

# Center for Climate Systems Modeling

## Annual Report 2014 (Phase II)

### Contact

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Pictures

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About C2SM	2
Governance	4
Main achievements	6
Scientific Highlights	11
Selected publications of members	14
Annex	18

The Center for Climate Systems Modeling (C2SM) is a competence center based at ETH Zurich and a joint initiative between ETH Zurich, MeteoSwiss, Empa, WSL, and Agroscope with the main objective to improve the understanding of the climate sys-tem and strengthen the predictive skill of climate models on time scales from months to millennia. The center was established in 2008 and is currently in its second phase (July 2012 – December 2016). This document highlights the main achievements in 2015.

The C2SM Steering Committee, February 2016.

# The climate modeling challenge

Climate change is a challenging scientific issue that involves a multitude of complex, non-linear processes operating over a wide range of spatio-temporal scales in all sub-components of the Earth system. Over the last decades, numerical models have been used increasingly in research and service activities related to climate change. They are now forming the backbone for many applications including short-term weather forecast, climate data assimilation, climate predictions and projections (from seasonal to centurial time scales), process and attribution studies, and the testing of strategies to mitigate and adapt to climate change. Thus, numerical modeling has developed into the third pillar of science, without which much of the research in climate sciences would no longer be possible.

At the same time, the continuing development of the numerical codes and supporting infrastructure is becoming an insurmountable challenge for individual research groups, making it hugely beneficial for participating groups to share models and the tasks to maintain, upgrade, develop, optimize, and run them. The emergence of new supercomputing architectures also implies a rapidly growing new challenge for climate model development and maintenance. In addition, coordinated efforts are required to store and analyze the increasing amount of climate data currently generated, including observations and model outputs.

Vision

## A premier institution for climate modeling and data provision

The center’s vision is to become one of the premier institutions in these fields worldwide and to en-gage in assembling scientific and technical expertise from different partners into one single framework, thereby contributing towards improving the understanding of the climate and weather system and strengthening the predictive skill of climate models on a wide range of temporal and spatial scales.

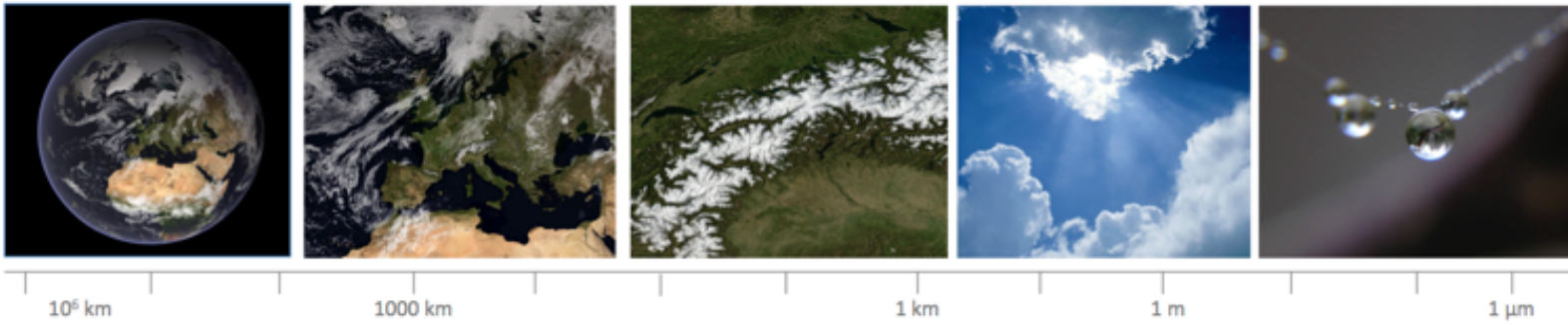
Mission

## The C2SM network

The center’s mission is to provide a network for the partners institutions i) to enable and facilitate collaborations within C2SM’s community and beyond, (ii) to exploit synergies among the partners in the areas of research, education, and outreach, (iii) to support the development and application of complex models of the Earth’s climate system, and (iv) to support the analysis of climate related data. The C2SM also acts as the primary entry and interaction point for ETH, for national and international institutions, and for society at large on issues related to climate and climate change.



