misuse of water appropriations by a major water user. These papers were followed by overviews on climate change with speakers outlining its effects on glacier melt, snow distributions, groundwater, lake water quality and agricultural water use. A special session focused on innovations to achieve sustainable groundwater use in India, where urban development and the W-E-F Nexus have large impacts.

Parallel sessions featured SWFP themes of water governance, ethics, water resource assessment, groundwater, urban water, the W-E-F Nexus and capacity development. In addition, topics covered security in the water space, monitoring Sustainable Development Goal 6 (SDG6) implementation and assessing changes in the hydrological cycle. Other sessions addressed water security in India and water infrastructure development challenges throughout the country. A special session on "Leaving no one behind: Digital water" focused on the use of new technologies such as big data, block chain technologies and Artificial Intelligence (AI).

A contingent from the Canadian Water Futures program node led discussions on the cryosphere in mountain regions. Their sessions, which have many links to the GEWEX program, addressed issues such as using Earth observations to measure glacier melt and to estimate water availability from snow melt. These discussions led to an agreement to develop a Future Earth Himalayan initiative proposal for the Southeast Asia Future Earth program.

The W-E-F Nexus and the challenges of implementing and monitoring SDG6 were also featured. The Indian government continues to invest in many areas of water research. GEWEX and SWFP could have a number of opportunities for joint work in India and Southeast Asia. The U.S. and Indian space agencies have collaborated on a joint mission known as the National Aeronautics and Space Administration (NASA)-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (SAR), or NISAR, mission. After its expected launch in 2022, it will provide new SAR data that will be optimized for monitoring hazards and global environmental change.

On the social side, our hosts were very attentive and kind. In addition to the support given at the meeting, site visits were arranged and a tour of Bengaluru was provided, which featured historical and cultural aspects of the city as well as some incidental exposure to monsoon type rains.

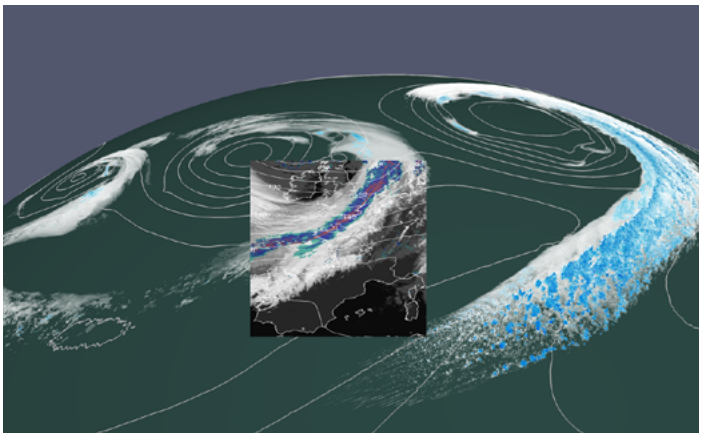
The draft statement from the conference involved a clear expression of intent to develop a data and information platform to support water management decision-making. This platform would take advantage of new information sources including satellites, big data and citizen data. The three main action areas for this development would include: 1) creating a digital environment, 2) creating the integrated platform architecture and 3) capacity development. This statement has been finalized and was introduced at the Budapest Water Summit in October 2019. Given the directions of this recommendation, it appears that there may be opportunities for the SWFP Data and Observations committee and other SWFP groups as well as GEWEX to become more active in developing the architecture of data services during the coming months and populating its data services with appropriate data sets and applications software.

The Latsis Symposium 2019– High-Resolution Climate Modeling: Perspectives and Challenges

Zürich, Switzerland
21–23 August 2019

Christoph Schär[1], Roy Rasmussen[2], Andreas Prein[2] and Christopher Castro[3]

[1]Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland; [2]National Center for Atmospheric Research, Boulder, CO, USA; [3]University of Arizona, Tucson, AZ, USA



The 2019 Latsis Symposium was hosted together with the 3rd GEWEX Workshop on Convection-Permitting Climate Modeling (CPCM) from August 21–23, 2019 at ETH Zürich in Switzerland. The symposium focused on scientific and technical challenges related to kilometer-scale global and regional climate modeling. It brought together climate modelers and computer scientists with the aim of addressing climate and weather time scales, the water cycle and extreme events, as well as emerging supercomputing platforms and software strategies.

