Climate Limited-area Modelling Community
CLM-Community Newsletter

DWD

No. 5 **July 2015**

Content

Welcome to the 5th newsletter of the CLM-Community

We are approaching our 10th anniversary very fast and a lot has happened in all these years of community work. In the last years, we have agreed to follow standards of source code development and a common science plan was accepted during the last assembly. These are major achievements of our community work and it is up to us now to fill the science plan with our research and the source code with our new developments. Please remember, the common source code improvement and cooperation across the community are the pillars of our CLM-Community. So please participate in our meetings and be part of the ongoing discussions. The Newsletter is about exciting locations of our next assemblies, introducing community members and presenting a glimpse of our community work with three brand new publications.

Enjoy reading!

Yours sincerely, Barbara Früh

CLM Assembly 2015....

By Andrew Ferrone

After nearly a decade of successful regional climate research, the 10th Assembly of the CLM-Community is going to be hosted this year at the Luxembourg Institute of Science and Technology (LIST) from 29th September to 2nd October 2015 in Belvaux, Luxembourg.

Furnace in Belval (photo: LIST)

As each of the previous Assemblies, also this year's meeting will feature highlights of scientific work done with COSMO-CLM, lots of community news, and an interesting social program, including a river cruise on the Moselle, where we will have our conference dinner.

Luxembourg city (photo: LIST)

The highlights of this year's program include an evening keynote of Filippo Giorgi (ICTP) and three solicited talks. Concerning the community decisions we have to answer the question if the model version 5.0 of COSMO will be adopted as new recommended version of the community.

Following the community approach we all chose to take, the Assembly can only be a success if everybody will contribute to it.

For more information about the program of the Assembly, the venue and for registering, please go to:

http://clm2015.list.lu

Moselle (photo: Navitour)

Registration will be open until the **18th September 2015** and we are looking forward to see you all in Belvaux.

CLM Assembly

29 September – 02 October 2015

Luxembourg Institute of Science and Technology
Belvaux, Luxembourg

The current version of the schedule can be found here

...and a preview to 2016

Lüneburg "Am Sande" (photo: B. Rockel)

Lecture room at Leuphana university (photo: B. Rockel)

In 2016, the CLM Assembly will be organized by our colleagues from HZG. It will be held in **Lüneburg**, Germany, from **September 20th to 23rd, 2016**. We will use the infrastructure and lecture rooms of the Leuphana university of Lüneburg.

... 2017?

The venue for 2017 is not decided yet. You can think about having it at your place!

Five questions to Hans-Jürgen Panitz, KIT

1. Which is your main research focus when using COSMO-CLM?

The research interests of the group I belong to can be overwritten as "modeling, analysis and interpretation of the intimately connected topics water and climate on the regional scale with high spatial resolution".
When I started to work with COSMO-CLM (still CLM at that time) the regional focus was on Central Europe with a special "high resolution" view on the region of the Federal State of Baden-Württemberg. The works were embedded in the research program „Herausforderung Klimawandel Baden-Württemberg".
Then I "jumped" from Europe to Africa and I took the scientific responsibility for the Africa CORDEX simulations that has been carried out with COSMO-CLM. Africa, especially West Africa and the potential decadal predictability of the West African Monsoon (WAM), is in the focus of the MIKLIP project "DEPARTURE". Here it was my task to perform, on the one hand, several decadal simulations with COSMO-CLM as one contribution to the multi-RCM ensemble that had been generated within DEPARTURE, on the other hand, to perform several sensitivity runs with changed boundary conditions (SST) and AOD representations in order to study their impacts on the WAM system.

2. Hans-Jürgen, you are a CLM-Community member almost from the first minute. What are, in your opinion the strength and the weaknesses of the CLM-Community?

I don't want to adorn myself with borrowed plumes. I didn't belong to the persons "of the first hour". I entered the community in 2007, if I remember correctly, shortly before the first unified version COSMO_4.0 had been released. And here we have already one example of the strength of the community. It is the inter-institutional, and in the meantime also international expertise from which one can profit enormously. One can find experts for a variety of topics and problems. I profited very much from this when I began to use COSMO-CLM. And also the model system itself should benefit from this

Hans-Jürgen Panitz (photo: private)

widespread expertise in such a manner that a lot of distinct research groups work on different aspects in order to improve the performance of the model. 2-Way-Nesting, coupling of ocean models and alternative SVATs, dynamical consideration of aerosol also in climate mode (COSMO-ART), and alternative schemes and methods of physical parameterizations are only a few examples. On the other hand, the heterogeneity of the community covers also the danger that a lot of promising new developments do not receive that attention that they deserve. I am sure that a lot of very good developments being done in various diploma, master, or PhD theses "ends up in the drawer", even if they have been presented once or twice during the User Seminar or the Assembly.

3. *A great part of your work for the CLM-Community happens in the background. To uncover these issues what are your main tasks in this aspect?*

Rather briefly after I started to work with COSMO-CLM I had been asked and "elected" to become the "source code administrator" of COSMO-CLM. My main tasks in this context are to perform basic technical tests on new COSMO releases, to carry out short-term (5 to 8 years) climate simulations under a predefined configuration, and to compare the results with those from already existing simulations with previous COSMO-CLM releases. In general, I report on these activities and their outcomes during the yearly CLM-Assembly. Up to now, I use for these tests my own "environment", which is based on the Africa CORDEX configuration of COSMO-CLM. For the future, I intend also to use the "Technical Test Suite", which had been developed by MeteoSuisse and adapted to our needs by Burkhardt Rockel. Only after all these tests a new COSMO release will be passed to the evaluation working group EVAL. Furthermore, I am the "gathering point" of bug fixes detected and corrected in the code by any user, and of new developments that have been carried out and tested by any research group or individual user. Finally, I implement bug fixes and/or new developments into a new COSMO-CLM subversion of a current COSMO release. And it is only for me to allocate a new subversion number. Of course, all bug fixes and developments are reported to DWD with the hope that they take it into account in a new COSMO release or at least in the unified version.