The C2SM network



C2SM aims to bridge across a range of scales within the climate system.

Research theme

## Multi-scale, multi-component interactions within the climate system

The “Multi-scale, multi-component interactions within the climate system” form the C2SM’s core research theme. This theme centers on one of the most challenging aspects associated with the modeling of the climate system. It is motivated by the fact that, while climate models have made rapid progress in the last decades, they still suffer from considerable limitations. This is partly because some of the underlying dynamical, physical, chemical, and biological processes remain uncertain, and partly because their numerical representations on current computing systems still mainly rely on coarse resolution and on parameterizations and approximations. The clear recognition that many processes relevant for climate change operate in, and at the interface of, several sub-components of the Earth system (including its atmospheric, oceanic, terrestrial, biospheric and cryospheric components) also results in a quest for increasingly complex models. In addition, many of these processes operate over a wide range of spatial and temporal scales and are interlinked by scale interactions, i.e. the processes operating at small scales strongly influence the phenomena at large scales and vice versa.

Activities

## Coordination, Education, Outreach and Support

C2SM coordinates a world-leading network of research institutions and experts. C2SM strongly relies on its affiliated research groups to provide the respective disciplinary expertise and capabilities to advance the frontiers of knowledge in their research fields. C2SM sees its primary role in bringing together the climate research community and integrating this knowledge base. A key set of activities aims to foster interdisciplinary research and interactions across disciplinary boundaries. A second set of activities centers around the establishment of a common and coherent modeling framework that allows

the community i) to bridge the gap between different spatio-temporal scales and between the different (atmospheric, hydrological, oceanographic and terrestrial) components of the climate system and ii) to expand on new research themes. These activities enable the partner groups and institutions to undertake the challenging model development and applications studies that would otherwise not be possible. More specifically, current activities include:

**Research coordination**

- To foster the collaboration between research groups by facilitating scientific discussions and exchanges
- To coordinate the development of large, collaborative research projects and to further manage them
- To develop a common modeling strategy that enables the development of new and original re-search avenues

**Education and training**

- To contribute towards an improved training of Ph.D. students through the establishment of projects across research groups, institutions, and disciplines.
- To train scientists (Ph.D. students, post-docs, etc.) in the areas of data visualization, data analyse, use and interpretation of climate data, and programming.

**Outreach and events**

- To inform the scientific community as well as broader audiences about climate and climate change
- To facilitate the dialog between the scientific community and the private and public sectors (including federal and cantonal agencies)

**Support for research and education activities**

- To maintain, improve, and provide to the center’s community a hierarchy of state-of-the-art climate and climate-related models. In particular, the center is responsible for maintaining and re-fining both a global and a regional climate model as well as the associated modules e.g., for aerosols, atmospheric composition, (biogeo)chemistry, oceans, land surfaces, and clouds.
- To develop, exploit and disseminate key national and international data sets by providing a repository for them and by developing analysis and data management tools.
- To prepare for the exploitation of the next generation of high-performance computers.



# Structure, organization, and personnel

The center was established in 2008 by the funding partners ETH, MeteoSwiss, Empa, and Agroscope, and became operational in March 2009. WSL joined the center in 2013 to enhance the collaborations and respective expertise in the area of climate change and climate change impact.

As of 31.12.2015, the center includes 35 members, who are professors or senior scientists at the partner institutions ETH, MeteoSwiss, Empa, WSL, and Agroscope (see Annex for a detailed list) and form the center’s Plenary.

The C2SM community includes all students, post-doctoral fellows, and technical and scientific staff from the research group of each member and thus represents a group of over 400 people. Eight members out of 35 form the Steering Committee (SC), which defines the overall strategy and over-see its implementation. The SC elects a chair and co-chair from its members. The Scientific Advisory Board (SAB) consists of recognized individuals from different Swiss and European institutions and advises and supports the center in its strategic planning (see Annex for a detailed list).

