C2SM Partners

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

MeteoSchweiz

Empa
Materials Science and Technology

WSL

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Wirtschaft, Bildung und Forschung WBF
Agroscope

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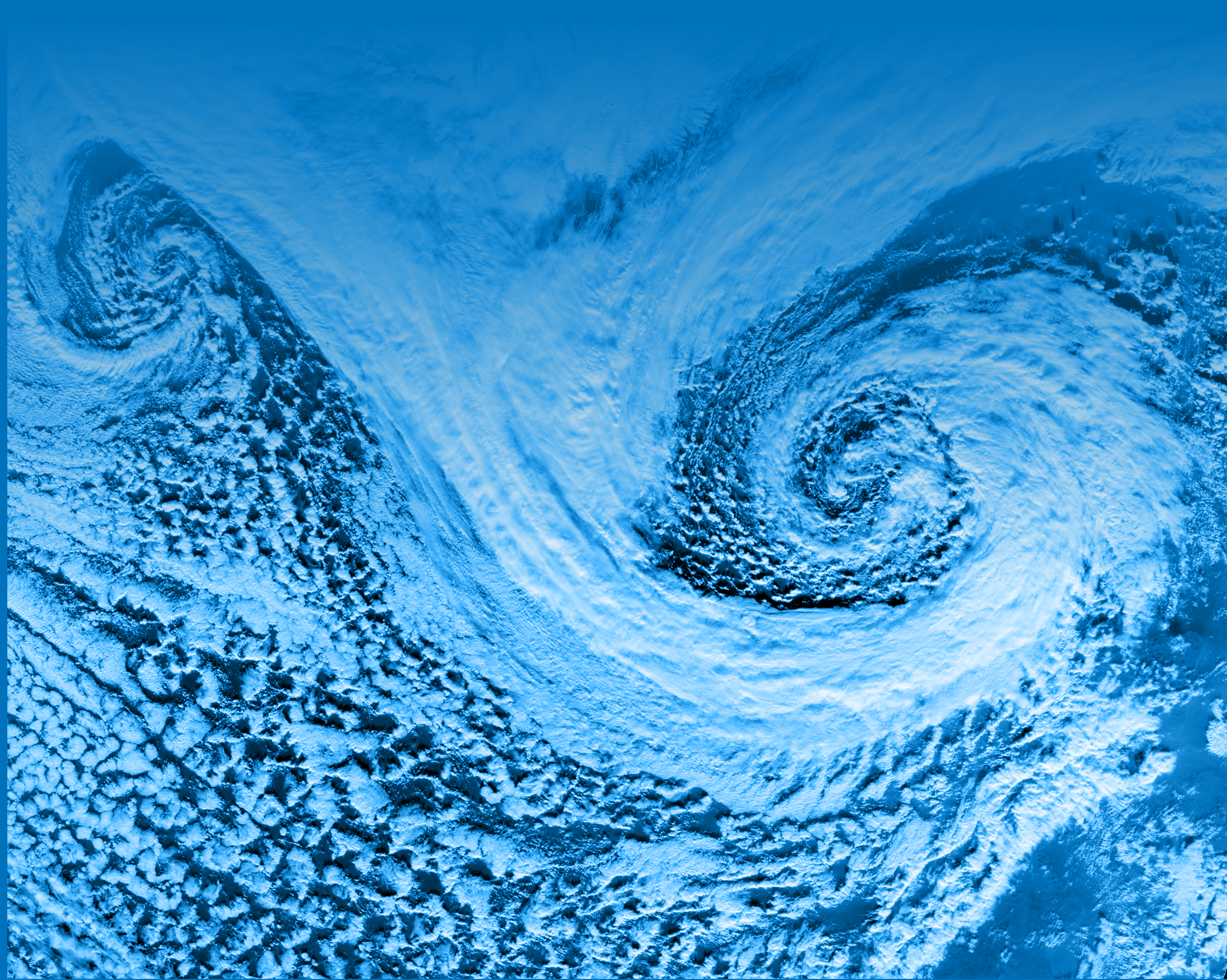
April 2019 Zurich

ETH zürich

C2SM

Annual Report 2018



C2SM
Center for Climate
Systems Modeling

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 system and strengthen the predictive skill of climate models on time scales from months to millennia. The center was established in 2008 and is now in its third phase (January 2017 – December 2020). This document highlights the main achievements in 2018.

The C2SM Steering Committee, April 2019

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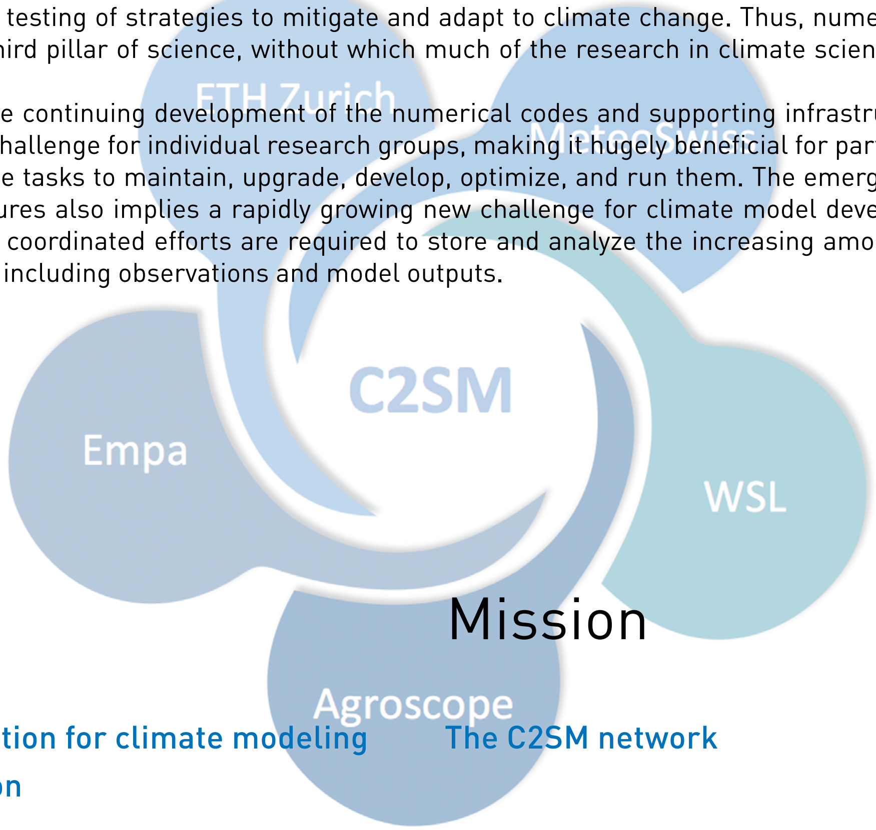
About C2SM

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 increasingly been used in research and service activities related to climate change. They now form the backbone for many applications including short-term weather forecast, climate data assimilation, seasonal climate prediction, climate predictions and projections (from decades to centuries), 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 science 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 core aim of C2SM is to provide expertise, know-how, and infrastructure to enable and enhance the partners' research portfolios and to foster synergies between the partners in the areas of weather and climate sciences, atmospheric transport, chemistry, and aerosol research, climate risks and impact, as well as agricultural applications. In particular, we aim to exploit the favorable constellation with ETH Zurich, MeteoSwiss, and CSCS to push forward in high-performance computing in the area of weather and climate modeling, which has been identified as one of the grand challenges not only in high performance computing, but also in the area of environmental sciences. The plan is to build on the success stories of previous HPC projects and strengthen these links, building a world-leading center for climate modeling.

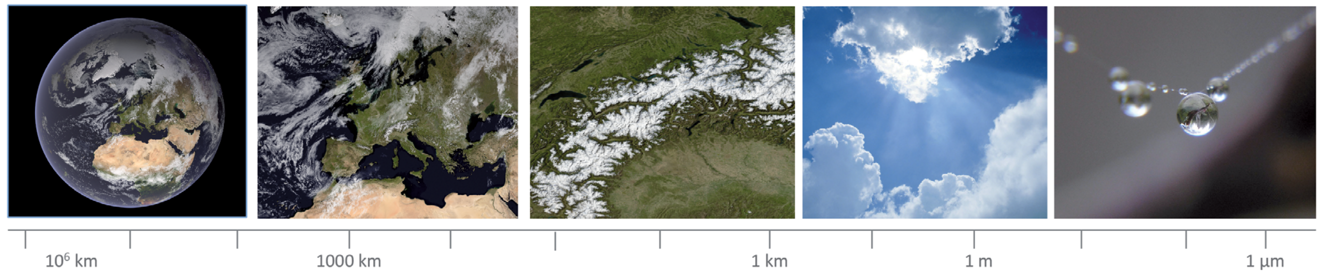
Mission

The C2SM network

The center's mission is to provide a technical and scientific platform and a network for its partners institutions

- to support the development and application of complex models of the weather and climate system and the analysis and visualization of climate data,
- to enable and facilitate collaborations within the C2SM's community and beyond,
- to exploit synergies among the partner institutions,
- to engage in a dialogue with the general public and other stakeholders about climate-relevant issues.