4. *Are you fine with the response from the CLM-Community to these activities? What would be your wish for improvement?*

Oh, I would say the best response is no response (except statements like "well done", they are always welcome (smiley)). I would interpret it in such a manner that the jobs done by others, for example Burkhardt Rockel as INT2LM administrator, and myself were o.k., everything was clear and well documented, no further questions were necessary. We are happy if we receive constructive hints to, for example, further bugs, preferably together with its documented fix, or suggestions that improve the model.
However, reality is sometimes different. We often feel as an advisory board that has to explain even basic things which are necessary in order to apply the whole model system successfully and which are on the other hand often rather well described in various documents the user has access to. Of course, if somebody used all the documented sources and could not solve the problem, he or she still can ask, preferably via the Forum. But in this case, please give us some hints in terms of namelist settings, for example, input data files and others, and don't simply say, "My job is not running. Can you tell me why?". This sometimes also happens.

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

Nice question for an "old" man like me. "To slow down and to prepare myself for the retirement", could be an obvious answer ☺. But, seriously, there are a lot of current and, hopefully coming challenging projects in which I am involved. And I still enjoy doing the research on the various topics and, of course, also doing the work with COSMO-CLM.
Thank you very much for the interview!

COSMO/CLM/ART Training Course 2015

The 8th COSMO/CLM/ART Training took place from 23 – 31 March 2015 in the training center of the DWD in Langen near Frankfurt/Main. We invited students and scientists interested to work or already working with COSMO/ CLM to participate in this Training Course. For the second time, the course was extended by 2 days for special training on COSMO-ART and the Community Land Model. In the first week, 56 participants took the opportunity to learn about installation and

COSMO/CLM/ART User Seminar 2015, Offenbach (photo: DWD)

usage of the COSMO model system, from which 22 joined the exercises for the regional climate modelling mode. The additional courses of COSMO-ART and Community Land Model have been attended by 34 people. The success of the training could be seen in a very concentrated and friendly atmosphere and quite some new membership applications for the CLM-Community. The training material is available online (login first, http://www.clm-community.eu/index.php?menuid=206)

The **next training course** is scheduled for **15 – 23 February, 2016**.

COSMO/CLM/ART User Seminar 2015

From 02 - 06 March 2015, almost 181 scientists from over 20 different countries participated in the COSMO/CLM/ART user seminar in Offenbach, Germany. In the usual manner, the development and application of the COSMO model system was discussed in different oral and poster sessions in the first three days. The last two days were filled with different working group meetings of the weather forecast and climate modelling communities. The presentations can be found on the web: http://www.clm-community.eu/index.php?menuid=205

The date of the **next User Seminar** will be the **07 - 11 March 2016**.

New member institutions

Justus-Liebig-Universität Giessen

(http://www.uni-giessen.de/cms/fbz/fb07/fachgebiete/geographie)

Characterize quantitatively the effects of Europe's and Germany's land use change on carbon, water and energy fluxes to the atmosphere and on its carbon sequestration capacity.

Contact: Merja Tölle

(Merja.Toelle@geogr.uni-giessen.de)

Alfred-Wegener-Institut; Helmholtz-Zentrum für Polar- und Meeresforschung

(http://www.awi.de/en/home/)

Intent to use COSMO-CLM in a coupled mode with the available ART component as well as coupled to the Community Land Model and a possible ocean-sea-ice model. The focus is on the interaction of surface and atmosphere.

Contact: Heidrun Matthes

(heidrun.matthes@awi.de)

Nigerian Environmental Study Team

(http://www.eldis.org/go/home&id=7850&type=Organisation)

Determining the fraction of photosynthetically active radiation under changing climatic conditions in Keffi (Local Government Area in Nasarawa State, Nigeria).

Contact: Nsikan-George Emana

(Kansynsy@gmail.com)

University of Tehran

(http://ut.ac.ir/en/contents/College-of-Aburaihan-EN/College.of.Aburaihan.html)

Analyse the performance of an ensemble of RCMs in reproducing the regional climate of Khuzestan plain, located in the western part of Iran. The simulated precipitation and temperature will then feed a rainfall-runoff model to generate time series of river discharge at the outlet of the basin. The river-reservoir system will then be simulated to analyse to which extend results from the hindcast have been successful in informing water resource and hydro-energy sector.

Contact: Najafi Husain
(husain.najafi@ut.ac.ir)

Pohang University of Science and Technology
(http://www.postech.ac.kr/ /)

Production and analysis of high-resolution climate change data over East Asia using COSMO-CLM under the predefined simulation environment of CORDEX-East Asia.

Contact: Donghyun Lee
(donhyunlee@postech.ac.kr)

Research notes

The impact of impervious water-storage parametrization on urban climate modelling.

Hendrik Wouters[1], Matthias Demuzere[1], Koen De Ridder[2], Nicole van Lipzig[1]

[1]KU Leuven, [2]VITO

More details and additional references can be found in:
Wouters, H., M. Demuzere, K. De Ridder, N.P.M. van Lipzig, 2015: The impact of impervious water-storage parametrization on urban climate modelling. *Urban Climate*, **11**, 24-50.

1. Introduction

For the last 200 years, the global population has increased sevenfold resulting in a strong urban expansion. Consequential changes in the landscape have led to drastic climate modifications, which ranks among the most significant human impacts on the environment. Most remarkable is that cities are exposed to higher air temperatures than those in the natural surroundings, known as the urban heat island, and results from several modifications in the surface energy balance by urbanization. Since outdoor thermal comfort is essential to our health and that of the environment, the urban-climate research community has been growing since the eighties. During the last 7 years, several urban land-surface parametrizations have been introduced in COSMO-CLM. They are compared in Trusilova et al. (in press) by the URBMIP project in the CLM-Community, and are currently intensively used for urban-climate modelling research at high resolution.

