Contact

ETH Zurich
Center for Climate Systems Modeling (C2SM)
Universitätstrasse 16
8092 Zurich

www.c2sm.ethz.ch

Publisher C2SM
Editors C2SM Steering Committee
Pictures

ETH zürich

Center for Climate Systems Modeling

Annual Report 2015 (Phase II)

C2SM Center for Climate Systems Modeling

EMPA Materials Science & Technology

WSL

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

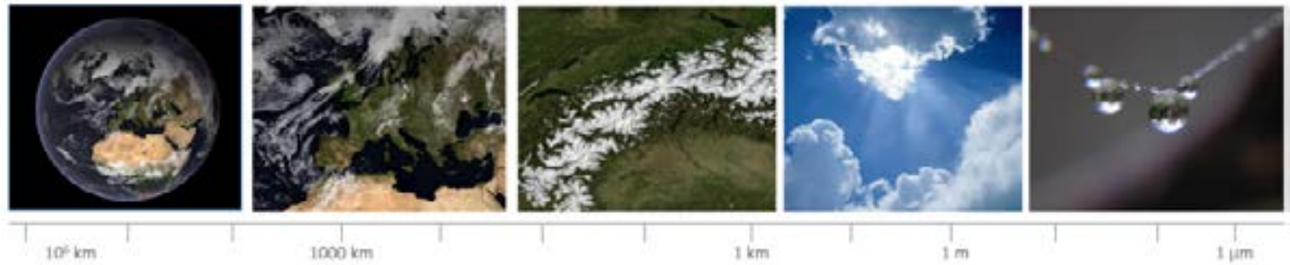
The center's vision is to become one of the premier institutions in these fields worldwide and to en-gage in assembling scientific and technical expertise from different partners into one single framework, thereby contributing towards improving the understanding of the climate and weather system and 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)

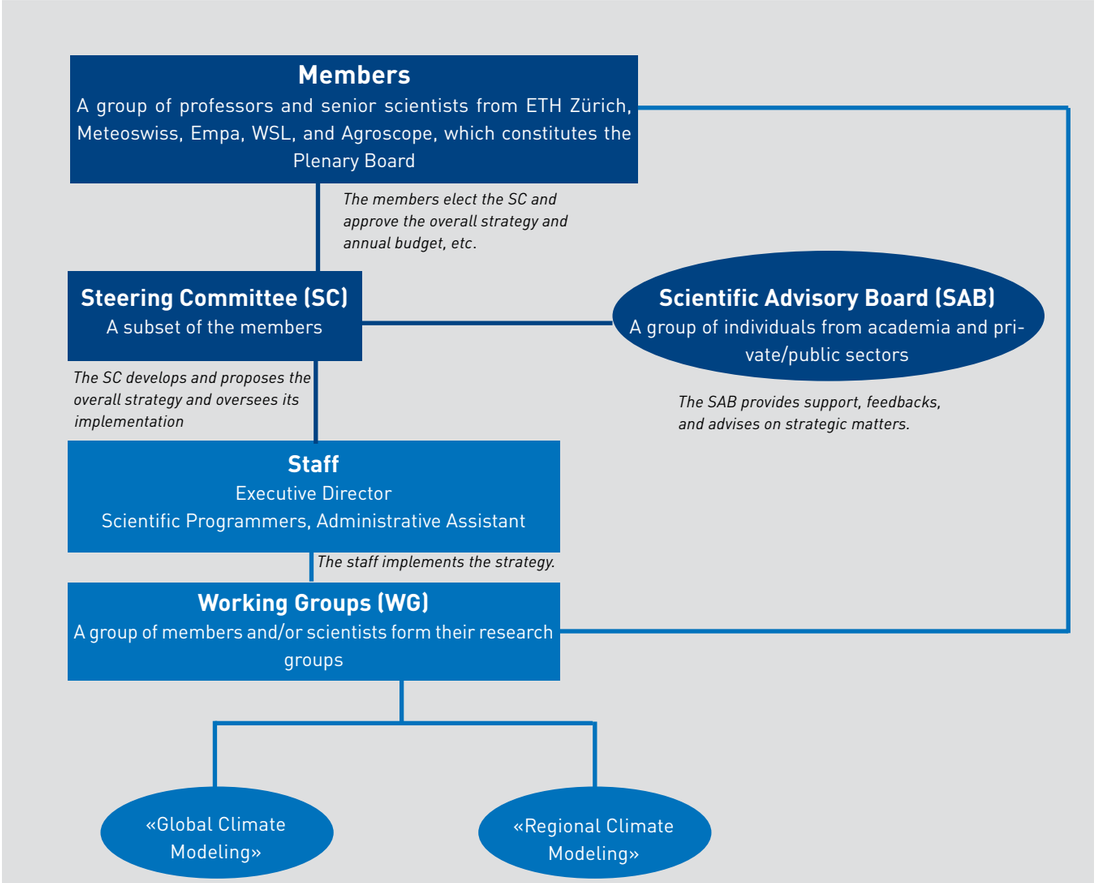
Support for research and education activities

