COSMOS

Network Plan

COSMOS

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Introduction

Comprehensive simulation of the climate or Earth system with the multitude of interactions and feedbacks between its components is a task which requires a network of scientists and institutes working in the various fields related to climate and Earth system dynamics. In 2003, therefore, the Max Planck Institute for Meteorology invited a number of scientists to Hamburg-Harburg. At this meeting, COSMOS –COmmunity earths System MOdelS – was established. COSMOS is defined as a network for the advancement of climate system and Earth system modelling. COSMOS invites national and international institutes and institutions to participate in the development and improvement of interactive comprehensive models of the climate system and Earth system. Contributions from Earth system models of intermediate complexity are also welcome.

With this Network Plan, the COSMOS Board briefly summarises the motivation for COSMOS, presents the current state of COSMOS – in particular the organisational structure –and discusses examples of projects emerging from COSMOS are projects which COSMOS is strongly involved. Last, but not least, a time line for the COSMOS network and budget considerations will be given.

Earth System Modelling Topics:

What is the carrying capacity of the Earth?

How will the Earth system respond to human-induced forcing over periods of decades to Millennia?

Will climate change affect the food production system in Europe and vice versa?

What is the impact of climate changes on biodiversity?

On which time scales can we predict the evolution of the Earth system?

Does it matter for the climate if people live in mega-cities or in the country?

Can we quantify the risk of not having enough water of quality?

Motivation and Scientific Perspectives

Perhaps the first climate model that was formulated to explore the role of greenhouse gases in climate is the model published at the end of the 19th century by Svante Arrhenius. The Swedish scientist showed that due to the "greenhouse effect" of carbon dioxide (CO_2), a doubling in the atmospheric concentration of carbon dioxide would lead to an increase in the mean surface temperature of approximately 5°C. Since the pioneering investigations more than a century ago, different types of models have been developed and used to study the climate system. These range from simple box models over models of intermediate complexity to comprehensive Global Circulation Models (GCMs) originating from weather forecast models used in "climate mode" to simulate climate variability. Later on, global ocean models developed to simulate the general circulation of the ocean were coupled to detailed atmospheric GCMs, to assess the evolution of climate, specially in response to anthropogenic perturbations. Coupling these two model components was not a simple operation. Drift in climate variables was noted as long simulations were performed, and had to be compensated for by introducing artificial energy fluxes at the ocean-atmosphere interface: This severely limited the credibility of climate predictions performed by these models. In recent years, coupled ocean-atmosphere models have been substantially improved, and amended e.g. by representations of sea-ice thermodynamics and of energy and water exchanges over land; state-of-the-art models remain drift-free without the introduction of flux corrections. Attempts are made to formulate additional processes, for instance relating to atmospheric chemistry and aerosol micro-physics in the atmosphere, and biogeochemistry in the ocean. Dynamic vegetation models are also under development and testing.

Scientific Questions:

How will (human-driven) changes in the nitrogen cycle perturb the carbon cycle?

What has maintained the past oscillations in atmospheric CO2 between 180 and 280 ppm?

How does climate change impact air quality and vice versa?

What is the stability of Earth's subsystems and combinations of subsystems?

The success of current models remains, however, limited by our lack of understanding of several fundamental physical, chemical and biological processes. Examples are the microphysical processes that lead to the formation of aerosols and cloud droplets, or the soil and other biological processes that control the exchange of carbon between land and the atmosphere. Another severe limitation in the development of complex, high-resolution models results from the super-computing resources that are, or better, are not available. With technological progress, faster computing systems and more powerful data handling systems will be accessible to the scientific community, and more realistic simulations and climate predictions using more complex models with higher resolution will be performed. In this way it will be possible in an unprecedented way to pose and answer scientific questions like those mentioned above. COSMOS pilot projects will tackle some of these questions.

So far, only the natural Earth system has been addressed with anthropogenic forcing taken as transient boundary condition by prescribed emissions of chemical substances or changes in land cover, for example. First attempts have been made to interactively couple anthropogenic activities - mainly by considering some aspects of economy - into conceptual, simple models of the Earth system. In COSMOS it is planned to ultimately incorporate anthropogenic components also into comprehensive Earth system models. This would, however, require major fundamental advance in this area.

