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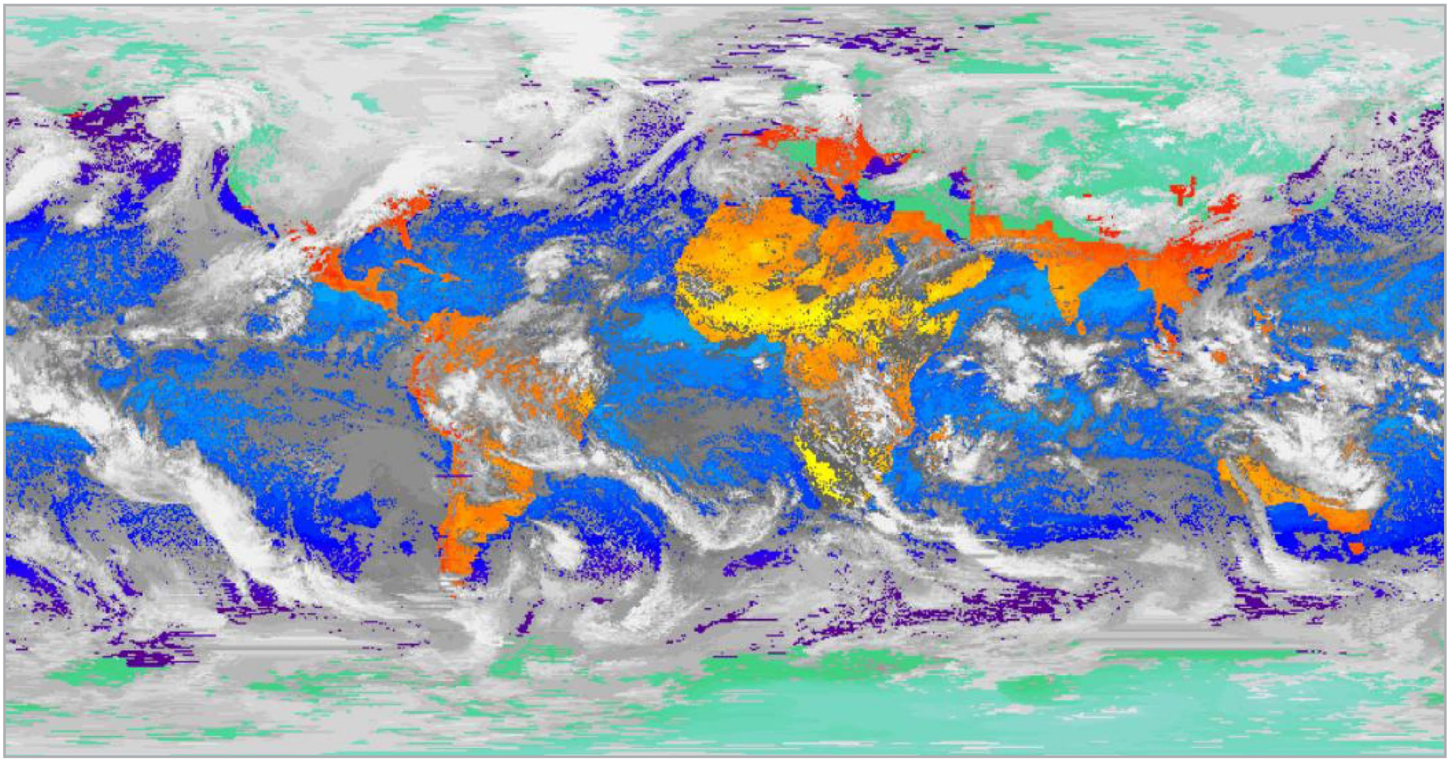
GEWEX is a Core Project of the World Climate Research Programme on Global Energy and Water Exchanges

40 Years of the International Satellite Cloud Climatology Project



The *History of the International Satellite Cloud Climatology Project* report covers 40 years of the International Satellite Cloud Climatology Project (ISCCP), from its inception to its current conceptual framework of understanding the full role of clouds in weather and climate variation. The evolution of ISCCP included two version updates: the first led to better understanding of cloud types and their vertical structures, and the second helped to support cloud process studies by taking advantage of advances in satellite measurements. For more, see Rossow on pg. 8; image above is "Global HX Picture", courtesy of William B. Rossow and Alison W. Walker.

Inside This Edition

Commentary

Jan Polcher
Co-Chair, GEWEX Scienctific Steering Group

The last 2022 issue of *GEWEX Quarterly* is a good opportunity to revisit the major events of the year. 2022 has been particularly exciting for our panels because we resumed our in-person meetings. First and foremost, the 3rd Pan-GASS Meeting was held in Monterey, California, USA, which drew more than 200 participants. The 6th Workshop on Convection-Permitting Climate Modeling was organized by the University of Buenos Aires and allowed discussion of the challenges brought on by kilometric scale climate modeling. It is essential for the engagement of the community to be able to meet and informally discuss ideas and debate the results obtained. We all know from experience that exchange with our peers is essential for the progress of our own understanding, and we are happy that this could resume in 2022.

The Scientific Steering Group (SSG) of GEWEX also conducted the evaluation and strategic planning for our program in person this year. The SSG met in Paris for a first discussion of where we stand and how we are progressing in our collaborations with other World Climate Research Programme (WCRP) projects. The second meeting was in parallel to the Pan-GASS Meeting and allowed the SSG to exchange with space agencies and other WCRP programs, and in particular, to discuss how to increase the engagement of scientists from the global South in our program. All members of the committee were happy to be able to discuss our progress face-to-face.

In 2022, GEWEX also took leadership of two important actions of WCRP. We have accepted to take the initiative on a Global Precipitation Experiment, which should in the coming years help us improve the observation and prediction of this essential flux and further our understanding of the processes involved. WCRP would also like to develop a better understanding of the state of the art on the quantification of the various cycles of the Earth system and which assumptions are being made to achieve closure. These efforts should cover all disciplines and expertises within WCRP. But as they have a strong overlap with our science goals, we believe that it is essential for GEWEX to take leadership. This year we also proposed helping to implement the new strategy of the World Meteorological Organization (WMO) on hydrology and water resources by advancing the dialogue between hydrological services and the climate research community. One question we believe needs to be addressed urgently is the characteristics future forecasting systems need to have in order to be reliable for a non-stationary water cycle in a changing climate and with evolving land and water uses.