- 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-sees 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 com-posed 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 →



Each WG discusses and proposes a strategy in a specific research focus area of the center

Core Staff (as of 31.12.2015)

Role	Person
Executive Director	Isabelle Bey
Administrative assistant	Rahel Buri
Scientist "Global climate modeling"	Colombe Sigenthaler-Le Drian / Urs Beyerle
Scientist "Regional climate modeling	Katherine Osterried
Communication	Tracy Ewen
Event organizer	Lisa Bettoni

As of 31.12.2015, the core staff corresponds to a total of 3 FTE. The administrative assistant is not on the payload of C2SM but directly supported by the Institute for Atmospheric and Climate Sciences. The C2SM staff also includes post-doctoral fellows and research assistants that are funded by projects (see page 6 for more details on the current projects).

www.c2sm.ethz.ch/the-center/people.html →

Main Achievements

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

The CHIRP2 project (which has ended in July 2015) combined the expertise and interests of 18 co-applicants from ETH Zurich, MeteoSwiss, and Agroscope. The project aimed to improve our quantitative understanding and our ability to quantitatively model a number of key processes and interactions within the Earth's water cycle.. The main tools were a set of models developed and maintained by C2SM and its community such as for example COSMO and ECHAM. Observations from in-situ net-works and remote sensing instruments have also provided additional crucial sources of information and constraints for the models. Seven PhD thesis have been awarded in the framework of the CHIRP2 project and the project has resulted in over 30 publications. The project has allowed major advances with respect to processes involved in the water cycle ranging over a wide range of scales and climate system components. These include (among others) the representation of moist convection (thunderstorms and rain showers) in high-resolution climate simulations, the role of small eddies for the exchange of energy between atmosphere and ocean, the impacts of anthropogenic aerosol on the sea surface temperature, or the behavior of evapotranspiration from land in relation to precipitation using long-terms in-situ measurements.

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 project has ended on 31 December 2015. The project has successfully developed several extensions to the COSMO model allowing to simulate the atmospheric transport of CO2 and CH4, to describe the exchange of CO2 between the atmosphere and the biosphere, and to quantify the fluxes of CO2 and CH4 from measurements at the CarboCount CH sites by inverse methods. In addition, three of the four observation sites setup by CarboCount CH are continuing to produce invaluable measurements of CO2 and CH4 to study biospheric fluxes and anthropogenic emissions of these greenhouse gases over Switzerland. Two PhD students have successfully graduated and first peer-reviewed publications are becoming available. Overall, the project was an excel-lent demonstration of the value of integrating observations and atmospheric modeling to study biospheric and anthropogenic greenhouse gas fluxes.

www.c2sm.ethz.ch/research/ghg/CarboCountCH.html →

Overview of the Carbocount-CH monitoring sites in Switzerland

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 is now contributing to the follow-up initiative so-called Platform for Advanced Scientific Computing (PASC). C2SM also currently leads the "Climate and Atmospheric Modelling" PASC network. C2SM is currently involved in two PASC-related projects, including GridTools and CLAW. The Gridtool project aims to develop well engineered abstraction layers for effective development of applications in weather, climate, and geophysics and potentially other fields. The CLAW project aims to develop an open-source tool that will allow to automatize the generation of code for a specific hardware target from a single Fortran source code. The focus is on domain-specific abstractions required in the physical parameterizations and the aerosol- and chemistry modules of climate models. These new tools will facilitate the adaptation of current weather and climate codes to efficiently exploit emerging computing platforms and help achieve a high degree of performance portability.

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 →

Named after Piz Daint, a prominent peak in Grisons that overlooks the Fuorn pass, this supercomputer is a Cray XC30 system used by many C2SM-community members for high performance computing.

CH2018

New climate scenarios for Switzerland

New climate scenarios for Switzeland C2SM aims to release new climate change scenarios for Switzerland ("CH2018") by 2018. The CH2018 initiative builds upon the excellent scientific network established in the predecessor project CH2011 and involves MeteoSwiss, ETH Zurich, C2SM, and the University of Bern. The new CH2018 scenarios will be based on the latest set of climate model simulations over Europe. A market evaluation is being performed among stakeholders in Switzerland to ensure that the provided scenario data and information optimally meets the variety of end-user needs. The CH2018 initiative is one of the focus area of the National Centre for Climate Services (NCCS), which was launched on November 16, 2015 and coordinates the development and dissemination of climate services in Switzerland. Three C2SM partner institutions, ETH Zurich, MeteoSwiss and WSL are members of the NCCS, together with the Federal Office for the Environment (FOEN), the Swiss Federal Office for Civil Protection (FOCP), and the Federal Office for Agriculture (FOAG).

