

Climate Limited-area Modelling Community

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Newsletter

No. 26

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See YOU at

ICCARUS 2026

16 – 20 March 2026

Offenbach, Germany

Announcement:

CLM Assembly 2026

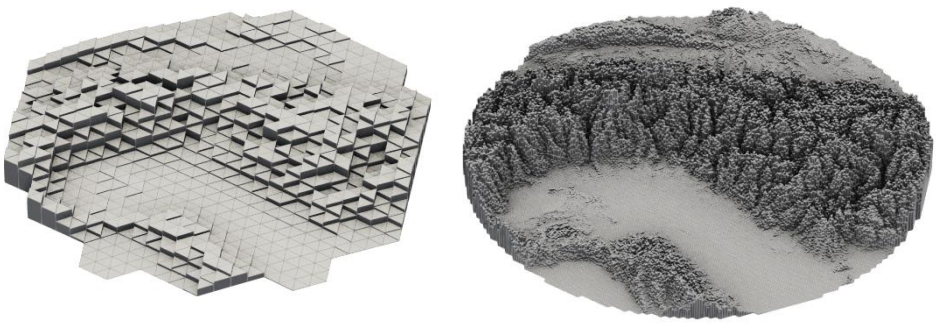
22 – 25 September 2026

Lüneburg, Germany

Dear Colleagues,

Welcome to the 26th CLM Community Newsletter.

We are very happy to announce that a new Project Group on Kilometer-scale ICON Continental Simulations (KICS) has been established. The goal of the Project Group is the preparation, conduction, and analysis of km-scale continental ICON climate simulations by 2030. This encompasses all aspects of regional climate modelling. The PG thus aims at enabling the CLM Community to perform such simulations, similar to 12 km simulations nowadays. The PG is led by Klaus Görgen (FZJ) and Alejandro Vichot Llano (CMCC). If you want to join the group or want to have more information, please visit the webpage of the PG: https://www.clm-community.eu/community/working-groups/KICS/



The Alps in ICON grids with 13 km and 1,6 km resolution.

This issue of the newsletter also contains an interview with Pavel Khain from IMS, a review of the CLM Assembly 2025 in Graz and an outlook to ICCARUS and the ICON-CLM Training in 2026. Research notes come from Angelo Campanale (CMCC) about the "First application of the coupled ICON modelling framework at regional scale: the case study of medicane Ianos" and Marie Hundhausen (KIT) about "Climate change signals of extreme precipitation in a transient convection-permitting simulation ensemble".

Enjoy reading!

Five questions to….
Pavel Khain
IMS



Pavel Khain leads the Numerical Modelling Department at the Israel Meteorological Service (IMS). After completing his military service as a weather forecaster, he earned a PhD in plasma physics from the Hebrew University of Jerusalem. During his doctoral studies, he discovered that his true passion lay in meteorology and began taking courses in this field. In 2012, he joined the IMS Research and Development Division as a scientist. That same year, IMS acquired its first HPC and became a cooperating member of ECMWF, marking the beginning of its numerical modelling activity and research. IMS R&D later joined the CLM and COSMO communities. Since 2020 and particularly since 2024 IMS operates its primary modelling infrastructure on ECMWF's ATOS supercomputer. In addition to participation in ICON model research and development, Pavel's department is responsible for operational runs of ICON driven by various models, COSMO, WRF, ICON hourly rapid update cycle and ICON ensemble. Moreover, it is responsible for the production of ICON-based climate projections at convective-permitting resolution, driven by multiple GCMs under a range of greenhouse-gas concentration scenarios

1. *Pavel, you work at the Israel Meteorological Service (IMS). Could you tell us a little about the IMS in general, and your role in particular?*

First of all, a bit of fascinating history. The first civil airport in Israel was founded in 1936, by the British Mandate's government. However, there was a shortage of qualified personnel, including experts in aviation meteorology. The solution emerged with a group of immigrants from Germany, who arrived for the 1936 Maccabiah Games as the Third Reich's glider team. Rudolf Feige, already a world-renowned meteorologist, headed the group. This very team went on to establish the aviation-forecasting department in March 1937, as part of the Mandate's civil aviation authority.

With the establishment of the State of Israel in 1948, the meteorological unit evolved into the newly established Israel Meteorological Service (IMS).
Today, IMS, a unit within the ministry of transport, provides forecasts for the public, emergency units, economic sectors, and aviation; operates a national network of meteorological stations; conducts comprehensive analyses for past and future climate, plays an active role in advancing NWP and climate modelling in collaboration with leading European meteorological institutions and organizations; provides operational forecasts for about 10 countries in the Balkans and Eastern Europe; and operates a regional WMO training center in applied meteorology. And all of this is done with only 63 employees.
I joined the IMS R&D division in 2012. Today, I lead the numerical modelling department. We focus on operating and developing numerical tools, ranging from nowcasting based on AI and INCA, through medium-range forecasting based on NWP (primarily ICON, but also COSMO and WRF), to climate projections using ICON in convective-permitting resolution.

