Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

MeteoSwiss

MeteoSwiss - C2SM COSMO User Workshop

22 October 2009

Goal

The COSMO User Workshop is intended as a platform to share experience and present current projects with the COSMO model. The informal workshop atmosphere is ideal to discuss possible problems with the model and initiate collaborations with other groups. Talks should be focused on the COSMO model and take approximately 12 minutes with 8 minutes for discussion.

Location

Raum 354, MeteoSwiss, Kraehbuehlstr. 58.
Take Tram 6 at the main station in direction of Zoo to Zuerichbergstrasse.
http://map.search.ch/8044-zuerich/kraehbuehlstr.58

Program

10.00 – 10.05	Philippe Steiner, MeteoSwiss **Welcome**
10.05 – 10.15	Isabelle Bey, C2SM **A quick overview of the current C2SM activities**
10.15 – 10.35	Linda Schlemmer, IACETH **Idealized studies of convective summer precipitation in a cloud resolving model**
10.35 – 10.55	Wolfgang Langhans, IACETH **Vertical heat and moisture fluxes during Alpine summertime convection as simulated at kilometer-scales**
10.55 – 11.15	Pirmin Kaufmann, MeteoSwiss **Comparison of COSMO-2 with a mobile wind profiler**
11.15 – 11.35	Guy de Morsier, MeteoSwiss **Tuning the horizontal diffusion in the COSMO model**
11.35 – 11.55	Heini Wernli, IACETH **COSMO modeling in the ETH atmospheric dynamics group: current actitivities and plans**
11.55 – 12.15	Daniel Leuenberger, MeteoSwiss **News from the COSMO General Meeting 2009 and future directions of the COSMO model**
	Lunch break

Look for the afternoon program on the next page!

13.15	– 13.35	Balázs Szintai, MeteoSwiss **High resolution COSMO runs for dispersion applications in complex terrain**
13.35	– 13.55	Christoph Knote, EMPA **COSMO-ART: Setup at CSCS and first evaluation**
13.55	– 14.15	Andreas Pauling, MeteoSwiss **A method to produce a birch distribution database as input field to COSMO-ART**
14.15	– 14.35	Sara Pousse-Nottelmann, IACETH **Aerosol processing in clouds in COSMO-CLM-M7**
		Coffee break
14.50	– 15.10	Edouard Davin, IACETH **Evaluation of the coupled atmosphere-biosphere CCLM-CLM model**
15.10	– 15.30	Ruth Lorenz, IACETH **Persistence of heat waves and its link to soil moisture memory**
15.30	– 16.00	***Open discussion***
16.00	– 17.00	***Apero***

Abstracts

Idealized studies of convective summer precipitation in a cloud resolving model.

L. Schlemmer, C. Hohenegger, C. Bretherton, J. Schmidli and C. Schär
Institute for Atmospheric and Climate Science, ETH Zurich

We investigate the response of convection to future climate changes in the cloud resolving model (CRM) setting of the COSMO model using a high spatial resolution of about 2 km. Using the CRM in an idealized setting, we are trying to infer the response of convection to altered temperature and moisture profiles.
The CLM model version CLM 4.0 is integrated on a grid of 0.01° - 0.02° (1.1-2.2 km), a resolution allowing the explicit formulation of deep convection. The domain spans 100 by 100 grid points in the horizontal, 50 vertical levels, and 10 soil layers. Periodic lateral boundary conditions in the x- and y-directions are employed. The model is initialized by a single vertical sounding. The calculations are performed without topography and in the absence of background rotation using metric terms.
To keep the simulations confined to the desired vertical profiles, the simulated atmosphere is consecutively relaxed towards this profile.
The simulations show a reasonable diurnal cycle of temperature, precipitation and energy fluxes. Variations of the static stability, temperature and the vertical distribution of humidity influence the evolution of convection and the amount of precipitation. The time of the precipitation peak occurs earlier or later in the afternoon.