NCCS:
www.nccs.ch →
Swiss Climate Change Scenarios at C2SM:
www.c2sm.ethz.ch/research/ch2018.html →

Education and Training

C2SM contributes on a yearly basis to the organization of the Swiss Climate Summer Schools. A project (C2SM @ Schools) has also been initiated with the ETH competence center for learning and instruction.

www.c2sm.ethz.ch/education.html →

2015 Swiss Climate Summer School: Extreme events and climate

Extreme weather events can result in large disasters. Climate change can lead to changes in the frequency, intensity, spatial extent, duration, and timing of extreme events. There is evidence from observations gathered since 1950 of change in some extremes. The 2015 Swiss Climate Summer School provided in-depth discussions about the processes underlying the formation of extreme events and their predictability. Almost 70 participants joined the summer school at Monte Verità, Locarno, to learn about (i) the mechanisms and processes responsible for the occurrence of extreme events, (ii) the observational evidence for changes in extreme events, (iii) the uncertainties in seasonal to inter-annual predictions and long-term projections of extreme events and (iv) the technical, economical, and societal challenges related to extreme events. The 2015 Swiss Climate Summer School "Extreme events and Climate" was jointly organized and sponsored by C2SM, ETH Zürich, the Oeschger Center for Climate Research at University of Bern, and MeteoSwiss. Additional sponsors include SwissRe, the Congressi Stefano Franscini (CSF) and the Global Water and Energy Exchanges (GEWEX) project of the World Climate Research Programme (WCRP).

www.c2sm.ethz.ch/education/summer-school/summer-school-2015.html →

C2SM @ Schools

In the framework of the CHIRP2 project (see page 6), C2SM has engaged into a collaboration with the ETH Competence Center for Learning and Instruction (EducETH) and in particular the "Math-ematics, Informatics, Natural sciences, and Technics" (MINT)-learning Center. The main objectives of this collaboration is to contribute to, and support financially, the development of teaching units in mathematics, physics and chemistry for the "Gymnasialunterricht" within the core curricula taking examples from the climate and atmospheric sciences. Ultimately, the main goal is to improving science education at the Gymnasium level in the MINT areas to ensure that students gain a better general education and are better qualified for studies and professions in the natural sciences and technology.

ETH Competence Center for Learning and Instruction (EducETH):
www.educ.ethz.ch/ →

Impression of the 2015 Swiss Climate Summer School

Outreach and Events

C2SM organized a number of events in 2015 targeting lay audience, scientists, and various stake-holders. .

ETH-Klimarunde 2015 "Vision Null: Wege zur einer CO2-neutralen Gesellschaft?"

"Vision Null: Wege zur einer CO2-neutralen Gesellschaft" was the topic of the 2015 edition of the ETH-Klimarunde. In light of the upcoming COP21 taking place in Paris in December 2015, the question of how to transition towards a low-carbon world was addressed. The current knowledge regarding the 2°C target and the related carbon budget, the process and opportunities for successful international negotiations and the potentiality for large-scale development of low- and neutral-carbon technologies was presented and discussed. More than 500 people joined the event for engaging into lively discussions. The first part of the event was dedicated to direct interactions between expert and the public while the second part featured keynote speakers such as Reto Knutti and Marco Mazzotti. The event was jointly organized by C2SM and the Energy Science Center at ETH.

www.c2sm.ethz.ch/events/klimarunde2015.html →

Impression of the Klimarunde 2015

Scientifica 2015 "Licht"

Scientifica is a scientific fair co-operatively staged by University of Zurich and ETH Zurich. The topic of the 2015 edition was "Risiko" and C2SM has contributed with a booth entitled "Unsichtbares Licht in der Erdatmosphäre". Interested public including kids could explore the global energy budget of the Earth, experiment how a change in the composition of the atmosphere can impact the Earth's radiation balance, and play with infrared cameras. The Scientifica 2015 was very well visited and the C2SM booth particularly well received.

www.scientifica.ch/ausstellung/pflanzen-und-umwelt/Unsichtbares-Licht-in-der-Erdatmosphaere/ →

People gathering at the C2SM booth at Scientifica 2015

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 →

Global climate modeling

Support in the are of global climate modeling at C2SM is provided for two models, as follows:

- 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 Meteorology (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 responsible 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 international 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 →

- 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 →

Regional climate modeling

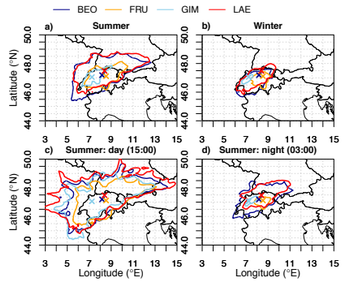
The regional climate modeling activities at C2SM focus on the COSMO model, a limited-area atmospheric model developed by the Consortium for Small-Scale Modeling (COSMO), including MeteoSwiss and other European meteorological services. The model, which can be used in CLimate Mode (COS-MO-CLM), is also 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 COSMO-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 for 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 →
www.clm-community.eu →

Scientific Highlights

The Carbocount-CH network

A paper by Oney et al., (2015) has described the CarboCount CH network, which includes four new sites in Switzerland where the atmospheric concentrations of carbon dioxide and methane are continuously measured. The paper contributed to the characterization of the individual sites in terms of their local environment and meteorological conditions and in terms of their areas of influence (e.g., the regions where surface fluxes are expected to have a measurable influence on concentrations measured at the four sites). These areas of influence are larger in summer than in winter and they are generally larger for the tall tower site Beromünster and the elevated site Lägern-Hochwacht than for the two other sites. Finally this study demonstrates that the network nicely covers the area of the Swiss Plat-eau (Oney et al., 2015).