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.



Research Theme

Scientific strategy

For the 2017 through 2020 phase, we will focus on building ICON as the common model platform for the C2SM community. We will further work in the area of high performance computing taking advantage of the opportunities that arise from current developments in climate modeling and from the unique setting of partners that are brought together by C2SM. Specifically, we propose to strongly enhance the collaboration with CSCS and MeteoSwiss and to focus our technology/research efforts on (i) model consolidation around the ICON model, (ii) the development of the next generation of modeling platform for weather and climate, (iii) the development of methods and tools to analyze massive amounts of data, particularly in the context of the Swiss Climate Scenarios, and (iv) to integrate nearby science fields such as climate impact and atmospheric chemistry research into the core weather and climate activities exploiting the already existing close collaborations and the locational advantage of the ETH domain institutions. In addition, we continue with the provision of specific services, training and outreach, building on the competences, products, and successes that were acquired and developed since 2008.

Activities

C2SM coordinates a world-leading network of research institutions and experts. It 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, as well as providing central technical, educational, and outreach services to the benefit of the whole community.

A key set of activities aims to foster interdisciplinary research and interactions across disciplinary boundaries. A second set of activities centers around establishing 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) expand on new research themes. These enable the partner groups and institutions to undertake the challenging model development and applications studies that would otherwise not be possible.

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 research avenues. Of particular importance is the planned consolidation of the supported model families through adopting the ICON weather and climate model.

Support for research activities

- To continue 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 refining 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 pro-actively gain expertise in the ICON model and support the members to transition to this model.
- To exploit and disseminate key national and international data sets by providing a repository for them and by developing analysis and data management tools.
- To support the ETH members in organizing funding for data storage and computing nodes.
- To prepare for the exploitation of the next generation of high-performance computers.

Education and training

- To contribute towards an improved training of PhD students through the establishment of projects across research groups, institutions, and disciplines.
- To train scientists (PhD students, post docs, etc.) in the areas of data visualization, data analysis, use and interpretation of climate data, programming, and data management.
- To continue organizing the Swiss Climate Summer Schools jointly with the Oeschger Center for Climate Research at the University of Bern.

Outreach and events

- To continue raising public awareness related to climate and weather through various channels while focusing on linking with other relevant themes, for which climate change has implications. The primary avenues will be the well-established "Klimarunde" and public outreach events such as Scientifica.

Governance

Structure, Organization, and Personnel of C2SM

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. In January 2017, C2SM entered its third phase, which covers the four-year period 2017 through 2020.

As of 31 December 2018, the center includes 36 members, who are professors or senior scientists at the partner institutions (see Annex for a detailed list) and form the center's Plenary.

The C2SM community includes all students, postdoctoral fellows, and technical and scientific staff from the research groups of each member and thus represents a group of over 400 people. Six members out of 36 form the Steering Committee (SC), who defines the overall strategy and oversees 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).

Operationally, the center is run by an executive director, who oversees an administrative office composed of scientific programmers, a project manager, a PR and communication specialist, and an administrative assistant. The scientific programmers 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 researchers, meet on a regular basis to discuss and propose the strategy to be developed and the tasks to be performed in each of the areas. The center also supports four postdoctoral fellows through specific research projects acquired by C2SM and its members (see page 26 for more details on the current projects). The structure and organization of C2SM is described in greater detail in the Terms of Reference, that can be downloaded from the C2SM website.

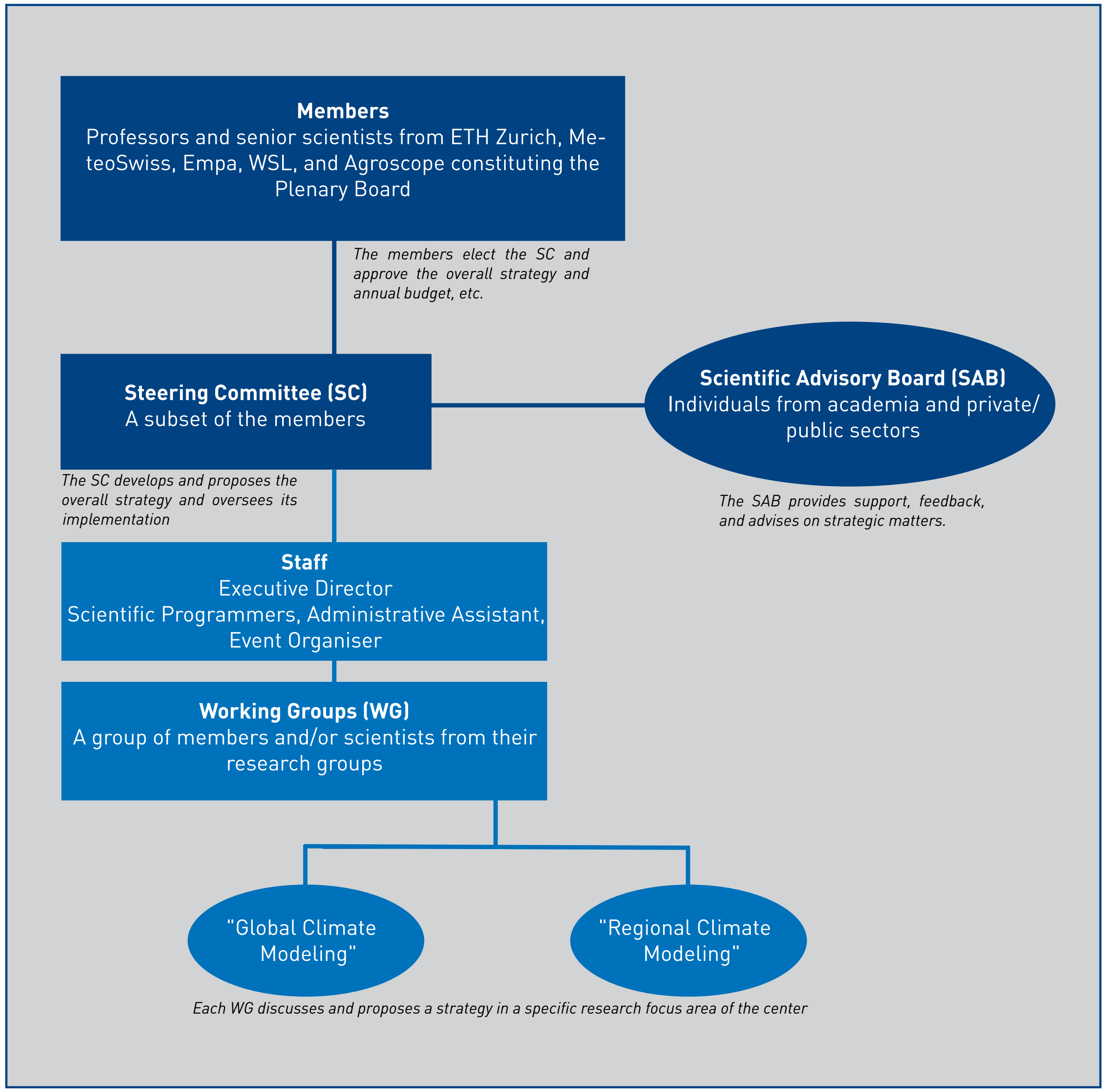
www.c2sm.ethz.ch/the-center/documents.html

Core staff

Role	Name
Executive director	Christina Schnadt Poberaj
Administrative assistant	Rahel Buri
Scientific programmer "Global climate modeling"	Colombe Siegenthaler-Le Drian, Urs Beyerle
Scientific programmer "Regional climate modeling"	Katherine Osterried
Scientific programmer "Scientific visualisation	Tarun Chadha
PR and Communication	Tanja Meier

* As of 31 December 2018, the core staff corresponds to a total of 3.75 FTE. The administrative assistant is directly supported by the Institute for Atmospheric and Climate Science, and only paid by C2SM to a small fraction. In addition to the core staff, postdoctoral fellows and research assistants are supported through funding from different projects.

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



Main Achievements

C2SM and its community have 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.

Research Coordination

High Perfomance Computing

Recent years have seen immense progress in our capacity to predict weather and climate evolution using numerical models. An important driver for this development has been the rapid progress in high-performance computing (HPC). It is expected that with the further increase of high-performance computing capacity, the computational resolution of such models will continue to be refined in the next decades. From a computer science perspective, this strategy poses major challenges. First, harvesting the computational capacity of emerging HPC architectures increasingly involves the use of heterogeneous many-core architectures consisting of both CPUs and accelerators (e.g., GPUs). The efficient exploitation of such architectures requires a paradigm shift and has only just started. Second, continuously adapting state-of-the art weather and climate models to emerging and new hardware and the associated programming models poses a formidable challenge, as these models typically entail huge code bases maintained by a large community of domain-scientists.

