Climate Limited-area Modelling Community

August 2018

Newsletter

No. 11

Content

See YOU at the

CLM Assembly 2018

18.09 – 21.09.2018

Karlsruhe, Germany

Registration deadline 24.08.18

Invited speaker:

Thomas Stocker

http://clm2018.imk.kit.edu

Announcement:

ICCARUS 2019

18. 03– 22. 09.2019

Offenbach, Germany

Welcome to the 11th newsletter of the CLM-Community!

One of the major challenges for the CLM-Community in the next months to years is the transition from COSMO-CLM towards a new regional climate model. The ICON model is now well established in the NWP section of DWD and it will replace COSMO completely for weather forecasts within the next 2 to 3 years. The CLM-Community has to prepare for that and make sure that a state of the art modeling system allowing climate research and providing climate projections in at least the quality of COSMO-CLM is available in the medium term. Therefore, the project group PG_ICON started in 2013 to investigate the necessary steps. A lot of progress has been made since then in developing a limited area version of ICON suitable for long-term climate integrations, see e.g. the research note of Trang Van Pham in this newsletter. As soon as an appropriate model version is available, test simulations will be conducted. The results will be compared to the results of the latest COSMO-CLM version. We are very curious about the outcome of this analysis. Everybody is invited to join this effort!
Furthermore, this issue contains a research note by Linda Schlemmer about a new groundwater and runoff formulation, reports on the latest IPCC meetings and on the status of the Special Report on Climate Change and Land, a note on CORDEX-CORE activities and an interview with Natalie Laube from KIT. Enjoy reading and we hope to see you all at the CLM Assembly in Karlsruhe!

Yours sincerely,
Barbara Früh,
Susanne Brienen and
Christian Steger

ICON grid with grid refinement over Europe.
Figure by F. Prill (DWD)

Five questions to … Natalie Laube

KIT, Karlsruhe


Photo by N. Laube

Natalie Laube is PhD student at the Karlsruhe Institute of Technology. She studied Meteorology at the University of Hannover (Germany) and received a master degree in 2012 (Master Thesis: Modeling the East Asian Monsoon with WRF). For her PhD thesis she evaluates the ability of COSMO-CLM to simulate heat waves on different time scales.

1. Natalie, you work at KIT. Can you please tell us something about your research and your tasks there?

I am currently finishing my PhD on the characterization of physical processes associated with European heat waves, their predictability and projected climate change signal. Specifically for heat waves, I performed and evaluated very high resolved regional climate projections, analyzed the impact of different land-surface schemes and assessed the predictive skill of heat waves as a user relevant variable in decadal predictions. These three topics are now combined into my PhD thesis. When I joined IMK, I first worked in the group "Regional climate and water cycle" (Dr. Schädler), and one year ago I joined the group "Regional climate and weather hazards" of Prof. Pinto.

2. Why do you think COSMO-CLM is especially useful for answering your research question?

Within our working groups, we have a long "tradition" working with the COSMO-CLM, so we have a broad experience and expertise in terms of the model performance and its advantages. For several research projects like MiKlip (decadal climate projections), PalMod (Paleo Modelling) and others, we have successfully applied COSMO-CLM and could generate huge data sets for our various research foci. Recently, we have completed a small ensemble of very high resolution climate projections for Southern Germany, which is one of the largest set of projections with a spatial resolution below 3 km.

3. What is your experience with the CLM-Community so far?

I joined the community five years ago. My experience so far has been very positive. In particular, meetings like the assembly and the trainings courses are great opportunities to meet fellow scientists working on different topics but with a similar basis (the COSMO model), and to establish contacts.

4. What are, in your opinion, the strength and the weaknesses of the CLM-Community?

The strengths are the different working groups with specific research topics, the web sites and online material, and the accessibility of the support group. Together with the training courses, new members get the possibility to be integrated very quickly into the community, and to find tips and answers for their own applications and problems. Another major advantage is the wide experience of all the different members contributing to the community. In my opinion, more internationalization (also outside Europe) would be helpful to strengthen the CLM-Community.

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

Right now, I focus solely on finishing my PhD thesis in the next months. I haven't made extensive plans for the time beyond that point. But during my PhD work and since I'm living in one of the hottest cities in Germany, I think, heat waves became a topic of special interest for me. This knowledge is also important for the broader public, especially with the climate change. We need to get a good grasp of the change of heat waves for future periods to adapt measures and public planning.

Thank you very much for the interview!

IPCC activities

IPCC 47th session

by Andrew Ferrone

The Intergovernmental Panel on Climate Change (IPCC) met from 13th to 16th of March in Paris, France. As the IPCC was founded in 1988, this year marks its 30th Anniversary. A special event, to mark the occasion, was organized by the government of France on 13th of March. The event consisted of several round tables looking back at the history of the IPCC and its relation with the world of policymaking, in particular with the United Nations Framework Convention of Climate Change (UNFCCC), and considering its future.

During the session, the IPCC launched the work of three groups:

- Task Group on the organization of the future work of the IPCC in light of the global stocktake
- Task Group on Data Support for Climate Change Assessments (TG-Data)
- Task Group on Gender

At it's next session to be held from 1st to 5th October in Incheon, Republic of Korea, the IPCC will adopt the "Special Report on Global Warming of 1.5 °C" and discuss it's Summary for Policy Makers line by line.

Over the summer, the following expert reviews will be open:

- Expert Review of the First Order Draft of the "Special Report on the Ocean and Cryosphere in a Changing Climate" (4th May to 29th June)
- Expert Review of the First Order Draft of the "Special Report on Climate Change and Land" (11th June to 5th August)
- Government and Expert Review of Second Order Draft of the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" (2nd July to 9th September)

APA1-5, SBSTA48, SBI48

by Andrew Ferrone

Under the United Nations Framework Convention on Climate Change (UNFCCC) the resumed session of the Ad Hoc Working Group on the Paris Agreement (APA1-5) and the 48th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA48) and of the Subsidiary Body for Implementation (SBI48) took place from 30th April to 10th May in Bonn, Germany.