Area of surface influence at the four measurement sites Beromünster (BEO), Früebüel (FRU), Gimmiz (GIM) and Lägern-Hochwacht (LAE) in (a) summer (Jun-Aug), (b) winter (Dec-Feb), (c) summer afternoon (15 UTC), (d) summer nighttime (03 UTC). Lines denote the isoline of surface sensitivity encompassing 50 % of the total surface sensitivities, color coded according to measurement site. Adapted from Oney et al. (2015).

Would global warming stop after carbon emissions end?

This study published in Environmental Research Letters suggests that simple models overestimate how much carbon we can emit if we want to stay below 2°C in the next centuries. C2SM-community member Thomas Frölicher and David Paynter from the Geophysical Fluid Dynamics Laboratory use comprehensive Earth System Model simulations to show that global mean temperature will increase by a further 0.5°C for nine hundred years after CO2 emissions cease when 2°C global warming is reached. Other complex climate models qualitatively agree on this result, whereas Earth System Models of Intermediate Complexity predict on average a cooling of -0.6°C. Because IPCC's carbon budget estimates were based on these simpler models, this implies a stricter budget than previously thought (Frölicher and Paynter, 2015).

Climate change does not cause winter cold snaps

C2SM Member Tapio Schneider led a team of scientists at ETH Zurich and the California Institute of Technology to explore the hypothesis that climate change, by inducing larger variability in temperature, may have resulted in recent winter cold snaps across the eastern United States. The authors used a broad range of climate simulations and theoretical arguments to show that, in most places, the range of temperature fluctuations decreases as the climate warms. In contrast to results from previous studies, they could show that the day-to-day temperature variability in mid-latitudes, especially in winter, generally decreases as the temperature difference between the poles and the equator diminishes. Cold snaps will therefore become rarer as this variability is reduced. However, heat waves will become more frequent because the mean temperature increases (Schneider et al., 2015).

Attribution of extreme weather to global warming

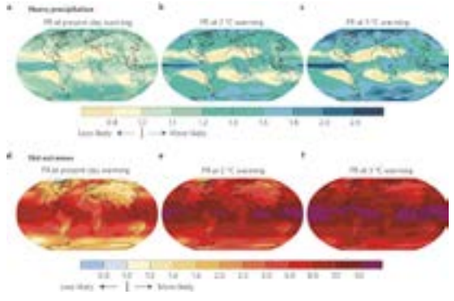
In a study published in Nature Climate Change, C2SM researchers Erich Fischer and Reto Knutti have concluded that already today, 75% of hot extremes and 18% of the heavy rainfall events occurring worldwide are attributable to the observed warming. Based on an ensemble of global climate models, the authors analysed heavy rainfall and high-temperature days that occurred about once in 3 years in pre-industrial conditions and quantify how their frequency changes with certain levels of global warming. As opposed to single-event attribution studies, their global aggregate approach and focus on moderate extremes makes it possible to quantify the human contribution to weather extremes for certain levels of global warming. With each increment of warming, the frequency of high-temperature and heavy precipitation extremes rises sharply. The authors showed that if temperatures rise globally by 2˚C, twice as many extreme hot days are expected worldwide than with a 1.5˚C increase (Fischer and Knutti, 2015).

Towards a better understanding of the development of heat waves

Heat waves in Europe, like the ones in 2003 and 2010, are typically associated with atmospheric blocking, that is with stationary high pressure anomalies in the middle to upper troposphere. C2SM-community members Stephan Pfahl and Heini Wernli from ETH together with Mischa Croci-Maspoli from MeteoSwiss have analysed a large amount of data from the past 21 years, including ground-measurements, balloons, aircraft and satellites from the European Centre for Medium-Range Weather Forecasts in Reading, UK. Their study reveals that the ascent of air masses from the lower troposphere, associated with latent heat release in clouds, contributes significantly to the formation of such blocking anticyclones. This process is not taken into account in current blocking theories, and may have implications for changes in blocking frequencies in a warming climate (Pfahl et al., 2015).

Revisiting the energy balance over land and oceans

Martin Wild and colleagues have assessed the energy budgets over land and oceans in the state-of-the-art climate models considered in the latest IPCC report using, to the extent possible, direct observations from both surface and space. They show that significant biases still remain, particularly in the simulated surface budgets. They also infer best reference estimates for the energy balance components, which are presented in global land and ocean energy balance diagrams (Wild et al., 2015).



Multi-model mean probability of exceeding the pre-industrial 99th percentile of daily precipitation (a–c) and temperature (d–f), relative to preindustrial. Ratios are shown for 30-year periods in which the global mean temperatures warmed 0.85 °C (present-day) (a,d), 2 °C (b,e) and 3 °C (c,f) above pre-industrial conditions. Adapted from Fischer and Knutti (2015).