For several years, C2SM has actively been contributing to this development preparing climate codes for the next generations of high-performance computers to exploit emerging computing capabilities. C2SM has been strongly collaborating with MeteoSwiss, ETH groups, and CSCS, and has been involved in several consecutive projects of the Swiss initiative for High Performance and High Productivity Computing (HP2C) (e.g., HP2C-COSMO, HP2C-OPCODE, and HP2C-POMPA) and since then has been contributing to the follow-up initiative, the Platform for Advanced Scientific Computing (PASC), where it was previously involved in the projects CLAW and GridTools. Currently, C2SM is involved in two PASC-related projects, ENIAC and PASCHA.

www.c2sm.ethz.ch/research/High_Performance_Computing

PASC ENIAC

The aim of the ENIAC project (July 2017 – Jun 2020) is to adapt the numerical weather prediction and climate model ICON to new hardware technologies such as GPUs and investigate the question of performance portability. A GPU-capable version of the model using OpenACC compiler directives is under development, and major steps have been undertaken to adapt the climate physics to run on this hardware. Key components such as the turbulence, soil interface, and microphysics can now run on GPUs using the directives.
First steps towards performance portability have also been taken by using the CLAW single column abstraction Domain Specific Language (DSL, Clément et al., 2018) for adapting the soil model JSBACH. This enables the automatic transformation and addition of directives to the existing Fortran source code of JSBACH in an optimal way depending on the target architecture.

C2SM employs two technical programmers in this project (2017-2019).

www.pasc-ch.org/projects/2017-2020/eniac-enabling-the-icon-model-on-heterogeneous-architectures/

PASC PASCHA

The aim of the PASCHA project (July 2017 – Jun 2020) is to provide portability for the COSMO model (avoiding the GPU vendor lock), increase the productivity of programming models like DSLs adopted in production and enhance the performance on accelerators by integrating a new functional parallelism (in addition to data parallelism) into the COSMO model.

The porting of the main components of the COSMO model for the Intel XeonPhi accelerator has been successfully finalized. Results show good performance comparable to P100 NVIDIA GPUs for physical parametrizations. A new backend of the Domain Specific Library named GridTools used for the COSMO dynamical core has been developed. Even if the Intel XeonPhi architecture has been discontinued, the ported code is still an efficient COSMO implementation for any modern CPU-based computing architecture.
A new high-level DSL toolchain is being developed within the project with the goal to further increase the performance and usability of weather and climate models on structured lat-lon grids like COSMO compared to the previously developed production DSL STELLA (specifically developed for COSMO)/ GridTools (generalization of STELLA). The language provides a Matlab-like high-level syntax that increases the productivity of model development. First initial results and performance level have been demonstrated for the COSMO dynamical core.

C2SM participation in the PASCHA project has been focused on incorporating the GPU enabled code into the official COSMO version, so that it can be used by the entire COSMO community. This includes porting to GPU and testing of the microphysics parameterization, the climate portion of the code, and some of the I/O interfaces.

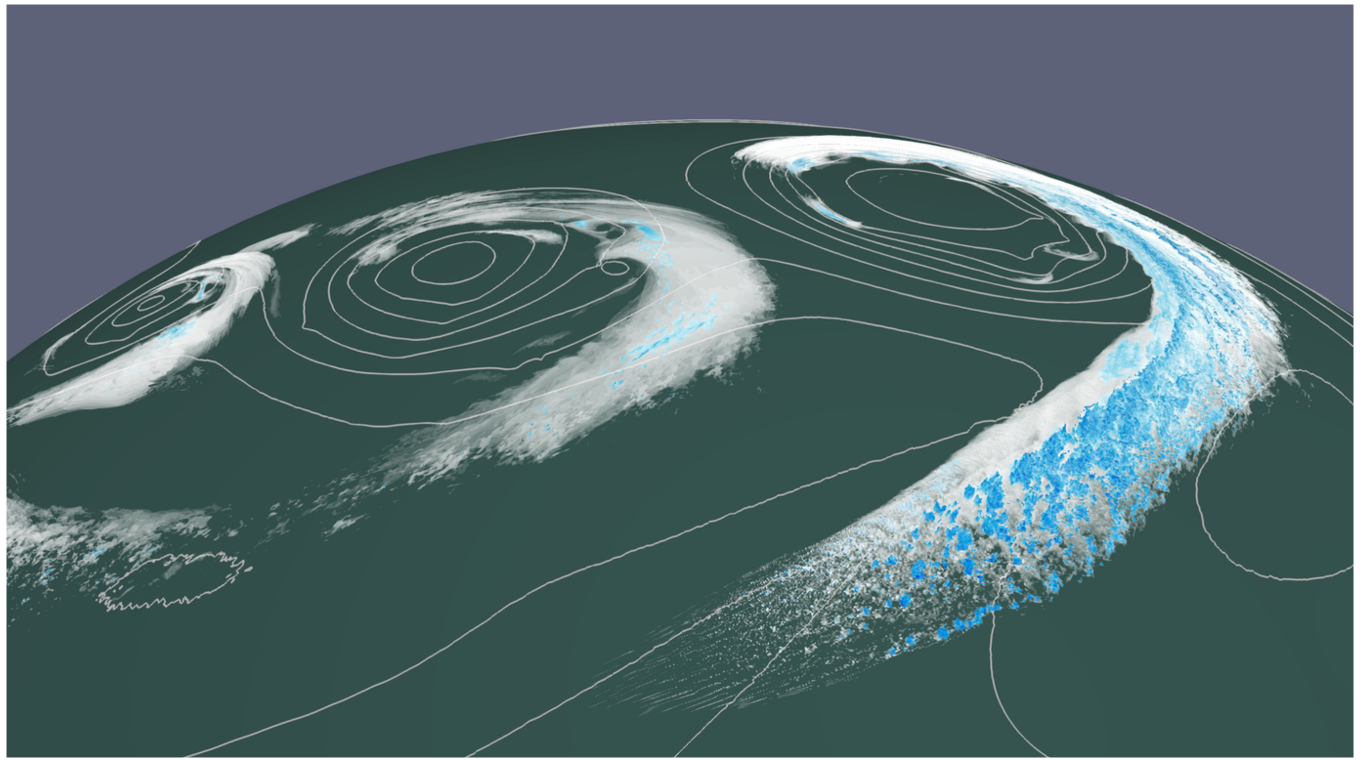
www.pasc-ch.org/projects/2017-2020/pascha/

crCLIM

Convection-resolving climate modeling on future supercomputing platforms

With the advancements of high-performance computing, the resolution of weather and climate models is increasing and their development is rapidly progressing. This increase in resolution allows reducing some of the key uncertainties in atmospheric and climate models, like the representation of moist convection (thunderstorms and rain showers). However, these developments pose major challenges, since long-term storage of such voluminous model output is expensive, and emerging hardware architectures increasingly involve the use of heterogeneous many-core architectures for which these codes are not yet ready.

The project crCLIM (Cloud-resolving climate modeling on future supercomputing platforms, May 2015 – October 2018) funded by the Sinergia program of the Swiss National Science Foundation and coordinated by ETH Zurich, explored the scientific potential of km-resolution climate modelling, and contributed towards solving the technical challenges between explicitly representing physical processes through simulations at high resolution on the one hand, and associated increases in computing and mass storage needs on modern heterogeneous many-core architectures on the other hand.



Perspective view of a near-global atmospheric simulation at a horizontal resolution of 1 km showing the development of a train of low-pressure systems (Fuhrer et al., 2018). To our knowledge, this is currently the fastest global simulation of its type. Image realised by Tarun Chadha (C2SM).

The overarching objective of crCLIM was to develop a European-scale convection-resolving climate modeling capability at a horizontal resolution of about 2 km for the next generation of high-performance computing architectures. The project has assessed how to efficiently exploit heterogeneous manycore computing architectures consisting of both "traditional" central processing units (CPUs) and accelerators (e.g., GPUs). It has developed a prototype of a data virtualization layer and online analysis platform for high-resolution models, and has contributed to a better understanding of the water cycle over Europe and its response to a warmer climate. The research has been based on a version of the COSMO model that runs entirely on GPUs. To our knowledge this is the first full atmospheric model with this capability. The crCLIM project has developed a modeling framework that will be further exploited in subsequent projects and studies.
Last but not least, the crCLIM project was a showcase of a successful interdisciplinary collaboration as it combined the expertise of both climate and computational scientists from ETH Zurich, CSCS, and MeteoSwiss in its consortium.