Operationally, the center is run by an executive director, who oversees an administrative office composed of scientists and officers for communication and event organization supported by an administrative assistant. The scientists are active in two main focus areas: Global Climate Modeling (GCM) and Regional Climate Modeling (RCM). Two working groups, composed of 6 to 8 C2SM members or re-searchers, meet on a regular basis to discuss and propose the strategy to be developed and the tasks to be performed in each of the three focus areas. The center also supports four post-doctoral fellows through specific research projects acquired by C2SM and its members (see page 6 for more details on the current projects). The structure and organization of C2SM is described in greater detail in the Terms of Reference, which can be downloaded from the C2SM website.

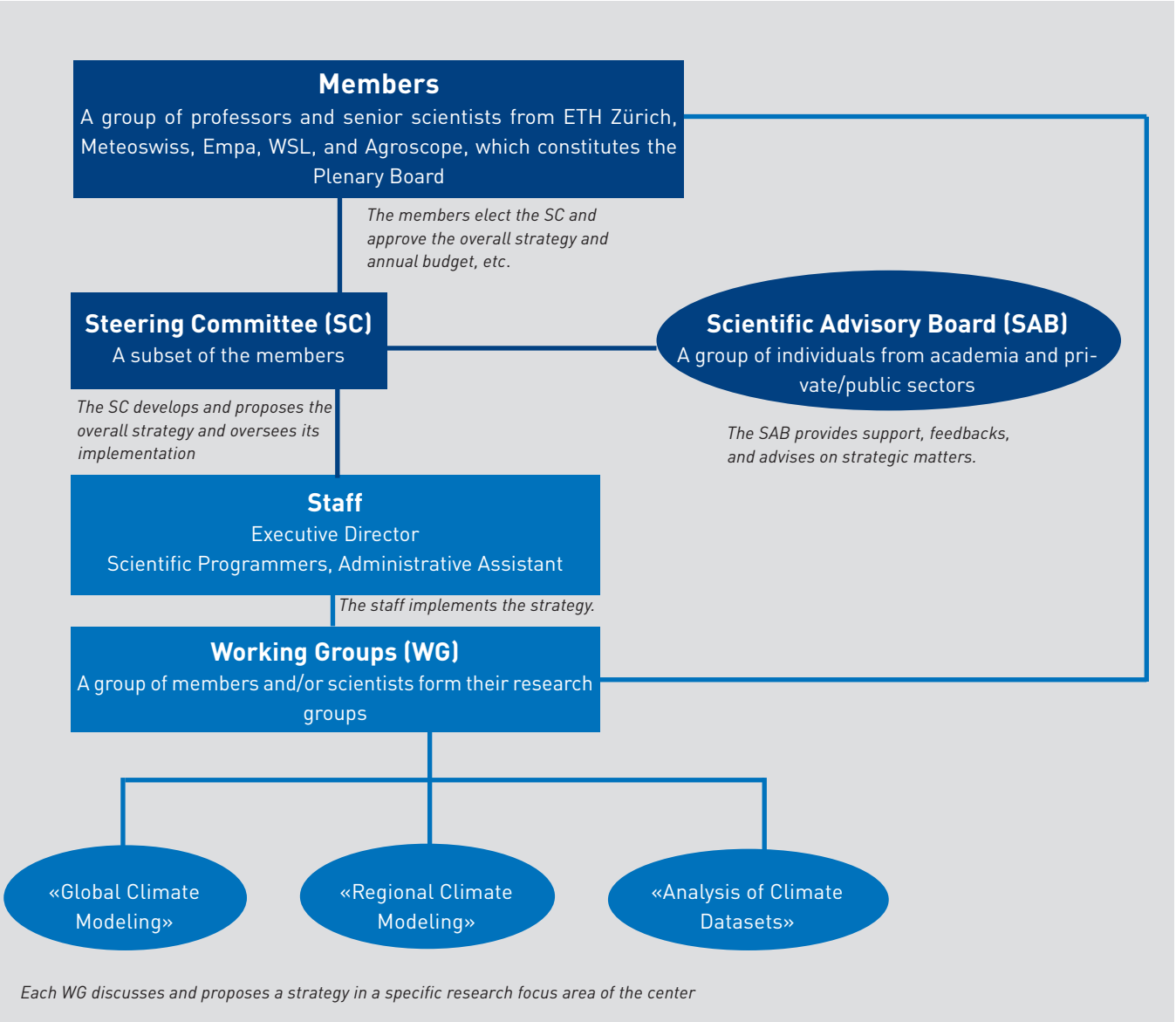
<http://www.c2sm.ethz.ch/the-center/documents.html> →