A revived Southern Ocean carbon sink

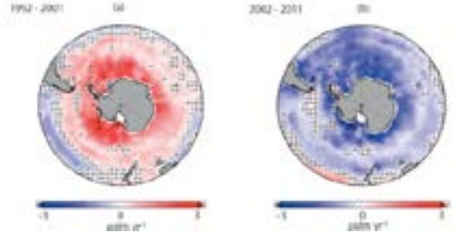
The carbon sink in the Southern Ocean was thought to have weakened in recent decades. But a new study shows that the carbon sink has regained its strength to take up anthropogenic CO2. Peter Land-schützer and Nicolas Gruber from C2SM and colleagues analysed surface ocean CO2 observations and showed that the weakening of the carbon sink in the Southern Ocean reversed around 2002, re-gaining its expected strength by 2012. The analysis was carried out using a neural network method to interpolate the CO2 observations, thus deriving a better spatial coverage of the sparse CO2 observations. All sub-basins of the Southern Ocean were found to contribute to the reinvigoration of the carbon sink and large decadal variability in the Southern Ocean carbon sink was found, suggesting a much more dynamic ocean carbon sink than previously thought. The authors note that continuing to measure surface ocean CO2 concentrations in the Southern Ocean will be an important step towards determining future changes in this important carbon sink (Landschützer et al., 2015)

Air-sea interaction in the Southern Pacific Ocean

A study led by Lukas Papritz and colleagues has revealed the relevance of cold air outbreaks from Antarctica for air-sea interaction in parts of the Southern Ocean. In particular, the study shows that the frequency of cold air outbreaks in the Ross Sea and the Amundsen and Bellingshausen Seas strongly determines the interannual variation of air-sea heat fluxes (Papritz et al, 2015). Lukas Papritz was a PhD student within the C2SM-hosted CHIRP2 project “Modeling the water cycle in a changing climate”.

Changes in heavy summertime precipitation in a changing climate

Using the COSMO model in a convection-resolving configuration (horizontal grid spacing of 2.2 km), Nikolina Ban and colleagues have found that projected increases in both extreme daily and hourly summer precipitation in summertime over continental Europe follow theoretical expectations from the Clausius-Clapeyron relation. These results are in contrast to previous studies that predicted an in-crease of extreme hourly precipitation faster than expected from the Clausius-Clapeyron relation (Ban et al., 2015).



Trends in the air-sea difference of pCO2 (the surface partial pressure of CO2) based on the neural network output for a) 1992 - 2001 and b) 2002 - 2011. Positive (red) pCO2 trends indicate a faster increase of pCO2 in the surface ocean than in the atmosphere (i.e., a decreasing sink) and vice versa for positive (blue) trends. Hatched areas indicate where the linear trends are outside the 5% significance level (P ≥ 0.05). Adapted from Landschützer et al. (2015).

Selected publications from the C2SM community

Aemisegger, F., Spiegel, J. K., Pfahl, S., Sodemann, H., Eugster, W., and Wernli, H. (2015): Isotope meteorology of cold front passages: A case study combining observations and modeling. Geophysical Research Letters, 42, 5652-5660, doi:10.1002/2015GL063988.

Ban, N., Schmidli, J. and Schär, C. (2015): Heavy precipitation in a changing climate: Does short-term summer precipitation increase faster? Geophysical Research Letters, 42, 1165-1172, doi:10.1002/2014GL062588.

Berkhout, F., Bouwer, L. M., Bayer, J., Bouzid M., Cabeza, M., Hanger, S., Hof, A., Hunter, P., Meller, L., Patt, A., Pfluger, B., Rayner, T., Reichardt, K., and van Teeffelen, A., (2015): European policy responses to climate change: Progress on mainstreaming emissions reduction and adaptation. Regional Environmental Change, 15, 949-959, doi:10.1007/s10113-015-0801-6.

Bieli, M., Pfahl, S. and Wernli, H. (2015): A Lagrangian investigation of hot and cold temperature extremes in Europe. Quarterly Journal of the Royal Meteorological Society, 141, 98-108, doi:10.1002/qj.2339.

Bircher, N., Cailleret, M. and Bugmann, H. (2015): The agony of choice: different empirical mortality models lead to sharply different future forest dynamics. Ecological Applications, 25, 1303-1318, doi:10.1890/14-1462.1.

Bretl, S., Reutter, P., Raible, C. C., Ferrachat, S., Poberaj, C. S., Revell, L. E. and Lohmann, U. (2015), The influence of absorbed solar radiation by Saharan dust on hurricane genesis. Journal of Geophysical Research Atmosphere, 120, 1902-1917, doi:10.1002/2014JD022441.

Brunamonti, S., Krieger, U. K., Marcolli, C. and Peter, T. (2015): Redistribution of black carbon in aerosol particles undergoing liquid-liquid phase separation. Geophysical Research Letters, 42, 2532-2539, doi:10.1002/2014GL062908.