An important aspect in urban climate modelling is the surface water balance, which includes the interception of rainwater by the surface, penetration into the soil, evaporation and (plant) transpiration, and run-off. The processes that control the water balance for urban land are very different from those found for natural land. In particular, a large part of the rain falling on urban land is lost to run-off due to the presence of water-impermeable (hereafter 'impervious') surfaces, whereas rainwater is better retained by the natural land with water-permeable soil and the vegetation. As a result, less water remains available for evapotranspiration (ET), which is one of the dominant drivers of the urban heat island effect. At the same time, this leads to a higher risk of pluvial floods in urban areas.

To date, large uncertainties exist in the surface water balance for cities. In particular, recent studies show that ET is the worst modelled component of the surface energy balance in urban land-surface models. As a forward step to unravel the uncertainties, a water-storage parametrization (WSP) for impervious surfaces is proposed in Wouters et al. (2015). It is implemented in the urban land-surface parametrization TERRA-URB. It has been developed for COSMO-CLM at VITO and KU Leuven. It is used to investigate the evaporation of water reservoirs on streets and buildings on urban-climate modelling The methodology and results are summarised in this research note. More details and references can be found in Wouters et al. (2015).

2. Methodology

2.1. TERRA-URB, an efficient urban land-surface parametrization for COSMO(-CLM)

TERRA-URB implements an efficient bulk representation for urban land in TERRA-ML. Herein, the urban environment consisting of buildings and streets are represented as a rough water-impermeable slab, and adopts urban bulk parameter estimates for albedo, emissivity, heat capacity and conductivity, and from recent urban-climate modelling studies (Demuzere et al., 2008; De Ridder et al., 2012). TERRA-URB employs the Monin/ Obukhov surface-layer transfer scheme of Wouters et al. (2012) for a consistent treatment of the turbulent transport for the building. A Brutsaert/ Kanda parametrization for thermal roughness lengths for urban areas have been employed. Both the building environment and the natural land are resolved and combined with a tile approach. The anthropogenic heat flux is added to the surface sensible heat flux, and acts as an additional heat source to the lowest model layer. A more detailed description of TERRA-URB can be found in section 2.1 of Wouters et al. (2015). Datasets for Impervious Surface Areas (ISA) and Anthropogenic Heat Fluxes (AHF) are employed, which have also been introduced recently in the latest release of EXTPAR (v2.6). In this study, TERRA-URB is employed in stand-alone mode by forcing it with observations.

The recent release TERRA-URB2.0 coupled to COSMO5.0_CLM3a allows for its application with the TKE-based prognostic surface-layer transfer scheme of COSMO instead of the Monin/Obukhov transfer scheme. This version is planned for adoption in the default COSMO5.3 release.

	LD12	LD100	ND12	ND100	DRY	PTEB
w_m (kg m^{-2})	1.31	1.31	1.31	1.31	0	1.00
δ_m (%)	12	100	12	100	0	46
δ	$\delta_m \left(\frac{w}{w_m}\right)^{2/3}$	$\delta_m \left(\frac{w}{w_m}\right)^{2/3}$	δ_m	δ_m	0	$\delta_m \left(\frac{w}{w_m}\right)^{2/3}$

Table 1 Overview of the different water-storage parametrizations for modelling evaporation from the impervious land-cover. The parameter values for w_m and δ_m are given in the first two rows. The last row shows the expression for δ. The PTEB-column corresponds to the default configuration of water-storage parametrization of the Town Energy Budget model (see Appendix B of Wouters et al.,2015).

2.2. Water-storage parametrization (WSP) for impervious surfaces

The WSP considers a set of water reservoirs on the impervious surface for which the depths are described with a Probability Density Function (PDF). By assuming that the PDF is a linear decreasing function of the reservoir depth, a 2/3th – power relation is retrieved for the evaporative area fraction δ_m as a function of the total water (w) in the reservoirs (more details on the assumptions and derivation of this relation can be found in Section 2.2 of Wouters et al. (2015):

$$\delta = \delta_m \, (w / w_m)^{2/3}$$

Hereby, the WSP accounts for two reservoir parameters: w_m is the maximum amount of water (per surface unit of the impervious surface area) and δ_m the maximum evaporative surface fraction. Employing this relation, the evaporation rate E from the impervious surface areas within the urban environment is calculated as:

$$dw/dt = E = \delta \, E_p$$

where E_p is potential evaporation rate.

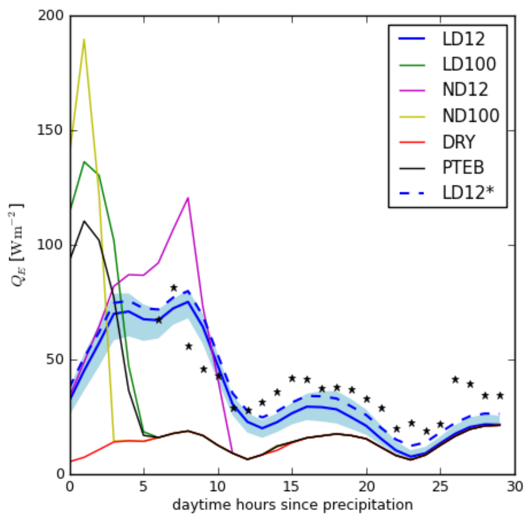

Figure 1 The modelled latent heat exchange Q_E with TERRA-URB configured for Toulouse averaged for four rain events. The day-time hours since precipitation are displayed, for which the incoming solar radiation exceeds 150 Wm^{-2}. The labels and description of the model runs (full lines) are summarised in Table 1. The observations are indicated with stars. The light-blue area represents the uncertainty in the model output due to uncertainty in the water-storage parameters. The dashed blue line LD12 corresponds to the reference run applying a bias correction with the model bias during four days before the rainfall events.