With the resumption of in-person conferences and meetings and the new initiatives started, 2023 will be a busy year. But it is also one where we hope GEWEX will make progress on its scientific goals and our ambition to further our understanding of the water and energy cycles of the Earth.

New GEWEX Panel Members

A former co-lead of the GEWEX Cloud Assessment and member of the GEWEX Data and Assessments Panel (GDAP) for 11 years, Dr. Stubenrauch now joins the Global Atmospheric System Studies (GASS) Panel as the lead for the GEWEX Upper Tropospheric Clouds and Convection Process Evaluation Study (UTCC PROES) Working Group, which intends to build a bridge between GASS and GDAP. She has previously served as a Review Editor on the International Panel of Climate Change Assessment Report 5 (AR5) and an expert reviewer for AR6, and is a member of the scientific advisory boards for the National Center for Atmospheric Research (NCAR) Climate Data Guide and the French Data Centre AERIS. Her research interests focus on the role of upper tropospheric cloud systems in the modulation of Earth's climate.

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New GEWEX Panel Members (Con't)

Hiro Masunaga is the new Co-Chair of the GEWEX Data and Analysis Panel (GDAP), replacing his predecessor, Rémy Roca, and working with the continuing Co-Chair, Tristan L'Ecuyer. Hiro is currently Associate Professor at the Institute of Space-Earth Environmental Research (ISEE) of Nagoya University in Nagoya, Japan. After receiving his Ph.D. in astrophysics from the University of Tokyo in 1999, he pursued his research career as an atmospheric scientist at the University of Tokyo, National Space Development Agency of Japan (NASDA, currently Japan Aerospace Exploration Agency or JAXA), and Colorado State University before joining Nagoya University. His research interests are centered on satellite meteorology and climatology with focus on tropical convection and dynamics. Hiro is a 2019 recipient of the Award of the Meteorological Society of Japan.

He has been involved in different bilateral or international initiatives related to present and future Earth-observing satellite missions including the National Aeronautics and Space Administration (NASA)-JAXA Joint Precipitation Measurement Mission Science Team (JPST) and the NASA Atmospheric Observing System (AOS) Algorithm Working Group. He currently serves as a Co-Chief Editor of the *Journal of Meteorological Society of Japan*. As a GDAP Co-Chair, he wishes to help the science community further assess the global and regional water/energy budget and imbalances by the innovative use of observations and numerical models.

Benoit Meyssignac is a researcher at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS) in Toulouse, France. After obtaining his Ph.D. from Toulouse Paul Sabatier University, he joined the French Space National Center (CNES). Benoit was a lead author of the Special Report on Ocean and Cryosphere of the Intergovernmental Panel on Climate Change, and served as an editor for *Journal of Geodesy*. He has been active in the World Climate Research Programme (WCRP) as a co-chair of the WCRP Grand Challenge on regional sea level rise and coastal impacts. Through the combined use of high precision geodetic observations and climate models, his research led to new insights on the response of the global energy–water cycle to climate change. By joining the GDAP Panel as a member, he wishes to promote geodetic observational and modeling studies of the energy–water cycle processes that can both contribute to improving models and to address challenging science questions that are at the core of climate research.

Helen Brindley has recently been elected as a member of GDAP. Professor Brindley is Deputy Head of the Space and Atmospheric Physics Group at Imperial College London. She also serves as a Divisional Director of the UK's National Centre for Earth Observation, overseeing research focused on the Earth's energy and water cycles, including climate model evaluation. A key theme throughout her career has been the concept of using temporally and spectrally resolved measurements of the Earth's outgoing radiation to disentangle the impacts of different climate forcers from feedback processes while properly accounting for natural variability in the climate system. Accordingly, she is principal investigator for the Geostationary Earth Radiation Budget (GERB) experiment and is playing a leading role in the European Space Agency (ESA)'s Far infrared Outgoing Radiation Understanding and Monitoring (FORUM) Earth Explorer. She is excited to become part of the GEWEX community, especially in the light of the new missions and initiatives that will come onstream in the next few years.

Maria Hakuba joins the GEWEX GDAP Panel as a new member. Currently, she is a research scientist in the Aerosols and Clouds group at Jet Propulsion Laboratory (JPL) in Pasadena, California. She is deputy PI for Libera, NASA's recent Earth Venture Continuity selection for future Earth radiation budget observations. She is the principal investigator of a JPL project that investigates radiation pressure accelerations acting on spherical spacecrafts to study the feasibility of a direct Earth energy imbalance (EEI) measurement from space. She studies Earth's energy and water cycles, exploiting satellite and surface observations as well as climate models. Having expertise with EEI assessments and relevant observations from space, she will extensively support GDAP's New Integrated Assessment on Earth's Energy Imbalance. She is a member of the committee organizing the upcoming workshop on EEI Assessments, organized by WCRP-GEWEX and the European Space Agency (ESA). Maria is also an active panelist of Global Climate Observing System (GCOS) Atmospheric Observation Panel for Climate (AOPC), co-chairs the American Meteorological Society (AMS) committee on atmospheric radiation, and is commissioner of the International Radiation Commission.

YESS Presence at the 13th AARSE Meeting and the YESS Regional Webinar Series

Faten Attig-Bahar[1], Gerbrand Koren[2], Valentina Rabanal[3], and the YESS Executive Committee

[1]University of Carthage, Tunisia Polytechnic School, Al Marsa, Tunis, Tunisia; [2]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, the Netherlands; [3]Servicio Meteorológico Nacional (SMN), Buenos Aires, Argentina

The Young Earth System Scientist (YESS) community, the Global Energy and Water Exchanges project (GEWEX), and the Young Hydrological Society (YHS) were pleased to host a one-day workshop as a side event of the 13th African Association of Remote Sensing of the Environment (AARSE) International Conference on Earth Observations and Geospatial Science in the service of Sustainable Development Goals, organized by AARSE and the Institut d'Enseignement Supérieur de Ruhengeri (Ines-Ruhengeri) in Kigali, Rwanda. The workshop's main goal was to raise the voice of Early Career Researchers (ECRs) in the related research topics and prepare for the participation of ECRs and the climate research-interested community in the WCRP Open Science Conference to be held in Kigali, Rwanda, in October 2023. During the one-day event, three talks were provided by senior scientists followed by a discussion roundtable that aimed to explore and reflect on the role of African Early Career Researchers and ECR networks in advancing and promoting Earth observations and geospatial science. This workshop was supported and sponsored by the World Climate Research Program (WCRP), GEWEX, and the World Meteorological Organization (WMO).