Brunner, D., et al. (2015): Comparative analysis of meteorological performance of coupled chemistry-meteorology models in the context of AQMEII phase 2. Atmospheric Environment, 115, 470-498, doi:http://dx.doi.org/10.1016/j.atmosenv.2014.12.032.

Chiacchio, M., Solmon, F., Giorgi, F., Stackhouse, Jr. P. and Wild, M. (2015): Evaluation of the radiation budget with a regional climate model over Europe and inspection of dimming and brightening. Journal of Geophysical Research Atmosphere, 120, 1951-1971, doi:10.1002/2014JD022497.

Dallafior, T. N., D Folini, R Knutti, and Wild, M. (2015): Dimming over the oceans: Transient anthropogenic aerosol plumes in the twentieth century. Journal of Geophysical Research Atmosphere, 120, 3465-3484, doi:10.1002/2014JD022658.

Dallafior, T. N., Folini, D., Knutti, R., and Wild, M., (2015): Dimming over the oceans: Transient anthropogenic aerosol plumes in the twentieth century. Journal of Geophysical Research Atmosphere, 120, 3465-3484, doi:10.1002/2014JD022658.

Elkin, C., Giuggiola, A., Rigling, A. and Bugmann, H. (2015): Short- and long-term efficacy of forest thinning to mitigate drought impacts in mountain forests in the European Alps. Ecological Applications, 25, 1083-1098, doi:10.1890/14-0690.1.

Fatichi, S., Molnar, P., Mastrotheodoros, T., and Burlando, P. (2015): Diurnal and seasonal changes in near-surface humidity in a complex orography. Journal of Geophysical Research Atmosphere, 120, 2358-2374, doi:10.1002/2014JD022537.

Finger, R. and Buchmann, N. (2015): An ecological economic assessment of risk-reducing effects of species diversity in managed grasslands. Ecological Economics, 110, 89-97, doi:10.1016/j.ecolecon.2014.12.019.

Fischer, E. M. and Knutti, R. (2015): Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. Nature Climate Change, 5.6, 560-564, doi:10.1038/nclimate2617.

Frenger, I., Münnich, M., Gruber, N., and Knutti, R., (2015): Southern Ocean eddy phenomenology, Journal of Geophysical Research Oceans, 120, 7413-7449, doi:10.1002/2015JC011047.

Frölicher, T. L., and Paynter, D. J. (2015): Extending the relationship between global warming and cumulative carbon emissions to multi-millennial timescales. Environmental Research Letters, 10, 075002, doi:10.1088/1748- 9326/10/7/075002.

Giordano, L., Brunner, D., et al. (2015): Assessment of the MACC reanalysis and its influence as chemical boundary conditions for regional air quality modeling in AQMEII-2. Atmospheric Environment, 115, 371-388, doi:10.1016/j.atmosenv.2015.02.034.

Greve, P., and Seneviratne, S. I. (2015): Assessment of future changes in water availability and aridity. Geophysical Resarch Letters, 42, 5493-5499, doi:10.1002/2015GL064127.

Harris, E., Zeyer, K., Kegel, R., Müller, B., Emmenegger, L., and Mohn, J. (2015): Nitrous oxide and methane emissions and nitrous oxide isotopic composition from waste incineration in Switzerland. Waste Management, 35, 135-140, doi:10.1016/j.wasman.2014.10.016.

Holzkämper, A., Klein, T., Seppelt, R., and Fuhrer, J. (2015): Assessing the propagation of uncertainties in multi-objective optimization for agro-ecosystem adaptation to climate change. Environmental Modelling & Software, 66, 27-35, doi:10.1016/j.envsoft.2014.12.012.

Ickes, L., Welti, A., Hoose, C. and Lohmann, U. (2015): Classical nucleation theory of homogeneous freezing of water: thermodynamic and kinetic parameters. Physical Chemistry Chemical Physics, 17, 5514-5537, doi:10.1039/C4CP04184D.

Isotta, F. A., Vogel, R., and Frei, C. (2015): Evaluation of European regional reanalyses and downscalings for precipitation in the Alpine region. Meteorologische Zeitschrift, 24, 15-37, doi:10.1127/metz/2014/0584.

Keller, M., Fuhrer, O., Schmidli, J., Stengel, M., Stöckli, R., and Schär, C. (2015): Evaluation of convection-resolving models using satellite data: The diurnal cycle of summer convection over the Alps. Meteorologische Zeitschrift, doi:10.1127/metz/2015/0715.

Keller, D. E., Fischer, A. M., Frei, C., Liniger, M. A., Appenzeller, C., and Knutti, R. (2015): Implementation and validation of a Wilks-type multi-site daily precipitation generator over a typical Alpine river catchment. Hydrology and Earth System Sciences, 19, 2163-2177, doi:10.5194/hess-19-2163-2015.

Kerkhoff, C., Kuensch, H. R., and Schär, C. (2015): A Bayesian hierarchical model for heterogeneous RCM-GCM multimodel ensembles. Journal of Climate, 28, 6249–6266, doi:JCLI-D-14-00606.1.

