Climate Limited-area Modelling Community

July 2024

Newsletter

No. 23

Content

See YOU at the
CLM Assembly 2024

22 – 25 October 2024

Oberpfaffenhofen, Germany

Dear Colleagues,

Welcome to the 23rd CLM Community Newsletter!

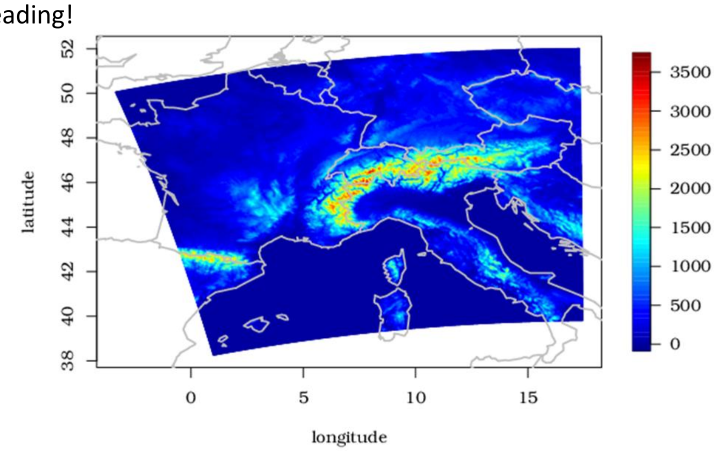
We are happy to announce, that the COPAT2 Team has agreed on a suggestion for a first recommended version and configuration for ICON-CLM. The results of the tests will be presented at the CLM Community Assembly in October. More information will follow afterwards.

The first bunch of convection-permitting climate simulations from the CORDEX-FPS Convection initiative is now available on the ESGF in the project “CORDEX-FPSCONV” (see e.g. https://esgf-metagrid.cloud.dkrz.de/ → all (except CMIP6) → General → Project: CORDEX-FPSCONV).

Many member institutions of the CLM Community contributed to this initiative. Several research papers using this data are already published. Please have a look at the publication list on the CLM Community web page for more details.

This issue of the Newsletter contains an interview with Ha Hagemann from Hereon, a short overview of the plans for CMIP7, an article about the ICON open source release and the new ICON webpage, a report about the restructuring of the CLM webpage, a review of ICCARUS 2024, an outlook to the CLM Assembly 2024 at DLR in Oberpfaffenhofen, and of course two research notes. The first one by Shuying Chen and colleagues from Forschungszentrum Jülich about renewable energy potential estimates based on high-resolution regional atmospheric modeling over southern Africa. The second one by Prashant Singh and Bodo Ahrens from University of Frankfurt on Modeling Lightning Activity in the Third Pole Region: Performance of a km-Scale ICON-CLM Simulation.

Enjoy reading!



Five questions to.... Ha Hagemann

Helmholtz Zentrum Hereon

Ha Hagemann has worked over 20 years on regional climate modelling. She completed her PhD in Vietnam using the RegCM3 model of ICTP (Italy). When she moved to Germany for a postdoc position in 2010, she coupled the COSMO-CLM model of the Consortium for Small-Scale Modelling with the ocean-sea ice model NEMO and the hydrological Institute discharge model HD for Europe. Since 2021, she has built up the coupled model system with the ICON model of the ICON Consortium. She is an expert in coupled regional climate modelling and atmosphere-ocean-sea ice interactions and related feedback. She is familiar with extreme climatic events over Europe and Southeast Asia. Her further interests comprise convection parameterizations and the utilization of machine learning approaches in climate research. Currently, she participates in the BMBF DAM project Coastal Futures. She is the coordinator of the Working Group on Atmosphere, Ice and Ocean in the Climate Limited-area Modelling Community (CLM-Community) since 2022. She is the research Theme Speaker for the topic on Coupled Regional Modelling in the Helmholtz-Verbund Regional Climate Change and Humans (REKLIM) since 2020, and the co-chair of the Working Group on Coupled Regional Earth System Models (Baltic Earth) since 2018.

1. *Ha, you work at Hereon in the Regional Land Atmosphere Modeling Department. Can you please tell us something about the institute, the work of the group and your tasks there?*

Helmholtz-Zentrum Hereon is part of the Helmholtz Association, Germany's largest scientific organization. The research center's approximately 1.100 employees make substantial contributions to clarifying major and pressing issues in key scientific, economic and social topics. The 14 research institutes of the Helmholtz Center Hereon work in the research areas Earth & Environment, Helmholtz Information and Matter. Within the research area Earth & Environment, the Institute of Coastal Systems - Analysis and Modeling provides multidisciplinary expertise in coastal research and coastal system modelling. It conducts research from physical, ecological and socio-economic perspectives on coastal system change due to climate change and use.