Under APA1-5 progress was achieved on all items related to the elaboration of the work program of the Paris Agreement. However, in order to put the Agreement into practice and to approve the work program at COP24 in December 2018, in Katowice, Poland, a supplementary session, was decided to be held from 4th to 9th September in Bangkok, Thailand.

Under the Subsidiary Body for Scientific and Technological Advice (SBSTA) the agenda item on "Research and Systematic conversation" was considered. In the conclusions (https://unfccc.int/sites/default/files/resource/l11_0.pdf?download) the SBSTA noted, inter alia, the importance of CMIP6 for the IPCC's sixth assessment report and CORDEX for climate services.

The SBSTA chair also convened the 10th Research Dialogue (https://unfccc.int/event/tenth-meeting-of-the-research-dialogue-rd-10), which aims at promoting the exchange between scientists and Parties. This year's Research Dialogue was organized around 4 themes based on suggestions received by Parties:

- Science for understanding - update on research and modelling on human settlements, oceans and land and their importance for the implementation of the Paris Agreement
- Science for action - strengthening the link between the research community and action to meet the goals of the Paris Agreement
- Renewable energy economics and co-benefits
- Global research on the carbon cycle, and its observation requirements, in support of the Paris Agreement

AR6 Chapter 10: Linking global to regional climate change

by Alessandro Dosio

The activities of the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WGI: the physical science basis) for the preparation of the 6th Assessment Report (AR6) started officially with the First Lead Author Meeting (LAM1) in Guangzhou (China) on 24-29 June.
The chapter outline of the Working Group I contribution to the AR6, as approved at the 46th Session of the IPCC, Montreal, Canada, is as follows:

- Chapter 1: Framing, context, methods
- Chapter 2: Changing state of the climate system
- Chapter 3: Human influence on the climate system
- Chapter 4: Future global climate: scenario-based projections and near-term information
- Chapter 5: Carbon budgets, biogeochemical cycles and feedbacks
- Chapter 6: Short-lived climate forcers and air quality
- Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity
- Chapter 8: Water cycle changes
- Chapter 9: Ocean, cryosphere, and sea level change
- Chapter 10: Linking global to regional climate change
- Chapter 11: Weather and climate extreme events in a changing climate
- Chapter 12: Climate change information for regional impact and risk assessment

The report will also include Frequently Asked Questions (FAQs) and Executive Summaries (ES) of each chapter. The report will include a Summary for Policy Makers (SPM) and a Technical Summary (TS), as well as options for cross-Working Group integration including the development of a joint Glossary and an Atlas resource on information for the regions. The Atlas may be envisaged as an online, interactive compendium of regional climate change observations and projections on multiple time-scales, including extreme statistics.

Finally, the inter-linkage between the WGI and WGII reports depends on the implementation of a 'handshake' between the use of regional information in climate assessment of climate mechanisms and responses to drivers with the use of regional information for application in decision making (risk management, including adaptation options) and impacts analysis.

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The former requires an assessment of the understanding of the underlying physical mechanisms, causes, and feedbacks of regional change, as well as associated uncertainty. The latter requires an assessment of the construction of regional climate information and its delivery (e.g. probabilistic information, regional Atlas, region- specific narratives climate variability and change). The cross-WG treatment of regional issues is expected to strengthen the coherency in the attribution of human influences in climate variables and impacts.

The meeting was attended by around 250 experts, including IPCC and WGs co-chairs, Coordinating Lead Authors (CLAs) and Lead Authors (LAs) of WG1. The complete list of AR6 WG1 LAs can be found here https://www.ipcc.ch/report/authors/report.authors.php?q=35&p.
Alessandro Dosio participated as Lead Author of Chapter 10 "Linking Global to Regional Climate change", which has the following outline:

- Executive Summary
- Regional phenomena, drivers, feedbacks and teleconnections
- Regional scale observations and re-analyses
- Interplay between internal variability and forced change at the regional scale, including attribution
- Evaluation of methods, including downscaling and bias adjustment
- Confidence in regional climate information, including quantification of uncertainties
- Scale specific methodologies e.g. urban, mountains, coastal, catchments
- Approaches to synthesizing information from multiple lines of evidence
- Frequently Asked Questions

This chapter builds on the foundations of prior chapters and extends the overall narrative of the WGI report to explicitly address the regional scale. The term "region" is used here in a generic sense to indicate the range of scales of importance for impact and adaptation, and is not prescriptive of formal region boundaries. The chapter is intended to be the first of a complementary set of three chapters (10, 11, 12) that address different aspects of information relevant to regions, and which support Chapter 12's key handshake with the WGII report.

The overarching purpose of the chapter is to assess the key foundations for information about regional climate change. First are the climate processes that condition the expression of climate change at local and regional climate scales.

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Second are the range of methods and approaches available for developing more detailed information for regions than is typically possible from global models. Third, the chapter assesses the frameworks for integrating the collective understanding of changes in regional processes along with downscaling approaches in order to build regional messages.

As the first internal draft is expected on October 14th, work is expected to commence as soon as possible; specific urgent tasks include the identification and appointment of Contributing Authors (CAs), the collection and assessment of relevant literature specific to the Chapters, the preliminary draft of the most important figure, etc. The next LAM (LAM2) is scheduled on January 7th -12th 2019. ▪

IPCC Special Report on Climate Change and Land

by Edouard Davin

As part of the IPCC Sixth Assessment Cycle, a Special Report on Climate Change and Land (SRCCL) will be prepared jointly by the three Working Groups of the IPCC. The report will be released in September 2019 and will explore the interactions between climate change and desertification, land degradation, food security, sustainable land management, and opportunities and risks associated with land-based adaptation and mitigation responses to climate change.

