Scientific report on the COSMOS (COmmunity earth System MOdelS) 2009 General Assembly,

including the ESF-MedCLIVAR focus session on Climate Impact Models for the Mediterranean Region

Tim Kruschke, Uwe Ulbrich

Introduction

The COSMOS - General Assembly 2009, which included the MedCLIVAR sponsored focus session, was held in Berlin, Germany, 15-17 June 2009 at the *Seminaris CampusHotel Berlin, Science & Conference Center*. The COSMOS *Community Earth System Models*-network is an international project initiated by the Max-Planck-Institutes for Meteorology, Chemistry, and Biogeochemistry, and the Potsdam Institute for Climate Impact. It is intended to foster the development and evaluation of state-of-the-art climate and earth system models (ESMs), to facilitate focused model inter-comparison in order to assess and improve these models, to encourage exchanges of software and model results, to strive, as a European based network, for international cooperation, and to help to establish the necessary computational resources.

Attendance and ESF-MedCLIVAR visibility

The Assembly was attended by 76 researchers from eleven countries. The co-sponsorship of ESF though MedCLIVAR and the intentions of the focus session were communicated to the auditory both in the agenda, the introduction and in the focus session itself, as well as by a MedCLIVAR poster at the conference room entrance. The focus session on model systems for impacts in the Mediterranean Region took place during the morning of the second day. It was designed to enhance the awareness for the Mediterranean region as a target for the applications of earth system models, including the simulation of socio-economic impacts of past, present and future climate variability and change. 5 talks of invitees for this session were foreseen, with an extended time slot for each of them. Regretfully, only four of them were given as M. Bindi, Università degli Studi di Firenze, had to cancel his attendance a week before the assembly due to personal reasons. The inclusion of the focus session about the *MedClivar*-initiative was very much appreciated by the assembly participants. The summaries of the talks given in the focus session are outlined in the section on scientific content, session 2. Interactions between the scientists invited for the focus session and the participants of the regular sessions were successfully initiated.

Scientific content

This year's COSMOS-GA was opened with four presentations about the current COSMOS-status and news from the network, as well as opportunities and challenges within the field of earth system modelling by M. Claussen (Chairman of COSMOS-Board, MPI-M, Germany), H. Järvinen (FMI, Finland), B. Stevens, and M. Giorgetta (both MPI-M).
The second part of **session 1**, titled *Chemistry and Climate*, chaired by M. Schultz (FZ Jülich, Germany) and M. Lawrence (MPI-CH, Germany) started the scientific part of the conference.

Lawrence opened this session with his talk, highlighting the importance of "megacities" and pollution hot-spots for local, regional and global air quality. He presented results of the *MEGAPOLI*-project which aims at assessing the impacts of those hot-spots and quantifying the feedbacks between air quality and climate change. Among these presented results was the new *EDGAR* emissions inventory which showed some interesting differences to other inventories, namely the *IPCC/IIASA*- or the *RETRO*-dataset. Another result was the *Megacity Pollutant Index*, measuring the air quality in megacities relative to guideline concentrations of the WHO, considering observations of multiple pollutants.
R. Sausen gave an overview on chemistry-climate modelling activities at DLR (Germany) and presented some examples of recent work like the implementation of *ATTILA* into *ECHAM5*. *ATTILA* is an advanced Lagrangian advection scheme, which is able to substantially reduce systematic errors in temperature and humidity. J. Feichter presented a short introduction into the current status of the chemistry-climate model *ECHAM5-HAMMOZ* at the MPI-M and gave some insights into an ongoing study about the formation of cosmic ray-ion induced clouds.
Subsequently, P. Stier (University of Oxford, UK) talked about a new revised aerosol-scheme in *ECHAM5-HAMMOZ.* This scheme allows the assessment of cloud lifetimes depending on aerosol concentrations. This feature facilitated quantitative estimations for anthropogenic radiative forcing through this indirect aerosol effect in the order of -1.2 (±0.7) Wm^{-2}.
S. Ferrachat (ETH-IAC, Switzerland) gave a talk about the cloud-aerosol interactions in the latest *ECHAM5-HAM* model and sensitivity studies that have been carried out focussing on the improved modelling of the Bergeron-Findeisen process and sulfate coating.
Finally, M. Schultz addressed the question, whether historic and future ozone trends can be modelled with current chemistry-climate models. He showed that the models are not able to capture the historic trend(s) of tropospheric ozone well, suggesting that projections of future ozone concentrations may be too low, resulting in a possible underestimation of the radiative forcing due to tropospheric ozone by a factor of 1.5-2.
The first day of this year's COSMOS-GA was closed with the short third part of session 1, which was about paleo-climate. The only talk in this part was given by G. Lohmann (AWI, Germany). He presented some challenging ideas and plans to use the COSMOS ESM in a low-resolution version to simulate the climate evolution during the last 150,000 years with a special focus on glacial cycles and deglaciation.
W. Hiller (AWI, Germany) finished with a short promotion of the new *OASIS4* model-coupling software, highlighting the improvements compared to the widely-used *OASIS3* coupler.