Vertical heat and moisture fluxes during Alpine summertime convection as simulated at kilometer-scales

W. Langhans, J. Schmidli and C. Schär
Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

Parameterizations of convective precipitation seem to be responsible for a large uncertainty in predictions of the European summer climate. Within this study we investigate the performance of the opposed explicit simulation of moist convective processes at kilometer-scale resolutions, thereby avoiding the usage of convection schemes. Numerical simulations of a convective summertime period are conducted using the nonhydrostatic regional climate model CCLM Version 4.3. The setup we use is similar to the operationally approved model versions COSMO2 at the Swiss Weather Service (MeteoSwiss) and COSMO-DE at the German Weather Service (DWD). The dynamics are based on a split-explicit 3rd-order Runge-Kutta scheme and a 5th-order accurate spatial discretization is applied for the horizontal advection of prognostic variables. Sub-grid scale vertical turbulent diffusion is described by a prognostic TKE-based scheme with a closure on level 2.5. Topographic corrections of radiative fluxes have been adapted from the latest model versions to account for the shading effects of orography. In order to study the physical and dynamical contributions to the potential temperature and moisture budgets in the Alpine region a budget analysis tool has been implemented into the code. By applying the aforementioned tool we investigate the relation of single numerical components to predicted heat and moisture budgets and study the bulk vertical heat and moisture transports between the planetary boundary layer and the free atmosphere above the Alps. The predicted surface precipitation is compared against gridded surface and radar measurements, available at least for Switzerland.
First sensitivity tests reveal a large reduction of mean precipitation by up to 35 % due to explicit horizontal diffusion, if applied to temperature and/or the horizontal wind components. Increasing the hyperviscosity coefficients and thereby enhancing the filtering of small-scale convective updrafts causes a systematic decrease of the vertical bulk heat and moisture exchange over the Alps. Further numerical sensitivities will be addressed and studied.
Our future work will focus on the convergence of simulations with horizontal grid-spacings reaching from 4 km to at least 1 km, whereby convergence among simulations will be reached as soon as the vertical heat and moisture exchange above the Alps remain unmodified.

Comparison of COSMO-2 with a mobile wind profiler

C. Hug and P. Kaufmann
MeteoSwiss

The project “Centrales Nucléaires et Météorologie” (CN-MET; Nuclear power plants and meteorology) devised and installed a new system providing meteorological information for emergency response purposes in Switzerland. This new system is based on forecast data from a refined numerical weather prediction (NWP) model combined with state of the art real time field observations. The Swiss Federal Nuclear Safety Inspectorate ENSI (Eidgenössisches Nuklearsicherheitsinspektorat) as the customer of these data set up target specifications for the accuracy of the model forecasts.
This talk presents a validation the new NWP model COSMO-2 relative to measurements from an independent wind profiler of MeteoSwiss. It is based on data collected during two field experiments and taking into account the most recent development including:

- The new model COSMO-2 of MeteoSwiss, using a fine grid size with horizontal resolution of 2.2 km and a rapid update cycle of three hours.
- The CN-MET network with the renewed surface observation network and the remote sensing sites featuring profiler and microwave radiometers in Grenchen, Payerne and Schaffhausen.

The first experiment has been undertaken from August to October 2008 in Kleindöttingen between the NPP sites Beznau and Leibstadt. The second validation study used measurements from mid-March to mid-June 2009 in Wileroltigen near Mühleberg.

Tuning the horizontal diffusion in the COSMO model

M. Müllner and G. de Morsier
MeteoSwiss

Theoretically when using the Runge-Kutta solver, the COSMO model does not need any horizontal diffusion. But in the operational implementation some diffusion near the upper and lateral boundaries is needed, as the model is forced to meet external conditions at these locations and therefore the diffusion can control the generated artificial structures. In spite of this diffusion, some individual cases show instabilities in the inside domain of the model.
The presented work tries to define a good choice for the horizontal diffusion coefficients for a wide range of different situations. The COSMO code was modified such that the user can determine the diffusion coefficient at the boundary and inside the domain separately. Thus the coefficients inside the domain can be chosen quite small. The diffusion of the temperature has a big impact on the precipitation and it is hard to predict which other processes are influenced by it, therefore the temperature shouldn't be diffused. Therefore only the winds (u,v,w) are diffused. To quantify the impact of the horizontal diffusion, the response function of the 4th order diffusion scheme and the kinetic energy spectra are used.