Knutti, R., Rogelj, J., Sedlacek, J. and Fischer, E. (2015): A scientific critique of the two-degree climate change target, Nature Geoscience, doi:10.1038/ngeo2595.

Landschützer, P., Gruber, N., Haumann, F. A., Rodenbeck, C., Bakker, D. C. E., van Heuven, S., Hoppema, M., Metzl, N., Sweeney, C., Takahashi, T., Tilbrook, B. and Wanninkhof, R. (2015): The reinvigoration of the Southern Ocean carbon sink. Science, 349, 1221-1224, doi:10.1126/science.aab2620.

Lejeune, Q., Davin, E. L. Guillod, B. P. and Seneviratne, S. I. (2015): Influence of Amazonian deforestation on the future evolution of regional surface fluxes, circulation, surface temperature and precipitation. Climate Dynamics, 44, 2769-2786, doi:10.1007/s00382-014-2203-8.

Levine, X. J., and Schneider, T. (2015): Baroclinic Eddies and the extent of the Hadley circulation: An idealized GCM study. Journal of the Atmospheric Sciences, 72, 2744-2761, doi:10.1175/JAS-D-14-0152.1.

Mahlstein, I., Spirig, C., Liniger, M. A., and Appenzeller, C. (2015): Estimating daily climatologies for climate indices derived from climate model data and observations. Journal of Geophysical Research Atmosphere, 120, 2808-2818, doi:10.1002/2014JD022327.

Mernild, S. H., Hanna, E., McConnell, J. R., Sigl, M., Beckerman, A. P., Yde, J. C. , Cappelen, J. , Malmros, J. K. and Steffen, K. (2015): Greenland precipitation trends in a long-term instrumental climate context (1890–2012): evaluation of coastal and ice core records. International Journal of Climatology, 35, 303-320, doi:10.1002/joc.3986.

Miller, N. B., Shupe, M. D., Cox, C. J. , Walden, V. P. , Turner D. D., and Steffen, K. (2015): Cloud Radiative Forcing at Summit, Greenland. Journal of Climate, 28, 6267-6280, doi:10.1175/JCLI-D-15-0076.1.

Molnar, P., Fatichi, S., Gaál, L., Szolgay, J., and Burlando, P. (2015): Storm type effects on super Clausius–Clapeyron scaling of intense rainstorm properties with air temperature. Hydrology and Earth System Sciences, 19, 1753-1766, doi:10.5194/hess-19-1753-2015.

Oney, B., Henne, S., Gruber, N., Leuenberger, M., Bamberger, I., Eugster, W., and Brunner, D. (2015): The CarboCount CH sites: characterization of a dense greenhouse gas observation network. Atmospheric Chemistry and Physics, 15, 11147-11164, doi:10.5194/acp-15-11147-2015.

Selected publications of members

Papritz, L., Pfahl, S., Sodemann, H. and Wernli, H. (2015): A climatology of cold air outbreaks and their impact on air-sea heat fluxes in the high-latitude South Pacific. Journal of Climate, 28, 342-364, doi:10.1175/JCLI-D-14-00482.1.
Pfahl, S., Schwierz, C., Croci-Maspoli, M., Grams, C. M. and Wernli, H. (2015): Importance of latent heat release in ascending air streams for atmospheric blocking. Nature Geoscience, 8, 610-614, doi:10.1038/ngeo2487.
Revell, L. E., Tummon, F., Stenke, A., Sukhodolov, T., Coulon, A., Rozanov, E., Garny, H., Grewe, V., and Peter, T. (2015): Drivers of the tropospheric ozone budget throughout the 21st century under the medium-high climate scenario RCP 6.0. Atmospheric Chemistry and Physics, 15, 5887-5902, doi:10.5194/acp-15-5887-2015.
Saffioti, C., Fischer, E. M. , and Knutti, R. (2015): Contributions of atmospheric circulation variability and data coverage bias to the warming hiatus. Geophysical Research Letters, 42, 2385-2391, doi:10.1002/2015GL063091.
Schneider, T., Bischoff, T., and Płotka, H. (2015): Physics of Changes in Synoptic Midlatitude Temperature Variability. Journal of Climate, 28, 2312-2331, doi:10.1175/JCLI-D-14-00632.1.
Schmucki, E., Marty, C., Fierz, C., Lehning, M. (2015): Simulations of 21st century snow response to climate change in Switzerland from a set of RCMs. International Journal of Climatolology, 35: 3262-3273, doi:10.1002/joc.4205.
Schwaab, J., Bavay, M., Davin, E., Hagedorn, F., Hüsler, F., Lehning, M., Schneebeli, M., Thürig, E., and Bebi, P. (2015): Carbon storage versus albedo change: radiative forcing of forest expansion in temperate mountainous regions of Switzerland. Biogeosciences, 12, 467-487, doi:10.5194/bg-12-467-2015, 2015.
Scolobig, A., Prior, T., Schröter, D., Jörin, J., and Patt, A. (2015): Towards people-centred approaches for effective disaster risk management. International Journal of Disaster Risk Reduction, 12, 202-212, doi:10.1016/j.ijdrr.2015.01.006.
Sheng, J.-X., D. K. Weisenstein, B.-P. Luo, E. Rozanov, A. Stenke, J. Anet, H. Bingemer, and T. Peter (2015): Global atmospheric sulfur budget under volcanically quiescent conditions: Aerosol-chemistry-climate model predictions and validation. Journal of Geophysical Research Atmosphere, 120, 256-276, doi:10.1002/2014JD021985.
Sitch, S., Friedlingstein, P., Gruber, N., et al. (2015): Recent trends and drivers of regional sources and sinks of carbon dioxide. Biogeosciences, 12, 653-679, doi:10.5194/bg-12-653-2015.
Wild, M., Folini, D., Hakuba, M. Z., Schär, C., Seneviratne, S. I., Kato, S., Rutan, D., Amman, C., Wood, E. F. and König-Langlo, G. (2015): The energy balance over land and oceans: an assessment based on direct observations and CMIP5 climate models. Climate Dynamics, 44, 3393-3429, doi:10.1007/s00382-014-2430-z.
Wills, R. C. and Schneider, T. (2015): Stationary Eddies and the zonal asymmetry of net precipitation and ocean freshwater forcing. Journal of Climate, 28, 5115-5133, doi:10.1175/JCLI-D-14-00573.1.
Wüest, R. O., Antonelli, A., Zimmermann, N. E., and Linder, H. P. (2015): Available climate regimes drive niche diversification during range expansion. The American Naturalist, 185, 640-652, doi:10.1086/680551.
Zellweger, F., Braunisch, V., Morsdorf, F., Baltensweiler, A., Abegg, M., Roth, T., Bugmann, H., and Bollmann, K. (2015): Disentangling the effects of climate, topography, soil and vegetation on stand-scale species richness in temperate forests. Forest Ecology and Management, 349, 36-44, doi:10.1016/j.foreco.2015.04.008.