Core Staff (as of 31.12.2014)

Role	Person
Executive Director	Isabelle Bey
Administrative assistant	Rahel Buri
Scientist "Global climate modeling"	Colombe Sigenthaler-Le Drian / Urs Beyerle
Scientist "Regional climate modeling"	Annes Roche
Scientist "Climate data analysis"	Harald von Waldow
Communication	Tracy Ewen
Event organizer	Lisa Bettoni

In addition to the core staff, post-doctoral fellows and research assistants are supported through funding for different projects. See page 6 for more details on the current projects.

[www.c2sm.ethz.ch/the-center/people.html](http://www.c2sm.ethz.ch/the-center/people.html) →



# Research Coordination

C2SM and its community has contributed to the successful acquisition and subsequent implementation of several large collaborative projects addressing a range of topics that encompass, for example, the quantification of greenhouse gases fluxes, the water cycle, and high-performance computing.

CHIRP-2

## Modeling the water cycle in a changing climate – a multi-scale interaction challenge

CHIRP2 involves a group of 18 co-applicants from ETH Zurich, MeteoSwiss, and Agroscope. The project aims to make essential advances in our understanding and our ability to quantitatively model a number of key processes and interactions within the Earth’s water cycle, with a focus on those that involve strong scale interactions. The main tools are a set of models hosted by C2SM and its community: COSMO-CLM (atmosphere), CLandM (land surface), and ROMS (ocean) at the regional scale, and ECHAM (atmosphere and ocean) at the global scale. Observations from in-situ networks and remote sensing instruments will provide additional crucial sources of information and constraints for the models. The main outcomes of this project will be an improved understanding of the Earth’s water cycle (including better constrained parameters and an improved numerical representations of critical processes in models), which will permit us to provide substantially improved projections of how the water cycle works in a changing climate.

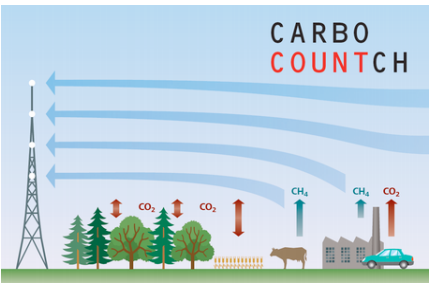
[www.c2sm.ethz.ch/research/CHIRP2.html](http://www.c2sm.ethz.ch/research/CHIRP2.html) →

CarboCount-CH

## Quantifying greenhouse gas fluxes

CarboCount CH is a collaborative project involving 8 partners from Empa, ETH, University of Bern, and C2SM and is funded by the Swiss National Science Foundation (Sinergia program). CarboCount CH investigates human-related emissions and natural exchange between atmosphere and biosphere of the two most important long-lived greenhouse gases carbon dioxide (CO2) and methane (CH4) in Europe and especially in Switzerland. The main outcomes of this project will be improved understanding of the processes contributing to CO2 and CH4 sources and sinks. C2SM contributes to the maintenance and further development of the modeling tools used within the project and supports the project management.