C2SM was involved in the project by providing technical support for the development and technical and climatological testing of the GPU-enabled COSMO code used for the high resolution climate simulations. In addition, in collaboration with the project team, C2SM developed and set up the crCLIM website www.crclim.ch. C2SM's scientific visualization expert processed crCLIM high-resolution output from a COSMO near-global simulation to produce an image of a cloud field overlaid by precipitation for a publication by Fuhrer et al. (2018). The involvement of C2SM in the crCLIM project is a prime example of how the center can enable science by means of second-tier support over a broad technical portfolio.

www.c2sm.ethz.ch/research/crCLIM.html
www.crclim.ch

IMPACT

IMPACT is a priority project financed by Deutscher Wetterdienst (DWD) that started in autumn 2018 and aims at improving weather forecast quality of the ICON model in its limited area mode (LAM). The speedup provided by emerging hardware architectures, such as graphical processing units (GPU) or field programmable gate arrays (FPGA), allows an increase in model resolution, complexity and the number of ensemble members.
The main tasks are:

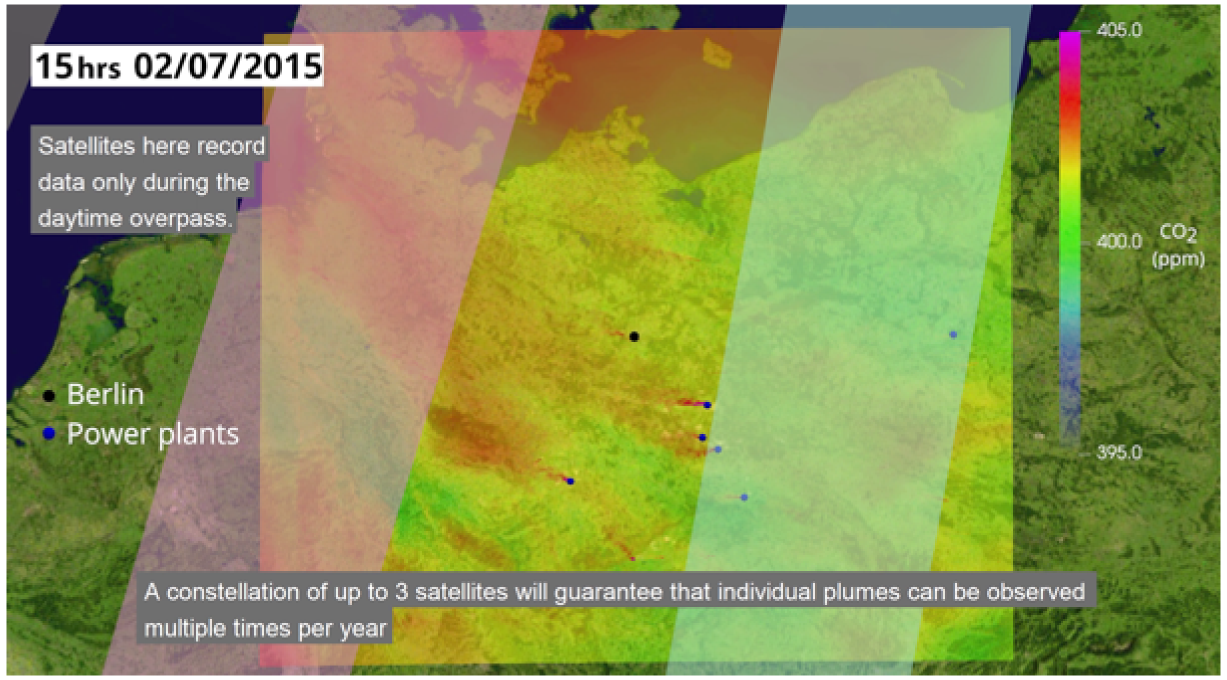
- Extend the automated testing infrastructure of ICON to strengthen GPU development where bit-reproducibility, which is not guaranteed across compilers and architectures, cannot be used as a benchmark.
- Port the high-resolution physics packages within ICON LAM to GPUs using OpenACC directives to set a performance baseline.
- Evaluate the performance of ICON LAM as compared to its predecessor model COSMO, starting with the dynamical core which has already been ported to GPU within the ENIAC project.
- Use domain specific languages, such as CLAW and GridTools, to further optimize the performance of ICON.

Other projects

ESA SMARTCARB

The combustion of fossil fuels is the main source of today's increase in atmospheric carbon dioxide (CO_2). To limit the risk and impact of climate change, the Paris climate conference agreed on the long-term goal of keeping the global average temperature increase below 2°C above pre-industrial values. Reaching this goal will require dramatic cuts to the emissions of CO_2 and other greenhouse gases (GHG) in the coming decades.
To support mitigation policies, the European Commission is currently designing a global CO_2 monitoring system that will quantify anthropogenic CO_2 emissions from atmospheric measurements in combination with atmospheric transport models at the national, city, and facility level. A key element of this system will be a constellation of CO_2 imaging satellites implemented through the European Earth observation program Copernicus.

The project SMARTCARB (February 2017- April 2018), funded by the European Space Agency (ESA) and led by Empa, analyzed the potential of such a future satellite constellation to quantify strong CO_2 sources such as cities and power plants. It also investigated the added value of measuring additional trace gases co-emitted with CO_2 such as carbon monoxide (CO) and nitrogen dioxide (NO2) from the same satellites. For the study, synthetic satellite observations were generated from highly realistic simulations of atmospheric CO_2, NO_2, and CO using the atmospheric transport model COSMO-GHG. The synthetic observations were then used to assess the performance of several instrument configurations with different precisions and spatial coverage and finally to formulate specific requirements.



ESA SMARTCARB project: Simulated atmospheric CO_2 (total column) on 2 April 2015. Overlaid is an example of how future satellites will observe the domain along their orbits with a 250 km wide swath. Image snapshot from C2SM SciViz visualization.

An important conclusion of the study was that an additional NO_2 instrument would greatly add to the success of the mission. C2SM contributed to the project by porting the GHG (greenhouse gases) extension to the GPU-accelerated COSMO-POMPA model. Furthermore, it realized a scientific visualization demonstrating the benefits of three satellites for the monitoring of local and regional CO2 emissions, of which a first version was presented at the ESA Living Planet Symposium in May 2019 (visualization will be made available at C2SM's vimeo channel: https://vimeo.com/user92148307). The project just entered into a second phase (May 2019 – Apr 2020). The results of the project will provide important guidance for ESA for the design of the future satellites.

www.empa.ch/web/s503/smartcarb

SDSC Carbosense4D

Directed by Empa, the Swiss Data Science Center (SDSC) project "CarboSense4D" (Four-dimensional mapping of carbon dioxide using a low power sensor network, December 2017 - December 2019) combines data science methods, atmospheric observations, and atmospheric transport modeling to determine the evolution of CO_2 over Switzerland at high spatial and temporal resolution.

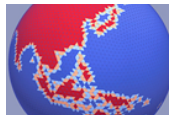
Such information is useful for the understanding of anthropogenic CO_2 emissions and biospheric fluxes, and for the validation of satellite CO_2 observations. Through Carbosense4D and its precursor Carbosense, more than two hundred low-cost sensors and 20 medium cost CO_2 sensors have been distributed over Switzerland, offering an unprecedented density of continuous CO_2 observations. All data are transmitted through Swisscom's new low power communication network LoRaWan. The measurements are complemented by high-resolution CO_2 simulations using the COSMO-GHG model for Switzerland and the GRAMM/GRAL dispersion model for Zurich. The measurements and model simulations are finally combined with spatial proxies such as population and traffic density to compute high-resolution maps of CO_2 based on geostatistical methods and machine learning. A particular focus is placed on the city of Zurich with the aim to quantify the city's CO_2 emissions directly from the observations. CarboSense4D serves as a proof-of-concept for the value of low-cost CO_2 sensors in carbon cycle research and will help improving our understanding of the CO_2 budget at regional and city scale. Carbosense4D is a collaboration between Empa, the ETH Domain's Swiss Data Science Center (SDSC), and the Center for Climate Systems Modeling (C2SM). Additional key partners are the Empa spin-off Decentlab and Swisscom. C2SM will devote four months on visualizing the scientific results of the project.

www.empa.ch/web/s604/carbosense4d

Support for Research Activities

C2SM provides community support in the area of global and regional climate modeling and scientific visualization.
www.c2sm.ethz.ch/services.html

Global climate modeling



Support in the area of global climate modeling at C2SM is provided for four models:

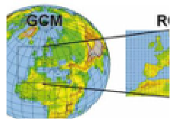
The Max Planck Institute Earth System Model (MPI-ESM) is an Earth System Model originally developed, maintained and distributed by the Max Planck Institute for Meteorology (MPI-M) in Hamburg. The atmospheric component ECHAM is coupled to comprehensive aerosol (HAM) and trace gas chemistry (MOZ) modules, resulting in the fully coupled aerosol-chemistry-climate model ECHAM-HAMMOZ. Between 2009 and 2018, ETH/C2SM were responsible for the hosting of ECHAM-HAMMOZ for the international HAMMOZ consortium, chaired by C2SM member Prof. Ulrike Lohmann. Since 2018, a transition of the hosting duties to TROPOS in Leipzig has been initiated. During the transition, C2SM continues providing support for the hosting duties, which include support to the internal and international communities with respect to implementation on new super computers, definition of running environments, user management, and provision of pre- and post-processing tools. In 2018, amongst others, C2SM prepared the input files for the World Climate Research Program (WCRP) Aerosol Chemistry Model Intercomparison Project (AerChemMIP) initiative for the HAMMOZ consortium, managed the official HAMMOZ input file distribution for both the international and the C2SM members communities, and performed the scalings and benchmarkings of the model on Piz Daint (CSCS) for the technical part of a production proposal.