2. *You have been working with COSMO-CLM/ICON-CLM in the Mediterranean and Israel, and have encountered several problems. Could you please explain what didn't work properly in those areas and how you tried to solve the problems?*

Numerical models are not perfect and their optimal configuration varies between geographical regions. It is unfortunate, but that what makes our work interesting. Already in 2013, we noticed that COSMO in convective-permitting resolution of 2.5km strongly underestimated precipitation over the Eastern Mediterranean. With great support from colleagues at DWD, it took us a couple of years to learn the model and realize that the "numerical competition" between the resolved and parametrized convection was the source of the problem. In the paper from 2021, we showed that restricting the activity of the shallow convection parametrization significantly improves precipitation forecasting, especially over the Mediterranean. This conclusion is also valid for the ICON model and serves us when running this model for NWP and climate applications.

However, the problems related to precipitation did not end there. When comparing the rain rates with observation over the Eastern Mediterranean, we typically saw overestimation of heavy rain and underestimation of light rain. This behavior was recently improved by careful tuning of sea-surface evaporation, microphysical parameters and saturation adjustment process.

An additional interesting problem was related to subgrid-scale cloud cover.

It turned out that over the Eastern Mediterranean ICON in convective-permitting resolution overestimates partially cloudy areas but underestimates overcast areas. As a result of a comprehensive analysis, a new tuning parameter was added, which allowed steeper increase of cloud cover as function of the relative humidity.

During the last years, we had fruitful collaboration with colleagues from the COPAT2 group of the CLM Community. As part of this work, many new ideas emerged aimed at reducing model biases. These include making surface albedo dependent on soil moisture, better consideration of irrigated croplands, improving land-use and soil-type databases over the Eastern Mediterranean and North Africa, etc.

The main problem that remains over the Middle East region is significant underestimation of the 2-meter temperature climatological trend, especially the trend of the daily minimum temperature. We suspect that the problem originates in the soil-moisture behavior in the upper soil layers. Compared to ERA5, it shows stronger and faster drying on the seasonal time scale and a negative drift on the yearly time scale. Intuitively, drier soil leads to cooler nocturnal temperatures and may explain the underestimation of the climatological trend of the daily minimum temperature.

Although NWP and climate simulations are aimed to represent different time scales, I believe that their verification and tuning should be tackled similarly. For example, we managed to better simulate the climatology of precipitation over our area, including maximum rates statistics and yearly sums, by carefully analyzing of precipitation forecasts during specific events simulated by NWP. Tackling precipitation monthly or yearly biases directly would make the path to improvement much longer. After all, besides several minor changes in metadata, one can perform a reasonable climatological simulation with the same ICON configuration used for NWP.

3. *You and your colleagues at IMS have also participated in the development of ICON. Could you provide a brief overview of IMS's main contributions?*

Our main contributions to ICON are related to microphysics and aerosols. The work is performed in collaboration with colleagues from DWD, and would not be possible without their great support. With respect to microphysics, we implemented a new Spectral Bin Microphysics (SBM) parametrization (activated with itype_gscp=8). SBM is a detailed cloud microphysics scheme used in atmospheric models that explicitly represents the size distribution of cloud particles by dividing them into discrete size bins.

Unlike bulk microphysics schemes that use only a few prognostic variables to represent entire particle populations, SBM tracks the number concentration of particles in each size bin, allowing for a more realistic representation of microphysical processes such as condensation, evaporation, collision-coalescence, and ice processes. Nowadays, we are working on implementing an important process of turbulent enhancement of collisions between hydrometeors. The SBM scheme is computationally expensive, making it primarily suitable for high-resolution simulations or research applications where detailed microphysical representation is essential for understanding cloud processes and their climate impacts.

With respect to aerosols, we implemented a new CAMS 49R2 aerosol climatology (irad_aero=7), and the option to utilize real-time 3-dimentional CAMS forecasts of aerosol mixing ratios instead of aerosol climatology (irad_aero=8). For example, in cases of dessert-dust outbreaks the aerosol optical depth strongly differs from the climatology. In such cases, using CAMS forecasts instead of climatology is crucial for correct radiation forecasts. Although there might be inconsistency between ICON and CAMS forecasts, this implementation is significantly computationally cheaper than using forecasted aerosols within ICON (as in ICON-ART). Therefore, the implementation of CAMS forecasts is especially unique. In both implementations, CAMS aerosols influence aerosol-radiation interactions in ICON. Nowadays, we are working on implementing CAMS aerosols for aerosol-cloud interactions as well.

4. *You are also involved in the Consortium for Small-Scale Modelling (COSMO). From your perspective, what are the main differences and similarities between COSMO and the CLM Community*

Both communities are fascinating, operate at high professional and scientific level, and consist of warm, dedicated people. Although my experience in various working groups is limited, my impression is that in the CLM community there is more attention to the implementation of coupled systems, where ICON is coupled with other models such as ocean models, rivers-discharge models, comprehensive soil description, dynamic vegetation, etc., while in COSMO the focus is on developing and improving existing parametrizations within ICON, followed by their careful tuning. Since CLM and COSMO communities focus on different time scales, this separation is natural. However, I found that many problems are common for the two communities, and stronger collaboration between them could be very fruitful.