It develops prediction methods and future scenarios for coastal systems and their resources, using coupled complex mechanistic and statistical models, as well as state-of-the-art AI methods. By developing digital twins of the coastal environment and providing our reconstruction and future scenarios, its research supports the sustainable and safe use of coastal systems and creates a scientific basis for future-oriented coastal management. With its research, it provides scientific and methodological support for decision-making processes in public and private sectors. As Hereon is shareholder of the German Climate Computing Centre, the institute has access to its high-performance computing facilities.
I work in the Regional Land and Atmosphere Modeling department since 2010. Two main research topics in our department are regional climate modeling and atmosphere-land/ocean interactions. My task is to develop the regional Earth system model (RESM) including the atmosphere, hydrology and ocean components, and apply the RESM for climate simulations and climate change projections over the European domain.

2. *You are originally from Vietnam. Can you tell us about your work in your home country before you came to Germany and maybe also about climate research activities in general there?*

Before I came to Germany in August 2010, I was working in the Faculty of Hydro-Meteorology and Oceanography, Hanoi University of Science, Vietnam as a lecturer and researcher. I gave lectures on climate modelling at the university and in parallel I did research with the RegCM3 climate model which I had worked with during the PhD time. The Department of Meteorology has been very active in regional climate modeling and conducted some important national projects related to studying climate change in Vietnam. Due to the lack of computing resources, they haven't been able to apply RESMs in their studies. But they are looking forward to international collaboration to bring RESMs to Vietnam.

4. *You are the coordinator of the working group Atmosphere, Ice, Ocean. What are the main topics in this working group and your tasks as coordinator?*

The main topics in this working group (WG) are the development and application of regional Earth system models in which the CLM Community climate models COSMO-CLM and ICON-CLM are the atmospheric component. The members of the WG are from different institutions in various countries,
and we are working together on coupling these two models with other components of the climate system such as ocean and sea ice, land, hydrology, wave, etc. My main task is to coordinate the common work within the group to avoid overlapping or multiple efforts for similar tasks. As I gained a lot of experience in the coupling of regional Earth system components, I'm also willing to share my experience with other members, support them with coupling technical issues, and to learn from their experience. Organizing group meetings during the CLM Assembly and the User Seminar once each year and updating the coupling status of the WG on the CLM Community website are other useful tasks of a WG coordinator.

4. *You worked a lot on ocean coupling with COSMO, ICON, NEMO and HD in the last years. What are the main achievements in this area so far and which problems remain from your perspective.*

The main achievements are the developed RESMs that can be used not only to conduct hindcast simulations in the past but also to conduct historical and scenarios simulations to investigate climate change over the EURO-CORDEX domain. The RESMs can also be applied to other areas of the world. RESMs provide an added value for simulating weather extreme events such as heavy rainfall, storm, heat wave, etc. so that they are a very good tools for studying climate change. However, the RESMs request a lot of computing resources that not all centers can afford, especially in developing countries.

Besides, using the high-performance computing system also can contribute an amount of CO_2 to the greenhouse gas emissions. Thus, in addition to the challenge of developing useful and complex RESMs, we must think about how to make the RESMs operating more effectively and to release a smaller carbon footprint, for example by using GPU computing systems.

5. *What are your personal goals with respect to your scientific career?*

My main goals are, on the one hand, to apply our RESMs in climate change studies with a focus on extreme events in Europe, and on the other hand to further develop the RESMs, adapt them to the new GPU computing system at the suitable time, and apply them to other areas of the world, for example Southeast Asia area where my home country is located. I believe that the output of RESMs will be useful for impact models in different local regions to contribute to the adaptation and mitigation policies in the warming world due to the climate change.

Thank you very much for the interview!

CMIP AR7 Fast Track and ScenarioMIP

By Christian Steger (Deutscher Wetterdienst)

The downscaling of the CMIP6 simulations is not completed yet, but CMIP and the global climate modelling community are already planning and preparing for CMIP7. CMIP7 will bring some changes compared to previous CMIP phases and new scenarios for the climate projections. This article will give a very short overview of the plans for CMIP7.

A new element in CMIP7 is the so-called fast track. It includes experiments that are considered to be very important for the next IPCC report and the global stocktake in 2028. These simulations should be produced quickly and with a very strict deadline to be available in time for both initiatives (see Fig. 1). Other community MIPs can operate on their own time line and provide the data also after these deadlines. The AR7 Fast Track includes the DECK experiments (amip, piControl, 1pctCO2, abrupt-4xCO2, piClim-Control, piClim-anthro, piClim-4xCO2, historical) and a number of other experiments that were selected from various MIPs. These include amongst others the initialised predictions for 2025 – 2036 and the ScenarioMIP experiments. You can find a more detailed description of the fast track on the CMIP7 website: https://wcrp-cmip.org/cmip7.

The recommendation in CMIP7 for the modelling centres will be to run emission driven experiments. This requires the representation of the full carbon cycle in the , it will also be possible to produce concentration driven runs as in CMIP6.