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 six separate models 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 CESM support is provided for the super computers used by our C2SM members (Euler cluster at ETHZ and Piz Daint at CSCS) with respect to implementation, set-up, and running the model. In 2018, one main focus was on porting the new CESM version 2.x to these systems.

www.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. Activities in 2018 involved improvements to the GPU version of the COSMO model such as the incorporation of a new soil runoff parameterization, the calibration of the GPU version of COSMO for climate runs, support for the porting of the GPU code into the official COSMO version, and the implementation of an online anthropogenic emissions module into the GPU version of COSMO. Since 2017, C2SM has taken over the source code administration of the so-called EXTPAR software module for the international COSMO consortium, one of the pre-processing modules to prepare surface boundary conditions for COSMO simulations. Activities around EXTPAR included producing a release that is fully compatible with the current COSMO and ICON versions, as well as developing a technical testsuite for EXTPAR and automation of testing with the Jenkins tool.

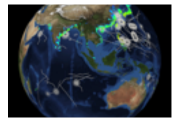
wiki.c2sm.ethz.ch/COSMO/WebHome

ICON modeling framework

The ICON (Icosahedral Nonhydrostatic) modeling framework is a joint project between the German Weather Service and MPI-M for developing a unified next-generation global numerical weather prediction and climate modeling system. The ICON model has been introduced into DWD's operational forecast system in January 2015 and will substitute the operational weather forecast model COSMO deployed at MeteoSwiss in 2022. C2SM aims at making ICON one of its main tools to enable atmospheric science at C2SM from the local to the global scale, covering numerical weather prediction, as well as weather and climate modeling. Activities in 2018 included both global and regional modeling and consisted in installing the ICON environment and making it work for the first students using the model, in gaining practical expertise in working with the model attending the ICON-HAMMOZ developer meeting in Leipzig in March 2018, and in participating in the ICON developers meeting in Karlsruhe in February 2018 to strengthen the links with the other international ICON developers. C2SM also organized ICON meetings for its community members at three-monthly intervals to exchange on technical issues around running ICON.

wiki.c2sm.ethz.ch/ICON/WebHome

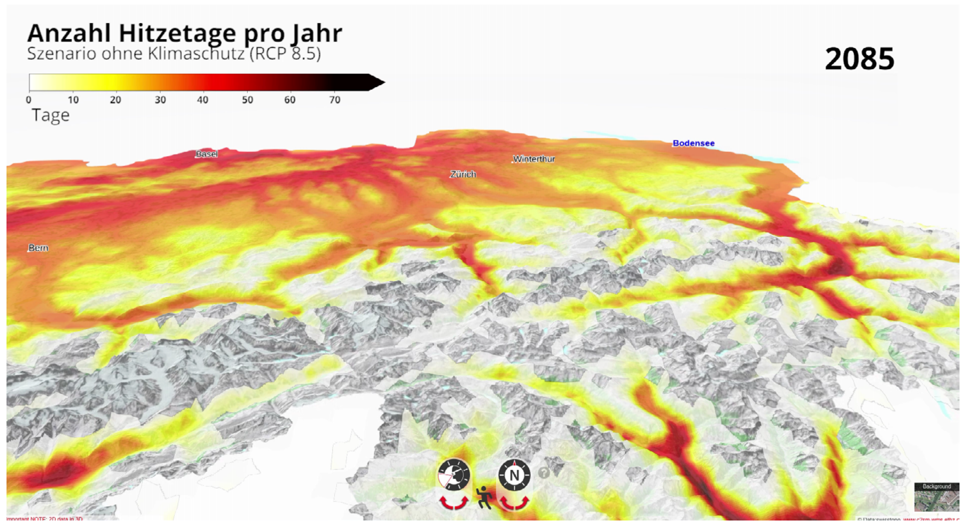
Scientific visualization



Scientific visualization and web programming service is being offered to the C2SM community since 2016. This activity is done in collaboration with the ETH Scientific IT Services (SIS). Any C2SM-affiliated research group (PI) can apply for the service following an established process (for details see Annual Report 2017 and the C2SM visualization website). A large part of the visualizations can be viewed at C2SM's vimeo channel "C2SM Weather and Climate Visuals" (https://vimeo.com/user92148307).

Completed visualizations included
- two animations for the LongRunMIP model intercomparison study showing long-term global temperature and sea ice anomalies, as well as temperature and ocean heat content anomalies as response to an abrupt CO_2 increase (Dr. Maria Rugenstein, group: Prof. Reto Knutti);
- a customized tool developed for visualizing tree-growth simulation data. The animation displays tree growth on a specified topography as a function of parameters evolving over time. In addition to steering the animation via a GUI, the software also works in batch mode (group: Prof. Harald Bugmann);
- an animation showing tropical cyclones and damage caused by them. This visualization is continued to be further developed (group: Prof. David Bresch);
- a visualization showing the development over time of observed and simulated number of hot days using data fields from the Swiss climate change scenarios project CH2018 over Swiss topography. A WMS (Web Map Services) server was set up to achieve this animation.

www.c2sm.ethz.ch/services/visualization.html



Scientific visualization of the number of heat days for observed and model data of the RCP 8.5 scenario (1996-2085), animation realized for the CH2018 project. The image shows a snapshot of the video for the year 2085. Full animation at https://vimeo.com/304385108.

Swiss Climate Change Scenarios 2018

More hot days in the Hinterrhein region?

Tropical nights in Thun?

How much snow in Saas-Fee?

The Swiss climate scenarios CH2018 show where and how climate change will affect Switzerland.

Heatwaves across Europe and Switzerland, torrential rainfall in Lausanne, and exceptional dryness - these headlines from 2018 sound remarkably similar to the new climate scenarios CH2018. Particularly summer 2018 was a textbook illustration of what climate change means for Switzerland and a thematic prelude for the publication of the new scenarios.

2018 constituted the last project year of the four-year CH2018 initiative to establish the new Swiss climate change scenarios CH2018. CH2018 is one priority theme of the National Center for Climate Services (NCCS) hosted at the Federal Office for Meteorology and Climatology MeteoSwiss, which coordinates the federal development and dissemination of climate services in Switzerland. The project built upon the excellent scientific network established in the predecessor project CH2011 and involved more than 40 scientists from MeteoSwiss, ETH Zurich, C2SM, the University of Bern, and ProClim, as well as a wealth of administrative and communication staff, and an advisory board.

With the science in place after the first three project years, 2018 marked a phase of joint and consolidated efforts to prepare a series of products of the scenarios. These products comprised a 300 page technical report in English available in electronic form, a short user-oriented and printed brochure of the key findings in the Swiss languages, the final datasets ready to be distributed to users, a web atlas containing about 20'000 standardized figures derived from the scenarios, and a dedicated and comprehensive website at the NCCS web portal. A communication team was set up including the project coordinators, the C2SM and NCCS directors, as well as communication experts from both MeteoSwiss and ETH. This group, in exchange with the Steering Group of the project, designed and produced a wealth of communication and advertising products such as flyers, posters, an explanatory video, and expert statements. The conceptualization and design of the brochure was originally developed by Kuno Strassmann (C2SM), one of the two co-project coordinators, and elaborated in collaboration with an external graphic designer, the communication team, and the Steering and Core Groups of the project.