5. *What are your personal career goals?*

Of course, it's subjective, but I work in one of the most fascinating fields. We are moving toward a significant leap forward in the accuracy of weather prediction—from time scales of just a few hours to projections that look years ahead. This is especially true when it comes to precipitation forecasting. A few years ago, producing an accurate forecast of severe precipitation at the scale of a single city or even a neighborhood, seemed almost unimaginable. Today, it's already coming into view. Likewise, climate-scale estimates of short-duration rainfall intensity were once little more than rough approximations, and the progress in this area has been remarkable.
These improvements, both those already achieved and those yet to come, have a direct impact on people's quality of life and have the potential to save lives and prevent property loss.
Being part of this transformative process and the drive to achieve neighborhood-scale precision in precipitation forecasting continues to guide my professional path and motivates my work for the years ahead.

Thank you very much for the interview!

Thank you very much for the interview, it is a great honor for me.

Review CLM Community Assembly 2025

By Susanne Brienen (Deutscher Wetterdienst)

The 2025 CLM Community Meeting was hosted by the colleagues of the Wegener Center in the beautiful city of Graz in Austria.
39 participants from 6 countries gathered in the rooms of the University to follow the presentations and discuss the newest developments and studies with the COSMO-CLM and ICON-CLM; 38 abstracts have been submitted. The working groups CRCS, SOILVEG, EVAL, AIO, SUPTECH and CP met as well and presented the status of current working group activities in the Community Meeting on Friday.
Two very interesting invited talks were given, followed by lively discussions: one on Tuesday by Andreas Prein (Department of Environmental Systems Science, ETH Zurich) on "Global Performance of GPU-Optimized ICON at Kilometer Scale",
and one on Thursday by Alex Hall (Institute of the Environment and Sustainability, University of California, Los Angeles) on "An Evaluation of Dynamical Downscaling Methods Used to Project Regional Climate Change".
Three major agenda items have been discussed in the Community Meeting on Friday. The first one was the adoption of the first recommended configuration for convection permitting simulations with ICON-CLM. Following a long tuning activity, the WG CRCS presented the results and the suggested configuration (named "CEI195c"). It was adopted by the participants through positive vote. The second point was the suggestion of a new project group called KICS (Kilometer-scale ICON Continental Simulations), which aims at the preparation, conduction, and analysis of km-scale continental ICON climate simulations by 2030. This suggestion was also adopted by vote. Finally, it was discussed how the Community could benefit from the German natESM program (https://www.nat-esm.de/); ideas have to be further explored in the working groups. Details on the community meeting can be found in the minutes: https://www.clm-community.eu/uploads/media/material/55e5147d-e08a-4e28-9acb-2088fa9de160/20250926_CLM-CommunityMeeting_Minutes.pdf.
For other presentations (if provided by the authors) and working group meeting minutes, see the links in the program: https://www.clm-community.eu/events/clm-community-assembly-2025/programme.

A nice social program complemented the scientific discussions: an ice-breaker in beautiful location of the Botanic Gardens, a guided tour through the City Center and a Conference Dinner in a Restaurant located on a (constructed) island on the river Mur. For those who wanted to take advantage of the mountains in the vicinity of Graz, Beate Geyer and Andreas Will organized a private hiking tour on the week-end following the Assembly.
Many thanks to Heimo Truhetz and his team (Simone Chen, Magdalena Posch, Veronika Rogenhofer, Sabine Tschürtz, David Kneidinger, Isabella Kohlhauser, Laurenz Roither) for organizing a wonderful Assembly 2025! We are looking forward to the Assembly 2026, which will be hosted by Hereon in Lüneburg, Germany, from 22 – 25 September 2026.



The famous Clock Tower on the Castle Hill in Graz, © Susanne Brienen



Group picture at the Assembly 2025, © Simone Chen

Outlook ICCARUS 2026

By Christian Steger (Deutscher Wetterdienst)

The ICCARUS (ICON/COSMO/CLM/ART USER Seminar) 2026 will take place from 16 to 20 March 2026 at the DWD headquarters in Offenbach, Germany. The conference will be largely organised as a hybrid meeting. Only posters will be presented only on-site.
ICCARUS brings together developers and users of the non-hydrostatic COSMO and ICON models, which are used in numerical weather prediction as well as in climate simulations and modelling of air quality and its feedback to the atmosphere. The seminar will provide a forum for COSMO and ICON groups to exchange information on model development, physics parameterisation, data assimilation, ensemble generation, verification and applications.
The first three days, from 16 to 18 March, are dedicated to plenary sessions. Plenary sessions can be attended online or in person, poster sessions will be held in person only. The final programme will be available in early February. It is not yet known which sessions will be offered. However, past experience suggests that there will amongst others be sessions on data assimilation, case studies, clouds and radiation, boundary layer and turbulence, aerosol and chemistry.
The four keynote talks and the invited talk are already known. Günther Zängl and/or Linda Schlemmer (DWD) will present the latest developments and plans for NWP. Ali Hoshyaripour (KIT) will give an update on ICON-ART. Marek Jacob or Roland Potthast will introduce AICON and the Warmworld project will be presented by colleagues from DKRZ/MPI-M. The invited talk about TeamX will be given by Manuela Lehner (Team X Programme Coordination Office, University of Innsbruck).