Session 2 dealt with *Regional Issues* and was chaired by U. Ulbrich (FU Berlin, Germany). The dominant part of this session was the

***ESF MedCLIVAR co-sponsored focus session on Climate Impact Models for the Mediterranean* Region**.

It was opened by **F. Rubel** (University of Vienna, Austria), talking about epidemics and virus dispersal depending on meteorological parameters. First, he presented schemes of different models for e.g. virus and virus' host life cycles in dependence of temperature input. His group was the first one worldwide to use climate projections in order to assess future developments of epidemics like *Usutu virus* infections until 2100. Subsequently, Rubel showed results of their work with a Lagrangian particle dispersion model to locally simulate the spreading of foot-and-mouth-disease, using wind, temperature, and humidity of numerical weather predictions. That kind of model is used to produce risk assessment maps for potential infections. The models were in particular applied to the Mediterranean Region, and transport paths of vectors within the Mediterranean region as well as exports from this region were considered.

K. Fedra (ESS GmbH, Austria) explained an *Integrated Environmental Information and Decision Support Systems* which are developed and distributed by his company, emphasising the philosophy behind these products. That philosophy focusses on domains sensitive to climate change, e.g. water-resources management or urban air-quality, looking for feasible scenarios in which a desired status can be maintained or reached independent of climate change. A region of particular sensitivity for climate change is the Mediterranean region, and decision support systems based on Earth System Models are needed, rather than just the pure output of such models. The basic idea is a complex cost-benefit analysis which chooses the solution closest to the "utopia state" through a multi-criterion optimization.
An overview of wind wave modelling within the earth system was given by **P. Lionello** (University of Salento, Italy). He pointed out, that state-of-the-art wave models are a consolidated tool for wind wave field simulations and provide valuable informations for coast evolution. They may be used also for the computation of feedbacks on the atmospheric circulation. Nevertheless, the quality of their results depends strongly on that of the driving wind fields. Regarding future wave climate, projections driven by wind fields of regional climate models suggest a continuation of the recent trend towards lower wave hights in the Mediterranean.
An insight into ongoing work and results of the *GLOWA-IMPETUS* project was given by **A. Fink** (University of Cologne, Germany). That project is an integrated approach to the efficient management of scarce water resources for present and future conditions in West Africa, in particular in Morocco. Many GCMs simulate warmer and dryer conditions in the future for the whole African continent. Though, the results for northern Africa show large uncertainties. Fink and his colleagues chose a statistical-dynamical regionalisation approach based on the recombination of circulation weather-types (CWTs) indicating an increase in rainfall south of the Atlas-mountains and in the Anti-Atlas but less rain in the high mountains for the future. Following impact modelling studies suggested a decrease in the probability of exceeding critical thresholds for discharge into water reservoirs used for agricultural irrigation.

At the end of session 2, challenges and possibilities in regional modelling were addresses by D. Jacob (MPI-M, Germany). Facing the spatial resolution and temporal coverage of RCM simulations, she stated that RCMs now and in the future are powerful tools to assess climate change and open possibilities for a better understanding of feedback processes what might be useful to improve the performance of GCMs, at least in specific regions.

Session 3, was about the components of earth system modelling. The first part of this session was chaired by R. Sausen and focussed on the ocean and volcanoes. J. Jungclaus (MPI-M, Germany) showed first results of the *Millenium experiment* in which for the first time millenium simulations were carried out in ensemble mode using a comprehensive earth system model including an interactive carbon cycle. Key findings were the significant effects of external forcings onto the carbon cycle, where volcanoes are the most powerful external factor and do lead to a decrease in atmospheric CO_2 while land-use changes lead to an increase. The simulations capture the warming trend of the $19^{th}/20^{th}$ century and suggest that the observed multidecadal variations partly are due to internal variability. Sensitivity experiments on solar forcing show a warming of 0.1K and an CO_2 -increase of 0.7ppm for an increase of $1Wm^{-2}$ total solar irradiance.
After that, C. Lévy (UPMC, France) introduced *NEMO*, the *Nucleus for European Modelling of the Ocean*. That numerical platform contains a dynamical model for the blue ocean, a sea-ice model, and an ocean-biogeochemistry model.
The COSMOS-related activities of AWI (Germany) were presented by Q. Wang and K. Fieg. They gave an introduction into *FESOM*, consisting of the hydrostatic primitive equations ocean model *FEOM* and the coupled sea-ice model *FESIM*. *FESOM*, as well as *NEMO*, could