Participants exploring the new web platform of NCCS at the CH2018 Launch event

Poster exhibition at the CH 2018 Launch event

Finally, a large effort was invested in preparing the publication event of the scenarios, the so-called launch event. The event was jointly prepared by C2SM and NCCS and in collaboration with ETH's event organization and took place on 13 November 2018 at ETH. The afternoon official program was preceded by a one-hour press conference in the morning, which was very well visited. The afternoon program was split into three blocks: in the first the main results were presented. The second block contained interactive sessions, in which the visitors had the possibility to obtain more detailed information around the scenarios, and the third presented a panel discussion, which highlighted the perspectives of different stakeholders and potential users of the scenarios. With 670 registered participants from the national to communal administration and politics, NCCS members and partners, scientists, research-oriented and private users of the scenarios, as well as the interested public, the CH2018 launch event turned out to be a huge success and one of the largest public events on climate change in Switzerland so far. Swiss media coverage of the scenarios was enormous: the topic made it to the front pages of the large Swiss newspapers, and it was broadcast by several television programs such as the newscast "10 vor 10".
On the same day, the new web platform of NCCS was launched. At this website, all available information on the Swiss Climate Scenarios CH2018 have been made available in a comprehensive and well-arranged form.

NCCS website
CH2018 Launch event
CH2018 Technical Report

Impressions of the Swiss Climate Change Scenarios CH2018 Launch event

Education and Training

C2SM organized and carried out several workshops.

Swiss COSMO User Workshop

The Swiss COSMO User Workshop is an informal one-day event whose goal is to bring together COSMO users and developers from Switzerland, share experience and knowledge about the COSMO model, and to get insights into some projects involving this model. Presentations could provide an overview of activities revolving around the COSMO model, the description of a technical problem, the presentation of results from a specific project, or the demonstration of a tool that can be useful for other COSMO users. 50 people registered for the COSMO User Workshop co-organized by C2SM and MeteoSwiss and held at ETH on 21 January 2018. Six new users of the COSMO model were briefly introduced, and 17 presentations were given highlighting the varied uses of COSMO within the Swiss user community. The program and presentations can be found at the C2SM wiki.

wiki.c2sm.ethz.ch/COSMO/EventsCUW2019

C2SM GCM User Meeting

The C2SM GCM User Meeting addresses GCM users of the C2SM community. Its goal is to strengthen the communication and synergies between global climate modeling users in IAC groups and C2SM partner institutions by learning about the research topics, methodologies, and modeling approaches of the other groups. On 10 July 2018, the workshop took place for the second time; 20 community members attended the event. We look back on a successful workshop with 14 presentations highlighting work from the atmospheric physics, climate and radiation, climate physics, atmospheric dynamics, and land-climate dynamics groups within the C2SM community. The program and presentations can be found at the C2SM wiki.

wiki.c2sm.ethz.ch/GCM/C2SMGCMUserWorkshop2018

Python visualization workshops

In 2018, C2SM in collaboration with Mathias Hauser from the Land-Climate Dynamics Group at the Institute for Atmospheric and Climate Science developed a two-day workshop to introduce interested researchers of the C2SM community to visualization in the Python programming language. The first workshop on 7-8 February 2018 was very well received by the C2SM community with all the seats being reserved within a couple of days and several people on the waiting list. Based on the strong interest from the community, the workshop was carried out on two more occasions, on 19-20 June and on 4-5 September 2018. Both workshops were fully booked. Based on its popularity and the very positive feedback from the attendees, the workshop is going to be continued on a regular basis. The next workshop is planned for June 2019.

Python visualization workshop

Data Management Information Event and Workshop

Good data management is a key prerequisite for effective data sharing and publishing increasing the visibility of one's scholarly work and likely increasing citation rates. Funding organisations like the Swiss National Science Foundation or Horizon 2020 mandate data management plans (DMPs) for projects they fund. The plans are already required at the proposal stage and should be updated throughout the project. In the field of weather and climate modeling, the massive amounts of data produced constitute a particular challenge in terms of data storage, reproducibility, and open accessibility.
On 5 March 2018, 29 C2SM community members attended C2SM's first Data Management Info Event and Workshop, which was organized in collaboration with ETH library and ETH Scientific IT Services (SIS). The event was split in two parts: in the morning, presentations on data management planning, active data management, publication of data, as well as data practices at the Institute for Atmospheric and Climate Science (IAC) and WSL provided comprehensive information on different aspects of data management from the time of their creation to publication also including valuable information on data management plans. In the afternoon, different core issues of data management in weather and climate science were discussed in different groups to come up with first ideas how to deal with these issues. In particular, a C2SM task force on data management was established, which over the course of 2018 regularly met with the aim to come up with recommendations for good data management practices in the field. The presentations, as well as information on data management plans, as well as two examples of DMPs can be found at the C2SM wiki.

wiki.c2sm.ethz.ch/DataManagement/WebHome

Outreach and Events

C2SM organized two events in 2018 targeting scientists, lay audience, and various stakeholders. One of them, Girls Day 2018, is described below. For a report on the Swiss Climate Scenarios CH2018 publication event, please see page 12.

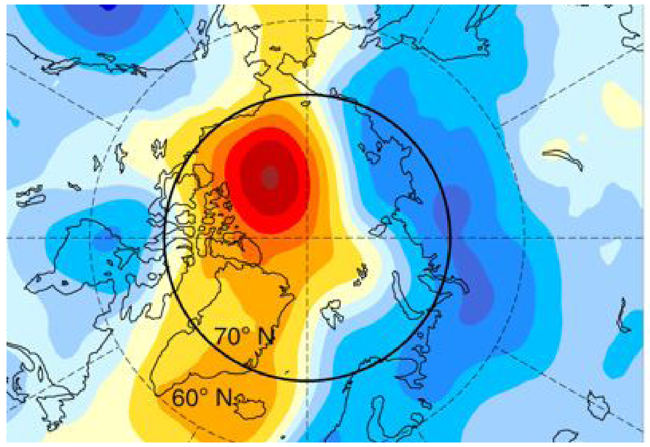
Girls Day 2018

The Institute of Atmospheric and Climate Science (IAC) Experimental Days for Girls is organized by C2SM every two years, alternating with the group of Prof. Ulrike Lohmann. On 17 July 2018, a group of 23 girls aged between 10 and 13 years visited IAC. In short presentations given by experts of the weather and climate sciences, they learned about what weather and climate are and how climate change endangers the world we know. The program also contained multiple workshops, in which the girls built weather instruments and conducted experiments on the global circulation, the greenhouse effect, as well as on aerosols and clouds. The program was advertised by the ProJuventute foundation and sponsored by ETH's gender equality office Equal!. The next Girls Day to be organised by C2SM will be carried out in 2020.

Girls Day 2018

Scientific Highlights

Role of polar anticyclones and mid-latitude cyclones for Arctic summertime sea-ice melting



Annual minima in Arctic sea ice extent and volume are decreasing rapidly since the late 1970s, with substantial interannual variability. Summers with a particularly strong reduction of Arctic sea ice extent are characterized by anticyclonic circulation anomalies from the surface to the upper troposphere. This study shows that these seasonal circulation anomalies are the result of individual Arctic anticyclones (with a lifetime of typically 10 days). Sea ice reduction is systematically enhanced during Arctic anticyclones and the summertime reduction of sea ice volume correlates with the area averaged frequency of Arctic anticyclones poleward of 70°N (correlation coefficient of 0.57, see Figure). These anticyclones are formed via the injection of air masses with low potential vorticity from the extratropical storm track regions into the Arctic upper troposphere. These results emphasize the fundamental role of extratropical dynamics in establishing Arctic anticyclones and in turn seasonal circulation anomalies, which are of key importance for understanding the variability of summertime Arctic sea ice melting.

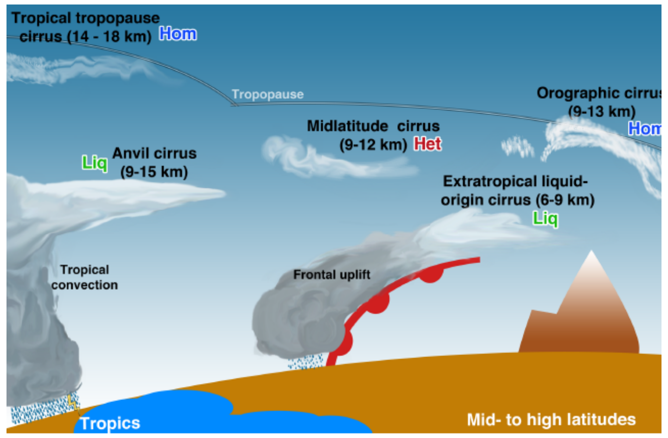
Wernli, H., and L. Papritz, 2018: Role of polar anticyclones and mid-latitude cyclones for Arctic summertime sea-ice melting, Nat. Geosci.,11,108–113, doi.org/10.1038/s41561-017-0041-0

How Predictable Are the Arctic and North Atlantic Oscillations? Exploring the Variability and Predictability of the Northern Hemisphere

The North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO) describe the dominant part of the variability in the Northern Hemisphere extratropical troposphere. Because of the strong connection of these patterns with surface climate, recent years have shown an increased interest and an increasing skill in forecasting them. However, it is unclear what the intrinsic limits of short-term predictability for the NAO and AO patterns are. This study compares the variability and predictability of both patterns, using a range of data and index computation methods for the daily NAO and AO indices. Small deviations from Gaussianity are found along with characteristic decorrelation time scales of around one week. In the analysis of the Lyapunov spectrum it is found that predictability is not significantly different between the AO and NAO or between reanalysis products. Differences exist, however, between the indices based on EOF analysis, which exhibit predictability time scales around 12–16 days, and the station-based indices, exhibiting a longer predictability of 18–20 days. Both of these time scales indicate predictability beyond that currently obtained in ensemble prediction models for short-term predictability. Additional longer-term predictability for these patterns may be gained through local feedbacks and remote forcing mechanisms for particular atmospheric conditions.