ICCARUS-Logo (Source: N. Leps, DWD)

The plenary sessions will be followed by face-to-face or hybrid working group meetings on Thursday and Friday, 19 and 20 March. The working group meetings will deal with overarching topics like ICON Infrastructure, Earth System Modelling and Soil, Vegetation and Land Surface and try to bring people from the different communities together. In addition, workshops about "The Community Interface ComIn" (Thursday, 19 March, 15:00 – 17:00 CET) and "Performance portability with C++/Kokkos in ICON" (Friday, 20 March, 09:00 – 16:00 CET) will be offered.
More information on ICCARUS 2026 is available at www.dwd.de/iccarus.

New CLM-Community Project Group "Kilometer-scale ICON Continental Simulations" (PG KICS) started

By Klaus Görgen (JFZ)

During the CLM-Community Assembly in September 2025 in Graz the new Project Group (PG) "Kilometer-scale ICON Continental Simulations" (PG KICS) was proposed, discussed and decided upon. The goal of PG KICS is the preparation, conduction, and analysis of km-scale continental ICON climate simulations by 2030. This encompasses all aspects of regional climate modelling. The PG thus aims at enabling the CLM Community to perform such simulations, similar to 12 km simulations nowadays.

The PG was proposed by WG CRCS after consultation with other CLM Community WGs. There was community consent that the PG is a timely and overarching effort. This is not only because time-intensive preparations are needed for production-readiness for this type of km-scale simulations within five years, but first and foremost because regional climate modelling is moving towards high (i.e., convection-permitting or km-scale) resolution, fully coupled regional climate or Earth system models, run for continental-scale model domains, long (transient) timespans, and large ensemble sizes, on the latest tier-0/1HPC systems (e.g., Schär et al., 2020). Published studies, past and ongoing experiments give evidence of these developments (e.g., Berthou et al., 2020; Leutwyler et al., 2017; Prein et al., 2020; Senior et al., 2021). Kilometer-scale continental simulations with ICON are scientifically and technically feasible, reaching already almost one simulated year per day (SYPD). Yet, they are still highly challenging "frontier simulations", both with respect to the investment of HPC resources, scientific questions, and the still "explorative" character of existing simulations. Given the extensive expertise and experience of the CLM Community, the PG's broad objectives are considered feasible.

Working towards the PG's goal, will lead to scientific and technical added value for the CLM Community as many research questions can be linked to PG KICS simulations, e.g., the locality and the impact of climate change, the representation of extreme (compound) events, the role of mesoscale convective systems, to name a few.

The PG will help to prepare the community for a future, already ongoing (inevitable) evolution in science and technology of regional climate modelling, potentially making the community ready for future frontier simulations in this field as envisioned in international contexts, for example EURO-CORDEX. A coordinated preparation of computationally efficient continental model runs may serve multiple scientific purposes in comparison to small-domain and/or uncoordinated continental scale simulations. New technical developments can be considered efficiently to address technical challenges of continental km-scale simulations (e.g., big data handling and analysis, HPC, configurations, workflow engines, quality assessment methods, etc.). This PG provides the CLM Community with an opportunity to systematically address model biases arising from overturning models to small regional domains. Kilometer-scale model results may serve as boundary conditions to extremely high-resolution simulations. Many CLM Community members may collaborate on a challenging common goal.

To put the PG into practice, Task Groups (TGs) are forming, these are cross-WG informal time-limited, sprint-like initiatives or activities on specific tasks or topics either with a more technical or a more scientific focus, that can work concurrently, collaborating through the PG KICS GitLab. Examples would be the COPAT or CECPI-Ger initiatives. TGs to realize initial coordinated km-scale ICON baseline simulation(s) are on the compute environments, the inputs, and the configuration, flanked by analysis TGs with a focus on the Mediterranean and on the Alps. Through monthly PG KICS meetings, the TGs collaborate towards joint experiment designs and simulations.

During the first inaugural meeting on 2025-12-08, Klaus Goergen (FZJ) and Alejandro Vichot Llano (CMCC) were elected as coordinators for the first year. The PG KICS homepage (https://www.clm-community.eu/community/working-groups/KICS/) gives an overview and provides relevant documents as well as organizational information on how to get involved and stay informed.