The international symposium hosted 112 participants from 19 countries who delivered 11 invited presentations, 35 oral talks and 41 poster presentations. The topics spanned global to regional kilometer-scale modeling, numerical and computational approaches, atmospheric processes in current and future climates and kilometer-scale models for prediction across scales. The symposium consisted of ten oral sessions, four poster sessions and a panel discussion. PDFs of the presented slides can be accessed from the workshop website at *https://latsis2019.ethz.ch/programme/pdownloads.html*.

Compared to the first two GEWEX CPCM workshops in 2016 and 2018, there was a clear group consensus on the need to develop global kilometer-scale modeling capabilities. The inclusion of the computer science community at this symposium enabled discussion of this objective, especially regarding the capabilities and requirements of next-generation high-

performance computing systems. Achieving the goal of global kilometer-scale modeling will demand a major restructuring of current numerical modeling codes and close collaboration between the model development, computer science and hardware development communities. A computational speedup factor of ~100 will be necessary to run coupled global climate simulations with a horizontal grid spacing of 1 km at a rate of one simulation year per day. Strategies for achieving such a speedup were discussed at the workshop and focused around the variety of possible numerical approaches, using emerging hardware architectures with accelerators (e.g., graphics processing units), the use of domain-specific languages (DSLs), the exploitation of reduced precision, the use of new programming models to optimize data handling and workflows and the development of new strategies to cope with the output avalanche from high-resolution models.

Participants at the Latsis Symposium

Besides addressing the technical aspects for bridging the software and performance gaps of kilometer-scale global weather and climate models, major development efforts will be necessary to improve the representation of processes and feedbacks in such models (e.g., energy and mass conservation, the coupling of Earth system components, model physics). Initiatives such as the DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains (DYAMOND, *https://www.esiwace.eu/services/dyamond*) aim to address the challenges of global kilometer-scale models. DYAMOND consists of nine global atmosphere-only models with a horizontal grid spacing of 5 km or less that simulate a common 40-day period. An important approach towards global kilometer-scale modeling is to improve regional kilometer-scale climate models on continental-scale domains. This approach has the advantage of being able to simulate several decades instead of only weeks, allowing for a more systematic evaluation of model performance and facilitating an easier detection and improvement of model deficiencies, especially with regard to process representation. Simulations of this type were presented by several groups focusing on Europe, North America, Africa and the tropical Atlantic.

Multiple presentations focused on the added value of kilometer-scale compared to coarser-resolution models. Substantial and consistent progress was demonstrated in the representation of convective processes. Particularly large improvements were found in the tropics, where kilometer-scale models resolve persistent model biases by better representing tropical overturning circulation, substantially improve the representation of tropical clouds and wind systems and enhance sub-seasonal predictability in mid-latitudes by improving the simulation of the Madden-Julian Oscillation. These results demonstrate the ability of kilometer-scale models to capture complex, multiscale process interactions that range from the storm to synoptic scales.

Another active research area was the simulation of extreme events and how they change under global warming. Presentations focused on rainfall extremes from single thunderstorms to mesoscale convective systems, orographic precipitation extremes, hail, wind gusts and tropical cyclogenesis. The presentations showed significant skill in the simulation of all these phenomena once model horizontal scales of a few kilometers were reached.

An evening side meeting on "convective-permitting modeling for sub-seasonal to seasonal forecasting" took place in the ETH video center and was attended by 40–50 in-person and remote participants, representing countries throughout the world. While kilometer-resolution models have been used in the context of historical climate simulations and climate-change projections, their application to the sub-seasonal to seasonal (S2S) forecast timescale (weeks to months) is com-

paratively underexplored. During the forum, there were several overview presentations given by forum facilitators on the topics of convective-permitting modeling, the Coordinated Regional Downscaling Experiment (CORDEX) project and lessons learned from dynamical downscaling of seasonal forecasts in the United States. The presentations were followed by an open discussion, oriented to both scientific and logistical aspects of initiating a possible new CORDEX-like effort to dynamically downscale S2S reforecast products. Subsequent to the Latsis Symposium, facilitators will prepare a summary document that will be shared with the World Meteorological Organization, as well as follow-on presentations at the American Geophysical Union (AGU) and American Meteorological Society conferences within the United States. The facilitators will use the list of registered attendees of the forum as a basis for pursuing any community research efforts proceeding forward.