In addition, the YESS community has organized webinars that are targeted to ECRs from selected regions. On October 11th, the webinar "Compartimos Ciencia ('Sharing Science')" was organized for Latin America that featured two connected topics presented by Julia Mindlin and Palmira Cuéllar and a discussion afterwards. To reach a larger audience and lower the barrier for active participation, the webinar was organized in Spanish. The YESS community remains committed to bringing science to ECRs that are non-native English speakers. On November 24th, a European webinar was scheduled that focused on the recent perspective article by YESS member Shipra Jain about concerns related to data-intense projects in science (*https://doi.org/10.1029/2022AV000676*). The webinar was moderated by the European representatives and presentations were given by YESS members Valentina Rabanal, Gaby Langendijk, and Gerbrand Koren. The European webinar was organized online in Zoom to stimulate interaction with and between the participating ECRs. Finally, the participants of the webinar–and the readers of the GEWEX newsletter–are encouraged to voice their opinion of the increasing data intensity of climate science research projects through the form at *https://forms.gle/hbWgwKjbiytCdJ9X6*.

Attention Student and Early Career Scientists!

Danyka Byrnes[1] and Dan Myers[2]

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We at the Hydrology Section Student Subcommittee for the American Geophysical Union (AGU-H3S, *agu-h3s.org*) are wrapping up for the 2022 year. But not before the AGU Fall Meeting in Chicago! We have an exciting lineup of events for early career scientists to develop professionally, network, and explore.

H3S Membership Applications are open! If you are interested in joining H3S and being part of the 2023–2024 cohort, you can find applications at *tinyurl.com/AGUH3SMembershipApplication*. If you want to talk to one of our members about their experiences, contact us through our website or find us at the AGU Fall Meeting. Applications close December 23rd, 2022.

H3S convened a series of sessions and other events at the AGU Fall Meeting, including:

- Building Your Network: Collaborating as an Early-Career Hydrologist
- Engaging in Diversity, Equity, and Inclusion (DEI) Initiatives as an Early Career Researcher
- A Cross-Career Stage Conversation about AGU Hydrology Section Initiatives
- Early Career & Student Trivia

We'd like to extend a huge thank you to the community and to the H3S members who have made our events and programs successful this year. We are confident that H3S has a bright future under the leadership of our 2023 chair, Danyka Byrnes, and the new chair-elect, Paige Becker. Engage with us on Twitter (twitter.com/AGU_H3S), Facebook (*tinyurl.com/h3s-faceb*), LinkedIn (*tinyurl.com/h3s-linkedin*), and our newsletter (*https://agu-h3s.org/contact-us/*) to keep up-to-date on exciting opportunities.

What H3S members said about how being part of H3S has benefited them.

Explaining and Predicting Earth System Change: A World Climate Research Programme Call to Action

Kirsten L. Findell[1], Rowan Sutton[2], and Nico Caltabiano[3]

On behalf of the EPESC Lighthouse Activity Scientific Steering Group and Science Plan Team

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A longer version of this article is available in early online release form (*https://journals.ametsoc.org/view/journals/bams/aop/BAMS-D-21-0280.1/BAMS-D-21-0280.1.xml?rskey=U8KERB&result=1*) from *The Bulletin of the American Meteorological Society*.

Abstract

The World Climate Research Programme (WCRP) envisions a world "that uses sound, relevant, and timely climate science to ensure a more resilient present and sustainable future for humankind." This bold vision requires the climate science community to provide actionable scientific information that meets the evolving needs of societies all over the world. To realize its vision, WCRP has created five Lighthouse Activities to generate international commitment and support to tackle some of the most pressing challenges in climate science today.

The overarching goal of the Lighthouse Activity on Explaining and Predicting Earth System Change is to develop an integrated capability to understand, attribute, and predict annual to decadal changes in the Earth system, including capabilities for early warning of potential high impact changes and events. This article provides a brief overview of both the scientific challenges that must be addressed, and the research and other activities required to achieve this goal. The work is organized in three thematic areas: (i) monitoring and modeling Earth system change; (ii) integrated attribution, prediction, and projection; and (iii) assessment of current and future hazards. Also discussed are the benefits that the new capability will deliver. These include improved capabilities for early warning of impactful changes in the Earth system, more reliable assessments of meteorological hazard risks, and quantitative attribution statements to support the Global Annual to Decadal Climate Update and State of the Climate reports issued by the World Meteorological Organization.

Introduction

The formulation of robust policies for mitigation of, and adaptation to, climate change requires quantitative understanding of how and why specific changes are unfolding in the Earth system, and what might happen in the future. Quantitative explanation of observed changes—through robust process-based detection and attribution—is also fundamental to specification of confidence in climate assessments, predictions, and projections. However, the capacity to deliver these capabilities is very limited, particularly for the annual to decadal (A2D) timescales that lie between the timescales of days-to-seasons—the focus of numerical weather prediction (NWP) and seasonal forecasting—and the multi-decadal-to-century timescales that are the primary focus of climate projection efforts. The World Climate Research Programme (WCRP) Lighthouse Activity (LHA) on Explaining and Predicting Earth System Change (EPESC) is intended to address this need. The overarching objective of this activity is: **To design, and take major steps toward delivery of, an integrated capability for quantitative observation, explanation, early warning, and prediction of Earth system change on global and regional scales, with a focus on annual to decadal timescales**.

