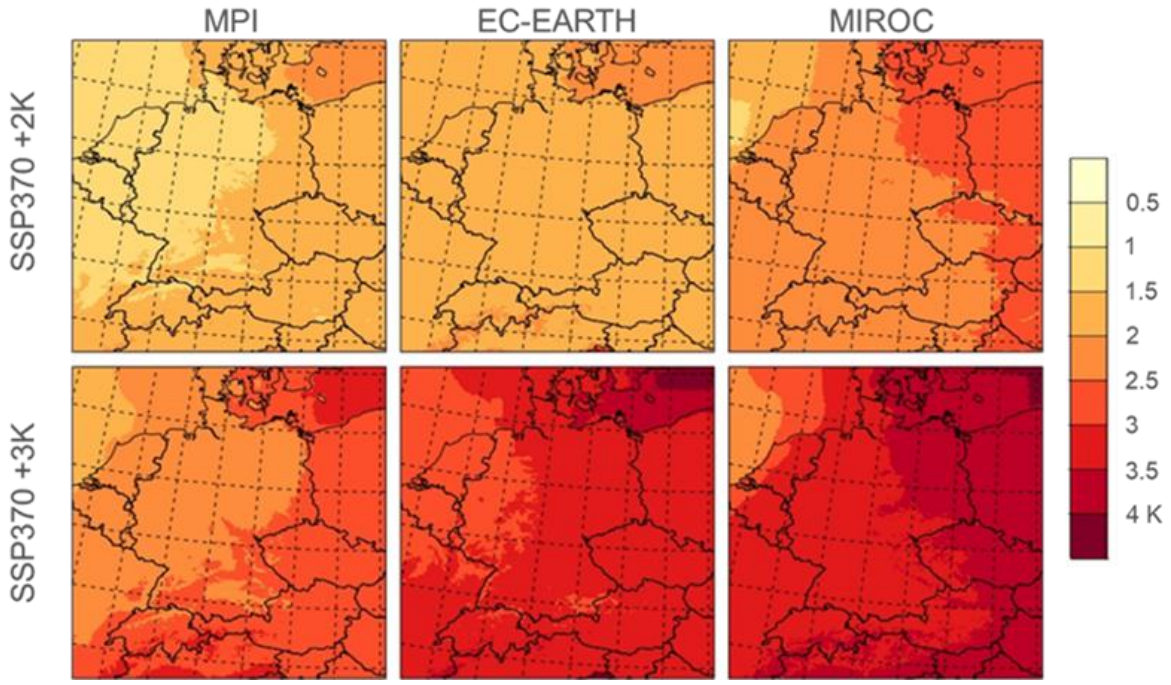


Figure 2: *Annual mean temperature increase for the ICON-CLM simulations (CPM: 3 km resolution) of the SSP3-7.0 scenario for the two Global Warming Levels +2K and +3K, driven by three different CMIP6 GCM simulations.*

A reference paper on the concept, the ensemble structure and the evaluation simulations is in preparation. The work and results of the first project phase of NUKLEUS will be used in ongoing research projects (e.g. BMBF UDAG) to optimize the regional model ICON-CLM. In the second project phase of NUKLEUS additional scenarios (SSP2-4.5 and 5-8.5) will be added to the ensemble with the long-term goal to make the data freely available through the ESGF. The overall goal of the second phase is the creation of the “Klimakataster”, a publicly accessible data portal for useful and usable climate information.

References:

Kotlarski, S., Keuler, K., Christensen, O. B., et al.: Regional climate modeling on European scales: a joint standard evaluation of the EURO-CORDEX RCM ensemble, Geosci. Model Dev., 7, 1297–1333, https://doi.org/10.5194/gmd-7-1297-2014, 2014.