2.3. Water-storage parameters for Toulouse centre

The water-storage parameters and uncertainty for the impervious surface area (roads and streets) at Toulouse centre are obtained by considering the correspondence between modelled and observed quantities for ET after rainfall. Hereby, multiple integrations with TERRA-URB are performed in stand-alone mode (ie., forced with observations) each with a different set of water-storage parameters. The observations are obtained from the intensive urban measurement campaign CAPITOUL. The following estimates are found for the Toulouse city centre: w_m = 1.31 ± 0.20 kg m^{-2} and δ_m =12 ± 4 %.

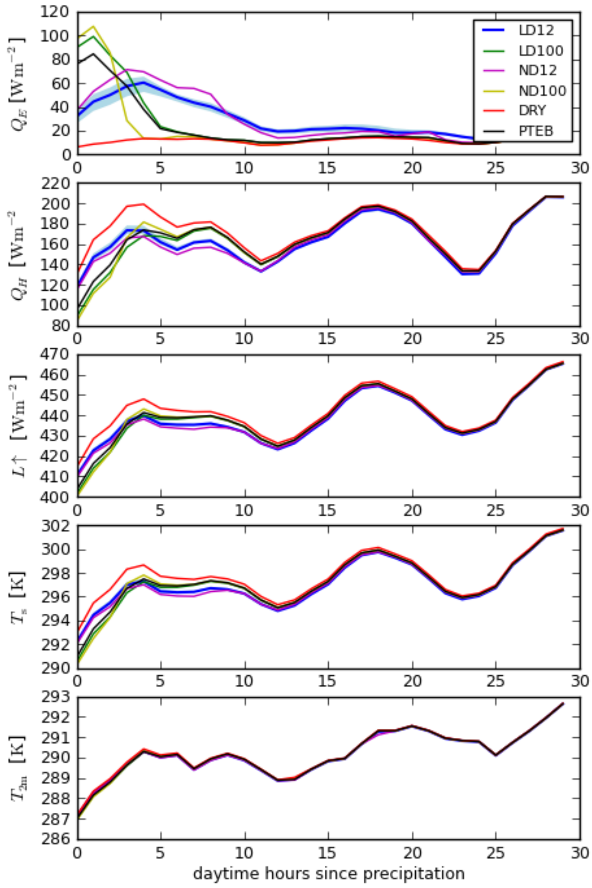

Figure 2 Annual-averaged daytime (ie, hourly-mean incoming solar radiation exceeding 150 Wm^{-2}) impact of WSP on latent heat exchange (Q_E), sensible heat (Q_H), and surface upwelling infra-red radiation (L), surface temperature (T_S), and 2-m temperature (T_{2m}), after the rainfall events of more than 1 kgm^{-2} in Toulouse. The labels and description of the model runs with TERRA-URB (full lines) are described at the beginning of Section 3.2, and are summarised in Table 1.

	LD12	LD100	ND12	ND100	DRY	PTEB
	Q_E					
RMSE	**13.30**	17.29	18.83	22.11	17.87	15.73
BIAS	**−8.75**	−13.22	−9.08	−13.78	−17.58	−14.22
R2	**0.82**	0.69	0.75	0.55	0.65	0.72
	Q_H					
RMSE	**27.69**	30.42	28.88	30.44	29.37	29.86
BIAS	7.52	9.29	**7.50**	9.44	14.17	10.28
R2	**0.96**	0.95	0.95	0.95	0.95	0.95
	$R^{\uparrow}(z_{ref})$					
RMSE	4.72	4.12	4.89	4.36	4.51	**3.94**
BIAS	**−0.35**	−1.54	−0.52	−1.84	1.56	−1.12
R2	0.99	0.99	0.99	0.99	0.99	**0.99**

Table 2 The root-mean-square error (RMSE), bias (BIAS), and determination coefficient (R2) of the offline model results with TERRA-URB for the latent heat Q_E, surface sensible heat Q_H and upward infrared radiation at mast height $R(z_{ref})$ for Toulouse centre during the rainfall events. The labels and description of the different water-storage parametrizations used in these model runs are summarised in Table 1. The best scores among the different runs are marked in bold.

3. Results and conclusions

In order to address the sensitivity of WSP on urban climate modelling, a set of annual simulations are performed, see Table 1. The model successfully reproduces the timespan and magnitude of increased ET for both urban observations campaigns CAPITOUL in Toulouse centre (see Figure 2 and Table 2) and BUBBLE in Basel. Urban WSP largely affects the performance of ET rates. The simulation employing the new WSP better matches the observations than other arbitrary or existing WSPs.

The modelled evaporation from the impervious land is discontinuous and intermittent throughout the year as it only occurs after rainfall. ET, the surface turbulent heat transport and the upwelling infrared radiation are affected until 12 day-time hours after the rainfall events on average, see Figure 1.

The modelled annual-mean evaporation from the urban site of Toulouse during the CAPITOUL campaign during 2004 amounts to 9.3 ± 0.51 Wm^{-2} for the reference simulation LD12 (see Table 3 Modelled annual mean values of QE, QH and L (upward infrared radiation at the surface) for TERRA-URB configured for Toulouse centre during the CAPITOUL campaign. The labels and description of the different water-storage parametrizations used in these model runs are summarised in Table 1. The values in brackets are the respective differences with the reference simulation LD12.Table 3). The portion arising from the impervious land (5.2 Wm-2; 56 %) was comparable to that from the natural surface fraction (4.1 Wm^{-2}; 44 %). Hereby, an annual-mean evaporation per unit impervious land (92 %) yields 5.6 ± 0.60 Wm^{-2}. Hence, only 12.5 ± 1.1 % of the annual precipitation (625 mm) evaporates back to the atmosphere. The evaporation from impervious land (5.6 Wm^{-2}) is an order of magnitude lower than ET from the heterogeneous natural surroundings (45 Wm^{-2} for 2005) derived from satellite data, which suggests a large influence of urbanization on ET rates.