The scientific questions raised provide the perspective of the current members of the COSMOS consortium, and they address issues within the range of their expertise. There are many possibly more pressing questions in the context of global climate change that are of the highest interest for humanity, but whose investigation requires expertise far beyond that available in COSMOS at this stage. Many of these questions do, however, also require the kind of modelling expertise that COSMOS is able to provide.

It is one of the consortium's central aims to provide that expertise as well as associated models and tools to the broader community of Earth System Modellers.

At the same time, COSMOS is open to expanding its scientific range. Thus, we explicitly invite all scientists from other disciplines who share COSMOS' spirit, appreciate our services, and find working with our models and tools productive and inspiring, to join the network and to actively participate.

Objectives

The idea behind COSMOS is that a single research institution cannot develop the most comprehensive models alone. Hence,

COSMOS is a community network towards the development of a

fully developed Earth system model.

The complexity of ESMs requires the involvement of an interdisciplinary team of scientists to develop Earth system models. This team has to be ready to work together intensively and share the knowledge and expertise of the team partners. So COSMOS constitutes a team of experts to develop a flexible and portable model infrastructure, following and supporting the ideas of the PRISM initiative.

The purpose is not only to develop models and their infrastructure, it is also to use them to address challenging problems involving the interactions between different components of the Earth system. These models will be central tools to assess important feedback processes in the Earth system, to assess environmental risks, and to develop mitigation and adaptation strategies.

COSMOS invites scientists from different countries to join its efforts and follows the principles of "Open Access". Several institutions in Europe have already expressed their intention to participate in this project, and it is hoped that these groups will make decisive contributions by developing specialised modules or by using the integrated modelling system to address innovative science questions. So COSMOS will develop an integrating effect for the scientific community.

COSMOS is intended

to foster development and evaluation of state-of-the-art climate and Earth system models,

to facilitate focused model inter-comparison in order to assess and improve these models,

to encourage exchanges of software and model results,

to adhere to the principles of Open Access,

to strive, as a European based network, for international cooperation, and

to help to establish the necessary computational resources.