First application of the coupled ICON modelling framework at regional scale: the case study of medicane Ianos

Authors: Angelo Campanale[1], Alija Bevrnja[2], Mario Raffa[1], Roland Potthast[2], Paola Mercogliano[1], Jan-Peter Schulz[2,1]

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Abstract

Medicanes, Mediterranean tropical-like cyclones, are driven by strong air-sea interactions and can produce extreme winds, heavy rainfall, and severe coastal impacts. Accurate prediction of these events requires modelling frameworks that explicitly resolve atmosphere-ocean feedbacks. This study presents the first high-resolution (2.5 km) application of the coupled atmosphere-ocean ICON system, with both components running at regional scale, focusing on the simulation of Medicane Ianos (September 2020). Comparisons with observations show that the coupled system substantially improves the representation of key storm characteristics, including wind intensity, sea-level pressure deepening, precipitation, and SST cooling, relative to uncoupled simulations with fixed SSTs. Improvements are most evident when the storm is forecasted several days before peak intensity, while storm-track accuracy remains mainly dependent on the initial atmospheric conditions. These results highlight the added value of regional coupled modelling for high-impact weather forecasting in the Mediterranean, where fine-scale air–sea feedbacks strongly influence cyclone evolution.

Model and results

The regional ocean component of ICON used here is based on the global ICON ocean system (Korn, 2017; Korn et al., 2022) and has been developed collaboratively by DWD and MPI-M. It solves the hydrostatic Boussinesq equations on an icosahedral grid, evolving the ocean state vector comprising horizontal velocity, sea surface height, potential temperature, and salinity. Boundary conditions are prescribed from a coarser-resolution ocean simulation and linearly interpolated in time to generate smoothly evolving fields at each time step. Compared to the global ICON-O used in ICON-ESM (Jungclaus et al., 2022), the Gent-McWilliams parameterization has been deactivated, allowing for an explicitly eddy-resolving configuration, while other parameterizations remain unchanged. A dedicated publication describing the implementation, configuration, and validation of ICON-O-LAM is in preparation.

The coupling between ICON-A-LAM and ICON-O-LAM is implemented via the Yet Another Coupler (YAC; Hanke et al., 2016), following the approach of the global ICON-ESM, with a simplified nearest-neighbour remapping due to the identical grid resolution. Both components run at 2.5 km resolution. At each coupling step, two-way exchanges occur: ICON-A-LAM provides wind stress, surface freshwater fluxes, radiation, latent and sensible heat fluxes, sea ice melt, 10 m wind, and sea level pressure; ICON-O-LAM supplies SST, surface velocities, ice and snow thickness, and ice concentration. Data are exchanged at every model time step and accumulated in YAC to ensure consistent two-way coupling.

This work presents the first high-resolution (2.5 km) application of ICON-O-LAM coupled with its atmospheric counterpart ICON-A-LAM, focusing on the simulation of Medicane Ianos (September 2020). Compared with observations, the coupled system substantially improves the representation of key storm characteristics, such as wind intensity (Figure 1), sea-level pressure deepening, precipitation, and SST cooling (Figure 2), with respect to uncoupled simulations with fixed SST condition, which provide physically inconsistent ocean conditions and excessive heat and moisture to the atmosphere throughout the event. These improvements are particularly evident when the storm is forecast several days before its peak, whereas storm-track accuracy remains primarily governed by initial atmospheric conditions. These results highlight the added value of high-resolution regional coupled modelling for extreme weather in semi-enclosed basins, where fine-scale air–sea feedbacks critically shape cyclone evolution. More details on this work can be found in the paper "*Exploring the regional coupled capabilities of the ICON modelling framework: the case of Medicane Ianos*", Campanale A. et al., submitted and currently under review in *Atmospheric Research.*

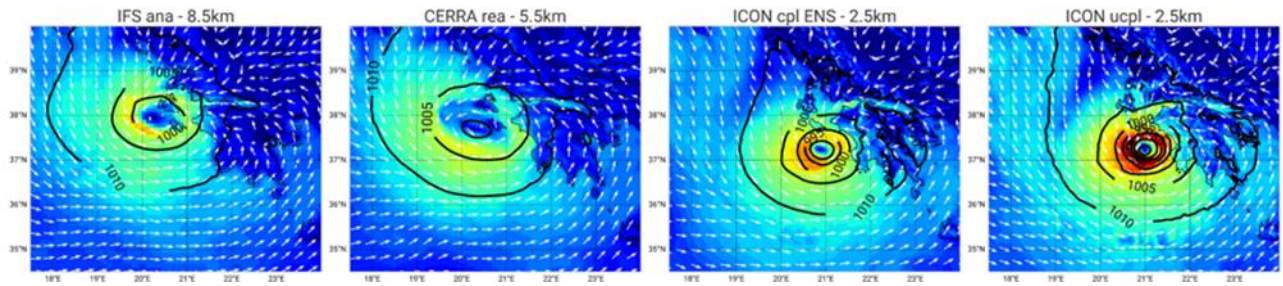

Figure 1: *10 m wind speed and direction (white arrows) with mean sea level pressure isobars (black in hPa) from IFS analysis (first panel), CERRA reanalysis (second panel), coupled ICON simulations (third panel), and the uncoupled ICON experiment (fourth panel), during IANOS most intense peaking phase (18 September 2020 at 00:00 UTC).*