[www.c2sm.ethz.ch/research/ghg/CarboCountCH.html](http://www.c2sm.ethz.ch/research/ghg/CarboCountCH.html) →

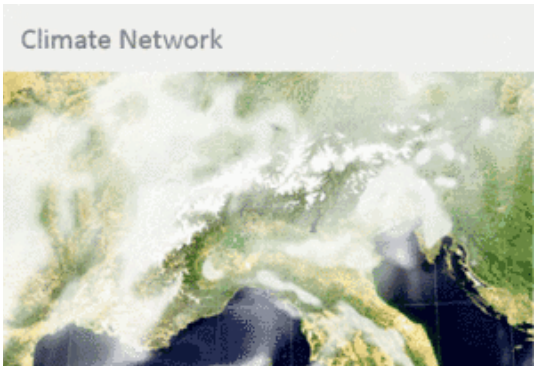


PASC

## High Performance Computing

C2SM aims to prepare climate codes for the next generation of high-performance computers to exploit the emerging computing capabilities and thereby continue to contribute at the highest level to climate system science. C2SM has been involved in several consecutive projects of the Swiss initiative for High Performance and High Productivity Computing (HP2C), and now becomes involved in the follow-up initiative, the Swiss Platform for Advanced Scientific Computing (PASC). The main goal of PASC is to promote collaborations between domain scientists, computational scientists and software and hardware vendors and providers. As a result of the key role played by C2SM in the HP2C initiative, climate was chosen as a relevant domain science for establishing one of the four PASC community networks in Switzerland and C2SM currently leads the “Climate and Atmospheric Modeling” network. C2SM is currently involved in a PASC project, so-called Gridtools, which goal is to develop well engineered abstraction layers for effective development of applications in weather, climate, and Geo-physics and potentially other fields.

[www.c2sm.ethz.ch/research/High\\_Performance\\_Computing.html](http://www.c2sm.ethz.ch/research/High_Performance_Computing.html) →



MAIOLICA-II

## Global methane variability in a changing climate

MAIOLICA-II is a collaborative project involving 4 partners from ETH, WSL, Empa, and C2SM and is funded within the ETH Competence Center Environment and Sustainability (CCES). The project aims at improving our understanding of the fundamental processes that contribute to the observed variability of atmospheric methane (CH4) concentrations in the recent past, focusing on natural CH4 emissions from wetlands and wildfires. Climate-related changes in atmospheric CH4 are also investigated including the feedbacks among terrestrial biosphere, atmospheric composition and climate.

[www.c2sm.ethz.ch/research/ghg/maiolica-2.html](http://www.c2sm.ethz.ch/research/ghg/maiolica-2.html) →

# Education and Training

C2SM organizes training workshops to provide specific skills related to climate data and modeling. Two workshops were organized in 2015.

[www.c2sm.ethz.ch/education.html](http://www.c2sm.ethz.ch/education.html) →

## Workshop: “Regional climate model data for Alpine impact research”

The SNF Sinergia project TEMPS and C2SM co-organized a 3-day workshop on the theoretical and practical aspects of utilising the output of regional climate models for Alpine climate impact research. The workshop primarily targeted climate impact researchers at the PhD or PostDoc level. The scientific part of the workshop consisted of focus lectures, hands-on sessions, and round-table discussions.

<http://lab.c2sm.ethz.ch/rcmworkshop2014/> →

## Technical Training: Scientific Programming in Python

C2SM, with support from the Atmospheric Dynamics Group at the Institute for Atmospheric and Climate Science, held a 1-day workshop to introduce interested researchers to the Python programming language, with special attention to its use in applied research. The target audience included PhD students, post-docs and staff from C2SM-associated research groups.

<http://lab.c2sm.ethz.ch/pythonws/> →

## Swiss Climate Summer School

C2SM contributes on a yearly basis to the funding and organization of the Swiss Climate Summer School, together with the Oeschger Centre for Climate Change Research (OCCR). Every year, C2SM and OCCR alternate to lead the organization of the Swiss Climate Summer School. The 2014 edition was the 13th edition of Swiss Climate Summer School and addressed the topic of “Linking Land Use, Land Cover, and Climate”.