On global-to-regional and A2D scales, changes in oceanic and atmospheric circulation and their consequent impacts are of particular interest because of their importance in shaping hazards, and because current capabilities to explain and predict changes in circulation are particularly limited. Some examples of changes of interest include the rapid warming of the North Atlantic Ocean that occurred in the 1990s (e.g., Robson et al., 2012; Yang et al., 2016; Cheng et al., 2017; Yeager, 2020); weakening of the North Atlantic subpolar gyre (Häkkinen and Rhines, 2004; Piecuch, 2017); changes in the phase of the Interdecadal Pacific Oscillation (e.g., Thoma et al., 2015; Meehl et al., 2016); persistent marine heatwaves such as in the North Pacific during 2013–16 (e.g., DiLorenzo and Mantua, 2016; Oliver et al., 2018); persistent droughts such as in the Sahel during the 1970s and 1980s (e.g., Held et al., 2005); and the apparent slow-down in global mean surface temperature rise that was observed in the 2000s (e.g., England et al., 2014; Fyfe et al., 2016). This last example is a particularly fitting case study of how natural decadal variability on top of long-term trends can combine to produce a long-lasting signal that can capture both research and public attention (Fyfe et al., 2016; Risbey et al., 2018).

This LHA is concerned both with events that have A2D duration and also with understanding how regional and larger-scale changes (e.g., broad atmospheric or oceanic circulation changes) on these timescales influence the characteristics of hazards (e.g., severe convective storms, tropical and extratropical cyclones, atmospheric rivers, terrestrial and marine heat waves, wildfires, etc.) occurring on shorter space and timescales. Examples of A2D variability influencing hazards can be found in the impact of Atlantic multidecadal variability on tropical cyclones in the Caribbean basin (Goldenberg et al., 2001) or of the El Niño-Southern Oscillation (ENSO) on droughts in the United States (e.g., Trenberth et al., 1988; Schubert et al., 2009; Findell et al., 2010) or on fire weather in Australia (Squire et al., 2021) and their secondary impacts (Damany-Pearce el al., 2022). Physical predictions on A2D timescales can be useful even for marine biological forecasting (Minobe et al., 2022).

Given the breadth of the targeted goals, we have found it useful to organize the scientific challenges and opportunities around three major themes with associated working groups:

- **Theme 1: Monitoring and Modeling Earth System Change;**

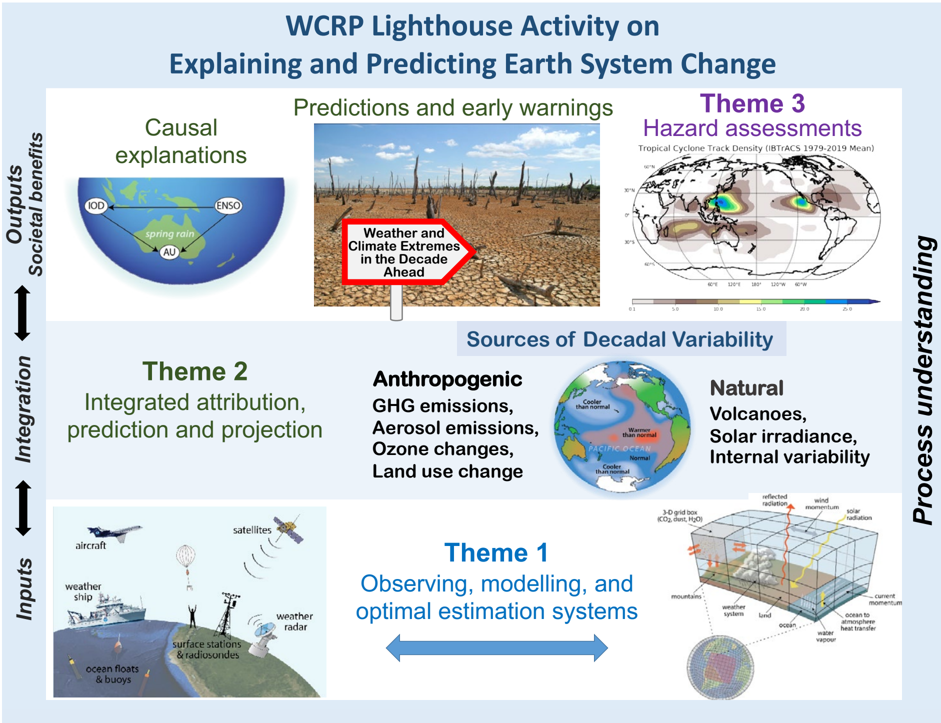

***Figure 1**. Key elements of the Lighthouse Activity. The bottom layer shows the importance of coordinated observational and modeling efforts serving as key tools and inputs to the integrated attribution, prediction, and projection efforts in the middle layer. Both of these layers feed into the outputs and societal benefits displayed in the top layer: causal explanations, predictions and early warnings, and hazard assessments. Arrows along the left side indicate that outputs (Themes 2 and 3) and integration (Theme 2) can feedback to improve the inputs (Theme 1). Fundamental physical process understanding runs through all aspects of the Lighthouse Activity. (Causal explanations figure following Kretschmer et al., 2021.)*

- **Theme 2: Integrated Attribution, Prediction, and Projection of Earth System Change;** and
- **Theme 3: Assessment of Current and Future Hazards.**

Fig. 1 provides an overview of the three scientific themes, how they interact, and how they will deliver benefits to society. Expertise in many areas relevant to these themes is found in WCRP's core projects and other Lighthouse Activities. Active communication between EPESC and other WCRP entities is crucial to the success of this endeavor.

Three cross-cutting dimensions connect the work of the LHA's three thematic elements. First, the development of a capability to observe, explain, and predict changes in the Earth system requires the **tight integration of observations and models**, including characterization and quantification of uncertainties. Comprehensive model calibration and evaluation of model skill each require not only observational data sets that capture the phenomena of interest, but also computational frameworks for achieving rigorous model calibration. Just as observations can be used to confront models, calibrate model parameters, and determine model skill, models can be leveraged as tools to inform the design of efficient, targeted observing systems (e.g., Fujii et al., 2019; Cheng and Zhu, 2016). We envision an interactive workflow between model and observing system improvement, as both represent incomplete yet complementary knowledge bases. Similarly, identification of causal factors and processes leading to large-scale climate regime shifts or changes in regional hazard risk require integrated usage of both observations and modeling systems.