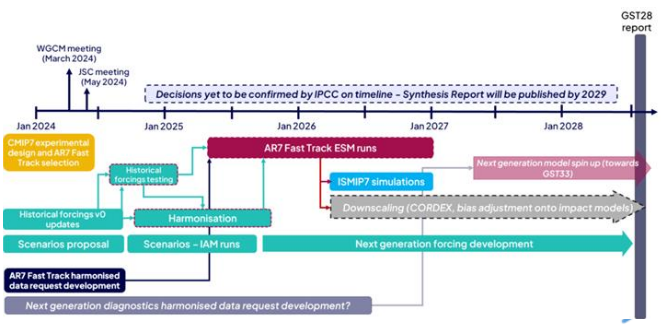


Fig. 1: Preliminary CMIP7 time line.

Furthermore, new scenarios will be provided as input for the climate simulations produced within ScenarioMIP. The scenario period will likely be extended from 2100 to 2125, but this is not finally decided. Figure 2 shows a schematic draft outline of the new emission scenarios. The suggested scenarios are:

- High (H): high emissions, but below SSP5-8.5
- Medium:
    - Medium (M): continuation of current policy
    - Medium Overshoot (MOS): delayed climate protection measures (Overshoot 2°C)
- Low (Paris Agreement):
    - Low (L): high probability to stay below 2°C
    - Very Low (VL): as little as possible above 1.5°C, but realistic
    - Low Overshoot (LOS): In 2100 similar to VL (~1.5°C), but with overshoot

For the full description of the new scenarios, please have a look at the proposal from the ScenarioMIP Scientific Steering Committee: https://wcrp-cmip.org/wp-content/uploads/2024/04/24-04-15_ScenarioMIP-CMIP7-proposal_final.pdf

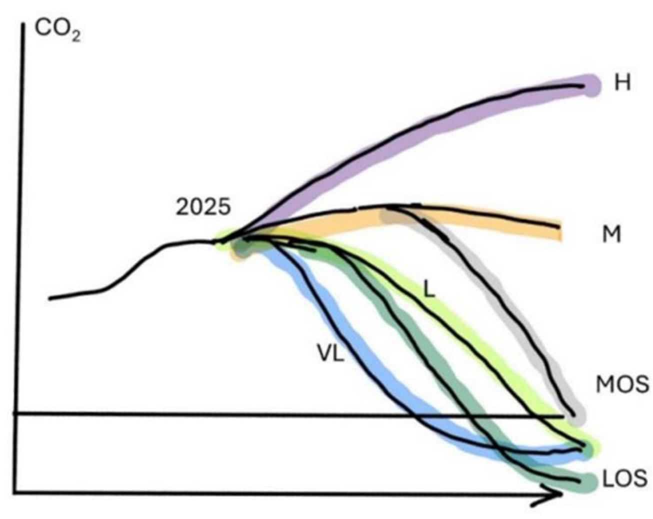


Fig. 2: Schematic draft outline for the scenarios developed on the final day of the workshop in Reading.

CLM Community Assembly 2024

By Susanne Brienen (Deutscher Wetterdienst)

The CLM Community Assembly 2024 will take place at the German Aerospace Center (DLR) in Oberpfaffenhofen, Germany, from 22 - 25 October as an on-site meeting. We are looking forward to seeing many community members again and to have many interesting discussions.

The number of abstracts has increased since the last assembly to 40. Therefore, a poster session is scheduled again this year to give everybody the opportunity to present and discuss their work during the week. 23 submissions will be presented as oral presentations in the plenary sessions, complemented by an invited talk. Meetings of the working groups AIO, MODEV, SOILVEG, CRCS, CP and CO are also planned. An important agenda item in the traditional community meeting on Friday will be the vote on the first recommended version of ICON-CLM as a result of the COPAT2 initiative. The full program is available on the community portal: https://www.clm-community.eu/events/clm-community-assembly-2024/programme.

Wednesday and Thursday evenings are reserved for social events that will hopefully also help to get to know each other more informally. On Wednesday we will have a guided tour through Munich and on Thursday we will go on a short hike to the “Holy Mountain of Bavaria”.

We thank Mariano Mertens, Patrick Jöckel and colleagues from DLR for organizing this event and hope to meet many community members in October in Oberpfaffenhofen!

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Restructuring CLM Community Portal and new log in procedure

By Christian Steger (Deutscher Wetterdienst), Philipp Sommer and Beate Geyer (Hereon)

One year ago, we reported in the newsletter about the unification of the old CLM Community Webpage and the RedC Wiki in the CLM Community portal. This was a very important step, because the membership and topic administration, event organization, wiki and webpage are organized via one system for the first time.