Edouard Davin from the CLM-Community has been selected as Lead Author of the final chapter of this special report. About 100 experts from 52 countries worked together to produce a "First Order Draft" of the report which will now undergo a formal expert review process.

If you are working on a publication that addresses the topic of climate change and land, note that papers have to be submitted no later than October 28, 2018 to be considered in the SRCCL report. For any questions contact edouard.davin[at]env.ethz.ch. ▪

CLM-Community issues

CORDEX-CORE

by Silje Sørland

The CORDEX-CORE initiative aims to provide a core set of projections across the major CORDEX domains, and it is an initiative by the WCRP CORDEX. During the last year, the framework for the coordinated simulations has been decided upon, where the dynamical downscaling of the GCMs will be of 0.22° horizontal resolution (except over Europe, where it will be 0.11°), and the RCPs 2.6 and 8.5 will be prioritized. The GCMs have been chosen to reflect high, medium and low climate sensitivity (HadGEM, MPI-ESM and NorESM).

As announced at the CLM-Assembly last year, the CLM-Community plans to contribute with simulations for a few domains. Some institutions have already started with testing of the model configurations and performing the simulations. However, if there are any other groups within the CLM-Community that would be interested in contributing with simulations or experience, it is still time to come forward! There is also a separate email-list regarding the CORDEX-CORE contribution from the CLM-Community. You can contact Silje Sørland (silje.soerland[at]env.ethz.ch) if you are interested in contributing, being on the email list or if you have any further questions! ▪

Review: ICCARUS 2018

ICCARUS 2018 took place from 26th of February to 2nd of March at the DWD (Deutscher Wetterdienst) headquarter in Offenbach, Germany. With about 200 participants from 17 countries, ICCARUS is well established as platform for information exchange for COSMO/COSMO-CLM and ICON developers and users. This year, the seminar was held under its new name ICCARUS (ICon Cosmo Clm ARt User Seminar) for the first time.

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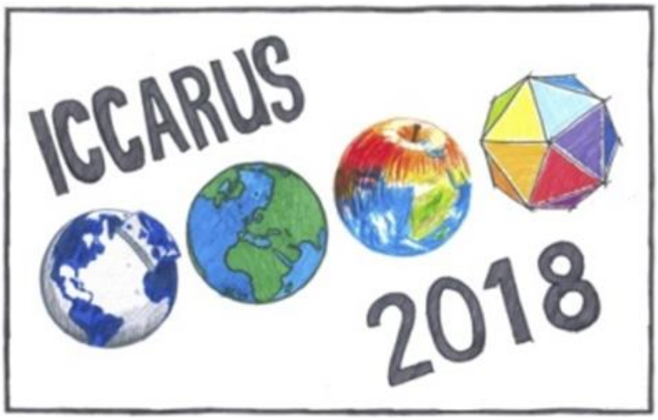

The conference program included 112 contributions in total. 44 oral presentations were presented in the plenary sessions and 68 posters during the three poster sessions. First and foremost, the CLM-Community members could present their work in the session on regional climate modelling, but they also contributed to the other sessions. Special highlights were the invited talks. Robin Hogan from ECMWF (European Centre for Medium-Range Weather Forecasts, Reading) talked about new developments and future challenges in the area of radiation in weather forecasting models. Martin Losch from the Alfred-Wegener-Institute (AWI) in Bremerhaven (Germany) gave an overview of the possibilities of sea ice modelling with high spatial resolution. His talk illustrated the importance of high spatial resolution for the correct representation of sea ice distribution and the processes involved.

In addition to the invited talks, there are traditionally some overview talks about the new developments in the different model components. Ulrich Schättler (DWD) presented the long-awaited COSMO model version 5.05. For the first time there were talks for both model components of ICON: Günther Zängl (DWD) reported on the recent developments for the NWP configuration of ICON, with special focus on the first verification results for the nest over Europe. Marco Giorgetta (MPI-M) presented results from ICON as atmospheric component of the upcoming MPI-M earth system model. In addition, Heike Vogel (Karlsruhe Institute of Technology (KIT)) explained in her talk the development progress and the applications of ICON-ART as forecast model for atmospheric trace gases and aerosol and their influence on the prediction of common variables.

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After the presentations in the plenary sessions from Monday to Wednesday, the seminar continued with the working group meetings on Thursday and Friday. The meetings of the working groups Atmosphere, Ice, Ocean (AIO), Chemistry, Clouds, Aerosols and Radiation (CCAR), Climate Projections (CP), Convection Resolving Climate Simulations (CRCS), Dynamics and Numerics (DYNNUM), Evaluation (EVAL), ICON, Soil and Vegetation (SOILVEG) took place on Thursday, while the Friday is traditionally reserved for the working group SUPort and TECHnical issues (SUPTECH) and the CLM-Community Coordination Group (CLM-CO). The work of the working groups is the basis for the community activities and model developments. Thus, we encourage everybody who has not joined a working group yet to do so and to provide his/her expertise to the community. You can find an overview of the working groups on the webpage and contact the particular coordinator for further information.

We thank all the participants for their contribution and we are looking forward to welcome you and everybody who could not participate this year at ICCARUS 2019 (18.03 – 22.03.2019) in Offenbach. ■

Review: COSMO/CLM Training Course 2018

Every year, DWD, the CLM-Community and the Karlsruhe Institute of Technology organize training courses for users of the COSMO-Model. The COSMO model is used for numerical weather prediction (NWP), regional climate projections (CLM) and the prediction of trace gas diffusion (ART – Aerosols and Reactive Trace Gases). The users of the COSMO model are national meteorological services, universities and research centers.

The 11th COSMO/CLM/ART training course took place from 12th to 16th of March at the convention center of DWD (Deutscher Wetterdienst) in Langen, Germany. The new users learned the theoretical backgrounds in several lectures and the application of the model on the basis of practical exercises.