Second, initial steps to develop a capability to observe, explain, and predict Earth system change will focus on a few (two or three) compelling **case studies** targeting climate "events" that have occurred in recent decades, such as the examples given above. Through these case studies, we seek to develop a systematic approach across all three themes to identify causal factors shaping these events, to assess the potential for predictions of the events themselves, to investigate opportunities for observations targeted at realizing predictability of the events, and, where relevant, to determine the impact of the event on hazard likelihoods.

Finally, we envisage that **large ensembles of single-forcing experiments** will inform the activities at the heart of each of the themes. These are essential to characterize the responses to different forcing factors, thereby informing observing system design (Theme 1), providing quantitative process-based attribution (Theme 2), and improving our understanding of the drivers of changing hazard frequencies and intensities (Theme 3).

Theme 1: Monitoring and Modeling Earth System Change

Key Research Questions:

- What are the observational and modeling requirements to measure, explain, and predict changes in the Earth system on A2D and regional to global scales?
- How can we most effectively combine observations and models to quantify, explain, and predict changes in the Earth system on A2D and regional to global scales?
- Which enhanced observations will offer the greatest improvements in predictive and explanatory skill, and where should those enhancements be targeted?

Theme 2: Integrated Attribution, Prediction and Projection of Earth System Change

Key Research Questions:

- How can we best identify and attribute the drivers of changes in the Earth system on global-to-regional and A2D scales?
- What are the requirements for an operational integrated attribution and prediction capability focused on global-

to-regional and A2D scales to provide early warnings to inform decision making?

Theme 3: Assessment of Current and Future Hazards

Key Research Questions:

- How do internal variability and external forcings influence the characteristics and occurrence of meteorological hazards on A2D scales in different regions?
- How can we use observations, models, and process understanding to deliver robust assessments of current and future hazards for specific regions and hazard classes?

Conclusions

The WCRP's new Lighthouse Activities constitute a bold effort to tackle some of the most persistent and difficult issues in climate science today. These efforts will require close collaboration with many different groups within WCRP and beyond to undertake a full, integrated assessment of our observational and modeling capabilities that cross component (ocean, atmosphere, land, ice) and disciplinary boundaries, and help push forward the capabilities of explanation, prediction, and uncertainty quantification for annual to decadal timescales. We see broad areas of common scientific interest between GEWEX and EPESC, including issues related to the attribution and prediction of changes in Earth's water cycle. We look forward to co-sponsoring a session at the 2023 WCRP Open Science Conference on this topic.

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History of the International Satellite Cloud Climatology Project

William B. Rossow

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The International Satellite Cloud Climatology Project (ISCCP) was established 40 years ago as the first project of the World Climate Research Programme (WCRP) to provide a globally uniform cloud climatology for climate research. WCRP Report 6/2022 (*http://doi.org/10.13021/gewex.isccp*) recounts the history of this project from the early planning, through development and two revisions of the data collection and processing approach, to its current operational phase, emphasizing the evolution of the project concept and how that evolution shaped the characteristics of the data products.

The earliest concept for the use of the data products was to quantify cloud effects on the top-of-atmosphere (TOA) radiation budget and check the fidelity of climate model representations of these effects. A more specific articulation of the tasks required and better definition of the needed cloud properties led to the extension of this concept to encompass cloud effects on both TOA and surface radiation, which also motivated the establishment of the Surface Radiation Budget (SRB) and Baseline Surface Radiation Network (BSRN) projects. In the 1980s and 1990s, BSRN, together with ongoing and planned NASA radiation budget satellite missions (Nimbus-6/7 and the Earth Radiation Budget Experiment, ERBE), would provide more direct evaluations of the fluxes calculated using the ISCCP cloud products. The first version of the data products, ISCCP-C, covered July 1983 through June 1991. Significant achievements by the time of the completion of the first version of the data products in the early 1990s were: (1) establishment of the first absolute radiance calibrations for the global constellation of weather satellite imaging instruments, (2) development and thorough testing of a cloud detection procedure based on a quantitative evaluation of available methods, (3) demonstration that usefully accurate determinations of cloud radiative effects on the TOA and surface fluxes could be obtained by employing radiative models for retrieval and flux calculation using the same cloud microphysics and ancillary data (ISCCP-FC and SRB), and (4) provision of almost a decade of globally uniform depictions of diurnal, synoptic, and seasonal cloud variations. However, in the 1980s, detailed knowledge of ice clouds was lacking, so this first version of the cloud products treated all clouds as liquid. Better information about ice clouds was developed in the late 1980s and early 1990s from an international set of field experiments (led by the U.S., Japan, and Europe) and early satellite retrievals of ice cloud properties, which led to a second version of the products in the mid-1990s that included a separate treatment of ice and liquid clouds.

The organization of GEWEX in 1989–1990 expanded the concept of the role of clouds in climate to include radiation and precipitation. This broader concept motivated the reporting in the second version of the ISCCP products, beginning in the mid-1990s, of both radiative and bulk mass cloud properties as well as the release of the higher resolution (pixel-level with 32 km, 3 hr sampling) products for cloud process studies. The processing of the second version of the data products, ISCCP-D, extended from the mid-1990s into the early 2010s: ISCCP-D finally covered July 1983 through December 2009. Using the second version of the products led to a better understanding of cloud type distributions and their vertical structures, which allowed the estimation of cloud effects on radiative flux profiles (ISCCP-FD). The release of the radiative flux products (SRB and ISCCP-FD) represented achievement of one of the primary goals of ISCCP: separating the TOA radiation budget into its surface and atmospheric components to evaluate cloud-radiative feedbacks on atmospheric and oceanic circulations. In addition, analyzing patterns in mesoscale cloud property distributions (cloud regimes or Weather States) helped advance understanding of the related variations of clouds, radiation, and precipitation in different meteorological conditions. All of these studies supported development of more comprehensive evaluations of cloud process feedbacks on the energy and water cycle with early emphasis on diagnosing these feedbacks on weather-scale to seasonal and slower climate variations [e.g., Madden-Julian Oscillation (MJO), African Easterly Wave (AEW), and El Niño events). Study results by the 2000s suggested that cloud-radiation-dynamics feedback is positive for storm systems (including large scale events like MJO and AEW), reinforcing latent heating feedback from precipitation, and negative in fair weather conditions, and that the combination of weather-scale effects enhances the equator-to-pole heat transport by the atmosphere and decreases the transport by the ocean.