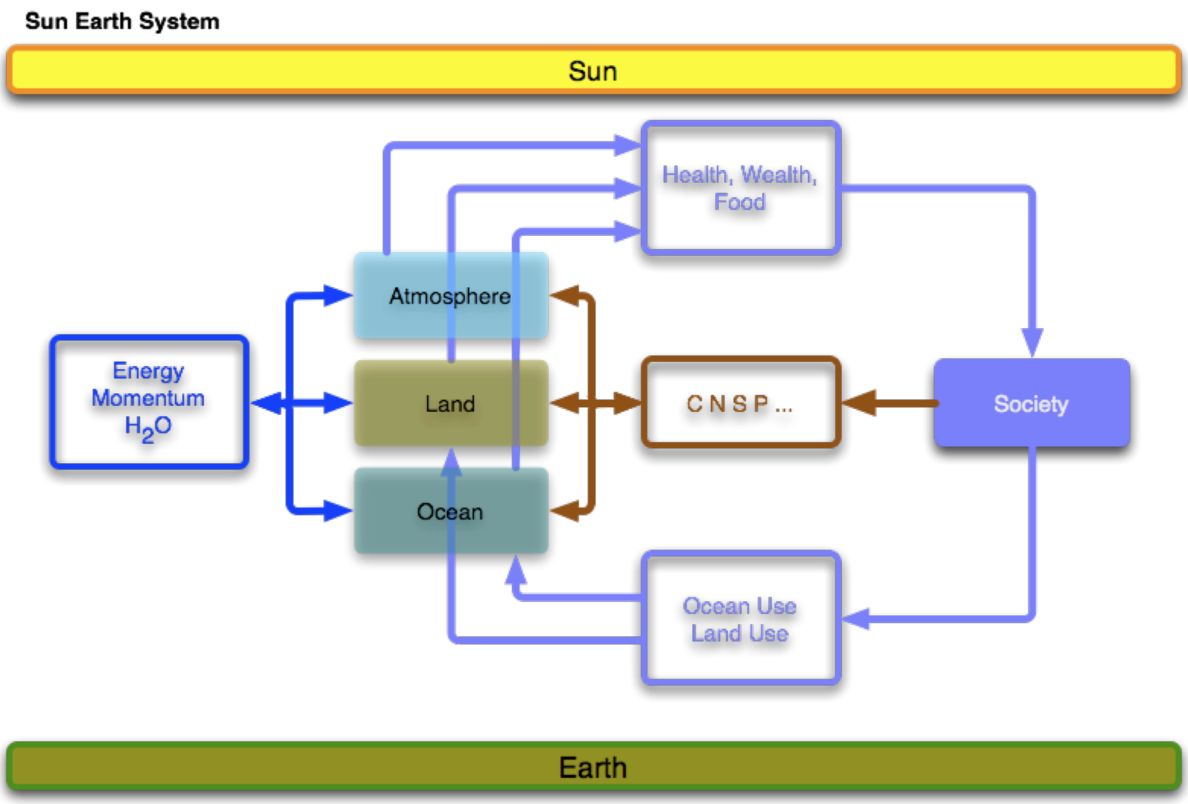

Figure 1: Schematic view of the major components of the Earth system: atmosphere, land and ocean, society and a number of coupling agents between the components. The physical climate system is driven by fluxes of momentum, energy and includes the hydrological cycle. Substances like carbon C, nitrogen N, sulfur S, phosphor P are important for the regulation of the fluxes of energy, momentum and water, for example by their role in the atmospheric radiative balance (by CO_2), or as a key substance in biology (P). Amounts and distribution of such key substances can be modified by humanity as a by-product of economic activity, which may also alter the environment by the use of land and ocean resources. Society itself is striving for life quality - for values like health, wealth or simply enough food and water, which depend on the climate and its variability or trends. Earth system models aim at the representation of the physical, chemical and biogeochemical system and its interaction with society as outlined here.

The Network

COSMOSv1 was distributed to:
SARA, NL
Bjerknes Centre, N
Senckenberg Inst., D
KNMI, NL
Kordi, South Korea
Uni Bremen, D
AWI Potsdam, D
FU Berlin, D
Chinese Academy of Sciences, China
IMAU, NL
Uni Bonn, D
IfM HH, D
Comenius Uni, SL
Iowa State, US
Leibniz-Institut f. Atmosphärenphysik, D
Intel Company, RU
FMI, FI
APEC Climate Centre, South Korea
JAMSTEC, J
AWI Bhv, D
Beijing Climate Center, China
Metri, South Korea
IAP, China
CSC, FI
UCA, E

The COSMOS network was initiated in 2003. The main methods for exchange within the COSMOS network are the meetings held regularly in spring (http://cosmos.enes.org), which see at least 50 participants each year, and experience growing interest. Furthermore activity groups are co-ordinated, which are open platforms for scientific discussions, for the exchange of opinions and ideas, and for the development of models, projects, and methods. These working groups crucially depend upon the deliberate work of their members. They communicate via small meetings, mailing lists etc. . The members of the COSMOS network sign a Memorandum of Understanding (MoU)

Since using an Earth system model, as it is developed in the COSMOS network, is scientifically and technically not a trivial task, support needs to be organised for the users; this has to be done not only via mutual support on a deliberate basis, but possibly also via third-party funded support in infrastructure centres like the Finnish CSC and/or DKRZ/M&D. Nevertheless usage of the model will mandate some support for the network by the users, too. The MoU covers these topics and organises the COSMOS network support structure.

Beyond these activities the network needs to be extended in quality – for many scientific fields there are no experts available in the network so far – and size – for many scientific fields there are not enough experts in the network. Major idea here is to enlarge the user base especially in universities, and especially in the new EU partner states in Eastern Europe. Last but not least special interest COSMOS workshops with invited partners alongside bigger conferences like EGU, ICESM and others will be planned.