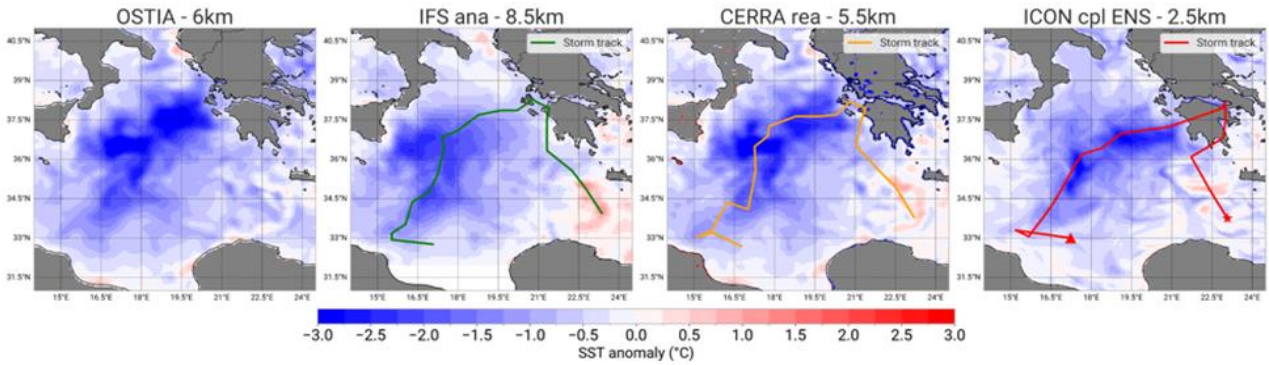

Figure 2*: SST daily cooling anomaly from the last day of the event (20 September 2020) relative to the first day of the event (15 September 2020), shown for OSTIA observations (first panel), IFS analysis (second panel), CERRA reanalysis (third panel), and coupled ICON simulations (fourth panel). This SST cooling anomaly would be impossible to simulate with ICON atmo-only.*

These results open promising avenues for the continued development of the ICON coupled modelling system. The next steps will include analysing other Medicane events to confirm the system's capability to better forecast such extremes and mitigate their impacts on coastal communities, further tuning of the entire coupled ICON "only" configuration at the regional scale, and testing it at climate timescales over the Mediterranean Sea, including the possibility of forcing both components with GCM climate change signals. Achieving this last objective would require close collaboration with, and support from, the CLM community.

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Climate change signals of extreme precipitation in a transient convection-permitting simulation ensemble

Marie Hundhausen (KIT)

The article:

Hundhausen, M., H. Feldmann, R. Kohlhepp, & J. G. Pinto (2024). Climate change signals of extreme precipitation return levels for Germany in a transient convection-permitting simulation ensemble. International Journal of Climatology, 44(5), 1454-1471, doi: 10.1002/joc.8393.

Introduction

The 6th IPCC assessment report provides broad evidence that heavy precipitation events are expected to become more frequent and intense with global warming. However, the magnitude of the regional changes in extreme precipitation intensities remains uncertain. The previous analysis of extreme precipitation changes in Germany in CPMs (convection-permitting models) is so far based on time slice approaches that are sensitive to the internal uncertainty of the climate system. Furthermore, previous CPM analysis is often derived from single CPM simulation runs and ensemble data are rare.

To address these shortcomings, our article uses the KIT-KLIWA ensemble to track evolution of future heavy rainfall in a transient convection-permitting, multi-GCM ensemble with a simulation period from 1971 to 2100. We investigate precipitation return levels (RLs) from hourly to multi-day event duration (ED) and for different return periods (RPs) up to 100 a.

Method

The CPM Ensemble

The ensemble is a regional downscaling of four CMIP5 GCMs with the emission scenario RCP8.5, namely MPI-ESM-LR (r1i1p1), EC-EARTH (r12i1p1), CNRM-CM5 (r1i1p1) and HadGEM2-ES (r1i1p1). Similar to Teichmann et al. (2018), we have chosen the Global warming (GW) within the period 1971–2000 as the reference period, where a GW of 0.46K compared to the pre-industrial conditions is assumed. In the projection GW is analyzed over the global temperature anomaly in 30-year running windows. The 30-year periods centered around 2° and 3° of GW are hereafter referred to as Global Warming Level GWL2 and GWL3.

The four GCMs are downscaled with COSMO5.0-CLM9 in the period 1971 to 2100. The downscaling strategy comprises three nesting steps. Convection in the first nest (0.44°) and second nest (0.0625°) is parametrized. The third, convection-permitting grid is centered over Southern Germany with a resolution of 0.025° (approximately 2.8 km). Here, only shallow convection is parametrized while deep convection is explicitly resolved. An overview of the nesting setup can be found in Hundhausen et al. (2023). A boundary region of 48 grid points was truncated. The resulting CPM domain is shown in Fig. 1a. The German part of the domain (hatched in Fig. 1a) is analyzed in the study.