After the unification of all tools in the community portal, we recognized that the structure of the webpage and the accessibility of the content was not ideal anymore. Some things were difficult to find in the old structure and some topics were mentioned several times on different subpages. This was discussed in the SUPTECH meeting at the Assembly last year and we decided to restructure the webpage and clean up content where possible. A task group was established and met several times to discuss and implement a new structure.

As a result, some overarching categories were introduced as a menu at the top of the page (Community, Working Groups, Models and Tools, Science, Meet & Exchange, Help). Each category has a drop-down menu that enables direct access to its subpages (see Fig. 1). The subpages of the previous structure were reordered and assigned to one of the main categories of the new structure. Some outdated or duplicate information has been removed. Overall, the information is now more condensed and easier to find. The webpage is of course not static and the information must be updated continuously. Everybody can help to keep the webpage up to date. If you spot any outdated information, broken links or something else that can be improved, please report it to the CLM Community Coordination Office.

At the end of May, also the login procedure changed to Single Sign On via the Helmholtz AAI. You can either log in via your home institution (if registered at the Helmholtz AAI) or use one of the popular log in providers like GitHub, Google or OrcID. The log in via the previous user and password no longer works. In case you haven't changed your log in information up to now, please do this as soon as possible. You can find more information in an e-mail that Philipp sent to all community members on 29 May 2024.

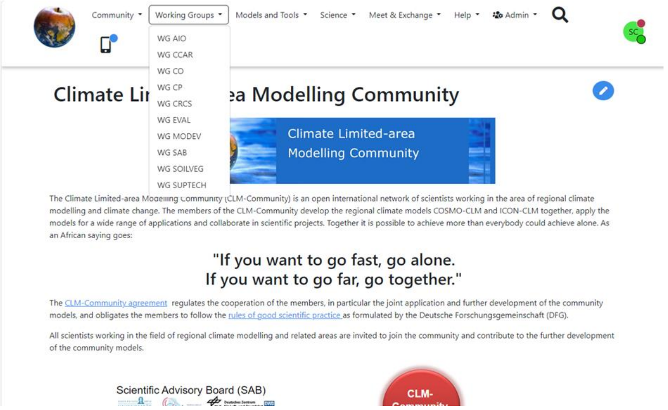


Fig. 1: Landing page of the CLM Community Portal with direct access to main topics via the menu at the top of the page.

ICCARUS 2024

By Christian Steger and Daniel Rieger (Deutscher Wetterdienst)

The ICCARUS (ICON/COSMO/CLM/ART User Seminar) is an international conference that brings together users and developers of the ICON model. Over the last two decades, ICCARUS has established itself as a hub for the exchange of information on model development, physical parameterisation, data assimilation, ensemble generation, verification and applications of the model systems (co-)developed by DWD. It thus provides an important link between COSMO, the CLM Community and ICON and ART developers.

Prof. Sarah Jones opened the event for the first time as President of DWD. In the last years, she always gave an overview of the most important activities related to the ICON model at the beginning of the event in her former role as FE Board Member. Roland Potthast then used his introductory speech to give a brief overview of current and planned projects for the use of artificial intelligence at DWD.

The scientific programme began afterwards. This year, on Monday, Tuesday and Wednesday, the programme comprised a total of 42 talks, which were divided into the thematic units "NWP Case Studies", "Clouds and Radiation", "Data Assimilation", "Community Interface ComIn", "Dynamic and Numeric", "SINFONY: Seamless INtegrated FOrecastiNg sYstem", "Upper Atmosphere", "Model Development", "Boundary Layer and Turbulence", "Earth System Modelling", "Regional Climate" and "Aerosol and Chemistry". The programme was enriched by four keynote lectures by Ali Hoshyaripour (KIT) on "Updates and Vision for ICON" and on "ICON-ART", Günther Zängl (DWD) on "ICON-NWP: Recent advances in our operational model configurations and plans for 2024", Oliver Fuhrer (MeteoSwiss) and Christoph Gebhardt (DWD) on "COSMO and ICON: news and highlights from MeteoSwiss and the consortium" and Wolfgang Müller (MPI-M) on "ICON-Seamless: Climate Configuration (ICON-XPP)". A highlight of the event was the invited talk by Thibaut Montmerle (Météo-France) entitled "The AROME model for NWP and Nowcasting at Météo-France", in which he explained the interaction of model-based weather forecasting and nowcasting at Météo-France, the counterpart to the developments and objectives of the DWD's SINFONY project.

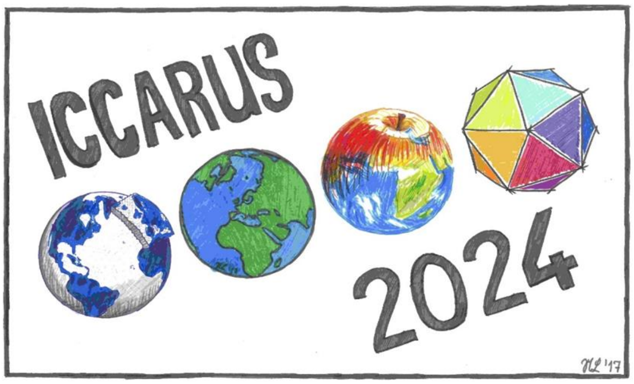
The poster session took place entirely online on Monday 11 March to give also participants who were not present on site the opportunity to present and view posters.