Domeisen, D., G. Badin, and I.M. Koszalka, 2018: How Predictable Are the Arctic and North Atlantic Oscillations? Exploring the Variability and Predictability of the Northern Hemisphere, J. Clim., doi:10.1175/JCLI-D-17-0226.1

Cirrus Cloud Properties as Seen by the CALIPSO Satellite and ECHAM-HAM Global Climate Model



Cirrus clouds impact the planetary energy balance and upper-tropospheric water vapor transport and are therefore relevant for climate. In this study cirrus clouds at temperatures colder than -40°C simulated by the ECHAM-Hamburg Aerosol Module (ECHAM-HAM) general circulation model are compared to Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite data. The model captures the general cloud cover pattern and reproduces the observed median ice water content within a factor of 2, while extinction is overestimated by about a factor of 3 as revealed by temperature-dependent frequency histograms. Two distinct types of cirrus clouds are found: in situ-formed cirrus dominating at temperatures colder than -40°C and liquid-origin cirrus dominating at temperatures warmer than -55°C. The latter cirrus form in anvils of deep convective clouds or by glaciation of mixed-phase clouds, leading to high ice crystal number concentrations. They are associated with extinction coefficients and ice water content of up to 1 km^{-1} and 0.1 g m^{-3}, respectively, while the in situ-formed cirrus are associated with smaller extinction coefficients and ice water content. In situ-formed cirrus are nucleated either heterogeneously or homogeneously. The simulated homogeneous ice crystals are similar to liquid-origin cirrus, which are associated with high ice crystal number concentrations. On the contrary, heterogeneously nucleated ice crystals appear in smaller number concentrations. However, ice crystal aggregation and depositional growth smooth the differences between several formation mechanisms, making the attribution to a specific ice nucleation mechanism challenging.

Gasparini, B., A. Meyer, D. Neubauer, S. Münch, and U. Lohmann, 2018: Cirrus Cloud Properties as Seen by the CALIPSO Satellite and ECHAM-HAM Global Climate Model, J. Clim., 31, 1983-2003, doi: 10.1175/JCLI-D-16-0608.1, 2018.

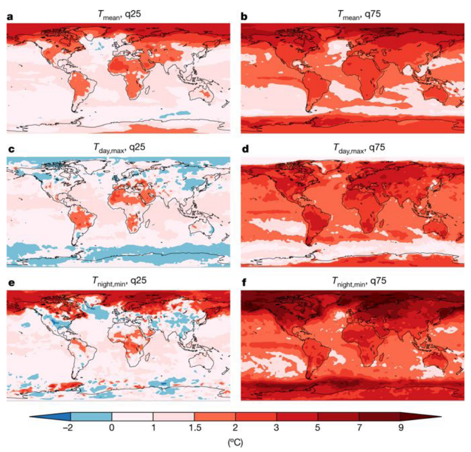
Future snowfall in the Alps

A recent paper by Prisco Frei and coauthors exploits the EURO-CORDEX regional climate scenarios to derive 21st century snowfall changes over the European Alps. Among others, a newly developed method to separate snowfall from total precipitation based on near-surface temperature conditions and accounting for sub-grid-scale topographic variability is employed. Snowfall projections reveal a robust signal of decreasing snowfall amounts over most parts of the Alps. Domain and multi-model mean decreases by the end of the century amount to –25 and –45 % for RCPs 4.5 and 8.5, respectively. Snowfall in low-lying areas in the Alpine forelands could be reduced by more than –80 %. These decreases are driven by the projected warming and are strongly connected to an important decrease in snowfall frequency and snowfall fraction and are also apparent for heavy snowfall events. In contrast, high-elevation regions could experience slight snowfall increases in mid-winter. These can be explained by a general increase in winter precipitation and by the fact that, with increasing temperatures, climatologically cold areas are shifted into a temperature interval which favors higher snowfall intensities.

The work originated from a Master thesis carried out in the "Climate and Water Cycle" group of ETH Zurich and has been jointly supervised by ETH and MeteoSwiss staff. It has been awarded the "Prix de Quervain 2017" Price for Polar and High Altitude Research and is available as MeteoSwiss scientific report.

Frei, P., S. Kotlarski, M. A. Liniger, and C. Schär, 2018: Future snowfall in the Alps: projections based on the EURO-CORDEX regional climate models, The Cryosphere, 12, 1-24, doi.org/10.5194/tc-12-1-2018

The many possible climates from the Paris Agreement's aim of 1.5 °C warming



The United Nations' Paris Agreement includes the aim of pursuing efforts to limit global warming to only 1.5 °C above pre-industrial levels. However, it is not clear what the resulting climate would look like across the globe and over time. In this paper, the authors show that trajectories towards a '1.5 °C warmer world' may result in vastly different outcomes at regional scales, owing to variations in the pace and location of climate change and their interactions with society's mitigation, adaptation and vulnerabilities to climate change. Pursuing policies that are considered to be consistent with the 1.5 °C aim will not completely remove the risk of global temperatures being much higher or of some regional extremes reaching dangerous levels for ecosystems and societies over the coming decades.

Seneviratne, S. I., J. Rogelj, R. Séférian, et al., 2018: The many possible climates from the Paris Agreement's aim of 1.5 °C warming, Nature, 558, 41-49, doi.org/10.1038/s41586-018-0181-4

Greenhouse gas fluxes over managed grasslands in Central Europe

Central European grasslands are characterized by a wide range of different management practices in close geographical proximity. Site-specific management strategies strongly affect the biosphere–atmosphere exchange of the three greenhouse gases (GHG) carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). The evaluation of environmental impacts at site level is challenging, because most in situ measurements focus on the quantification of CO_2 exchange, while long-term N_2O and CH_4 flux measurements at ecosystem scale remain scarce. Here, we synthesized ecosystem CO_2, N_2O, and CH_4 fluxes from 14 managed grassland sites. We found that grasslands were on average a CO_2 sink, but a N_2O source, and either a CH_4 sink or source. The net GHG balance (NGB) of nine sites where measurements of all three GHGs were available was found to be negative and ranged between −2,7 and −58 g $CO_{2\text{-eq.}}$ m^{-2} $year^{-1}$, with N_2O and CH_4 emissions offsetting concurrent CO_2 uptake. The only positive NGB was found for one site during a restoration year with ploughing. The predictive power of soil parameters for N_2O and CH_4 fluxes was generally low and varied considerably within years. The application of animal slurry to grasslands increased N_2O and CH_4 emissions. Although grassland management led to increased N_2O and CH_4 emissions, the CO_2 sink strength was generally the most dominant component of the annual GHG budget.

Hörtnagl, L., M. Barthel, N. Buchmann, et al., 2018: Greenhouse gas fluxes over managed grasslands in Central Europe, Glob. Change Biol., 24,1843–1872, doi.org/10.1111/gcb.14079

A global historical data set of tropical cyclone exposure (TCE-DAT)

Tropical cyclones pose a major risk to societies worldwide, with about 22 million directly affected people and damages of USD 29 billion on average per year over the last 20 years. While data on observed cyclones tracks and wind speeds are publicly available, these data sets do not contain information about the spatial extent of the storm and people or assets exposed. Here, we apply a simplified wind field model to estimate the areas exposed to wind speeds above 34, 64, and 96 knots. Based on available spatially explicit data on population densities and gross domestic product (GDP) we estimate (1) the number of people and (2) the sum of assets exposed to wind speeds above these thresholds accounting for temporal changes in historical distribution of population and assets and assuming fixed 2015 patterns. The associated spatially explicit and aggregated country-event-level exposure data (TCE-DAT) cover the period 1950 to 2015 and are freely available at https://doi.org/10.5880/pik.2017.011. It is considered key information to (1) assess the contribution of climatological versus socioeconomic drivers of changes in exposure to tropical cyclones, (2) estimate changes in vulnerability from the difference in exposure and reported damages and calibrate associated damage functions, and (3) build improved exposure-based predictors to estimate higher-level societal impacts such as long-term effects on GDP, employment, or migration. We validate the adequateness of our methodology by comparing our exposure estimate to estimated exposure obtained from reported wind fields available since 1988 for the United States. We expect that the free availability of the underlying model and TCE-DAT will make research on tropical cyclone risks more accessible to non-experts and stakeholders.