Models

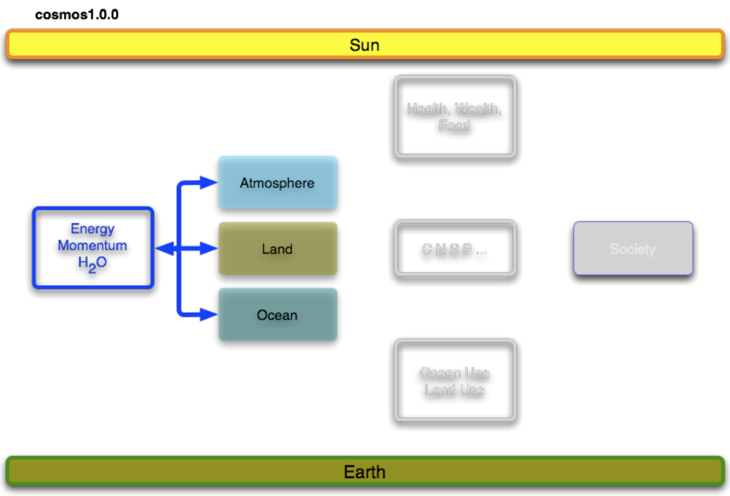

Figure 2: COSMOSv1.0.0 *represents the physical climate system considering atmosphere, land and ocean. These components interact by fluxes of energy, momentum and water, including a closer hydrological cycle. Society and material fluxes are planned to be included in later versions. See also Fig. 1.*

The COSMOS network crucially depends upon the availability and easy access to models. These models do not only have to be very well tested and mature, but also scientifically and technologically very advanced. The MPI-M has developed a suite of models in a framework, called "COSMOSv1"[0]. The configurations possible with this modeling framework are indicated in the table below. This is available to the COSMOS network. It is assembled following the PRISM philosophy:

- Coupling of atmosphere and ocean GCMs by OASIS3
- Configuration of model types and building of executables for specific machines by the standard configuration environment
- Running and data storage by the standard runtime environment

Model configurations can be ported to, run, maintained and developed on supercomputers with relative ease.

This first version of the model of the COSMOS network, called COSMOSv1, has 28 users from 10 countries, some of which are listed in the table on page 6.

The chemistry of the atmosphere can be simulated with the new MESSy approach, the Modular Earth Submodel System (http://www.messy-interface.org/). It has been successfully coupled to ECHAM5, and applied in multi-year integrations in different configurations and resolutions. ECHAM5/MESSy can be used to simulate ozone and related chemistry of the lower and middle atmosphere up to the mesopause at about 80 km, with no artificial boundaries applied, e.g., between the troposphere and stratosphere. The modular structure allows the selection of particular configurations to increase or decrease the level of

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0 http://www.mpimet.mpg.de/en/wissenschaft/modelle/model-distribution/available-models.html

Model Configurations with COSMOSv1	Model Components
Atmosphere GCM	ECHAM5
Atmosphere + Aerosols	ECHAM5-HAM
Ocean GCM	MPIOM
Ocean + Biogeochemistry	MPIOM-HAMOCC
Atmosphere / Ocean GCM	ECHAM5 / OASIS3 / MPIOM
Carbon Cycle	ECHAM5-JSBACH/OASIS3/MPIOM-HAMOCC
Aerosol system	ECHAM5-HAM / OASIS3 / MPIOM-HAMOCC
Carbon+sulfur cycle model	ECHAM5-HAM-JSBACH/MPIOM-HAMOCC(work in prog.)

detail in describing processes such as tropospheric multiphase chemistry, aerosols, transport and deposition.

The COSMOSv1 package integrates in a flexible and modular way models for the circulation of the atmosphere, the ocean and sea ice, and optionally includes processes for aerosols, vegetation, and marine biogeochemistry. The integration of atmospheric chemistry into the COSMOS system will lead to the next generation: COSMOSv2. This will take profit from the ECHAM5 based atmospheric chemistry models:

- ECHAM5-MESSy for tropospheric and stratospheric chemistry (already distributed)
- ECHAM5-HAMMOZ for coupled aerosols and chemistry in the troposphere, and
- HAMMONIA for the neutral and ionized chemistry, covering the entire atmosphere.

The PRISM standard environments of COSMOSv2 will allow for different model configurations, including atmospheric chemistry.

Scientific Projects

Below, two examples are given how COSMOS plans to interact with science, in the form of projects, which it can initiate, like the Millennium Project (Expl. 1) and programs, like the Baltex Program, it strongly interacts with (Expl. 2). Other types of interaction depend on the activities of the individual researchers and institutions.