During the ICCARUS week, the posters could be presented in short pitches in specially organised sessions in the plenary on Monday and Tuesday. On Monday evening, after the scientific programme, there was a small reception for the participants in Offenbach.

When planning the working group sessions this year, the main aim was to bring the developers and users of the ICON model from the different, traditionally grown communities (COSMO, CLM and ICON) closer together in order to facilitate a better exchange and intensify cooperation. To this end, the working group meetings were no longer organised in internal community groups, but sessions on various topics were offered that were open to all interested parties. For example, there was an exchange across the traditional communities on "Soil, Vegetation & Land Surface", "ICON AI", "Radiation, Cloud, Aerosol, Chemistry", "Earth System Model", "Verification & Evaluation" and "Atmospheric Boundary Layer". The working groups were organised either as hybrid meetings on Thursday and Friday during the ICCARUS week, or as purely virtual meetings in the two following weeks.

A total of 280 people was registered for ICCARUS 2024, which was just short of the record number of participants set last year (286). 151 people were on site in Offenbach. There was a total of 97 scientific contributions (42 presentations, 55 posters). These figures impressively demonstrate the great interest in ICCARUS and its importance for the exchange between developers and users of ICON at universities, research institutes and national weather services. Following the release of the ICON code under an open source licence in January 2024, interest in ICCARUS is expected to increase further in the future.

The date for ICCARUS 2025 will not be announced until later in the year due to the availability of rooms in Offenbach and the need to avoid weeks with major trade fairs in Frankfurt. However, it will most likely be in March 2025.



ICON Open Source, new webpage and community interface (ComIn)

By Christian Steger and Daniel Rieger (Deutscher Wetterdienst)

ICON is open source! On 31st January 2024, ICON version icon-2024.01 was released under a permissive open source license (BSD-3C, see https://opensource.org/license/bsd-3-clause).

New ICON versions will be released regularly (approx. every 6 months) and the naming will have the following scheme: icon-yyyy.mm, where yyyy is the year an mm is the month of the release.

Together with the first open source release, a new ICON webpage has gone live: www.icon-model.org. New releases can be downloaded from this webpage and the page also provides additional information related to ICON, e.g. news, upcoming events, getting started with ICON, supported configurations and publications.

The new Community Interface (ComIn) organizes the data exchange and simulation events between the ICON model and third-party modules. It is part of the first open source release. Further information is available on the webpage. The community interface offers multi-language support (C/C++, Fortran, Python) and enables scientists to connect their own plugins with the ICON model without having to change the complex model code. Applications range from connecting complex models (e.g. chemistry, hydrology), interpolation of input/output data to exploiting the vast possibilities of Python's libraries. This not only promotes flexibility in research, but also represents a decisive building block for the transition from research to application. A ComIn exercise was already part of the ICON-CLM Training Course this year. A dedicated ComIn training takes place in the scope of a NatESM workshop in July.

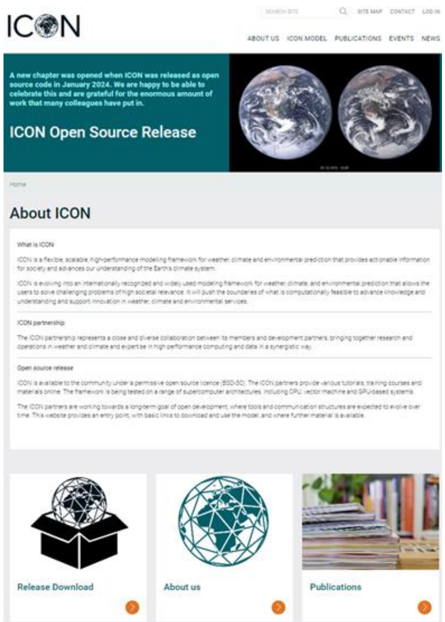


Fig 1: Screenshot of the new ICON Webpage.

Renewable energy potential estimates based on high-resolution regional atmospheric modeling over southern Africa

Shuying Chen, Stefan Poll, Harrie-Jan Hendricks Franssen, Heidi Heinrichs, Harry Vereecken, and Klaus Goergen (Forschungszentrum Jülich)

Approximately 580 million people in Africa lack a reliable electricity supply, accounting for 75% of the global population without access to electricity. Renewable energy is widely recognized as a crucial solution for addressing the power supply gap and mitigating climate change in Africa. Information on renewable energy potential (REP) is essential for the expansion of renewable energy planning. However, conventional REP estimates face challenges related to meteorological input data, such as coarse spatial resolution, gaps in data across space and time, and overall data quality in Africa.