This study focussed on the role of WSP on modelling the surface energy and water balance in cities by running TERRA-URB in stand-alone mode. TERRA-URB coupled to COSMO(-CLM) will allow to address the role of WSP and urbanization on atmospheric fields for temperature, moisture, and precipitation.

4. Outlook

TERRA-URB coupled to COSMO-CLM is currently being used in several urban-climate modelling applications. This includes the high-resolution climate ensemble modelling for Belgium for supplementing the 'CORDEX.be' climate service (Belgian Science Policy). Herein, the role of urban expansion versus climate change and uncertainty on temperature, moisture, and precipitation are addressed. Heat-stress maps were constructed for Belgium for the present-day climate and future scenarios, which are being published this summer in the Flemish Climate Report of the Flemish Environmental Agency (VMM).

5. Acknowledgements

TERRA-URB was developed at the Flemish Institute of Technological Research (VITO) and the Catholic University of Leuven (KU Leuven)

	LD12	LD100	ND12	ND100	DRY	PTEB
Q_E	9.3	13.6 (4.2)	10.1 (0.8)	14.6 (5.3)	4.1 (−5.2)	12.2 (2.9)
Q_H	71.3	68.1 (−3.1)	70.7 (−0.6)	67.3 (−3.9)	75.1 (3.8)	69.1 (−2.1)
$L^{\uparrow}$	396.5	395.6 (−0.9)	396.3 (−0.2)	395.3 (−1.1)	397.9 (1.4)	395.9 (−0.6)

Table 3 Modelled annual mean values of Q_E, Q_H and L (upward infrared radiation at the surface) for TERRA-URB configured for Toulouse centre during the CAPITOUL campaign. The labels and description of the different water-storage parametrizations used in these model runs are summarised in Table 1. The values in brackets are the respective differences with the reference simulation LD12.

with the support of European Community's 7th Framework Programme under Grant Agreements Nos. 308497 (RAMSES) and 308299 (NACLIM), the Belgian Science Policy Office through its Science for a Sustainable Development Programme under Contract SD/CS/041 (MACCBET), the European Union 7th Framework Programme (FP7 2007-2013) under Grant Agreements No. 308299 and No. 308497, and from the Flemish regional government through a contract as a FWO (Fund for Scientific Research) post-doctoral position.

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De Ridder K., C. Bertrand, G. Casanova, W. Lefebvre, 2012: Exploring a new method for the retrieval of urban thermophysical properties using thermal infrared remote sensing and deterministic modeling. *J. Geophys. Res*. **117** (D17), 1–14.

Trusilova K., S. Schubert, H. Wouters, B. Früh, S. Großmann-Clarke, M. Demuzere, P. Becker: The urban land use in the COSMO-CLM model: a comparison of three parameterizations for Berlin. *Meteorologische Zeitschrift* (in press).

Wouters, H., K. De Ridder, N.P.M. van Lipzig, 2012: Comprehensive Parametrization of Surface-Layer Transfer Coefficients for Use in Atmospheric Numerical Models. *Boundary-Layer Meteorology*, **145** (3), 539-550.

A review on regional convection-permitting climate modeling: Demonstrations, prospects, and challenges

Andreas Prein

National Center for Atmospheric Research, Boulder, Colorado, USA

Summary of the equally named review paper by
Prein A.F. ,W. Langhans, G. Fosser, A. Ferrone, N. Ban, K. Goergen, M. Keller, M. Tölle, O. Gutjahr, F. Feser, E. Brisson, S. Kollet, J. Schmidli, N.P.M. van Lipzig, R. Leung, 2015. *Reviews of Geophysics*, doi: 10.1002/2014RG000475

This work is based on a longstanding cooperation of scientists working together on the establishment of convection permitting model (CPM) climate simulations within the convection resolving climate simulation (CRCS) working group of the CLM-Community. The strength of this cooperation is reflected in the list of contributing authors as well as in the important role of scientific contributions from the CLM-Community. The final paper clearly shows the leading role of the CLM-Community in the field of CPM climate simulations.

Based on results mainly from the numerical weather prediction community we defined CPMs as models with a horizontal grid spacing (Δx) of ≤ 4 km. Beyond this threshold non-hydrostatic numerical models are able to explicitly trigger deep convection and therefore no longer rely on convection parameterization schemes, which had been identified as a major source of errors and uncertainties in large-scale models (LSMs; horizontal grid spacing > 10 km). Moreover, CPMs allow for a more accurate representation of surface and orography fields. The drawback of CPMs is the high demand on computational resources.

The physical justification for the application of convection parameterizations starts to break down for Δx approximately smaller than 10 km such that parameterizations have to be either reformulated or switched off. Simulations with Δx in between the convection-permitting (Δx < 4 km) and the convection parameterized scale (Δx ≥ 10 km), called "gray zone", should be avoided if no suitable

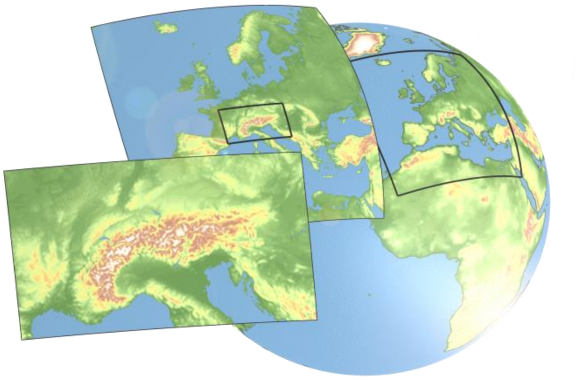

Figure 4: An example of a CPM climate simulation downscaling experiment with the COSMO-CLM model. Global ERA-Interim reanalysis (Δx~80 km) data is downscaled in a first nesting step to Δx=12 km over Europe and to Δx=3 km over the Alpine region.

scale-aware parameterizations are used (for a nesting strategy example see Figure 3). Several studies report minor sensitivities for grid spacings smaller than 4 km, especially when compared to the sensitivities stemming from physical parameterizations such as microphysics.