Example 1: The Millennium Project

The last millennium is the best-documented period of climate change in a multi-century time frame. Climate has varied considerably during the late Holocene. These changes left their traces in the historical climate record. However, the relative magnitude of climate fluctuations due to internal variability of the Earth's climate system, due to variations in the natural forcing factors (sun, orbital, volcanic), and due to anthropogenic land-use changes, on the one hand, and the present global warming, on the other hand, is still under debate. Since reconstruction of the past climate beyond the instrumental record have to rely on relatively sparse data sources, numerical model simulations are necessary to investigate the underlying causes of climate change. Moreover, model simulated climate data can be used to validate reconstruction methods. Due to the internal variability in the climate system and its non-linear evolution it is necessary, in order to assess the range of internal variability, to carry out several experiments with the same forcing, but with slightly different initial conditions (ensemble simulations).

So far, millennium-scale simulations of climate have been carried out with simplified models, so-called Earth System models of intermediate complexity (EMICs), or with relatively coarse-resolution general circulation models (GCMs). Due to lack of computational resources GCM simulations were most often not carried out in ensemble mode.

Considerable progress has been documented in the recent climate model development carried out in the framework of the upcoming Intergovernmental Panel of Climate Change (IPCC) fourth assessment report (AR4). State-of-the-art models do not require flux adjustment and, due to higher resolution and to improved parameterisations, simulate the climate more realistically than the previous generation. Moreover, the inclusion of additional components, such as biogeogechemistry and advanced land (vegetation) models, demonstrates the progress in Earth System modeling. So far, IPCC-style GCM experiments with realistic forcing (solar, volcanic, greenhouse gases) have mostly been restricted to the industrialised era (1860-2000)

Therefore, the simulation of the last millennium with comprehensive GCMs is a challenging project that requires high-performance super-computing facilities and advanced data management. Using modern climate models and sophisticated computational optimisations on dedicated systems in an innovative infrastructure, such as COSMOS, it will be possible to achieve this goal.

The results expected from the simulations will allow to tackle, amongst others, the following scientific questions:

- Comprehensively evaluate the model used for climate projection in the framework of past variability
- Explore in-depth the role of natural solar and volcanic forcing, and anthropogenic land-use-changes, and their relative role in the climate evolution
- Investigate interannual, multi-decadal to multi-century climate variability, atmospheric modes (e.g. NAO, ENSO), and ocean circulation changes
- Assess regional climate change and regional/global scale teleconnections
- Identify regional „hot-spots“ where climate change manifests itself particularly
- Evaluate the model’s low frequency ecosystem feedbacks
- Test statistical methods

The simulations will be carried out using the COSMOSv1 climate-carbon cycle model developed at the Max Planck Institute for Meteorology (MPI-M). During the process of the IPCC simulations the climate model has been intensively tested and evaluations have demonstrated the ability of the model to simulate the present climate realistically. The ability to reproduce climate features, such as the El-Nino Southern Oscillation phenomenon, realistically is of utmost importance in order to answer the questions posed above.

The project is conducted within the COSMOS network. COSMOS is a community effort to develop and build an Earth System Model. It is also a network under which large scientific question are carried out. The community simulations of the last Millennium (COMSIMM) was selected as a key project of the COSMOS network. Research institutions and universities from Germany, Sweden, Finland, Poland, Norway, and Britain contribute to, or have expressed their interest in, COMSIMM. In addition, the millennium experiment is also an integrative part of the newly established Earth System Network of Integrated Modeling and Assessment (ENIGMA), a joint project of the Max-Planck-Institutes for Meteorology, Hamburg, for Chemistry, Mainz, for Biogeochemistry in Jena, and the Potsdam Institute for Climate Impact research.

As a community effort, the data will be made publicly available through the DKRZ data base.