In the recently published study by Chen et al. (2024), we implemented and ran the atmospheric model ICON v2.6.4 from the German Weather Service (DWD) and partners in its limited area mode (ICON-LAM). A high-resolution, convection-permitting hindcast setup with a 3.3 km resolution (R3B09) is used, as a one-way single nest into DWD's global ICON forecasts with a 6-day reinitialization of the atmosphere. This setup serves as a demonstrator for producing a novel, physically consistent three-year meteorological dataset, specifically designed for renewable energy potential (REP) estimates over southern Africa, using the numerical weather prediction configuration from DWD. We evaluated the renewable energy variables wind speed (sfcWind) and solar irradiance (rsds) from these simulations against an extensive dataset of in-situ observations that we compiled, as well as satellite and other composite data products. Comparing results with the more than 200 stations from three different in-situ networks (Figure 1 and 2), we demonstrated that ICON could reproduce REP-related variables with a level of sophistication that likely adds value over conventional inputs for REP assessments. This study exemplifies how regional climate models can help to fill data gaps in regions with scarce information. As this was a new model setup, we also included a basic evaluation of precipitation and air temperature.

In a subsequent work (Chen et al., under review), we additionally evaluated the simulated 60 m wind speeds from our ICON-LAM simulations, the commonly used 31 km-resolution ERA5 reanalysis, and the combined Global Wind Atlas-ERA5 product at 18 weather masts, where data became available throughout the study. We then compared the estimated wind energy potentials based on ICON-LAM and the two ERA5 variants using the renewable energy model RESKit (Ryberg et al., 2019a and 2019b) with 1.8 million eligible wind turbine placements from a land eligibility and placement identification study (Heinrichs et al., 2023; Franzmann et al., 2023) across southern Africa. The simulated wind power over existing wind farms in South Africa for 2019, based on these three products, was also validated against measurements. The results demonstrate that the high-resolution, physically consistent wind speed product from ICON-LAM provides generally more accurate wind speed simulations and wind power calculations. The new dataset reveals a higher wind energy potential available in southern Africa compared to other widely used products. An underestimation of wind energy yield can hinder the expansion of local wind farms due to lower expected economic performance. This highlights the importance of highly resolved weather data and these findings may be used as usable information for the local renewable energy industry.

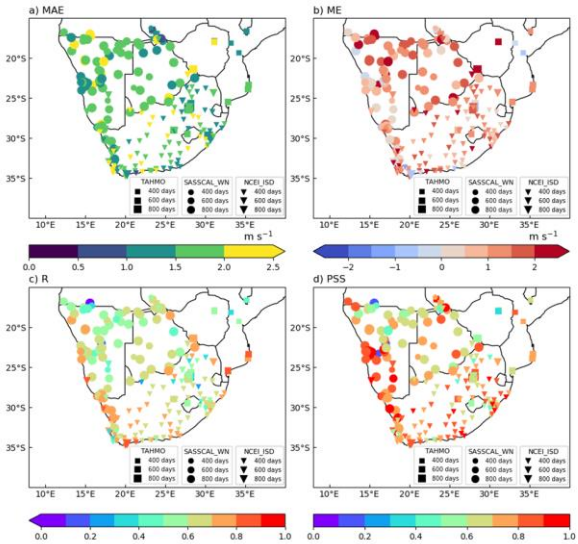


Figure 1: *Spatial distribution of mean absolute error (MAE), mean error (ME), Pearson correlation coefficient (R), and Perkins Skill Score (PSS) of hourly sfcWind for the period 2017 to 2019 at ground meteorological stations. Statistics are calculated by comparing simulated sfcWind by ICON-LAM and observed sfcWind by ground meteorological stations. Symbols identify different observational networks. Rectangles: TAHMO, circles: SASSCAL_WN, triangles: NCEI_ISD. The symbol's sizes indicate the number of valid observations.*