Several approximations and simplifications in the numerics of LSMs lose their validity or cause instabilities when convection-permitting grid spacings are approached. CPM simulations demand a non-hydrostatic formulation of the dynamical core since the hydrostatic approximation is no longer valid for Δx < 10 km. CPM simulations demand higher accuracy and stability of numerical discretization schemes because of steeper slopes (better resolved orography). The effective resolution, which is largely set by the implicit diffusion of discretizations, needs to be high in order to prevent too strong smoothing of the small-scale dynamics and in order to not unnecessarily waste computational resources. The setup of CPM climate simulations is often adapted from numerical weather prediction models because of the high computational costs of testing the physical settings in CPM climate simulations. Whether these settings are appropriate for simulations on climate timescales is, however, largely unknown.

There is clear evidence that CPM climate simulations are able to add value to LSMs. However, it is also important to mention that CPM climate simulations are not the cure for all model biases. Added value has been shown for the representation of extreme precipitation on hourly time scales, the timing (onset and peak) of the diurnal cycle of summertime convection, the improved simulation of wet-day frequencies, winter precipitation (e.g., build up and melting of snowpack) in mountainous regions, improvements in temperature at a height of 2 m related to improved representation of orography, and the simulation of the center pressures and small-scale processes in tropical cyclones.

Due to the high computational costs, only a small number of groups investigated climate change issues using CPM climate simulations. All these studies show highly relevant differences in the regional to local climate-change signals between CPM climate simulations and LSM simulations. In addition, these studies delivered insights into changes of some meteorological processes which would not have been gained with LSMs. Important differences are an higher increase in short-duration extreme precipitation events during summer, less hail in low elevation areas and increased runoff, a stronger decrease of central pressures and stronger maximum 10 m wind speed in extreme intense tropical cyclones in the north-western Pacific Ocean, and decreases in the future runoff from the Colorado Headwaters due to increased evapotranspiration which counteracts the predicted increase in runoff due to increased precipitation.

Climate-relevant feedback mechanisms derived with CPMs not only reveal different magnitudes, but some even differ in sign. Those mechanisms include the soil moisture-precipitation feedback, the vegetation atmosphere interaction, or the scaling of daily temperature at a height of 2 m with hourly precipitation.

Even though CPMs have proven to be useful tools especially for local to regional climate studies there are some major challenges that need to be addressed to exploit their full potential. These challenges include the development of turbulent parameterizations that are able to operate on scales between 10 km and 100 m, an improved understanding of microphysical processes and cloud-aerosol interactions, a set of highly accurate numerical solvers, the ability to run efficiently on future generation high performance computers, and the processing of large amounts of data.

Influence of different Amazonian deforestation scenarios on the local climate

Quentin Lejeune, Edouard Davin, Benoit Guillod and Sonia Seneviratne

Swiss Federal Institute of Technology, Switzerland

More details about this work can be found in:

Lejeune Q., E.L. Davin, B.P. Guillod, S.I. Seneviratne, 2015: Influence of Amazonian deforestation on the future evolution of regional surface fluxes, circulation, surface temperature and precipitation, *Climate Dynamics.*

Introduction

Deforestation can affect climate through the release of carbon to the atmosphere, but also by modifying the biogeophysical properties of the land surface, such as surface albedo, evapotranspiration and roughness. The Amazonian forest being the largest rainforest in the world and being threatened by ongoing deforestation, it is of major interest to determine the biogeophysical effects of possible future deforestation on the regional climate. Besides, it has been suggested that these effects could evolve nonlinearly, including tipping points. In a recently published study, Lejeune et al. (2015) address this question by investigating how different scenarios projecting various intensities of Amazonian deforestation would impact the local

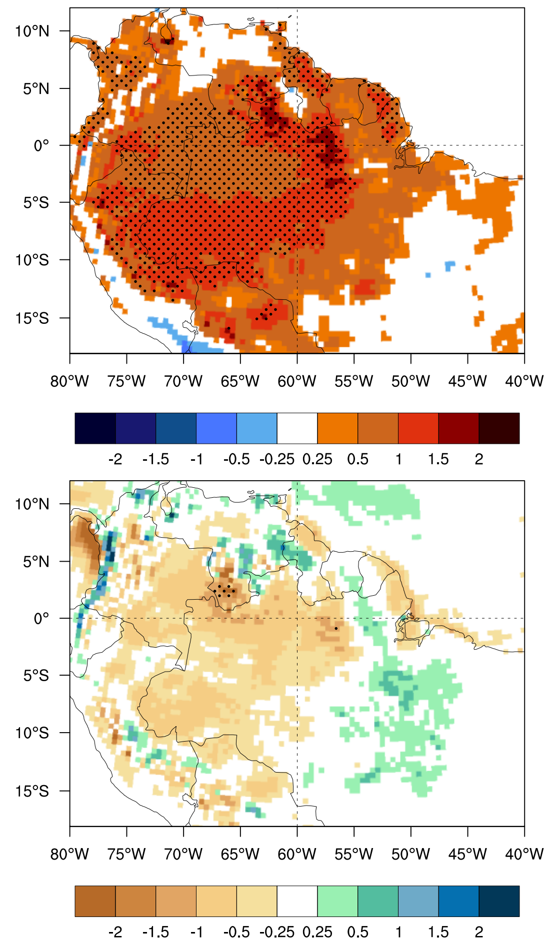

Figure 5 Deforestation-induced annual mean anomalies in 2 m- temperature (top, in °C) and precipitation (lower, in mm/d) in the DEF_TOT simulations compared to CTL, for the period 1987-2010. Anomalies for DEF_50% and DEF_A2 experiments are smaller but exhibit the same spatial pattern. Stippling marks changes that are different from 0 at the 5% significance level after evaluation with a two-tailed t-test

climate.