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For the practical part of the course the participants are divided in a NWP and a RCM applications group. On Friday afternoon, the colleagues from MeteoSwiss offered an optional course on the accelerated dynamical core. The training course is a very good possibility for young scientists and experienced users of other model systems to become familiar with the different aspects of the COSMO model.

This year, 36 participants from Belgium, Brazil, Burkina Faso, Germany, Ecuador, Greece, India, Italy, Mexico, Romania, Switzerland and Vietnam followed the invitation. Ulrich Schättler and Daniel Rieger from the research department of DWD held the NWP exercises, Burkhardt Rockel (Helmholtz-Zentrum Geesthacht, Germany), Merja Tölle (Justus-Liebig-Universtiy Gießen, Germany) and Christian Steger (DWD) supported the participants during the RCM exercises. Ivonne Anders (Zentralanstalt für Meteorologie and Geodynamik (ZAMG), Austria) and Andreas Will (Brandenburgische Teschnische Universität Cottbus – Senftenberg, Germany) gave lectures on the Evaluation of climate runs and Dynamics and Numerics. The other lectures were held by DWD and KIT staff.

The training course 2019 will take place from 8th to 12th of April in Langen. From 2019 on the COSMO/CLM/ART training course and the ICON training will be combined and the NWP part for the COSMO model will be replaced by the ICON course. The RCM part will be carried out as usual. We hope to welcome many new users of COSMO-CLM next year in Langen. ■

Outlook: CLM-Community Assembly 2018

The 13th CLM-Community Assembly is approaching! It takes place from 18-21 September 2018 in Karlsruhe, Germany. Do not forget to register: the deadline is 24 August 2018! Further information (program, venue, hotel reservation deadlines etc.) can be found on the homepage: http://clm2018.imk.kit.edu/

The structure of the assembly is as usual: a mixture of plenary talks with respect to the different model developments and applications, a poster session and the various working group meetings. We would like to encourage especially the new members to inform you about the different working groups and join the meetings! →

Only with the common effort of all members, we will bring the COSMO-CLM development forward.

One highlight will certainly be the Climate Lecture on Wednesday evening, which is organized by the KIT-Center "Climate and Environment". Thomas Stocker (Professor at the University of Bern and Co-Chair of WG1 of the IPCC from 2008-2015) will give a talk on risks of a failure of the Paris agreement, especially with respect to availability of resources.

Building where the Assembly 2018 is located.
Photo: Natalie Laube (KIT)

Further invited talks during the Assembly include: a report on the current status of COSMO-CLM and INT2LM developments and the roadmap towards the next model unification with NWP (B. Rockel); a presentation of the possibilities and usage of the online diagnostic tools in the COSMO-CLM/MESSy system (A. Kerkweg); an overview on recent activities regarding the IPCC-AR6 and related opportunities for regional climate modelling communities (A. Dosio), and a report on the status of ICON-CLM, the limited-area mode of ICON for climate application with a first test simulation (C. Steger). Furthermore, the community members are invited to gather and network during the ice-breaker (Tuesday evening) and the conference dinner (Thursday evening).

As a preparation for the assembly, please read carefully the updated community documents which have been sent around recently. These changes are necessary due to the new protection rules for personal data of the EU. We will have to vote on the changes during the community meeting! ■

ICON-CLM Development

Trang Van Pham[1], Christian Steger[1]
[1]*DWD*

Background

On the 20th of January 2015, ICON (**Icosahedral Nonhydrostatic model,** Zängl et al., 2015) replaced GME as operational model for global weather forecast at Deutscher Wetterdienst (DWD). In December 2016, a domain with grid refinement for Europe (ICON-EU-Nest) within the global ICON replaced COSMO-EU for high-resolution forecasts on the European domain. It is planned that the Limited-Area-Mode of ICON (ICON-LAM) will replace the high resolution COSMO for the German domain in the second half of 2020 and DWD will stop the operational use of the COSMO model after 15 years. Afterwards, the support for the COSMO model will be reduced gradually. The CLM-Community has been using the climate version of COSMO, called COSMO-CLM (CCLM, Rockel et al., 2008) for more than a decade. The last reunification of the COSMO model and COSMO-CLM is planned for the end of 2018. In order to have a state of the art tool for regional climate modelling for the upcoming years, the CLM-Community wants to adapt ICON-LAM for regional climate applications. DWD started the development of the ICON **C**limate **L**imited area **M**ode (ICON-CLM) in the project ProWaS (**P**rojection **S**ervice for **W**aterways and **S**hipping) – a joint pilot program of several German Federal Agencies – to prepare a regular federal forecasting and projection service about the influence of climate change on coastal and waterway traffic.

From ICON-LAM …

The development of the regional climate model version of ICON is based on ICON-LAM (ICON-**L**imited **A**rea **M**ode), which is the limited area mode of the weather prediction model. By the time the ProWaS project started, ICON-LAM was mainly tested and used for time scales from days to weeks. For climate applications the model must be able to perform long term simulations, up to the timescale of centuries. At the lower boundary, sea surface temperature (SST) and sea ice values are constant during the weather forecasts, because within a short forecast period, these values do not change much in reality either. In climate simulations, a frequent update of these fields from the driving model is necessary. Furthermore, ICON-LAM used input data in GRIB format, while the standard for climate applications is the NetCDF format.

Lateral boundary data from ERA-Interim reanalysis (Dee et al., 2011) in NetCDF format can now be used as input data for ICON-LAM. One of the first steps towards a regional climate model version of ICON was a series of tests to confirm the ability of ICON-LAM to reproduce binary identical results after restarts.

… to ICON-CLM

After many tests, there is now a first technically stable version of the climate limited area mode of ICON available. At ICCARUS (**I**CON **C**OSMO **C**LM **A**RT **U**ser **S**eminar) 2018, the CLM working group SUPTECH decided to name this model version ICON-CLM (ICON-**C**limate **L**imited area **M**ode).