be implemented into the COSMOS model system as an alternative to the MPI-OM. Additionally they presented a more detailed overview of the development and possibilities of the new *OASIS4* coupler.
The volcanic activity group in COSMOS was represented by S. Lorenz (MPI-M, Germany), who informed the assembly about current studies at the participating institutions. Although there is no doubt that volcanic eruptions can state a major forcing on the climate system, the *Yellowstone super-volcanoe experiment* conducted by the MPI-M showed that even a huge eruption does not necessarily disturb the climate system over a longer time scale.
In the second part of session 3, chaired by D. Jacob, news from various projects within the COSMOS network and by external institutions were presented.
Talks about current activities at DLR were given by U. Burkhardt and R. Sausen. Burkhardt talked about the development of a new ice cloud scheme in the *ECHAM* model to be consistent with cloud microphysics and the modal aerosole module *MADE*. Sausen showed results of studies for environmentally friendlier flight planning. Facing the fact, that a reduced demand for air traffic seems to be no realistic scenario, flight emissions and subsequent radiative forcings and temperature changes were simulated depending on changed mean flight altitudes. In the following more sophisticated approaches via a four-dimensional (longitude, latitude, altitude, time) environmental cost function will have to be chosen in order to fulfill the requests of a real environmentally friendlier flight planning.
After that, H. Schmidt (MPI-M, Germany) spoke about *IMPLICC*, a project to assess the implications and risks of geoengineering solar radiation to limit climate change by simulating these (proposed) activities with a number of different earth system models.
Another new project which has just started in May 2009 was presented by M. Giorgetta (MPI-M, Germany). The *Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection (COMBINE)* is set for the next four years in order to explore the role of different processes for feedbacks that regulate climate change and to answer questions about the predictability on the decadal time scale related to internal variability of the climate system and initialization techniques. These answers might help to iteratively improve certain mitigation scenarios.
A program to foster the integration of the European ESM community was launched in March 2009. R. Budich (MPI-M, Germany) introduced this initiative called *IS-ENES*, which aims for providing the necessary infrastructure for high-end simulations, the development of ESMs, and applications for research on climate change impacts to the community.
Thereafter two presentations were given by C. Jones (SMHI, Sweden). The first one was about the status and development of *EC Earth*, which is a common project of currently 19 national meteorological/climate centers and universities to develop a new global climate and earth system model. The system consists of the *IFS* atmosphere model, the *NEMO* ocean model and the *LIM* sea ice model. Jones showed some promising preliminary results from the already completed coupled spin-up run of *EC Earth v2*. A third version is currently under development at SMHI, integrating newer versions of the model components partly with higher spatial resolution and might be able to contribute to *CMIP5* decadal hindcasts and predictions. Jones' second presentation was about the *Coordinated RegionalDownscaling Experiment (CORDEX)* which aims at providing a set of regional climate scenarios covering the period 1950-2100 for the majority of the global populated land-regions and a generalized framework for testing and applying RCMs and downscaling techniques for the recent past and future scenarios. A standard spatial resolution of 50km for the RCM simulations is chosen in order to facilitate the participation of as many groups as possible. Nevertheless, the participants are encouraged to conduct simulations with higher resolutions as well. An initial focus for future climate scenarios will be on Africa with the aim to provide a contribution to *IPCC AR5*.

ESM activities within the *NorClim*-initiative in Norway, that might be valuable in a possible collaboration with COSMOS, e.g for inter-comparison purposes, were presented by O. Otterå. The *Nansen Center* and the *University of Bergen* developed the *Bergen Climate Model (BCM)*, which already participated in *CMIP3*. Since then, several extensions and improvements were integrated, enabling sophisticated simulations to assess the carbon cycle feedback, the role of natural forcings during the last 600 years, and to other processes. However, in the meantime a new *Norwegian Earth System Model (NorESM)* is being developed, based on the *CCSM4* from *NCAR* (USA). Its components are *CAM* (atmosphere), including a new chemistry-aerosol-cloud package, *CLM* (land), *CSIM/CICE* (sea-ice), an extensively modified version of *MICOM* (ocean), an adaptation of *HAMOCC* (ocean carbon cycle), and the *CPL7*-coupler.
The topic of biosphere and ecosystem modelling was addressed by C. Reick (MPI-M). He reported from the *GINKGO* network which successfully initialized the *TERRABITES* project that has just been started. The main objective of this project is a cross-disciplinary assessment of the current understanding of the terrestrial biosphere from an earth system perspective to improve the reliability of future earth system projections in coupled climate-biosphere simulations.