The model consists of the atmosphere model ECHAM5 and the ocean model MPIOM. The entire carbon cycle is considered, enabled through the implementation of modules for ocean biogeochemistry (HAMOCC5) and a new sub model for land processes and vegetation (JSBACH,). HAMOCC5 is embedded in the ocean model and JSBACH in the atmosphere. The ocean and atmosphere are coupled through the PRISM/OASIS (http://prism.enes.org) coupler. The model resolution will be the same as in the IPCC AR4 simulation. The atmosphere model has a spectral T63 truncation (1.875°x1.875° spatial resolution,) and 31 vertical levels (192x96x31 grid points) and the ocean model uses a conformal mapping grid with a horizontal grid spacing of 1.5° and 40 vertical levels (256x220x40 grid points).

Example 2: The Baltex Program

A major objective of GEWEX (Global Energy and Water Cycle Experiment) is to determine the energy and water cycles globally as well as on catchment scales, investigated in the Continental Scale Experiments (CSE). One of the CSEs is BALTEX (the BALTic Sea EXperiment), including three compartments of the water cycle: the atmosphere, the Baltic Sea and the land surfaces which influence the soil moisture and the river run-off.

Besides ongoing process studies numerical models with fine spatial resolution were developed separately for the atmosphere, the Baltic Sea, and hydrological processes during the last years. The individual models could be applied successfully as demonstrated by many comparisons with observations. Because of their fine resolution and resulting detailed information, these models are also suited to be used for studies of climate and climate change in the Baltic Sea region. However, not all aspects and branches of the water and energy cycles could be simulated satisfactorily so far. For example, an accurate estimate of the annual cycles of precipitation and evaporation over the Baltic Sea, important quantities of the fresh water budget, is missing. One reason is that parts of the water and energy cycles were investigated separately in the involved scientific disciplines: e.g. the atmospheric water balance in the field of meteorology, evaporation from the Baltic Sea in the field of oceanography, and river runoff in the field of hydrology.

In BALTEX, two fully coupled modelling systems for the Baltic Sea region (RCAO and BALTIMOS) have been developed and validated by linking existing model components for the atmosphere, for the ocean including sea ice, for the hydrology as well as for lakes and vegetation.

These activities have established a large network of scientists from many disciplines and countries around the Baltic Sea, and they plan to continue cooperation in phase II of BALTEX which stretches from 2003 to 2012. BALTEX phase II will not follow an entirely new research plan but enlarge drastically the scientific scope and thus strengthen the outreach of BALTEX. BALTEX phase II will still continue to pursue those objectives and aims from phase I that have so far not been met in a satisfactory manner. The main objectives in

BALTEX phase II are now to provide a solid framework for and execute environmental investigations and more realistic climate and climate impact studies.

The Baltic Sea and its rivers are not only a resource for fishery industry, hydropower and transportation; the region is also an area of increasing importance for tourism, leisure and water sports. In view of recent harmful incidents (e.g. traffic accidents in the Baltic Sea, and disastrous floods like in Sweden and Poland) research dedicated to the entire Baltic Sea basin for the assessment, mitigation of and adaptation to the risk is urgently needed. The application of coupled regional atmosphere/ocean/land-models developed by the BALTEX science community that are nested into global coupled atmosphere/ocean/land models allow more detailed projections of climate change in the Baltic Sea basin for various scenarios of human activities on global scale.

The use of regionally coupled climate models on a well defined area imbedded in global climate modeling systems like COSMOS can be seen as regional Earth system models. This shows clearly the benefit, which could be achieved by integrating BALTEX as a pilot in COSMOS. A strong link between the two communities will be beneficial for both sides. Currently the extension of the BALTEX RCMs to include more components, similar to the COSMOS global model, is ongoing.