The advent of more advanced satellite cloud measurements in the late 1990s and 2000s, notably Moderate-resolution Imaging Spectroradiometer and Polarization and Directionality of Reflectance (MODIS and POLDER), Advanced Infra-Red Sounder and Infrared Atmospheric Sounding Interferometer (AIRS and IASI), Special Sensor Microwave Imager and Advanced Microwave Radiometer (SSMI and AMSR), and CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), supported a second revision of the ISCCP products by refining the radiance calibrations and revising the assumed properties of clouds in the retrieval models. In particular, the cloud particle size, phase, and vertical layer structure were revised in both the retrieval and flux calculation models. Increased computer capabilities also allowed switching the processing from the 32-km-sampled to the 8-km-sampled imaging data and creating a pixel-level product that is globally-merged at 0.1° every 3 hr for better tracking of cloud systems. These changes enhanced the usefulness of the ISCCP products for cloud process studies in com-

Founders and facilitators of ISCCP at the 30th anniversary symposium. Clockwise from lower left: Robert A. Schiffer [founder, International Project Manager, National Atmospheric and Space Administration (NASA)/USA], Thomas Vonder Haar [founder, Chairman of Working Group for Radiative Fluxes (WGRF) oversight, representative of the International Radiation Commission (IRC), Colorado State University (CSU)/USA], William B. Rossow [head of the ISCCP Global Processing Center (GPC), 2nd Chairman GEWEX Radiation Panel (GRP) oversight, later Project Manager, NASA/City College of New York (CCNY)/USA], Christian Kummerow (3rd Chairman GRP oversight, CSU/USA), Ehrhard Raschke [founder, representative of IRC, member of WGRF, U. Koln/U. Hamburg/Max Planck Institute (MPI)/Germany]. Not pictured: Garth Paltridge [founder, Commonwealth Scientific and Industrial Research Organization (CSIRO)/Australia], Pierre Morel (founder, Director WCRP Joint Planning Staff, France), Roy Jenne [founder, National Center for Atmospheric Research (NCAR)/USA], Graeme Stephens [1st Chairman GRP oversight, CSU/Jet Propulsion Laboratory/USA].

bination with the newer satellite measurements. In the 2010s, there was also a growing emphasis on extending the length of record for climate studies to provide long-term background context for field experiments and advanced satellite measurements, which usually have limited space-time sampling or coverage. This purpose led to the decision to transition the project to a fully-operational organization to maintain and extend the record. Today, the ISCCP record covers 1983 through 2018, but will soon be extended. Similar action is needed for other global data products to build up a more comprehensive global observing system.

The evolution of the ISCCP concept under GEWEX in the 2000s encompassed the complete role of clouds in the weather and climate variations of the energy and water cycle. The global pixel-level product allows tracking of meteorological systems to directly estimate the bulk cloud process time derivatives for comparison with weather and climate models. Thus far, the ISCCP datasets have been used to quantify (1) the cloud effects on radiative fluxes at 3 hr, 100 km intervals covering the globe for multiple decades, separated by cloud types and weather states and including estimates of vertical profiles in the atmosphere; (2) the cloud properties associated with different kinds of weather systems; (3) the cloud properties associated with differing precipitation rates; and (4) Lagrangian cloud system dynamics for tropical convection, tropical cirrus, subtropical marine stratus, and extratropical cyclones. Ongoing studies using ISCCP products will include the diagnosis of cloud processes on the exchanges of radiative and latent energy and the evolution of cloud properties over the lifecycle of tropical and extratropical storms and during slower atmospheric variations. Together with products from other GEWEX projects [SRB/BSRN, Global Precipitation Climatology Project (GPCP)/Global Precipitation Climatology Center (GPCC), GEWEX Water Vapor Project (GVAP), GEWEX Aerosol Climatology Project (GACP), SEAFLUX, LandFlux] combined into the GEWEX Integrated Product, direct and systematic quantitative estimates could now be made of cloud feedbacks on weather systems and on atmospheric and oceanic variations on scales from intra-seasonal to multi-decadal.

In 2022, a new opportunity exists because all operational weather satellite imagers have (at least) 10 common spectral channels. These extra channels would allow pixel-level retrieval of more cloud microphysical information (particle size and phase), the key to connecting cloud variations with precipitation, and of better information about overlapping cirrus, both of which would improve both the cloud property retrievals and the radiative flux determinations. The increased imaging frequency now common to these satellites would allow a reduction of the time sampling interval to at least 30 min, still with global coverage (with multiple polar orbiters), and allow for better study of the connection of smaller-scale turbulence and cloud properties and better identification of the conditions at precipitation onset. Moreover, the range and coverage of other operational satellite measurements of surface and atmospheric properties, particularly the microwave water vapor sounders (providing below-cloud humidity), are now more extensive and frequent (6 hr sampling intervals). While continuing the current ISCCP to extend the length of a homogenous time record (now 35 years in length), a new project in parallel could be established to collect and process the more extensive observations based on the same operational agency arrangements for ISCCP (in fact, the current project could be just a subset of the expanded project). Available computer power makes such a project feasible with global spatial-temporal sampling intervals of at least 3 km and 30 min, especially with highly modular processing code like that used by ISCCP. New analysis procedures, such as neural-network-based schemes, have been demonstrated that can perform the necessary multichannel retrievals rapidly and with good accuracy. Such a project, called ISCCP-NG, has been proposed.