Geiger,T., K.Frieler,and D. N.Bresch, 2018: A global historical data set of tropical cyclone exposure (TCE-DAT), Earth Syst. Sci. Data, 10, 185-194, doi.org/10.5194/essd-10-185-2018

Marine Heatwaves are threatening marine ecosystems

Marine heatwaves (MHWs) are periods of extreme warm sea surface temperature that persist for days to months and can extend up to thousands of kilometres. Some of the recently observed marine heatwaves revealed the high vulnerability of marine ecosystems and fisheries to such extreme climate events. Yet our knowledge about past occurrences and the future progression of MHWs is very limited. Here we use satellite observations and a suite of Earth system model simulations to show that MHWs have already become longer-lasting and more frequent, extensive and intense in the past few decades, and that this trend will accelerate under further global warming. Between 1982 and 2016, we detect a doubling in the number of MHW days, and this number is projected to further increase on average by a factor of 16 for global warming of 1.5 degrees Celsius relative to preindustrial levels and by a factor of 23 for global warming of 2.0 degrees Celsius. However, current national policies for the reduction of global carbon emissions are predicted to result in global warming of about 3.5 degrees Celsius by the end of the twenty-first century, for which models project an average increase in the probability of MHWs by a factor of ~40. At this level of warming, MHWs have an average spatial extent that is approximately 20 times bigger than in preindustrial times, last on average ~110 days and reach maximum sea surface temperature anomaly intensities of 2.5 degrees Celsius. The largest changes are projected to occur in the western tropical Pacific and Arctic oceans. Today, a little less than 90 per cent of MHWs are attributable to human-induced warming, with this ratio increasing to nearly 100 per cent under any global warming scenario exceeding 2 degrees Celsius. Our results suggest that MHWs will become very frequent and extreme under global warming, probably pushing marine organisms and ecosystems to the limits of their resilience and even beyond, which could cause irreversible changes.

Frölicher, T. L., E. M. Fischer, and N. Gruber, 2018: Marine heatwaves under global warming, Nature, 560, 360-364, doi: 10.1038/s41586-018-0383-9

Regional climate models reduce biases of global models and project smaller European summer warming

The assessment of climate change is often based on complex model chains involving GCMs, RCMs and impact models. It is a common belief that the errors in such model chains behave approximately additive. If this hypothesis was true, the application of model chains would not lead to any intrinsic improvement except for higher-resolution details. Here, we investigate the bias patterns and climate change signals of two RCMs that have downscaled a comprehensive set of GCMs. Results show that the biases of the RCMs and GCMs are not additive and not independent. The two RCMs are systematically reducing the biases and modifying climate change signals of the driving GCMs, even on scales that are considered well resolved by the driving GCMs.

Sørland, S.L., C. Schär, D. Lüthi and E. Kjellström, 2018: Regional climate models reduce biases of global models and project smaller European summer warming. Env. Res. Lett., 13, 074017, doi.org/10.1088/1748-9326/aacc77.

Scientific Highlights

Key Publications of C2SM Members

Key Publications of C2SM Members

*For all publications with more than ten authors we cite the first author together with the author from the C2SM community

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Annex

As of 31 December 2018

Plenary Members

Steering Committee members

Prof. Nicolas Gruber, Chairman	ETH D-USYS	Environmental Physics
Dr. Mischa Croci-Maspoli	MeteoSwiss	Climate Change, Climate Services
Dr. Dominik Brunner	Empa	Atmospheric Modeling
Prof. Reto Knutti	ETH D-USYS	Climate Physics
Prof. Heini Wernli	ETH D-USYS	Atmospheric Dynamics
Prof. Niklaus Zimmermann	WSL	Landscape Dynamics

Regular members

Prof. Christof Appenzeller	MeteoSwiss	Analysis and Forecasting
Dr. Marco Arpagaus	MeteoSwiss	Numerical Predictions
Prof. David Bresch	ETH D-USYS, MeteoSwiss	Environmental Decisions
Dr. Brigitte Buchmann	Empa	Mobility, Energy and Environment
Prof. Nina Buchmann	ETH D-USYS	Grassland Sciences
Prof. Harald Bugmann	ETH D-USYS	Forest Ecology
Prof. Paolo Burlando	ETH D-BAUG	Hydrology and Water Resources
Prof. Jan Carmeliet	Empa, ETH D-MAVT	Building Science and Technology
Prof. Daniela Domeisen	ETH D-USYS	Atmospheric Predictability
Dr. Lukas Emmenegger	Empa	Air Pollution/Environmental Technology
Prof. Daniel Farinotti	ETH D-BAUG, WSL	Glaciology
Prof. Andreas Fischlin	ETH D-USYS	Terrestrial Systems Ecology
Dr. Oliver Fuhrer	MeteoSwiss	Numerical Predictions
Prof. Michael Lehning	WSL	Snow and Permafrost
Dr. Jens Leifeld	Agroscope	Air Quality and Climate
Dr. Mark Liniger	MeteoSwiss	Climate Prediction
Prof. Ulrike Lohmann	ETH D-USYS	Atmospheric Physics
Prof. Nicolai Meinshausen	ETH D-MATH	Statistics
Prof. Anthony Patt	ETH D-USYS	Human-Environment Systems
Prof. Thomas Peter	ETH D-USYS	Atmospheric Chemistry
Prof. Christoph Schär	ETH D-USYS	Climate and Water Cycle
Prof. Thomas Schulthess	ETH D-PHYS	Theoretical Physics
Dr. Cornelia Schwierz	MeteoSwiss	Climate Monitoring
Prof. Sonia Seneviratne	ETH D-USYS	Land-Climate Dynamics
Prof. Konrad Steffen	WSL	Climate and Cryosphere
Dr. Philippe Steiner	MeteoSwiss	Numerical Prediction
Dr. Reto Stöckli	MeteoSwiss	Climate Fundamentals
Prof. Heather Stoll	ETH D-ERDW	Climate Geology
Prof. Martin Wild	ETH D-USYS	Climate and Radiation

As of 31 December 2018

Scientific Advisory Board (SAB) Members

Scientific Advisory Board (SAB) members

Dr. Karin Ammon	ProClim, Bern, CH
Dr. Albert Klein Tank	Met Office, Exeter, UK
Prof. John Mitchell	University of Reading, Reading, UK
Dr. Jürg Füssler	INFRAS, CH
Prof. Bjorn Stevens	MPI-Meteorology, Hamburg, DE

The SAB has the mandate to advise the Center on strategic matters and 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
crCLIM	C. Schär (ETH)	SNF Sinergia	01/11/2014 - 31/10/2018
CH2018	R. Knutti, C. Schär (ETH)	MeteoSwiss	01/09/2015 - 31/12/2018
	C. Schwierz, M. Croci-Maspoli (MeteoSwiss)		
ESA SmartCarb	D. Brunner (Empa)	ESA	01/02/2017 - 30/04/2018
PASC ENIAC	U. Lohmann (ETH)	PASC	01/07/2017 - 30/06/2020
PASC PASCHA	T. Hoefler (ETH)	PASC	01/07/2017 - 30/06/2020
WEW-COSMO	P. Steiner (MeteoSwiss)	MeteoSwiss	01/01/2017 - 31/12/2020
PostCH2018	R. Knutti (ETH)	MeteoSwiss	01/09/2018 - 31/01/2019
Vorhersage COSMO	H. Wernli (ETH)	MeteoSwiss	01/07/2018 - 31/05/2019
Carbosense4D	D.Brunner (Empa)	SDSC	01/12/2017 - 31/12/2019

Reporting period (1 January 2018 - 31 December 2018)

Budget

Saldo (CHF) 01/01/2018	358'702

Income (CHF) 01/01/2018-31/12/2018	
ETH School Board	160'000
USYS Department	100'000
ETH members	47'000
MeteoSwiss	50'000
Empa	70'000
WSL	50'000
Agroscope	10'000
Third-party and project contributions *	43'424
SciViz Fees	14'310
Klimarunde 2017 (ESC contribution)	10'620
C2SM reserve fonds	11'119
Total income	**566'473**

Expenses (CHF) 01/01/2018-31/12/2018	
Salaries core staff	525'823
Events	12'328
Running costs	11'901
Travel	7'648
Data storage	12'603
Total expenses	**570'303**

Saldo (CHF) 31/12/2018	354'872

*The PASC PASCHA, WEW-COSMO, and Sinergia Paleofires projects have contributed to the core C2SM budget.