Organisation

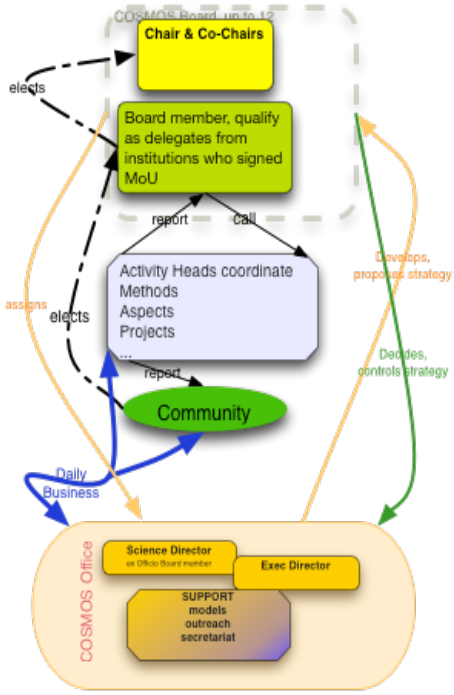

Figure 3: COSMOS organisational processes

The most important body of the COSMOS network is the community of Earth system scientists ready to work on and with the scientific tools and endeavours it promotes. The community meets at least once a year for the COSMOS General Assembly. At these meetings it takes strategic decisions, e.g. new scientific cooperation and projects. It also determines the configuration of the board, which should not have more than 12 members, as a workable size. The members of the board need to come from institutions having signed the COSMOS–MoU. 3 of these members are the Chair and two Co-chairs; the board decides about these positions.

The board calls activity heads for working groups and other activities. The activity heads assignment is to organise and run groups to think about and act upon projects, methods, aspects etc. of Earth system modeling. Examples are to be found in fig. 4. The activity heads report about the activities of their enterprises to the board and to the community. In their daily business they are interacting intensively with the COSMOS office.

The COSMOS office consists of the Science Director, an ex-officio member of the board, and a Project Manager running day-to-day business. The office gets secretarial assistance for office issues and meeting organisation. Support positions for technical work on the model system as well as outreach activities are applied for. The office supports the chair and the co-chairs. It is assigned by the board, and it develops and proposes the strategies and plans for COSMOS.

The processes involved in this organisation can be found in fig. 3. In fig. 4 the persons known so far (Thursday Feb 14 2008) are shown.

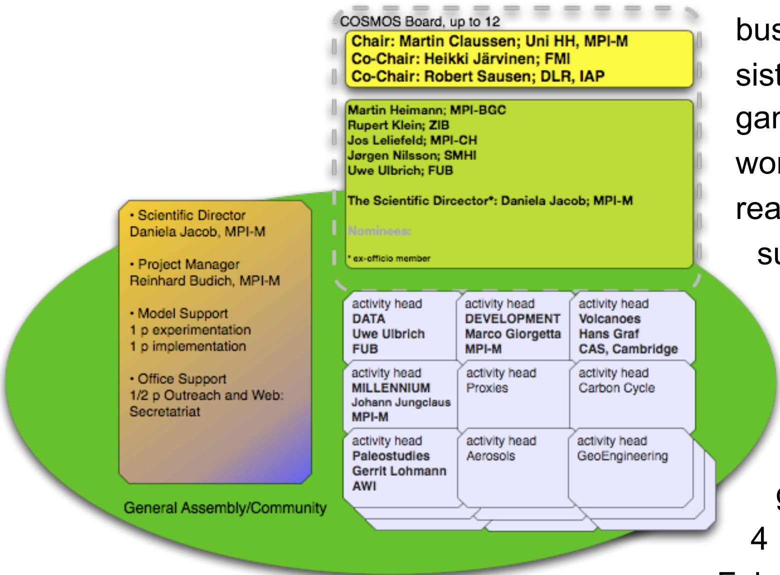

Figure 4: The COSMOS Board

Support

The development of COSMOSv1 is a core business of MPI-M, executed with the scientific assistance of and in mutual exchange with other institutions. Distribution, maintenance and technical development of the models in support of the community seem to be an assignment more naturally suited for support centres like the Finnish CSC or M&D/DKRZ. Already today the model has been distributed (by MPI-M) to more than 25 institutions worldwide; the high number of support requests via emails and phone calls the developers receive w.r.t. to the models document the rather substantial support requirements. Basically, the support activities assume so much room in the working day of the code developers at MPI-M, that it is impossible to view these activities as an initial investment for COSMOS, as was the case in the early days of the network.