Compared to ICON-LAM, several adjustments have been implemented in the source code. ICON-LAM has an option to use time-dependent SST and sea ice values, but the update is done only on a monthly basis. A new implementation of the instant SST and sea ice data update at the lower boundary was integrated into the climate version. This implementation is based on a feature that was introduced to a model development branch of ICON-AES (global climate model version of ICON developed at Max-Planck-Institute for Meteorology (MPI-M)). In ICON-CLM, SST and sea ice fields can be given to the model in a user-chosen interval (monthly, daily, 6 hourly, etc.).

Furthermore, some fixes for flexible input reading and output writing were implemented to fit the requirements for climate simulations. In the ICON-NWP version, total precipitation is accumulated from the start till the end of the experiment. This is not problematic for short term weather predictions, but for climate applications the accumulation of total precipitation during long simulation periods would cause data imprecision. This has been changed and users can now specify an output interval for total precipitation (for instance 6 hours, 1 day) via namelist. The values of the respective variable are set to zero after the given interval. A similar feature was used for maximum and minimum 2m-temperature. ICON-NWP calculates these extreme values for six hour periods. A new namelist variable was introduced in ICON-CLM with a user-defined period for these maximum and minimum values.

For the lateral boundary conditions, ICON-NWP needs the time-dependent specific cloud liquid and ice water content. These data can be retrieved in reanalysis data such as ERA-Interim, but are often missing in data from global climate simulations. Hence, a flexible input reading was implemented in ICON-CLM with a new logical namelist variable.

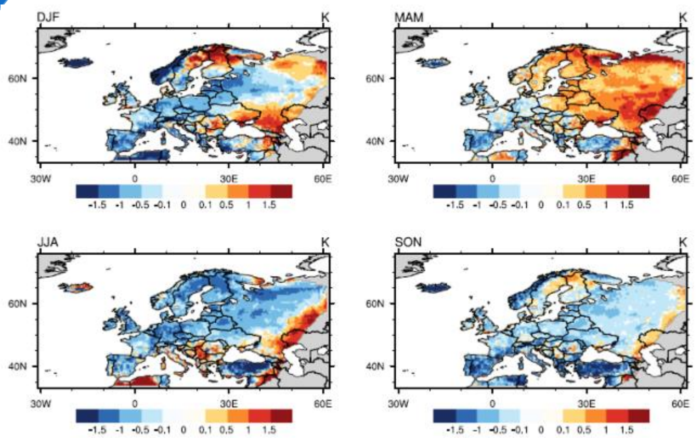

Figure 1: Seasonal biases of 2m-temperarure values (in Kelvin) of ICON-CLM compared to E-OBS. Evaluation period 1979-1991.

Users can specify whether ICON-CLM should look for these fields in the lateral boundary data or use only the initial data.

The technical infrastructure which is necessary for a long climate simulation is now also available along with the first version of ICON-CLM. The subchain script from the CCLM starter package was adapted for ICON-CLM. The chain currently includes the steps prep, int2icon, icon, arch and post. Within the int2icon step, the global data is remapped to the ICON grid and initial, lateral and lower boundary data are prepared for the actual run. One difference compared to COSMO-CLM is that the lower boundary data is given to the model in a separate file.
In the icon step of subchain, the regional climate simulation is carried out for the current month. Afterwards, the output from ICON-CLM is prepared for archiving and post-processed in the arch and post steps. For analyzing the model output, the ETOOL package has been adjusted for ICON-CLM output. This tool allows for calculation of the annual and seasonal biases, biases averaged by time or space and Taylor diagrams. The subchain and ETOOLS scripts work very similar for ICON-CLM and COSMO-CLM and they should be easy to use for experienced COSMO-CLM users. It is also possible to use the ETOOL to compare ICON-CLM and COSMO-CLM results. In addition to that, a climatological test suite has been prepared for ICON-CLM, which is based on the COSMO-CLM test suite. This test suite can later also be used to find an optimal configuration for ICON-CLM.

First test simulation
A test simulation for the EURO-CORDEX domain was conducted with a resolution of R02B06 (about 40 km). Initial and boundary data were taken from ERA-Interim. →

For this test simulation, the monthly averaged SST and sea ice from ERA-Interim were used at the lower boundary because by the time the simulation started, the implementation of instant SST and sea ice update was not finished.

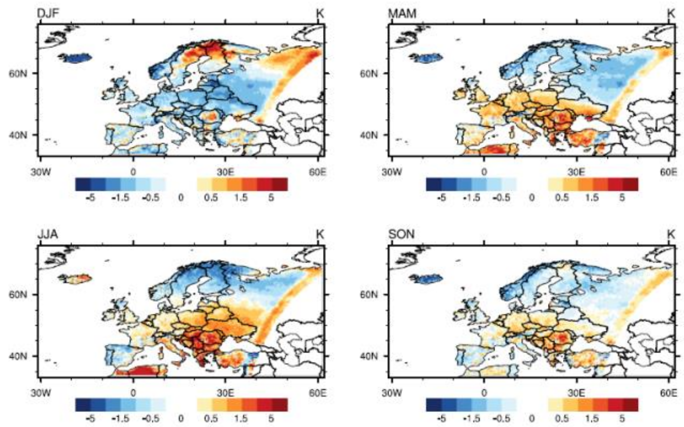

Figure 2: same as for Fig 1. but for COSMO-CLM. Evaluation period 1981-2000. Please note the differences in the color scale.

The simulation covers the years from 1979 to 1991 and the results have been compared to E-OBS observations (Haylock et al., 2008). The first model assessment was done only for 2m-temperature. Fig. 1 shows the average seasonal biases of 2m-temperature values for the period 1979-1991. In general, the biases stay within +/- 1.5 K for most part of the domain. Autumn shows the smallest deviation from the observations with a bias mainly within +/- 1 K. The bias of ICON-CLM are already in the same range as the bias in the evaluation run of COSMO-CLM (Fig. 2, results from COPAT project; note that there are differences in the color scales and the evaluation periods differ). It should be emphasized that the development of ICON-CLM is in a very early stage and there is still much potential to improve the model performance (see plan below).