Data and methods

In this study, the regional climate model (RCM) COSMO-CLM^2 was used at a resolution of 0.44° over the South America CORDEX domain. The model consists of the atmospheric component of the COSMO4.8-CLM11 RCM, coupled to the Community Land Model version 3.5 (CLM3.5). The latter is a land surface model which can represent 15 different vegetation types, characterised by specific optical, morphological and physiological parameters. It was shown to outperform the default land surface module of COSMO-CLM (TERRA-ML) in this configuration, for both Europe (Davin and Seneviratne, 2012) and tropical Africa (Akkermans et al., 2012). Four simulations of 32 years (including eight years of spinup) were run, differing only in terms of vegetation map: one control simulation (CTL) with the current vegetation map, one forced with the map from the A2 scenario of the IPCC (DEF_A2), one implementing a level of deforestation halfway between these two maps (DEF_50%), and a last simulation representing a total deforestation scenario (DEF_TOT). In the three latter simulations, forests were mostly replaced by croplands, as well as to a lower extent by grasslands. Each run was forced with ERA-Interim boundary conditions as well as CO_2 concentrations from years 1979 to 2012.

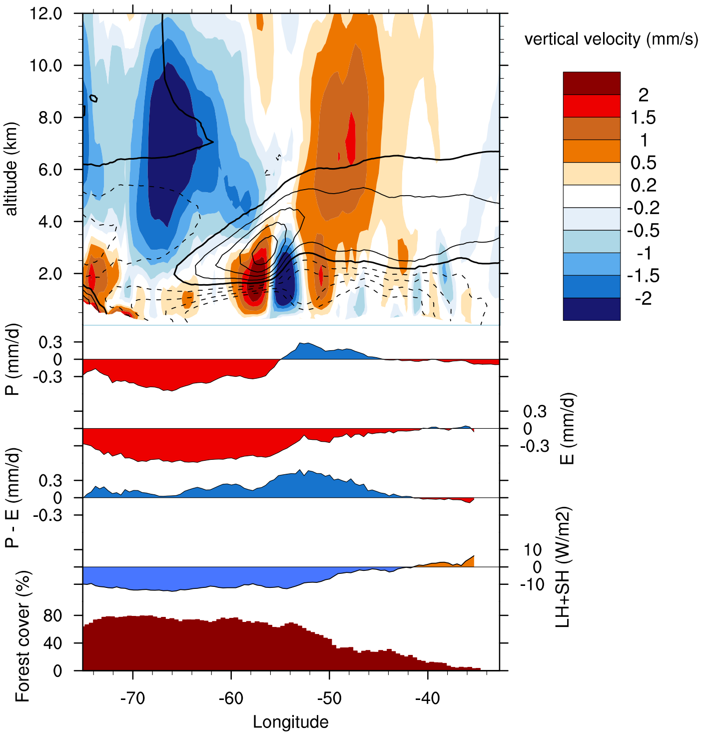

Figure 6: Longitudinal cross-sections showing annual mean changes in several variables in the DEF_TOT simulation compared to CTL. Values are latitudinally averaged between 0 and 12°S. Changes in DEF_50% and DEF_A2 are similar in sign but of a lesser magnitude. Upper panel: changes in vertical (coloured contours) and zonal wind velocities (contour lines) with altitude. Contour lines are drawn every 0.1 m/s, and dashed lines indicate an increase in mean wind speed in the westward direction. 2nd, 3rd and 4th panels: mean changes in precipitation (P), evapotranspiration (E), and in precipitation minus evapotranspiration (P-E), in mm/day. 5th panel: changes in the sum of latent and sensible heat fluxes, in W/m2. Lower panel: absolute amount of trees in CTL, in % of the grid cells.

Results

COSMO-CLM^2 simulates an increase in 2 m temperature over deforested areas (Figure 4 top). The response is more contrasted for precipitation, which decreases over the western part of the Amazonian forest but increases over its eastern border (Figure 4 lower). The mechanisms underlying these responses were analysed along a West-East transect going through the Amazonian forest. The results of this analysis are shown on Figure 5, which reveals a decrease in evapotranspiration reaching 0.5 mm/d in the western part of the transect (3rd panel), where the deforestation rates are highest (see lower panel). This drives the increase in 2 m temperature through reduced evaporative cooling, but also diminishes the input of water from the surface into the atmosphere. This is partly compensated by enhanced moisture convergence into the Amazonian region (4th panel), as a result of the decreased roughness length which entails an increase in wind speed within the first 2 km of the atmosphere (1st panel). Because of the higher albedo of grasslands, less energy gets absorbed by the land surface after deforestation, hence less energy is transmitted back to the atmosphere under the form of sensible and latent heat fluxes (5th panel). This eventually reduces convective activity on the western part of the transect, as shown by the decreased upward vertical velocity (1st panel). A compensating enhancement of convection occurs over its eastern part, where the strength of the easterlies is reduced between 2 and 6 km. The increase in atmospheric moisture convergence is therefore maximal over this region where convection is strengthened, leading to a small increase in precipitation locally, whereas the diminution in evapotranspiration dominates and entails a decrease in rainfall elsewhere.