Investigating soil moisture precipitation feedbacks in the Eastern European Alpine region via Pseudo Global Warming

Heimo Truhetz and Aditya N. Mishra

Wegener Center for Climate and Global Change (WEGC), University of Graz, Graz, Austria
e-mail: heimo.Truhetz@uni-graz.at

See also:

Truhetz H, Mishra AN. 2023. Soil moisture precipitation feedbacks in the Eastern European Alpine region in convection-permitting climate simulations. Int. J. Climatol., (43): 6763–6782. https://doi.org/10.1002/joc.8234

Experimental setup

In our study1, we make use of one-year (October 2008 to September 2009) convection permitting (~3 km grid spacing) soil moisture sensitivity simulations with CCLM2 in the Eastern Alpine region (Figure 1). The experiments are embedded into a Pseudo Global Warming3,4 (PGW) framework but with continuously forced deep (below 4 m) soil moisture from four prescribed perturbation storylines (-10 %, -5 %, +5 %, +10 %). This 1) avoids a fading of the perturbations, which otherwise occurs if just the initial moisture is perturbed5, and 2) gives fully established SMP feedbacks and a controlled drying/wetting of the upper (hydrologic active) soil layers.

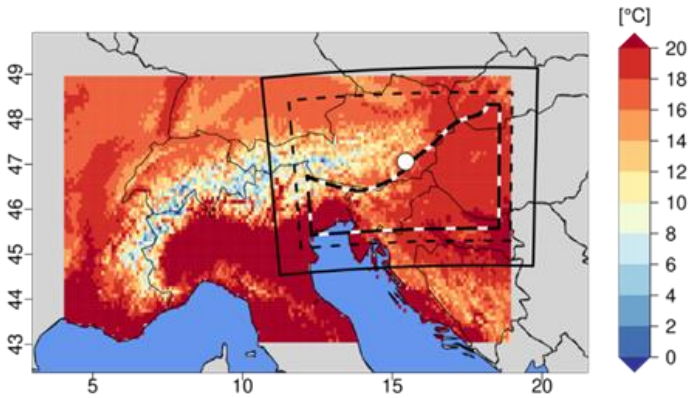


Figure 1: *Modelling domain (solid lined polygon), its lateral sponge zone of 20 grid cells (dashed polygon), and the study area (b/w dashed polygon) that starts at the City of Graz (white dot) and extends to the South and East. Shaded colours indicate mean summertime (JJA) temperature [°C] of the period 1971 to 2000 from gridded observational data.*

PGW is implemented by imprinting vertical columns (averaged across the CCLM domain) of end-of-the-century climate change signals for temperature, relative humidity, and pressure from four global climate models (HadGEM2-CC, IPSL-CM5A-MR, MIROC-ESM, and GFDL-ESM2M) (representing RCP8.5) onto the model's driving data IFS6. This leads to four different possible, thermodynamic changes of the summer season 2009 on top of the deep soil moisture storylines giving domain-averaged seasonal summer precipitation changes ranging from -50 % (MIROC-ESM) to +20 % (HadGEM2-CC).

Results and conclusions

The simulations reveal that 1) the locations of precipitation events are highly sensitive to soil moisture modifications while intensities and the internal structure of precipitation events are nearly unaffected and 2) high precipitation intensities are more likely in combinations with positive temporal but distinctive (either strong positive or strong negative) spatial SMP coupling (low precipitation intensities are in favour of combinations of negative temporal and positive spatial coupling) (see Figure 2, left panel).