On the first evening of the event, a public lecture was held on the topic of why we need better climate models. The presentation by Reto Knutti provided an overview of climate change and the role of models in quantifying past and future changes and informing mitigation and adaptation decisions. It gave a broad perspective on the challenges and opportunities of the next generation of weather and climate models and their value to society. The lecture was attended by about 250 people from both the workshop and local community and was followed by a very active and interesting discussion.

The symposium closed with a panel discussion covering major challenges and opportunities in kilometer-scale modeling such as observational needs, future software and hardware demands, data volume and sharing, emerging science topics and the integration of high-resolution model results into larger-scale efforts such as the Climate Model Intercomparison Project (CMIP). The community realized that it is important to integrate institutions that do not have the necessary resources to run large kilometer-scale models into high-resolution modeling efforts. Furthermore, writing a community white paper was suggested as one of the outcomes of the meeting. This paper would outline the need and potential benefits of kilometer-scale climate models.

The 4th GEWEX Convection-Permitting Climate Modeling workshop will be held in Kyoto, Japan from September 2nd to 4th 2020 (*http://www.jmbsc.or.jp/tougou/WS2020/WS2020index.html*). Furthermore, a kilometer-scale climate modeling session (*https://agu.confex.com/agu/fm19/webprogrampreliminary/Session80373.html*) took place at the AGU Fall Meeting (San Francisco, U.S.A.; December 9–13, 2019) and another is planned for the European Geosciences Union (EGU) General Assembly (Vienna, Austria; May 3–8, 2020). Updates about these meetings and other community activities will be posted through the Convection-Permitting Climate Modeling community e-mail list (*ral-cpcm@ucar.edu*; to subscribe, send an e-mail to *prein@ucar.edu*).

2019 GEWEX Hydroclimatology Panel (GHP) Meeting

Sydney, Australia
11–12 October 2019

Joan Cuxart and Francina Dominguez
GHP Co-Chairs

Hosted by Jason Evans, the 2019 GHP Meeting and the Determining Evapotranspiration Workshop were held at the Climate Change Research Center (CCRC) of the University of New South Wales in Sydney, Australia. During the GHP meeting, participants shared and reviewed the status of current and future GHP projects. We also welcomed four new Panel members: Vidya Samadi of the University of South Carolina; Li Jia from the Earth Observation for the Water Cycle (EO-Water) Lab, part of the Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences; Ali Nazemi of Concordia University; and Andreas Prein of the National Center for Atmospheric Research (NCAR). Two other new members, Ivana Stiperski (University of Innsbruck) and Paola Arias (Universidad de Antioquia), could not be present. After seven years of excellent leadership, Jason Evans stepped down as co-chair of GHP at the end of the meeting. Francina Dominguez was appointed as the new co-chair of GHP. Silvina Solman ended her service as Panel member after her second three-year term.

GHP is comprised of three different types of projects: Regional Hydroclimate Projects (RHPs), an essential tool in understanding and predicting hydroclimates; Cross-Cut Projects (CCs), which encourage proliferation of knowledge from region to region, allowing the synthesis of results at a global scale; and Global Data Centers, which collect and distribute hydrologically-relevant data. The progress of ongoing and initiating GHP projects in each category was reviewed during the meeting.

Current Regional Hydroclimate Projects (RHP) and Cross Cut (CC) Projects

The Hydrological cycle in the Mediterranean eXperiment (HyMeX) RHP, focusing on the Mediterranean Basin, will end in 2020 after a 10-year span. There are still ongoing activities on convective precipitation in Corsica and on deep water formation in the Eastern Mediterranean. The last experimental campaign planned for April to October 2020 is the Land Surface Atmosphere Interactions over the Iberian Semi-Arid Environment (LIAISE) project, which concentrates on the effects of irrigation and terrain heterogeneity. The possibility of HyMeX transitioning to a GHP network was discussed.

The Baltic Earth RHP, concentrating on Earth system science for the Baltic Sea region, proceeds with its current main research themes, which include water oxygenation in coastal areas, marine ecosystems and climate variability and projections. The RHP is producing nine Baltic Earth Assessment Reports (BEARs) and has a large number of activities planned for the coming years.