The increase in air surface temperature of 0.8°C simulated in response to total deforestation (100%) on average over the Amazonian region compares well with the mean of previous estimates from over 20 similar experiments conducted either with RCMs or General Circulation Models (GCMs, see Figure 6). However, about 80% of them report a decrease in average precipitation by more than the ~0.2 mm/d simulated with COSMO-CLM^2. If the latter suggests a relatively linear evolution of regional mean surface temperature and precipitation with deforestation, the comparison on Figure 6 shows that this is model-dependent. The differentiation of the GCM studies of total defores-

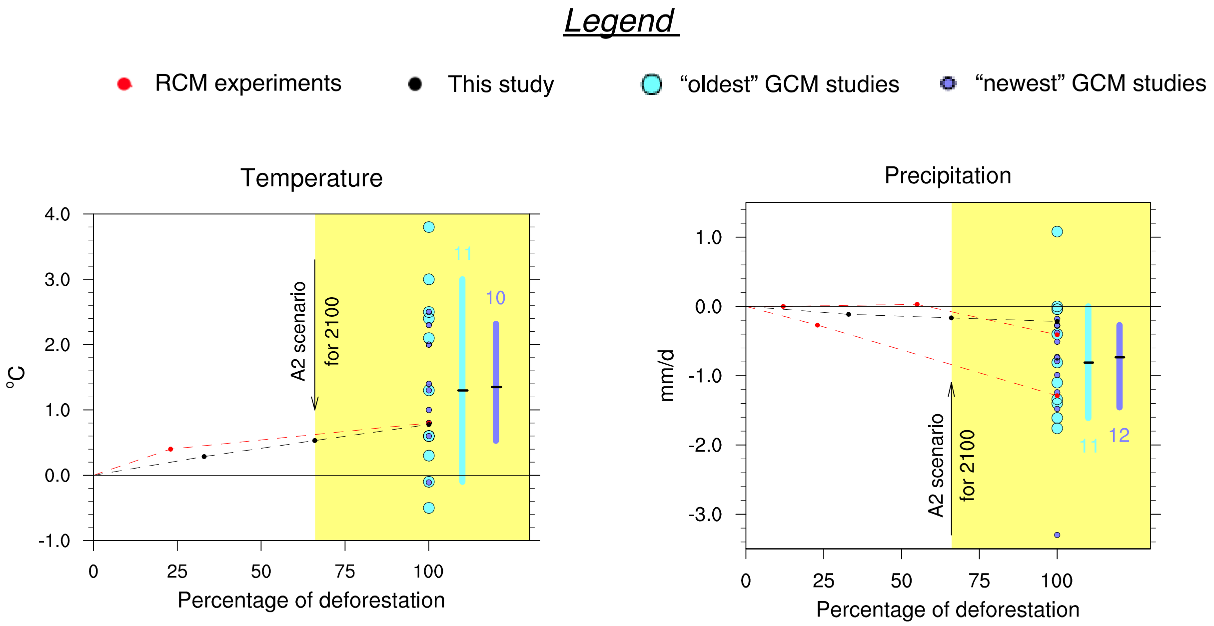

Figure 7 Changes in annual mean surface temperature (left) and precipitation (right) against percentage of deforestation, as simulated in this study and previous ones. Big light blue dots represent the results from the "oldest" GCM studies, and small dark blue ones those from the "newest" GCM studies. Small markers stand for the results from our study (black) or from two other series of RCM experiments (red). The 0% level of deforestation refers to present-day land cover. The vertical bars show the range between the first and ninth deciles for the "oldest" (light blue bar) and the "newest" studies (dark blue bar). The horizontal black lines inside each bar indicate the median for each category of models, while the numbers above or below the bars indicate how many models are included in each category.

tation between the "oldest" ones, which were published earlier and conducted with older GCM versions, and the "newest" ones, which used more recent versions or were published later on, reveals that the spread between the estimates of changes in rainfall and surface temperature is lower for the second category. In particular, the "newest" GCM studies exclude an increase in rainfall and a decrease in surface temperature in response to Amazonian deforestation.

Conclusion

In this study, one control as well as three deforestation experiments were conducted over South America with the COSMO-CLM^2 RCM. An increase in surface air temperature and a decrease in precipitation were simulated on average over the Amazonian region in response to local deforestation. However, resulting modifications of the surface fluxes and of the regional-scale circulation lead to an increase in precipitation over the eastern part of the Amazonian forest. 2 m temperature and precipitation evolve relatively linearly with deforestation in these simulations, but a comparison with previously published studies suggests this could be model-dependent. The conducted analysis of the literature on this topic reveals that most studies, especially those using more recent (improved) climate models, simulated changes in surface temperature and precipitation of the same sign after deforestation. However, this study highlights the added value of employing a mesoscale resolution and a state-of-the-art land surface model to address this type of research questions, since they enable a better representation of regional contrasts in both land cover changes, their impact on surface water and energy fluxes, as well as their overall effect on climate.

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Remember

… part of your scientific success relies on the work of those people providing the reference model, 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" in each publication.

Upcoming events

- **2015 August, 06th - 07th**, 13th International Conference on regional Climate, Amsterdam, Netherlands
- **2015 August, 23th - 28th**, 14th International Swiss Climate Summer School– Extreme Events and Climate, Ascona, Switzerland
- **2015 August, 31th - September 04th**, 33rd International Conference on Alpine Meteorology, Innsbruck, Austria
- **2015 September 07th - 11th**, 15th EMS Annual Meeting & 12th European Conference on Applications of Meteorology (ECAM) in Sofia, Bulgaria
- **2015 September 07th -11th,** COSMO General Meeting in Wroclaw (Breslau), Poland
- **2015 September 21st - 24th**, Deutsche Klimatagung, Hamburg, Germany
- **2015 September 29th - October 02nd**, CLM-Community Assembly in Belvaux, Luxembourg
- **2015 October 05th - 06th**, DKRZ Rechnereinweihung, Hamburg, Germany
- **2015 October 29th - 30th**, (Regional-)Modellierer-Workshop, Offenbach, Germany
- **2015 November 05th - 06th**, Baltic Earth workshop, Rome, Italy
- **2015 Dezember 14th - 18th**, AGU Fall Meeting, San Francisco, USA

see also

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Recent publications

2015

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Dr Barbara Früh
Deutscher Wetterdienst
Frankfurter Str. 135
63067 Offenbach, Germany
clm.coordination@dwd.de