COSMO modeling in the ETH atmospheric dynamics group: current actitivities and plans

H. Wernli(1,2), M. Böttcher(2), C. Frick(1), H. Joos(1), A. Kerkweg(2), S. Pfahl(2) and A. Winschall(2)
(1) Institute for Atmospheric and Climate Science, ETH Zürich
(2) Institute for Atmospheric Physics, University of Mainz

Numerical studies with the COSMO model are an essential part of the research of the atmospheric dynamics group at ETH Zürich (and the University of Mainz). This presentation tries to provide a brief overview on the many scientific activities and plans involving the COSMO model. These activities include (i) sensitivity experiments for dynamical case studies of high-impact weather events (mainly extratropical storms), (ii) detailed analyses of the potential vorticity evolution along warm conveyor belts, (iii) modifications of the microphysical melting scheme for the prediction of snow and ice storms, (iv) inclusion of water vapour tagging and of the physics of stable water isotopes into the model, and (v) a coupling of the model to the numerical chemistry and climate simulation system ECHAM/MESSy.

High resolution COSMO runs for dispersion applications in complex terrain

B. Szintai
MeteoSwiss

The capability of the COSMO model for simulating the mean and turbulence properties of the Planetary Boundary Layer (PBL) is investigated on two case studies. First, the LITFASS-2003 campaign is presented which is characterized by strong surface heterogeneity. The sensitivity of the COSMO simulation (at 1 km horizontal resolution) is investigated with respect to numerical horizontal diffusion and vertical level distribution. Results are compared to turbulence measurements and Large Eddy Simulation data. Secondly, the performance of the COSMO model is investigated in the highly complex topography of the Southern Alps using measurement data from the TRANSALP-89 campaign. Next to the meteorological simulation the tracer dispersion is also studied using the operational emergency response system of MeteoSwiss. Sensitivity of the modelling system towards the soil moisture, horizontal grid resolution and boundary layer height determination approach is investigated.

COSMO-ART: Setup at CSCS and first evaluation

C. Knote
EMPA

Designing efficient strategies to reduce the impact of air pollutant emissions on air quality and climate is not a straightforward problem. Changes in technology sometimes counteract reduction efforts: Expected decreases in NO2 and ozone concentrations through the reduction of NOx emissions, for example, were partly inhibited by an increasing fraction of diesel powered vehicles. Likewise, a reduction of particulate matter emissions, which is highly desirable from an air quality perspective, may on the other hand lead to a decrease in the cooling effect of aerosols and thus to enhanced global warming.

Chemistry transport models are able to simulate these complex interactions and are therefore probably the best tool to evaluate the impact of planned emission reduction strategies. COSMO-ART is an extension to the COSMO model and provides gas-phase chemistry of reactive species and aerosol processes which are online coupled to the meteorology. It has been developed at Forschungszentrum Karlsruhe in Germany. COSMO-ART is not only useful for studies of air quality but can serve likewise in climate studies, as the generation, transport and deposition of aerosols are simulated with great detail.

We have set up COSMO-ART on the Cray at CSCS (Manno/TI) and implemented an interface for the input of emission and chemistry fields needed as additional initial and boundary conditions for the ART extension. As chemical boundary conditions we take model output generated by the EU project GEMS which evaluated the performance of several chemistry transport models in Europe. Emissions are derived from detailed inventories of TNO (Netherlands) for the European domain, and from BAFU for Switzerland, respectively. Finally, the meteorology is driven by analyses of the IFS model of the European Centre for Medium-range Weather Forecast (ECMWF).

In the first part of our study we simulate weekly / monthly episodes for the European domain with about 20 km horizontal resolution and in a nested run over Switzerland at convection-permitting scales (about 2 km).

We compare those results with station data from the Swiss Federal air quality network (NABEL).

The talk will give a short overview of the model system and the additional input data and present results from first evaluations of the model performance.

A method to produce a birch distribution database as input field to COSMO-ART

A. Pauling
MeteoSwiss

Pollen dispersion modelling requires detailed knowledge of the emission location and emission strength. Therefore, plant distribution density is an essential input to the dispersion model COSMO-ART. However, this kind of data is not available and needs to be derived from several sources. We demonstrate how information from the Swiss forest inventory and land use data can be combined to generate a birch distribution database covering Switzerland. Calibrating this dataset with the Global Land Cover database yields a birch distribution that encompasses the whole COSMO domain. In a second step, birch pollen measurements from 327 stations all over Europe have been used to produce another birch distribution dataset. Combining the two approaches results in a birch distribution database that can be used as input to COSMO-ART. This method may also be applied to other species.