Selected publications of members

Annex

As of 31.12.2015

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	D–USYS, ETH	Climate Physics
Prof. Ulrike Lohmann	D-USYS, ETH	Atmospheric Physics
Prof. Tapio Schneider	WSL	Climate Dynmaics
Prof. Nicklaus Zimmerman	WSL	Landscape Dynamics

Regular Members

Dr. Marco Arpagas	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	D-ARCH, ETH & EMPA	Building Science and Technology
Dr. Mischa Croci-Maspoli	MeteoSwiss	Climate Monitoring
Dr. Lukas Emmenegger	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	Agroscope	Numerical Modelling
Prof. Martin Funk	ETH Zurich	Glaciology
Prof. Gerald Haug	D-ERDW, ETH	Climate Geology
Prof. Torsten Hoefler	D-INFK, ETH	Computational Sciences
Dr. Mark Liniger	MeteoSwiss	Climate Prediction
Prof. Michael Lehning	WSL	Snow and Permafrost
Prof. Nicolai Meinhausen	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	CSCS & D-PHYS, ETH	Computational Sciences
Dr. Cornelia Schwierz #	MeteoSwiss	Climate Monitoring
Prof. Sonia Seneviratne	D-USYS, ETH	Land-Climate Dynamics
Dr. Philippe Steiner	D-USYS, ETH	Weather Forecasting
Dr. Reto Stöckli #	D-USYS, ETH	Climate fundamentals
Prof. Heini Weinli	D-USYS, ETH	Atmospheric Dynamics
Prof. Martin Wild	D-USYS, ETH	Climate and Radiation
Prof. Niklaus Zimmermann	WSL	Landscape Dynamics

 # New member elected in 2015

Annex

As of 31.12.2015

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)H

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
OPTIWARES	U. Baltensperger (PSI)	CCES	01.08.2012 – 31.07.2016
COSMO GAW	U. Lohmann (ETH)	MeteoSwiss-GAW+	01.01.2014 – 31.12.2017
CH2018	R. Knutti, C. Schär	MeteoSwiss	01.08.2015 – 31.12.2018

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

Reporting period (01.01.2015 – 31.12.2015):

Budget

Saldo (CHF) 01.01.2015	**404'324**
Income (CHF) 01.01.2015 – 31.12.2015	
ETH School Board	160'000
USYS Department	100'000
Members	18'000
MeteoSwiss	150'000
Empa	50'000
WSL	50'000
Agroscope	10'000
Funding through projects *	85'908
Total Income	**585'908**
Expenses (CHF) 01.01.2015 – 31.12.2015	
Salaries core staff	507'108
Project support	30'000
Events	24'131
Running costs	8'486
Travels	16'999
Total Expenses	605'265
Saldo (CHF) 31.12.2015	**384'967**

* The Carbocount-CH, OPTIWARES, and COSMO-GAW projects have contributed to the core C2SM budget (see page 6 for details about the projects). In 2015, the HAMMOZ consortium (in particular the Finnish Meteorological Institute) has supported C2SM in the framework of the ECHAM-HAMMOZ hosting (see section "Support for research and education activities, Global climate modeling").