Plan and outlook
In cooperation with the Research Department at DWD, a nudging option for global climate model data at the upper boundary of ICON-CLM will be implemented. We are also working on including a time-dependent green house gas option into ICON-CLM and some output manipulation to make the post-processing faster and to meet the NetCDF CF Metadata Conventions.
The next test version is planned for October 2018. After testing the nudging feature and the clearance of some other technical issues, an optimal configuration of ICON-CLM must be detected. With this optimal configuration, an ERA-Interim simulation will be carried out at the resolution of about 10 km (R02B08). The results from this simulation will be compared to the results of the COSMO-CLM evaluation runs from the COPAT project. →

Furthermore, a climate simulation with boundary conditions from a global climate model is planned. A converter program for the reformatting of global climate model data from CMIP to the necessary format for the iconremap tool will be prepared.
Up to now, ICON-CLM is installed and tested on two computer systems: Cray at DWD and Mistral at DKRZ (German Climate Computing Center, Hamburg). For the sake of model development and implementation, the ICON-CLM source code and the necessary script packages will be provided to the developers within the CLM-Community via GIT Servers. A starter package, which includes the necessary run scripts and evaluation tools, will be made available to users via CLM Redmine.

Acknowledgement
We acknowledge the E-OBS dataset from the EU-FP6 project ENSEMBLES (http://ensembles-eu.metoffice.com) and the data providers in the ECA&D project (http://www.ecad.eu).
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A groundwater and runoff formulation for weather and climate models

Linda Schlemmer, Christoph Schär, Daniel Lüthi, Lukas Strebel
ETH Zurich, Institute for Atmospheric and Climate Science, 8092 Zurich, Switzerland

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https://doi.org/10.1029/2017MS001260

Introduction

The moisture content of the soil influences the daily to seasonal variability of the atmosphere by modifying the surface water and energy balance. Despite the importance of a correct representation of soil moisture in weather and climate models, the water transport and runoff in the soil is often handled in a very crude way. However, an unrealistic formulation of runoff can have detrimental effects on the simulation of the land-surface water balance. Indeed, many global and regional climate models show an unrealistically large drying of the soil during summer and fall. This summer-drying is suspected to support too warm summer temperatures (e.g. Vidale, 2007). Especially the drainage of soil water across the lower soil boundary is often formulated in a very simplified way, which can result in such a drying.

The steepness of the orography has a strong influence on the lateral sub-surface water flow. Yet, lateral flow is not represented as long as the soil is represented by an array of independent soil columns. As a result, the precipitation climate has a dominant influence on the soil-moisture distribution. Here we take a heuristic approach that extends the Richards-equation formulation for soil-water transport by applying limiters to the soil-water fluxes and introducing a modified formulation for the ground runoff.

Formulation

The rate of change of the liquid water fraction (volumetric water content) θ is given by the divergence of the volumetric soil-water flux F and the runoff from the soil Q according to

$$\frac{\partial \theta}{\partial t} = -\frac{\partial F}{\partial z} - Q$$

There are no lateral groundwater fluxes, in order to enable a consistent formulation across a wide range of horizontal scales.

The vertical soil water flux is parameterized using the Richards equation (Richards, 1931).

Many weather and climate models use a free-drainage condition at the bottom of the soil column. This means that water drips out at the bottom of the soil column, representing groundwater runoff. Here we rather use a zero-flux lower boundary condition, and propose a new parameterization for groundwater runoff formation.

a. Groundwater runoff

We propose to formulate the runoff term Q as:

$$Q = {L_g}^{-1} K_0 S,$$

where K_0 is the saturated hydraulic conductivity, S the slope of the orography and L_g a heterogeneity parameter. In essence, this formulation assumes that the runoff is proportional to the terrain-following saturated flow, described by Darcy's law.
Runoff occurs only from the saturated part of the soil, i.e. where $\theta = \eta$ (where η is the porosity). Thus, the depth of the water table needs to be identified. The water-table depth is diagnosed by conservatively redistributing the water within the last partly saturated layer above the saturated part of the soil:

$$d = z_{k+\frac{1}{2}} - \Delta z_k \frac{\max[\theta_k - \theta_{k-1}, 0]}{\eta - \theta_{k-1}},$$

where k is the lowermost non-saturated model level.

b. Flux correction

The numerical simulation of the above equations is challenged by the fact that the soil must not be emptied completely, nor oversaturated, i.e.

$$0 < \theta < \eta.$$

Violating these conditions will inevitably lead to inconsistencies or numerical instabilities. To avoid such violations we use a variant of the flux corrected transport (FCT) methodology. This method originates from the work of (Boris, 1973) and (Zalesak, 1979).
The basic idea of FCT is to limit the fluxes in finite-difference or finite-volume conservative formulations so as to avoid the generation of numerically generated artificial extremes. In our case we require consideration of both the overdepletion ($\theta_{k+1} < 0$) and overfilling problems ($\theta_{k+1} > \eta$).

Implementation into TERRA_ML of COSMO-CLM

We implement the formulation for the ground-water transport and the runoff into TERRA_ML (Heise, 2003), the land-surface model of COSMO-CLM. The simulations are performed with version 5.0_clm6 of the Consortium for Small-Scale Modeling Model in Climate Mode (CCLM). 10 soil layers with thickness varying from 1 cm at the surface to 7.48 m in the deep soil are used.

Only a fraction of the soil layers are hydrologically active. Only for the active layers the Richards equation is solved, while the lower, inactive layers are considered climatic layers.