[www.c2sm.ethz.ch/education/summer-school.html](http://www.c2sm.ethz.ch/education/summer-school.html) →

# Outreach and Events

C2SM organized and supported a number of events in 2014 targeting lay audience, scientists, and various stakeholders.

## ETH Klimarunde 2014 “Welche Schlüsse ziehen wir aus dem neusten UNO-Klimabericht?”

C2SM and the Energy Science Center (ESC) of ETH Zurich have jointly organized the second edition of Klimarunde. Following the release of “Climate Change 2014”, the Synthesis Report of the Fifth Assessment Report, the 2014 edition addressed “innovations for the climate”. On Wednesday November 5, 2014, leading experts have discussed emerging innovations for a transition into a greenhouse gas emission free future of our energy systems. Keynote speakers and panelists include: Ottmar Edenhofer (PIK Potsdam), Jasmin Staiblin (CEO Alpiq), Walter Steinmann (Director Bundesamt für Energie), Toni Patt (ETH Zurich), Kees Christiaanse (ETH Zurich).

[http://www.c2sm.ethz.ch/events/past-events/eth\\_klimarunde\\_2014.html](http://www.c2sm.ethz.ch/events/past-events/eth_klimarunde_2014.html) →

## Latsis Symposium 2014 –“Atmosphere and Climate Dynamics: From Clouds to Global Circulations”

C2SM supported the Latsis Symposium 2014 “Atmosphere and Climate Dynamics: From Clouds to Global Circulations” which goal was to bring together researchers from diverse sub-communities in the climate sciences, in order to map out the most promising research avenues and answer the most pressing questions in climate dynamics.

<https://climatedynamics.ethz.ch/latsis2014/index.html> →

## C2SM Community Day

An internal workshop was also organized in fall 2014, with the objectives to bring together the C2SM Community and give the opportunity to the community to learn more about support provided by C2SM. Opportunities were also given to the Community to help shape the Center and its future through a few presentations and in the following discussion and social event.

[www.c2sm.ethz.ch/events/past-events/c2sm-community-day-2014.html](http://www.c2sm.ethz.ch/events/past-events/c2sm-community-day-2014.html) →

# Support for research activities

C2SM provides support to its community for activities in the area of global and regional climate modeling.  
[www.c2sm.ethz.ch/services.html](http://www.c2sm.ethz.ch/services.html) →

## Global climate modeling

Support in the are of global climate modeling at C2SM is provided for the ECHAM model family and since this for the NCAR CESM, as further described in the following:

- The Max Planck Institute Earth System Model (MPI ESM) is an Earth System Model originally developed and currently maintained and distributed by the Max Planck Institute for Meteorolo-gy (MPI-M) in Hamburg. The atmospheric component ECHAM is coupled to comprehensive aerosol (HAM) and trace gas chemistry (MOZ) modules, leading to the formation of the fully coupled aerosol-chemistry-climate model ECHAM-HAMMOZ. Since 2009, ETH/C2SM are re-pensible for the hosting of the ECHAM-HAMMOZ model for the international HAMMOZ consortium, which is chaired by Prof. Ulrike Lohmann. New versions, which include latest developments from the community, are released on a regular basis. Support to the internal and in-ternational communities is also provided with respects to implementation on new super computers, running environments, inputs files, and pre- and post-processing tools.

[redmine.hammoz.ethz.ch/projects/hammoz](http://redmine.hammoz.ethz.ch/projects/hammoz) →

- The Community Earth System Model (CESM) is a fully-coupled, community, global climate model that provides state-of-the-art computer simulations of the Earth's past, present, and future climate states. It consists of 6 separate models simultaneously simulating the Earth's atmosphere, ocean, land, land-ice, sea-ice, river runoff and ocean wave, plus one central coupler component. The CESM model can be configured in a number of different ways from both a science and technical perspective. CESM supports several different resolutions and component configurations. Local support is provided for the local computer with respect to implementation, running set-up, etc.