Meeting/Workshop Reports

2022 GEWEX Hydroclimatology Panel (GHP) Meeting

Monterey, California, USA
28–29 July 2022

Ali Nazemi and Francina Dominguez, GHP Co-Chairs

After two years of online meetings, the 2022 GHP Panel gathered to meet during the Pan-GEWEX meeting in Monterey, California. Facilitated by face-to-face interactions, the annual GHP meeting had lively peer-to-peer discussions during and after the sessions. Although some Panel members and project leads were unfortunately not able to travel, some attended the meeting virtually through Zoom. As the meeting occurred during the 2022 Pan-GEWEX Meeting, Panel members attended the cross-panel discussions and Pan-GEWEX Plenary that included reports on individual Panels by SSG rapporteurs and responses from Panel co-chairs. SSG members and invited speakers also attended the Panel meetings and contributed to the discussion. This provided an opportunity for positioning GHP activities within the broader GEWEX context. Some lessons learned during Covid-19 restrictions were still applied during the in-person meeting. For example, different projects submitted their presentations and reports in advance and Panel members reviewed each activity prior to the meeting. During the meeting, presentations were limited to a few slides and most of the time was given to discussions. This boosted the effectiveness of the meeting.

GHP is comprised of four different types of projects: (1) Regional Hydroclimate Projects (RHPs), aiming at understanding and predicting hydroclimatology in a specific region; (2) Crosscutting Projects (CCs), encouraging knowledge mobilization and global synthesis around a specific problem; (3) Global Data Centers, collecting and distributing hydrologically-relevant data; and (4) Networks, maintaining collaboration and building capacity for activities relevant to GEWEX science. During the GHP meeting, the group reviewed and discussed the progress of ongoing and prospective projects in these four categories.

Ongoing and Prospective Regional Hydroclimate Projects (RHPs) and Networks

RHPs are generally large, multidisciplinary projects, developed for improved understanding of the physical processes that affect water and energy exchanges within a region. There are currently three ongoing RHPs, including Global Water Futures (GWF), Baltic Earth, and the Regional Hydrology Program for the Andes (ANDEX). GWF and Baltic Earth are mature RHPs with large groups of active researchers and established ties with local communities and end-users. While their approach toward pursuing an RHP is quite different, they demonstrate continuous progress and cutting-edge science. ANDEX is an initiating RHP, and its integrated science and implementation plans were approved by the Panel in late 2021. Since then, ANDEX has elected a new leadership, Jhan Carlo Espinoza and Mariano Masiokas, although the founding co-chairs, Germán Poveda and René Garreaud, are active within the program. GHP was pleased to see how ANDEX is taking off.

GHP also includes five prospective RHPs that are at different levels of development. Three prospective RHPs are quite advanced and are almost ready to launch and become initiating RHPs. These include Third Pole Environment-Water Sustainability (TPE-WS), the Asian Precipitation Experiments (AsiaPEX), and the United States RHP (U.S. RHP). TPE-WS showed good progress in its program and has submitted its science and implementation plan, which is currently under Panel review. AsiaPEX also had a fruitful year, with new findings regarding precipitation in Japan, the Philippines, and the Tibetan plateau. The Panel expects AisaPEX's science and implementation plan by late 2022 or early 2023. The U.S. RHP continues to grow through its Affinity Group, which has now reached a critical mass, allowing for the establishment of working groups and moving towards drafting science and implementation plans in 2023.

Two prospective RHPs, Central Asia and the second phase of the Hydrological cycle in the Mediterranean eXperiment (HyMeX), are still at their early stages. The Central Asia group is now trying to deepen its local network. The Panel expects that these efforts will flourish some years from now. In addition, in a data poor region like Central Asia, establishing an RHP can be challenging and will require support from a broader community. It was suggested that linking with GWF and the second phase of the International Network for Alpine Catchment Hydrology (INARCH-II) could be helpful. After the official sunset of the first phase of HyMeX in 2020, a new group of young researchers from the region has been trying to come up with an agenda for the second phase of HyMeX. The Panel sees that the new phase of HyMeX is evolving toward an umbrella for understanding the regional response to climate change and the associated impacts on stakeholders. Although the new team has been active and secured new funding sources, the efforts made have not yet converged toward an RHP. Informed by the successful experience of the Pannonian Experiment (PannEx), the Panel suggested that HyMeX could consider becoming a GHP network, allowing more flexibility in the research and outreach agendas.

PannEx, a GHP network that aims to provide a better understanding of Earth system processes over the Pannonian Basin, is currently the only active GHP network. PannEx started as an initiating RHP, and later evolved into a vibrant network of scientists from different disciplines interested in hydroclimatic processes of the region. The network runs several activities, such as new projects and organizing special issues and workshops. Prior to the 2022 GHP Meeting in Monterey, the PannEx team met in Budapest. After 7 years of service, Monika Lakatos stepped down as PannEx chair and Rita Pongrácz was elected as the new chair. The Panel wishes all the best for Monika and looks forward to working with the new leadership team.

Ongoing and Prospective Crosscutting (CC) Activities

CCs are integral activities within GHP aimed at addressing

GEWEX Science Questions and creating collaborations between RHPs, other GEWEX Panels, and WCRP activities. GHP currently includes three active and three prospective CCs. The Transport and Exchange Processes in the Atmosphere over Mountains Experiment (TEAMx) aims at improving the current understanding of exchange processes in the atmosphere over mountains and how these processes are parameterized in climate models. TEAMx now has a revised plan for its observational campaigns; it is moving towards numerical modeling experiments and new funding resources. INARCH-II is now officially launched as an active CC after its science plan was approved by the Panel in late 2021. The team is now working toward a Common Observation Period Experiment (COPE) that can be used for diagnosis and modeling. Determining Evapotranspiration (dET) is another active CC, with the goal to advance the understanding and determination of evapotranspiration across scales. dET has now completed the Land Surface Atmosphere Interactions over the Iberian Semi-Arid Environment campaign (LIAISE), a major observational field experiment that can support future process understanding and simulations. The dET team also submitted its science plan, which was reviewed by the Panel and is now being revised by the dET leadership. The Panel is pleased to see dET's continuous progress and how the effort is shaping toward a flagship international program.