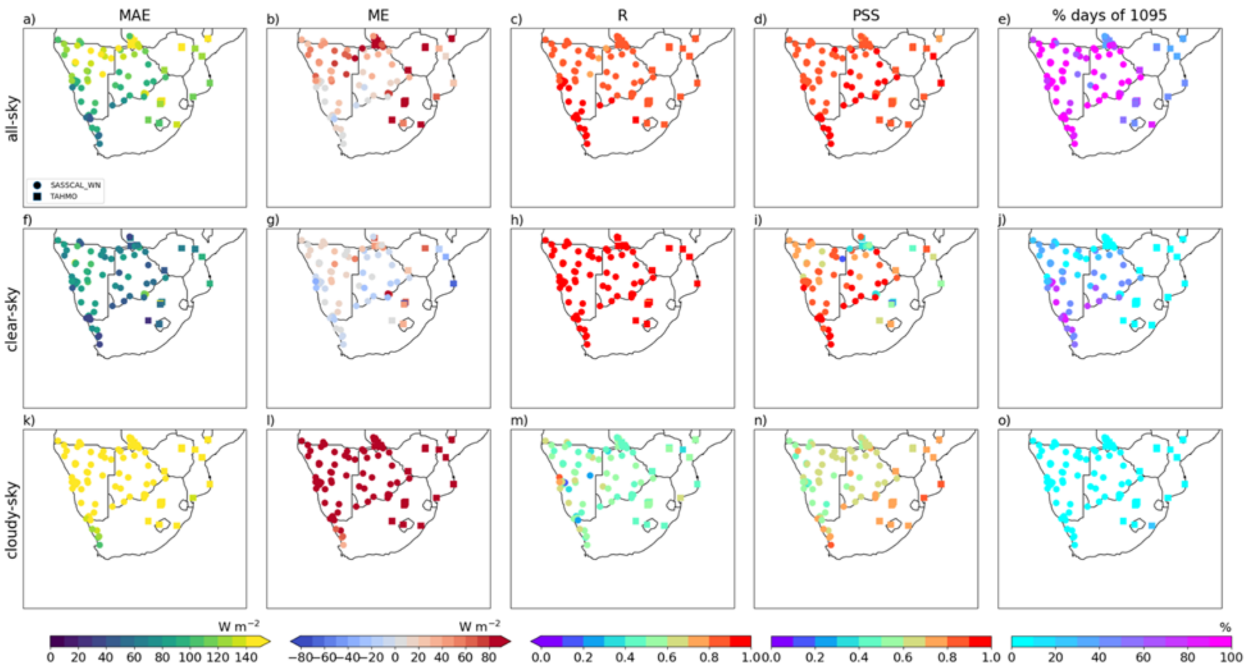


Figure 2: *As in Figure 1, but for daytime hourly rsds [W m-2] under sky conditions of all-sky, clear-sky, and cloudy-sky (rows). The last column "% days of 1,095" indicates the percentage of days out of the full three years (1,095 days) that are available with the corresponding sky condition over each station.*

Reference:

Chen, S., Poll, S., Hendricks Franssen, H.-J., Heinrichs, H., Vereecken, H., & Goergen, K. (2024). Convection-permitting ICON-LAM simulations for renewable energy potential estimates over Southern Africa. Journal of Geophysical Research: Atmospheres, 129(6), e2023JD039569. https://doi.org/10.1029/2023JD039569

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Modeling Lightning Activity in the Third Pole Region: Performance of a km-Scale ICON-CLM Simulation

Prashant Singh and Bodo Ahrens (Goethe University Frankfurt)

This research[1] focused on lightning activity within the Third Pole region, particularly the Himalayas, which frequently witness lightning strikes, especially during the pre-monsoon and monsoon seasons. Forecasting lightning in this area poses challenges due to complex wind patterns and difficult terrain. We used the ICON-CLM model at a km-scale resolution (3.3 km) to replicate lightning events for a year (from October 2019 to September 2020)[1,2]. The model-generated lightning potential index (LPI) and the product of Convective Available Potential Energy (CAPE) and Precipitation (CP) were compared with satellite-detected lightning events and climatological data. The model successfully identified over 80% of the events, exhibiting varied magnitudes compared to observations. While LPI offered more precise predictions regarding lightning event locations, the flash counts were marginally lower than those derived from CP. Thus, the study suggests that the combined use of ICON-CLM's simulated LPI and CP can be a valuable predictor for lightning events over the Third Pole region.