In the following the COSMO model is used in different configurations. If the default version of TERRA_ML is used, runs will be denoted with “DEF'”, while runs employing the modified formulation for water transport and runoff in addition with using the Décharme formulation will be denoted with “MOD'”.

Regional climate simulations

The setup closely follows the simulations by the CORDEX program (Giorgi, 2009). A grid spacing of 0.44˚ (~50 km) is employed and the model uses its standard suite of parameterizations. S is calculated using the GLOBE dataset that has a resolution of 1 km x 1 km. The slope is computed on the fine grid and then aggregated to the grid of the simulation to represent subgrid-scale effects.

The domain covers Europe and consists of 126 x 123 grid points in the horizontal. In the vertical a height-based hybrid Gal-Chen coordinate with 40 layers is used. The simulations cover the period 1979-1990. The first two years are regarded as spin-up period, and only the last 10 years (1981-1990) are used for the evaluation. For the parameterization of ground water runoff in MOD we use L_g=3.33 m^{-1}.

Impact on temperature and precipitation

The simulated seasonal-mean 2m-temperature and precipitation are evaluated against the E-OBS dataset (Haylock, 2008). Even though our main interest is to validate the simulated soil-moisture distribution, our final aim is to correctly simulate temperature and precipitation. Moreover, observations of 2m-temperature and precipitation are directly accessible, while soil-moisture observations are sparse and only available at few selected sites across Europe.

In DEF, temperatures are too cool in DJF over most parts of Europe (Figure 1a). In MAM this cold bias persists in North-Eastern Europe, while the rest of the domain shows hardly any bias. In JJA the previously described pattern emerges: while simulated temperatures are too cold in the North of Europe, a positive bias occurs across southern and south-eastern Europe with values of up to 3 K. This warm bias has been brought in connection with a too low soil-moisture (e.g. Christensen, 2012). In SON this positive bias is already eroded again, and the model simulates the mean climate fairly accurately. →

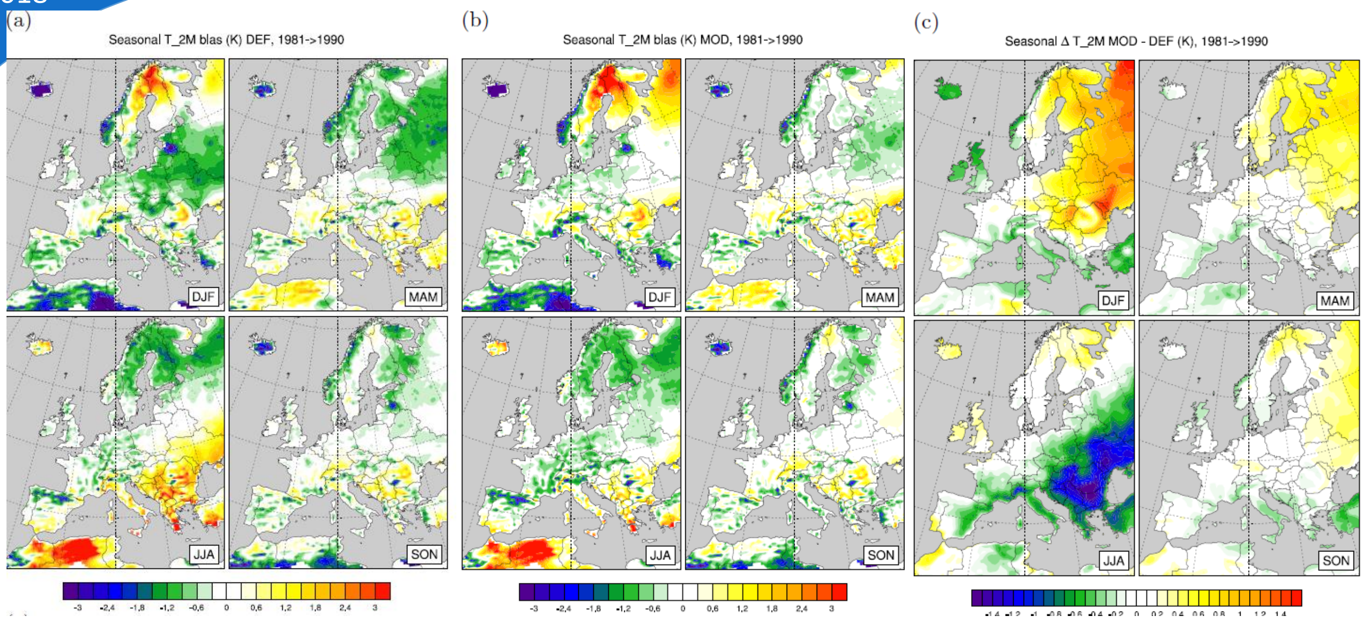

Figure 1: (a, b) Seasonal mean bias of 2m-temperature (K) for (a) DEF and (b) MOD. (c) Difference in 2m-temperature (K) between MOD and DEF. All plots are valid for the period 1981-1990.

In MOD the cold-bias in DJF is slightly reduced (Figure 1b) indicating even a positive bias over North-Eastern Europe. An equal reduction of the cold-bias in MAM is also discernible in MOD, while the biases is unaltered in the rest of the domain. In JJA the full benefit of the modified formulation is visible across Southern Europe. The warm bias is considerably reduced, while the bias in the rest of the domain is mostly unchanged. In SON there is hardly any difference between DEF and MOD and biases are overall small.

Precipitation shows mostly a positive bias (not shown), especially during DJF and MAM. Overall values of the bias are however small and the impact of MOD on the precipitation signal is overall small.
It should be noted that DEF has experienced a prolonged period of calibration, while MOD has not undergone such a procedure. We expect that biases can be further reduced in MOD with a similar procedure that we anticipate for the future.