It is estimated that about 2 person-years per year would currently be needed to cope with these requirements. These persons could e.g. be allocated at M&D solely, or at M&D and another institution (2/3 to 1/3), if this seems to be more appropriate. Their assignment would be to

- Maintain the svn code versioning system used for COSMOSvn
- Keep the code in a production-ready shape for the different platforms used in the COSMOS network
- Distribute the code to other centres, including the management of the licenses necessary
- Consult scientists in getting the code productive on their “home” systems
- Most importantly, help scientists to keep the code running on their “home” systems
- Help in the mutual exchange and knowledge built-up of the COSMOS network community

All this needs to be done in close co-operation with the developers in the different centres, for the time being mainly at MPI-M.

Funding possibilities are continuously sought for, and COSMOS partners are asked to explore national windows of opportunity. Some partners managed to use the COSMOS initiative as a convincing argument for funding already. Calls in the current FP7 program of the European Commission should be explored, and discussed among COSMOS partners.

List of Acronyms

AR4	Assessment Report #4 of the IPCC
BALTEX	The Baltic See Experiment, see http://www.gkss.de/baltex/
BALTIMOS	see http://www.baltimos.de/
COMSIMM	Community simulations of the last Millennium, see e.g. http://www.mpimet.mpg.de/en/wissenschaft/working-groups/millennium.html
COSMOS	Community Earth System Models
CSC	Centre for Scientific Computing, see http://www.csc.fi/
DKRZ	Deutsches Klimarechenzentrum, see http://www.dkrz.de
ECHAM5	ECHAM is a comprehensive general circulation model of the atmosphere, see http://www.mpimet.mpg.de/en/wissenschaft/modelle/echam.html
EGU	European Geosciencesl Union, see http://www.copernicus.org/EGU/
EMICs	Earth System models of intermediate complexity
ENIGMA	Earth System Network of Integrated Modeling and Assessment, see http://enigma.zmaw.de/
ENSO	El Niño / Southern Oscillation, see e.g. http://www.mpimet.mpg.de/en/presse/faq-s/das-el-nino-southern-oscillation-enso-phaenomen.html
EU	European Union
FP7	Framework Program 7 of the EC, see e.g. http://cordis.europa.eu/fp7/home_en.html
GCM	Global Circulation Model
GEWEX	Global Energy and Water Cycle Experiment see http://www.gewex.org/
HAM	Hamburg Aerosol Model, see http://www.mpimet.mpg.de/en/wissenschaft/modelle.html
HAMMONIA	HAMburg Model of the Neutral and Ionized Atmosphere, see http://www.mpimet.mpg.de/wissenschaft/ueberblick/atmosphaere-im-erdsystem/modellierung-der-mittleren-und-hohen-atmosphaere/hammonia.html
HAMMOZ	Combination of MOZECH and HAM, see http://www.fz-juelich.de/icg/icg-2/index.php?index=399# (German only!)
HAMOCC	HAMOCC is a sub-model that simulates biogeochemical tracers in the oceanic water column and in the sediment. See http://www.mpimet.mpg.de/en/wissenschaft/modelle/mpiom/mpiom-description.html
ICESM	International Conference on Earth System Modeling, see http://www.mpimet.mpg.de/fileadmin/static/icesm/
IPCC	Intergovernmental Panel on Climate Change, see http://www.ipcc.ch/
JSBACH	The Land-Biosphere in the MPI-M Earth System Model, see http://issmes.enes.org/uploads/media/7Reick_JSBACH.pdf
M&D	Model and Data Group, see http://www.mad.zmaw.de/
MESSy	Modular Earth Submodel System, see http://www.messy-interface.org/
MoU	Memorandum of Understanding
MPI-M	Max-Planck-Institut für Meteorologie, see http://www.mpimet.mpg.de
MPIOM	MPIs Ocean Model, see http://www.mpimet.mpg.de/en/wissenschaft/modelle/mpiom/mpiom-description.html
NAO	North Atlantic Oscillation, see e.g.: http://www.ldeo.columbia.edu/res/pi/NAO/
OASIS	OASIS is a software allowing synchronized exchanges of coupling information between numerical models representing different components of the climate system.See http://www.cerfacs.fr/globc/software/oasis/oasis.html
PRISM	Program for Integrated Earth System Modeling, see http://prism.enes.org
RCAO	Rossby Centre regional Atmosphere-Ocean model, see http://www.smhi.se/sgn0106/if/rc/rcao.htm
RCM	Regional Climate Model