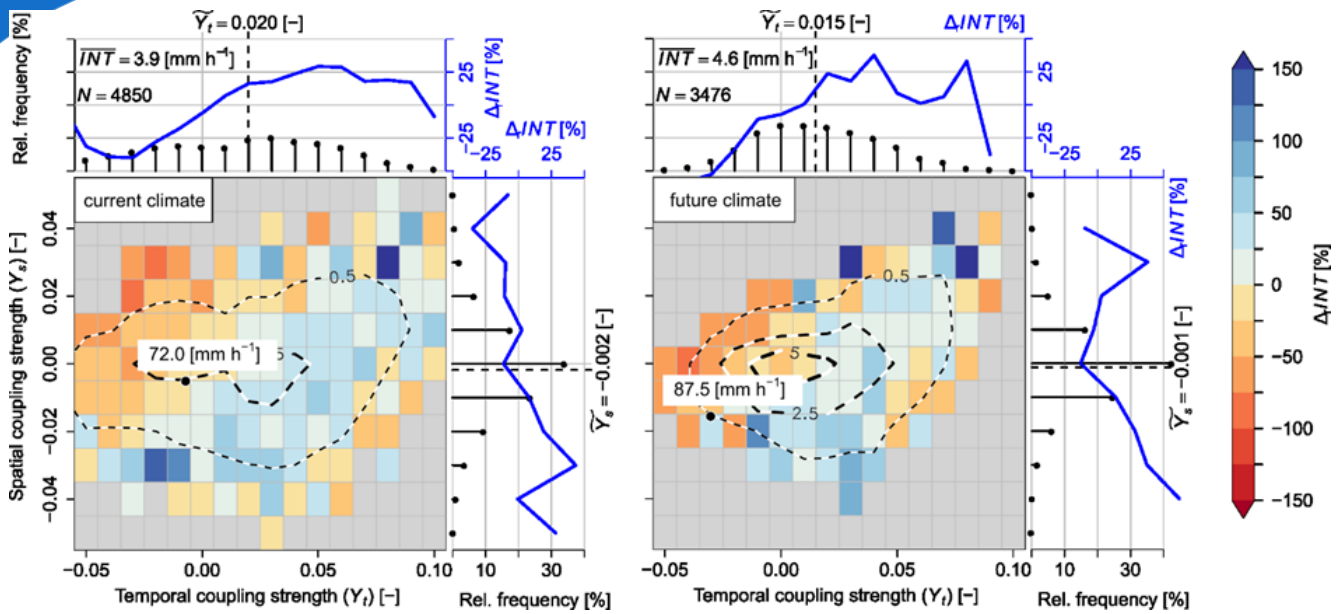


Figure 2: *Interplay between spatial and temporal SMP coupling strengths (Y_s and Y_t, respectively) and maximum hourly precipitation intensities (INT) of N isolated precipitation events (pooled across all soil moisture perturbation storylines) during JJA 2009 in the study area. The colour shaded area depicts estimated intensity anomalies (Δ_r INT) from bins (with a width of 0.01) of Y_s and Y_t related to the given averaged maximum intensity ((INT)¯). The maximum INT of all events (black dot) is indicated. The dashed contour lines at levels of 0.5 % and 2.5 % of the underlying bivariate percent relative frequency distribution of Y_s and Y_t are shown. Marginal percent relative frequency distributions of Y_s and Y_t (black dots) together with corresponding percent relative intensity anomalies (blue line) are shown at the top and to the right of each subfigure. Median feedback strengths ((Y_s)¯, (Y_t)¯) are given. (left panel) current climate (IFS); (right panel) future climate (MIROC-ESM).*

The analyses furthermore suggest that soil moisture at a given time acts as a guiding field for the location of the next precipitation event. Interestingly, this behaviour is independent of climate change (see Figure 2, right panel), although the coupling strength's increase is 1.5 to 1.7 times larger than expected from linear climate change scaling when climate becomes 50 % dryer (for MIROC-ESM). Finally, it is found that 1) local deviations of up to +/- 40 % in the climate change signal of summertime precipitation are caused by uncertainty in deep soil moisture in the range of +/- 10 % and 2) these local deviations in the climate change signal are dominated by soil moisture uncertainty in future climate conditions.

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CLM-Community Coordination Office
Dr. C. Steger, Dr. S. Brienen, A. Thomas
Deutscher Wetterdienst
Frankfurter Str. 135
63067 Offenbach, Germany
clm.coordination[at]dwd.de