Session 4 of the COSMOS-GA was about data activities and the general questions regarding the COSMOS network and future strategies.
M. Giorgetta presented a GCM study on emission pathways to climate stabilization. This study explored the implications of the feedback between climate change and carbon cycle to estimate allowable emissions in respect to given targets of acceptable warming. The results showed that only aggressive mitigation scenarios are able to limit the global warming to 2°C until 2100, while other scenarios like the A1B are not. Following these results, the allowable emissions of CO_2-equivalents will have to decrease to a level of 65% (17%) in 2050 (2090) of those in the 1990's. Yet no estimations of uncertainties could be done. These can be expected from multi-model ensembles.
S. Legutke gave a short overview on coordination activities at MPI-M regarding *CMIP5*.
U. Ulbrich reported on IPCC data activities and the goal of "quick-checks" for the forthcoming German *CMIP5*-runs in order to screen them on obvious problems. Ulbrich's talk was intended to gain suggestions from the community, facing the requirements towards that kind of "quick-check"-diagnostics, which should be well established, sensitive to model problems but stable regarding the results, based on observational data of sufficiently long time series, and considering relevant aspects of the climate system.
Afterwards, F. Kaspar (DWD, Germany) solicited the datasets of *EUMETSAT*'s *Satellite Application Facility on Climate Monitoring (CM-SAF)* as a potential contribution to COSMOS model validation and emphasized the DWD's intention to better interact with the climate research community via its newly established *Climate Data Center (CDC)*.
H. Billing (FU Berlin) promoted *MEDOKADS*, a 20-year daily AVHRR data series for the analysis of land surface properties especially in the mediterranean area .
The last scientific contribution of this year's COSMOS-GA was given by P. Räisänen (FMI). He presented several results of his work, comparing *ECHAM5*-simulations, i.e. cloud and radiation fields, with satellite data. These comparisons suggest a fairly well performance of *ECHAM5* regarding the net radiation at the top of the atmosphere on the one hand, but a substantial underestimation of total cloud fraction on the other hand. Reasons for that are to be found in the simulation of too frequent optically thick clouds at the expense of too few optically thin clouds in low and middle altitudes.
M. Claussen closed the assembly with a report from the board meeting, an outlook towards upcoming COSMOS events, and the moderation of a discussion between all GA-participants

about general questions regarding future activities, strategies and directions of the COSMOS network.

Results and Impacts

The COSMOS-GA 2009 can be seen as highly successful with respect to their expected outcome as posted by M. Claussen. The primary goals of the assembly were to inform the community about recent data and model developments and new projects and scientific activities as well as to discuss the further COSMOS strategy. One of the aspects was the state and the importance of impact models, and of the Mediterranean region as a focus region. The aim to enhance the exchange and cooperation between the network partners, and to stimulate interaction with scientists focussing their work on the Mediterranean region, was reached.

Regarding the primary goal of information, a lot of new developments especially in the modelling of chemistry-aerosol-microphysics but also in the field of ocean-, volcanoe- and carbon-cycle-modelling were presented. The topic of regional climate modelling was addressed with a focus on upcoming opportunities and challenges as well as detailed insights into impact modelling. The network partners very much acclaimed that impact aspect and it became one important topic to be discussed at the end of the assembly when it came to future extensions and strategies for the COSMOS ESM. Various new data sets were introduced, being possibly valuable elements of future model evaluation. Additionally, other ESM approaches like in the *NorClim* initiative were presented as potential collaboration partners.
The discussion on the future strategy of COSMOS was very fruitful. Core questions to be answered in that complex were about strengthening the network idea, the internationality of the network, and whether a single COSMOS model is preferable compared to a suite of model systems. The idea of a COSMOS network has been endorsed and more emphasis is to be laid on partnership. The issue of model systems rather than a single configuration was acclaimed in principle. Answering of the question, whether the network has to become more international, referred to the basic idea of COSMOS as being a "European based international network" which tries to attract new centres and people globally through its excellent work.
The joint interest of the network partners in data and impact research was emphasized. Concerning the latter, future projects related to the Mediterranean can be expected, as discussions at the end of the talks and during the breaks were very vital and several plans for new projects and cooperations emerged. During the second day of the assembly, besides the main program a *Breakout Session on the status of the ECHAM5-HAMMOZ development* took place with those scientists participating, who are involved in the topic of chemistry and aerosol modelling.
The idea of a developer's workshop was born. The participants agreed on that idea to be an important activity further enhancing the cooperation within the network and decided this workshop to be organized as soon as possible, addressing topics like model environment, version control, model coupling, bug-tracking-methods, documentation, and computation-networking.
Regarding future project opportunities, especially the *MiKlip*-initiative of the *German Federal Ministry of Education and Research* tackling the issue of climate-predictions on a time scale of up to ten years, and the field of climate chemistry interactions were highlighted.

Berlin, August 2009