Aerosol processing in clouds in COSMO-CLM-M7

S. Pousse-Nottelmann, E. Zubler and U. Lohmann
Institute for Atmospheric and Climate Science, ETH Zurich,

Aerosol particles undergo significant modifications during their residence time in the atmosphere, between their formation or emission and their removal. Processes like coagulation, coating, water uptake and aqueous surface chemistry alter the aerosol size distribution and composition. At this, clouds play a primary role as physical and chemical processing inside cloud droplets contribute considerably to the changes in aerosol particles. Globally averaged, atmospheric particles are cycled three times through a cloud before being removed from the atmosphere [1].
An explicit and detailed treatment of cloud-borne particles will be implemented in the regional weather forecast and climate model COSMO-CLM. The employed model version includes a two moment cloud microphysical scheme [2] that has been coupled to the aerosol microphysical scheme M7 [3] as explained in [4]. So far, cloud-borne aerosol number and mass were not considered. Distinction between in-droplet and in-crystal particles will be made to more physically account for processes in mixed-phase clouds, such as the Wegener- Bergeron-Findeisen process as well as contact and immersion freezing.
The new scheme will allow an evaluation of the cloud cycling of aerosols. Global simulations of aerosol processing in clouds have recently been conducted by Hoose et al. [5]. Our investigation regarding the influence of aerosol processing on the aerosol size distribution will apply the approach developed by Hoose et al. [6] on a regional scale using a cloud-system resolving model with much higher resolution. Emphasis will be placed on orographic mixed-phase precipitation. The new parameterization will be validated with observations and recent simulations [6] of total and interstitial aerosol concentrations and size distributions at the high alpine research station Jungfraujoch (Switzerland).

[1] Pruppacher & Jaenicke (1995) Atmos. Res., 38, 283-295.
[2] Seifert & Beheng (2006) Meteorol. Atmos. Phys. 92, 45-66.
[3] Stier et al. (2005) Atmos. Chem. Phys., 5, 1125-1156.
[4] Muhlbauer & Lohmann (2008) J. Atmos. Sci., 65, 2522-2542.
[5] Hoose et al. (2008) Atmos. Chem. Phys., 8, 6939-6963.
[6] Hoose et al. (2008) J. Geophys. Res., 113, D07210.

Evaluation of the coupled atmosphere-biosphere CCLM-CLM model

E.L. Davin, R. Stöckli and S.I. Seneviratne
Institute for Atmospheric and Climate Science, ETH Zurich,

We coupled the CCLM Regional Climate Model with the CLM Land Surface Model. The CLM (Community Land Model) is a state of the art Land Surface Model maintained at NCAR (National Center for Atmospheric Research). It includes mechanistic formulations of biogeophysical and biogeochemical processes that determine the terrestrial fluxes of radiation, heat, water and carbon in response to climate forcings. The goal of this coupling is to achieve a more comprehensive representation of land surface processes for regional climate simulations. These processes are indeed important in shaping the exchanges of energy, water and trace gases between the land and the atmosphere. Ultimately, these exchanges are crucial for realistically simulating surface climate conditions. Here we present a first evaluation of CCLM-CLM, by comparing its performances with those from the standard CCLM Regional Climate Model. We analyze climate simulations over Europe at 50 kilometer resolution. Overall, the coupled CCLM-CLM leads to an improvement of the simulated temperature and precipitation fields. In particular, the cold bias present in the standard CCLM in the summer season is suppressed in the coupled CCLM-CLM. On the other hand, the coupling as a more limited effect in winter as expected from the fact that European winter climate is more affected by atmospheric circulation than by land-atmosphere coupling. Finally, we show that the improved performances of CCLM-CLM as compared to the standard CCLM are due to a more realistic simulation of land surface fluxes.

Persistence of Heat Waves and its Link to Soil Moisture Memory

R. Lorenz
Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

We performed a study with COSMO-CLM in order to assess the role of soil moisture for heat wave persistence. Several studies have investigated changes in the frequency of hot summer days but very few investigated changes in persistence. We found that inferred changes in heat wave persistence may highly depend on the threshold used to define a heat wave. Indeed, a change in mean temperature can lead to a change of the inferred heat wave duration for a used threshold. This may not necessarily imply a change in intrinsic persistence (i.e. persistence of days hotter than 90th-percentile). We identify that simulations with prescribed constant soil moisture present a lower intrinsic heat wave persistence than simulations with interactive soil moisture. This is also the case for simulations with constant dry conditions. In addition, the probability for shorter heat waves is increased, and the frequency of longer ones is decreased with constant soil moisture content. This highlights the importance of soil moisture memory for heat wave events.