Calculation of precipitation return levels

The analysis of extreme precipitation in the CPM ensemble is based on the simulated hourly precipitation time series. For each grid point, we derive return levels (RLs) for return periods (RPs) from 1 a to 100 a and event durations (EDs) from 1 h to 3 days. As our work intends to be close to the hydrological application for Germany, the calculation of RLs is based on the German DWA-A 531 guideline, which is the basis for the German national raster data for heavy precipitation, the KOSTRA-DWD-2010R dataset (“Koordinierte Starkniederschlagsregionalisierung und -auswertung des DWD”, Malitz and Ertel (2015), details regarding the calculations are in Hundhausen et al. 2024). An evaluation of RLs in the CPM data compared to observational station data and the KOSTRA dataset can be found in Hundhausen et al. (2025).

- Calculation of the climate change signal
- The climate change signal of return levels

Analysis of the evolution of the hourly 10-year return level (event duration, ED = 1 h; return period, RP = 10 years) shown in Fig. 2a indicates that all ensemble members project a positive shift in the median from the historical period to GWL3. The distributions remain consistently right-skewed, with upper tails extending toward higher return levels, indicating the potential for locally exceptional extremes. The distributions broaden from the historical period to GWL3, as evidenced by the increased interquartile range, suggesting that extreme precipitation is projected to become more variable in the future.

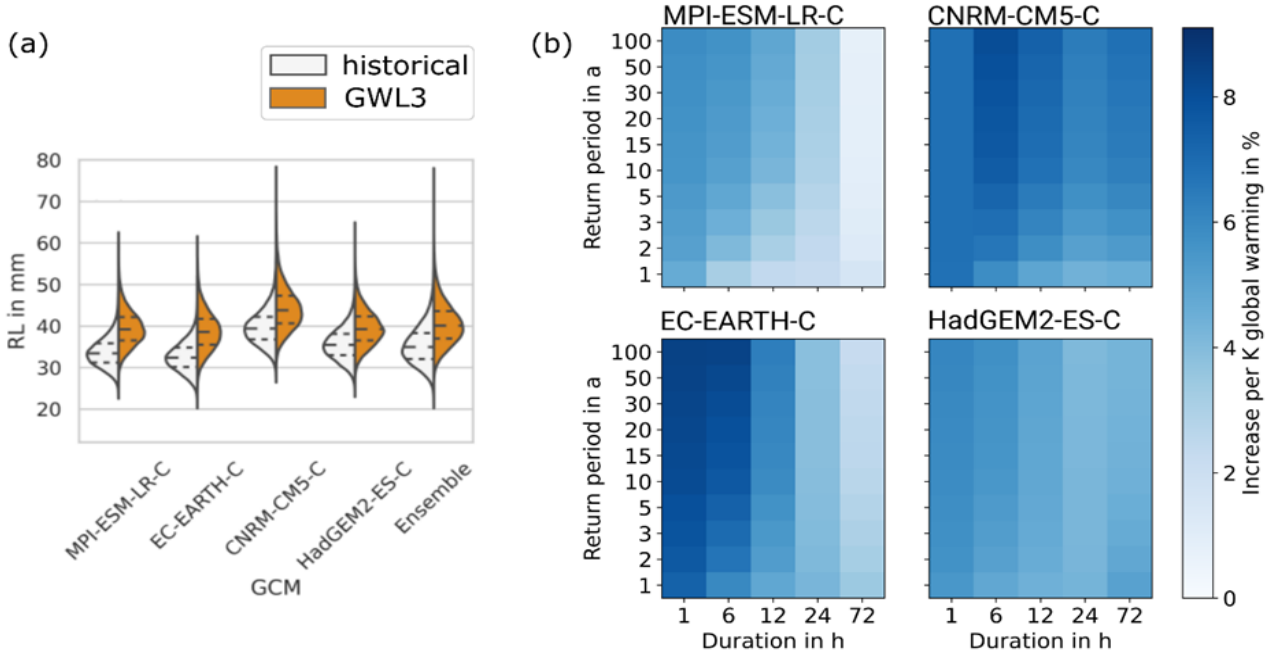

Figure 2: *(a) shows the distribution of the hourly 10-year RL over all grid points in the analysis domain in the historical time slice and GLW3. The median, along with the 25th and 75th percentiles, is indicated in the plot. Ensemble members are labelled by the driving GCM name with the suffix "-C" denoting the corresponding CPM downscaling. (b) Domain-median relative change in return levels. The four panels correspond to the four ensemble members and show results for different event durations (ED, x-axis) and return periods (RP, y-axis).*

From the analysis of return level (RL) changes across event durations ranging from hourly to multi-day scales and return periods of up to 100 years (Fig. 2b), several consistent patterns emerge:

If ED is kept constant and RP is varied, three out of four ensemble members project an enhanced increase of RL with RP for ED<24h. Only CNRM-CM5-C shows an approximately constant change factor for all RPs and ED=1h. For large ED=72h, a reverse pattern is observed for the majority of the ensemble members, where the relative increase is slightly larger for small RPs than for large RPs.

If RP is kept constant and ED is varied, increasing ED generally leads to decreasing change factor for ED<24 h. Only CNRM-CM5-C shows lower values for ED=1h and thus no steady decrease. For ED=72h, there is no common trend in the ensemble.