[www2.cesm.ucar.edu](http://www2.cesm.ucar.edu) →

## Regional climate modeling

The regional climate modeling activities at C2SM focus on the COSMO model, a limited-area atmospheric model developed by the Consortium for Small-Scale Modeling (COSMO), including MeteoSwiss and other European meteorological services. The model, which can be used in CLimate Mode (COS-MO-CLM), is also further refined and applied in several groups at ETH, Empa and in the international "Climate Limited-area Modeling" Community. Over the years, the COSMO model has been coupled to different modules dedicated to tropospheric chemistry, aerosols, aerosol-cloud interactions, and land-atmosphere interactions, allowing for the investigation of additional processes relevant for the climate system. In particular, the COSMO-ART and COS-MO-M7 versions, which include a detailed representation of atmospheric chemistry and aerosols and the COSMO-CLM2 version, which includes a more detailed representation of the land surface component (i.e., the Community Land Model (CLM)) are used within the C2SM community. C2SM provides extensive support for the COSMO model, e.g., by maintaining a code repository, providing local user support, and developing specific scientific and technical features that are needed by community-wide research projects. This greatly facilitates the joint use, and sharing, of COSMO and several of its extension within the C2SM community and thus contributes to strengthen the collaboration between the partner institutions.

[www.cosmo-model.org](http://www.cosmo-model.org) →  
[www.clm-community.eu](http://www.clm-community.eu) →

## Climate Data

The data related activities focused on data acquisition, management and dissemination. In particular, C2SM supported the acquisition, storage, and management of data from the Coupled Model Inter-comparison Project Phase 5 (CMIP5) in support of IPCC's Fifth Assessment Report and data from the Coordinated Regional Climate Downscaling Experiment (CORDEX), in collaboration with the Institute for Atmospheric and Climate Science (IAC). In addition, C2SM contributed to the CH2014-Impact initiative, which was initiated in 2012 by the Swiss research community to describe quantitatively the impacts of climate change in Switzerland on ecosystems, food, health, etc.. C2SM provided support regarding the utilization of the CH2011 scenarios and other climate data, and many members substan-tially contributed their expertise to several chapters of the CH2014-Impact report addressing climate scenarios, climate indices, cryospheric aspects, biodiversity, forest properties and ecosystem ser-vices, and agricultural production. The 2014-Impact report was published in the first quarter of 2014.

[www.ch2014-impacts.ch](http://www.ch2014-impacts.ch) →

# Annex

As of 31.12.2014

## Plenary Members

Steering Committee Members		
Prof. Nicolas Gruber, Chairman	D-USYS, ETH	Environmental Physics
Prof. Christof Appenzeller, Co-chairman	MeteoSwiss	Climate Division
Dr. Brigitte Buchmann	Empa	Mobility, Energy and Environment
Prof. Reto Knutti <a href="#">Δ</a>	D-USYS, ETH	Climate Physics
Prof. Ulrike Lohmann	D-USYS, ETH	Atmospheric Physics
Prof. Tapio Schneider <a href="#">Δ</a>	WSL	Climate Dynmaics
Prof. Nicklaus Zimmerman	WSL	Landscape Dynamics