Soil-water distribution

An essential part of our new formulation is the storage of soil-water within an aquifer-like system. Figure 2 shows the spatial distribution of the diagnosed water-table depth *d* for the different seasons. First of all, it shows considerable variations in space. While the water table is close to the surface across the northern parts of Europe, it tends to be far away from the surface in southern Europe. An exception to this rule is the mountain range in Norway, where the water table is deep, and the Balkans, where the water table is shallow. Second, the water table shows a pronounced annual cycle. For example in the Eastern Balkan region, the water table is close to the surface in MAM and decreases over the summer, until it is being recharged during wintertime. A similar effect can also be observed in the Carpathian Mountains of Southern Poland. The annual cycle is further illustrated for two selected PRUDENCE regions (Figure 3). Over the British Isles the water table varies between 40 cm to 1 m (Figure 3a), while over Eastern Europe variations between 2.5 and 5.5 m are seen (Figure 3b). The curve also illustrates, that it takes roughly 10 years from the model start in the year 1979, until the soil water has reached a new equilibrium around the year 1989.

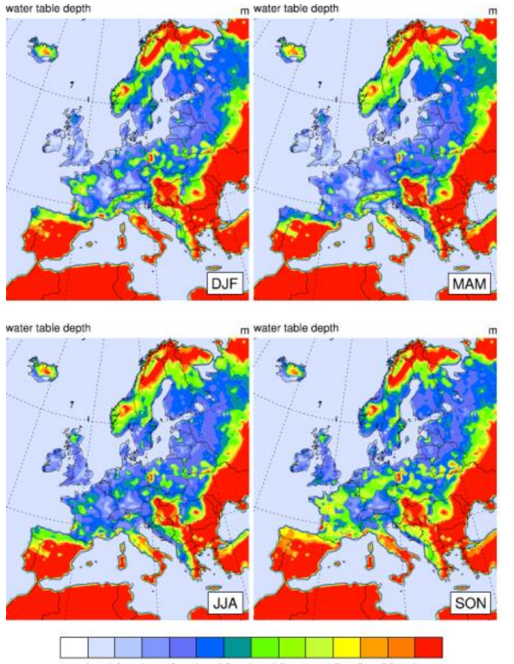

Figure 2: Seasonal mean water table depth d (m) in MOD averaged over the period 1989-2007.

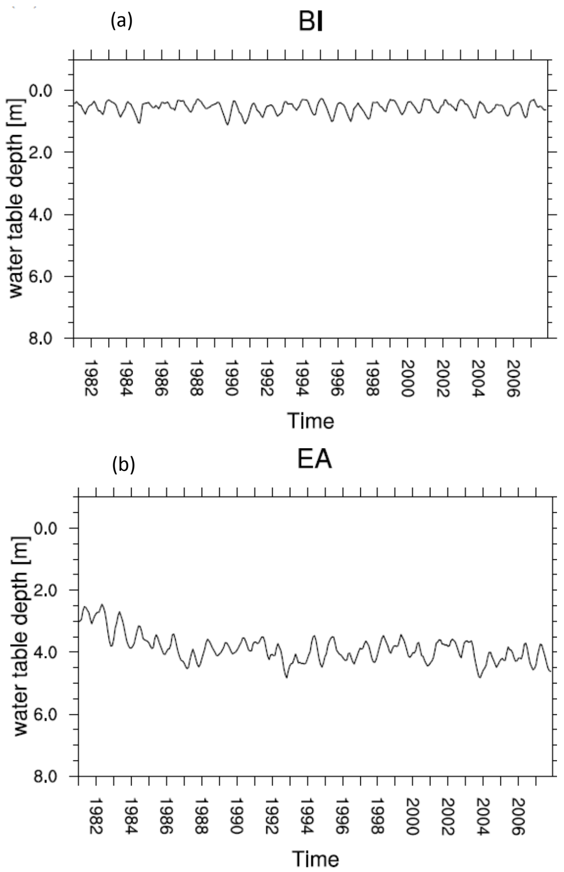

Figure 3: (a) and (b) Water table depth d (m) averaged over the PRUDENCE region British Isles (BI, a) and Eastern Europe (EA, b).

Summary

We have developed a new formulation for the vertical transport of soil water that extends the Richards-formulation to impermeable lower boundary conditions and thereby enables the build-up of groundwater storage. It makes use of flux limiters to ensure a physically and numerically consistent treatment. This formulation has been combined with a formulation for runoff from the soil that depends on the slope of the underlying topography. We have implemented this new framework into the land-surface model TERRA_ML of the regional weather and climate model COSMO-CLM. Decade-long coupled simulations over Europe show an improved representation of 2m-temperature, and considerably reduce the long-standing summertime warm bias across southern Europe as compared to the standard model version. An inspection of the simulated water-table depth shows a meaningful behaviour with a varying depth across Europe and over the course of the year.

The new formulation has some additional attractive properties. In particular, the distribution of the soil-water content with altitude exhibits a much more realistic pattern, and overcomes the “wet mountain dry valley” problem commonly observed in climate simulations. Although our pursued strategy does not perfectly replicate all hydrological processes in detail, the heuristic approach yields much better results than the previously implemented free-drainage lower-boundary condition. Moreover, the approach is easy to implement, computationally cheap and introduces few additional tuning parameters. As the sub-grid scale of the underlying orography is considered we do not expect the results to change too much by refining the grid.

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Recent publications

Please send all information on new publications related to COSMO-CLM (peer-reviewed, reports, theses, etc.) with corresponding links to clm.coordination[at]dwd.de. Please do not forget to name the project in the topic browser to which it is related.

Remember!

… part of your scientific success relies on the work of those people providing the reference model setup, maintain the codes, etc. Therefore, it would be more than a sign of courtesy to offer them co-authorships once in a while.

Please, do not forget to state that you used the "COSMO model in Climate Mode (COSMO-CLM)" and, please, also include the statement "COSMO-CLM is the community model of the German regional climate research community jointly further developed by the CLM-Community" in each publication.

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

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