Conclusion

The transient CPM ensemble over Germany shows robust agreement that extreme precipitation intensifies with global warming across all considered time scales. Systematic patterns in the magnitude of change were identified as a function of event duration and return period. Figure 3 provides a synthesis of the patterns in the relative climate change signal.

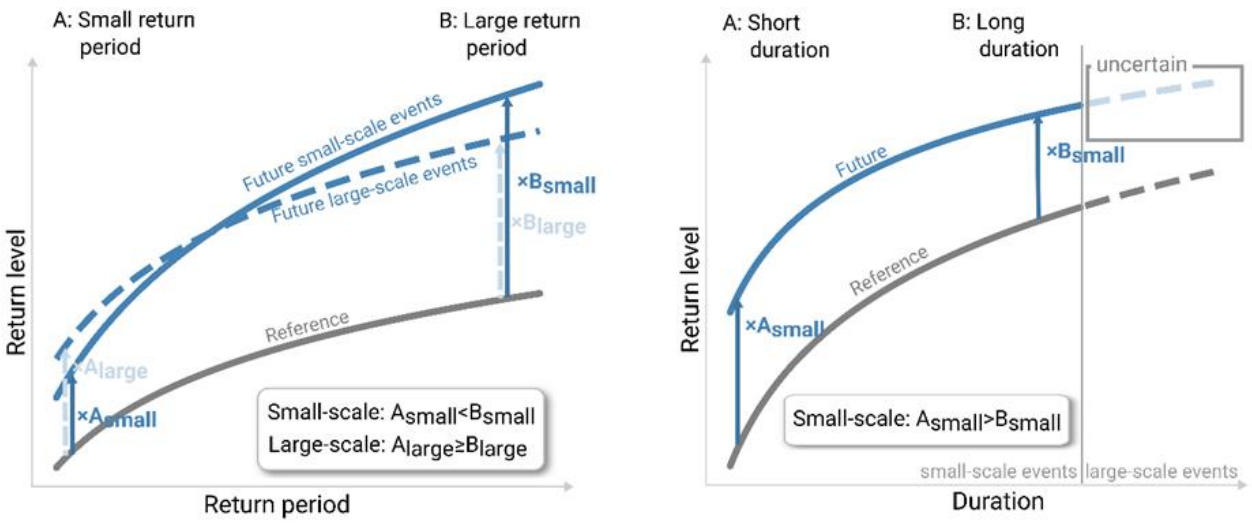

Figure 3: *Schematic for the development of future intensity and duration curves. Changes are expressed in terms of relative change factors. The dependency of those change factors Asmall/large and Bsmall/large on return period and duration is illustrated. The absolute values are not the subject of the diagram. Reprinted from Hundhausen et al. (2024).*

Overall, the study emphasizes that new products for rainfall risk management are needed for climate adaptation and gives an indication of which thresholds are particularly sensitive to climate change, namely short-duration and long return periods. Moreover, we found an increased variability of future extreme precipitation, indicating that the incorporation of uncertainty, also in impact modelling, may become more important.

In addition, the study emphasizes the considerable standard error associated with evaluating individual time slices as it is common practice in CPM downscaling. By utilizing a transient projection and considering inherent variance, we obtained a more robust change factor. This highlights the benefits of conducting long transient ensemble simulations and underscores the necessity for such simulations.

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ICON Training Course 2026

By Christian Steger (Deutscher Wetterdienst)

The Numerical Model Training Course will take place from 23–25 June 2026. This upcoming course will only cover ICON-CLM. The Met Services and NWP for academia courses will be restructured and will therefore not take place in 2026 or at a later date.

The course's lecture programme will be reduced to include only a basic introduction to ICON, ICON-CLM, and the CLM Community.
The exercises will be carried out to the same extent as in previous years. Participants will receive an introduction to the ICON-CLM runtime environment, SPICE, and learn how to set up the model for different time periods and domains. They will also learn how to use CMIP6 GCM data as forcing, run a nested simulation and evaluate model results, as well as how to use the Community Interface, ComIn.

The registration deadline for participants who require a visa is 15 January 2026. They will receive confirmation of the status of their application by 29 January 2026 at the latest.
All other participants can register until 31 March 2026 and will receive confirmation shortly afterwards.

Due to the limited capacity of the classroom, we may not be able to accept all applications.

Further information about the training can be found at www.dwd.de/training. The training team is looking forward to the ICON-CLM course and hopes that it will be interesting, informative and helpful for participants, as well as simplifying the use of and work with the model.



Logo Numerical Model Training Course Logo (Source: N. Leps DWD)

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(https://www.iiserb.ac.in)

Contact: Raj Pritam Gupta

Wroclaw University of Environmental and Life Sciences
(https://upwr.edu.pl/en/)

Contact: Dr. Samia Gurmani

Upcoming events

2026
January 27 – 29: EURO-CORDEX General Assembly, Hamburg, Germany
March 16 – 20: ICCARUS (ICON/COSMO/CLM/ART USER Seminar) , Offenbach, Germany
June 23 – 25: ICON-CLM Training, Offenbach, Germany
September 22 – 25: CLM Community Assembly 2026, Lüneburg, Germany

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