Regular Members		
Dr. Marco Arpagas <a href="#">#</a>	MeteoSwiss	Weather Forecasting
Dr. Dominik Brunner	Empa	Atmospheric Modeling
Prof. Nina Buchmann	D-USYS, ETH	Grassland Sciences
Prof. Harald Bugmann	D-USYS, ETH	Forest Ecology
Prof. Paolo Burlando	D-BAUG, ETH	Hydrology and Water Resources Management
Prof. Jan Carmeliet <a href="#">#</a>	D-ARCH, ETH & EMPA	Building Science and Technology
Dr. Mischa Croci-Maspoli	MeteoSwiss	Climate Monitoring
Dr. Lukas Emmenegger <a href="#">#</a>	Empa	Air Pollution and Environmental Technology
Prof. Andreas Fischlin	D-USYS, ETH	Vegetation Dynamics
Prof. Jürg Fuhrer	Agroscope	Air Quality and Climate
Prof. Olivier Fuhrer <a href="#">#</a>	Agroscope	Numerical Modelling
Prof. Martin Funk	ETH Zurich	Glaciology
Prof. Gerald Haug	D-ERDW, ETH	Climate Geology
Prof. Torsten Hoefler <a href="#">#</a>	D-INFK, ETH	Computational Sciences
Dr. Mark Liniger	MeteoSwiss	Climate Prediction
Prof. Michael Lehning	WSL	Snow and Permafrost
Prof. Nicolai Meinhausen <a href="#">#</a>	D-MAVT, ETH	Mathematics and Statistics
Prof. Antony Patt	D-USYS, ETH	Human-Environment Systems
Prof. Thomas Peter	D-USYS, ETH	Atmospheric Chemistry
Prof. Christoph Schär	D-USYS, ETH	Climate and Water Cycle
Prof. Thomas Schulthess <a href="#">#</a>	CSCS & D-PHYS, ETH	Computational Sciences
Prof. Sonia Seneviratne	D-USYS, ETH	Land-Climate Dynamics
Dr. Philippe Steiner	D-USYS, ETH	Weather Forecasting
Prof. Heini Weinli	D-USYS, ETH	Atmospheric Dynamics
Prof. Martin Wild	D-USYS, ETH	Climate and Radiation
Prof. Niklaus Zimmermann	WSL	Landscape Dynamics

[Δ](#) New member elected in the Steering Committe in 2014  
<#> New members elected in 2014

As of 31.12.2014

## Scientific Advisory Board (SAB) members

Scientific Advisory Board (SAB) members	
Dr. David Bresch	Swiss Re, Zurich, CH
Dr. Albert Klein Tank	KNMI, De Bilt, NL
Prof. John Mitchell	University of Reading, Reading, UK
Dr. Christoph Ritz	ProClim, Berne, CH
Prof. Bjorn Stevens	MPI-Meteorology, Hamburg, DE
The SAB has the mandate to advise the Centre on strategic matters and in particular to provide feedback regarding the achievements as well as the planned developments	

Within the C2SM community

## Research projects related to C2SM

A number of projects were initiated within the C2SM community, with some of the projects contributing to the core budget [see below].

Project name *	Lead PI	Funding mechanism	Duration
CarboCount CH	D. Brunner (Empa)	SNF Sinergia	01.01.2012 – 31.12.2014
MAIOLICA II	T. Peter (ETH)	CCES	01.08.2012 – 31.07.2016
CHIRP-2	N. Gruber (ETH)	ETH	01.01.2012 – 31.12.2014
HP2C-Plus	P. Steiner (MeteoSwiss)	MeteoSwiss	01.10.2013 – 01.05.2015
Turbinism	P. Steiner (MeteoSwiss)	MeteoSwiss	01.04.2013 – 30.06.2015

\* See page 6 for more details on the current projects.

Reporting period (01.01.2014 – 31.12.2014):

## Budget

Saldo (CHF) 01.01.2014	441'897
Income (CHF) 01.01.2014 – 31.12.2014	
ETH School Board	160'000
USYS Department	100'000
Members	15'000
MeteoSwiss	120'000
Empa	50'000
WSL	50'000
Agroscope	10'000
Funding through projects *	79'213
Total Income	659'213
Expenses (CHF) 01.01.2014 – 31.12.2014	
Salaries core staff	551'623
Project support	68'438
Events	40'802
Running costs	16'961
Travels	7'622
Total Expenses	696'786
Saldo (CHF) 31.12.2015	404'324

\*The projects Carbocount-CH and MAIOLICA II have contributed to the core C2SM budget.