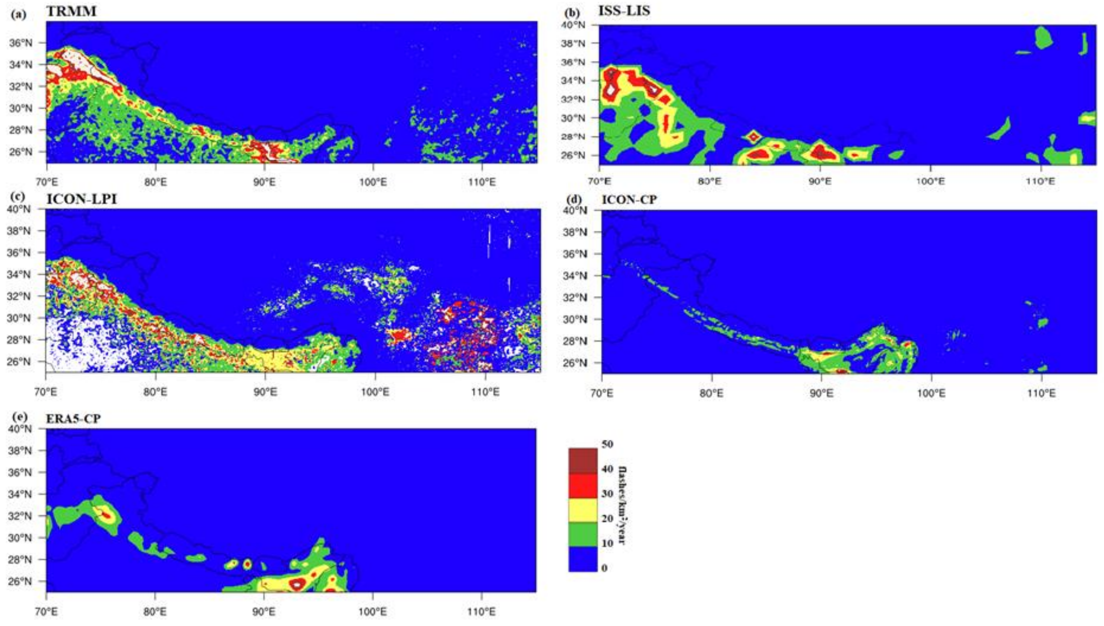

Figure 1 (a): *Long-term (1996–2015) average of lightning flash rates from the TRMM, (b) all the events observed by the ISS-LIS during October 2019–September 2020, (c) the annual mean (October 2019–September 2020) of the adjusted lightning potential index (LPI), (d) the mean CAPE × Precipitation (CP) from ICON-CLM, and (e) the CP from ERA5.*[1]

The detailed analysis reveals that the annual average of the Adjusted LPI across the domain presents similar spatial characteristics of lightning hotspots as shown by the Tropical Rainfall Measuring Mission (TRMM) lightning climatology data, as well as International Space Station/Lightning Imaging Sensor (ISS-LIS) observations for the same period (Figure 1). Conversely, the CP from ICON-CLM and ERA5 presents an incomplete depiction of the lightning hotspot regions. The simulated LPI excels CPs from both the simulation and ERA5 in capturing the seasonal variation of lightning relative to TRMM lightning climatology (Figure 2). In most parts of the domain, including the Western, Central, and Eastern Himalayan regions, the lightning climatology indicates peaks during the pre-monsoon season (April-May-June), which the LPI accurately replicates. In contrast, CP shows a peak during the monsoon period (June-July-August). Over the Tibetan Plateau, however, both CP and LPI show a similar peak in July, as observed.

In the Himalayan region, the LPI diurnal pattern exhibits a bimodal peak consistent with climatological observations, with one peain the afternoon and another in the early morning. Moving west to east along the Himalayan range, the early morning peak intensifies while the afternoon peak diminishes. In contrast, the CP from both ICON-CLM and ERA5 shows a single diurnal peak in the afternoon, which aligns with the local CAPE diurnal pattern. Over the Tibetan Plateau, lightning exhibits a single peak, where both LPI and CP agree well with the observed trend.

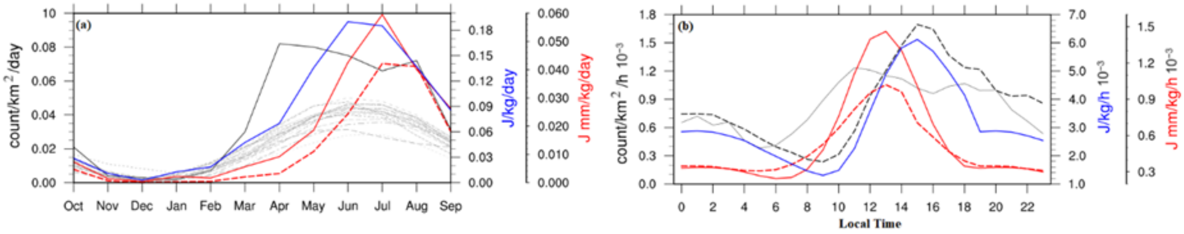

Figure 2 (a): *Monthly occurrence of lightning over the Third Pole region from 1995 to 2014 using the TRMM data (black dashed curve), ISS-LIS (black curve), ICON-CLM simulated LPI (blue curve), and CP (red curve), and ERA5 CP (red dashed curve) from October 2019 to September 2020. (b) Average diurnal cycle using TRMM lightning climatology (black dashed curve), LIS-ISS (black curve), ICON-CLM simulated LPI (blue curve) and CP (red curve), and ERA5 CP (red dashed curve).*[1]

Further analysis of over 41,000 individual events detected by the ISS-LIS, using the ICON-CLM simulated LPI and CP, demonstrates that the model can replicate lightning signatures with varying magnitudes within a 90 × 90 km² area around the observed lightning point within a 2-hour window. However, the precision is limited when considering the exact grid location of the observed lighting events. By using the ICON-CLM simulated LPI with CP together over the Third Pole region, the accuracy of lightning detection can be significantly enhanced through model simulation, resulting in more precise forecasts of lightning activity in terms of magnitude and location of lightning events.

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