GHP also includes three prospective CCs at different levels of development. After an active year in 2020 of focusing on intercomparison of irrigation algorithms in current Earth system models, activities in the Irrigation CC have slowed. GHP is very much interested in this CC, and together with the GEWEX Global Land-Atmosphere System Studies (GLASS) Panel, will investigate how activities related to understanding and representing irrigation can be boosted and shaped as an active CC. This is the same for the Precipitation over Mountainous Terrain project (MOUNTerrain), which aims at better process understanding, model development, and prediction of precipitation in mountainous terrain. In contrast, the prospective Flood CC, which looks at a wide spectrum of challenges around understanding flooding processes from observation to model development to socio-economic impact assessments, had a fruitful year. The current leadership has run a survey with the broader community to assess global interest in the topic. The Flood CC is now moving toward forming working groups and converging towards a defined set of research objectives.

Data Centers

GHP currently includes two Global Data Centers, the Global Precipitation Climatology Centre (GPCC) and the Global Runoff Data Centre (GRDC). GPCC is well connected to the other GHP and GEWEX activities. Steady progress was reported related to precipitation data. After years of service, Udo Schneider has stepped down as GPCC director and Stephanie Hänsel, who was present in the meeting, is now GPCC director. GHP appreciates Udo's years of service and wishes Stephanie all the best in this important role. GRDC focuses on acquisition, harmonization, and storage of global historical river discharge data. The center progresses very well and new data are continuously added into the system. Also, the usage of GRDC has significantly increased since the launch of GRDC's online tool that made the GRDC data accessible to the broader research community.

Due to the importance of reliable information related to surface water storage for current and future GHP activities, GHP has started to investigate new sources of data that can compliment the data currently available through the International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE). For this purpose, the Panel invited Cedric David from NASA's Jet Propulsion Laboratory (JPL) to discuss advances in using satellite remote sensing data for measuring areas and storages of surface waterbodies. The Panel recognizes this as a new avenue for continuous gathering of surface water data and considers future investments in this direction.

Other Business

As the GHP meeting took place during the Pan-GEWEX event, GEWEX Scientific Steering Group members including the Panel rapporteurs attended the presentations and panel discussions. Several insightful comments were received from rapporteurs with regard to the need for continuous documentations and high-level overview of various activities within the Panel, particularly now that the Panel is growing in terms of number and size of activities. Panel leadership recognizes these needs and will invest in these directions. The Pan-GEWEX event also provided an exceptional opportunity for cross-panel interactions and discussing possibilities for collaborations. GHP and GLASS have had continuous collaborations through the years. The two Panels are currently working together on the dET and Irrigation CCs and consider extending their collaboration to other initiatives such as the Flood and TeamX CCs. GHP recognizes tremendous opportunities to work with the GEWEX Data and Analysis Panel (GDAP) over integrated data products, which can then support RHPs in benchmarking and model validation attempts. GDAP can also provide improved precipitation products that can support several activities in GHP and link the Flood CC to relevant satellite products for better flood inundation information. Although traditionally there have not been many interactions between GHP and the Global Atmospheric System Studies Panel (GASS), the two Panels identified several avenues for future collaborations, particularly in terms of kilometer-scale modeling, and improving the representation of hydrology in climate models that the GASS community uses. GHP continues working with the three GEWEX Panels to approach these initiatives.

GHP is continuously enriched through new Panel members. This year, GHP welcomed a new member, Dr. Santosh Pingale from the National Institute of Hydrology, Roorkee, India. Dr. Pingale's expertise is in surface and groundwater management and using modeling and observation techniques for irrigation management. He has previously worked in Africa and therefore can link the Panel activities to two currently underrepresented regions in the Panel. The Panel looks forward to working with Dr. Pingale and linking the Panel's activities to to the end-user communities most in need.

2022 GDAP Annual Meeting and ISSI Global Water-Energy Cycle Challenges Workshop

Tristan L'Ecuyer[1], Rémy Roca[1], Hirohiko Masunaga[1], and Benoit Meyssignac[2]

[1]GEWEX Data and Analysis Panel (GDAP) Co-Chairs; [2]GDAP Panel Member and Earth Energy Imbalance (EEI) Assessment Co-lead

The 2022 GEWEX Data and Analysis Panel (GDAP) Meeting was held concurrently with an International Space Science Institute (ISSI) workshop entitled "*Challenges in the Understanding of the Global Water-Energy Cycle and Its Changes*" in Bern, Switzerland, from 26–30 September 2022. The workshop provided a forum for fruitful scientific exchanges on the state of global energy and water cycle science before concluding with updates on all major GDAP projects and activities. Most Panel members and activity leads were able to join both the ISSI workshop and Panel meeting in person.

Given the strong overlap between the ISSI workshop theme and GDAP's mission to test consistency between global energy and water cycle data sets and identify observing system gaps, most of the week was devoted to presentations describing the state of the art in global energy-water cycle science and engaging discussions outlining a path to move the field forward. At the root of these discussions is the fundamental principle that radiative processes are key to the climate's water-energy cycle: climate is determined by the imbalances of solar radiative heating and long-wave radiative cooling. The circulation of the atmosphere and ocean, the environment on land, and the biosphere are all driven by local radiative imbalances. Changes in climate can be caused by alterations of the radiation budget at the top of the atmosphere or at the surface, such as those induced by changing amounts of greenhouse gases or aerosols in the atmosphere or by changing land surface properties. The sensitivity of the climate response to changes in the radiative forcing is determined by many feedback processes that alter the radiation budget, especially the processes involved with clouds and water vapor. Understanding and quantifying the climate response to changes in radiative forcings requires consistent, global-scale observations of the principal energy fluxes in the climate system.

Throughout the workshop, scientists from Europe, North America, and Japan assessed the current state of knowledge with respect to monitoring water-energy cycle changes from satellites. The workshop focused on coordinating space observations of the water and energy fluxes in the Earth system, evaluating their consistency, and advancing analysis methods to apply them in climate change assessments. Participants identified and discussed the observational challenges to improving our understanding of the global water and energy cycle with emphasis on observing capabilities in the next decade.

During the workshop, the experts took stock of the status of the different emerging themes related to the Earth's coupled water-energy cycle. The topics covered included estimates of water and energy in the atmosphere, global-scale changes in droughts and extreme precipitation, changes in the Earth's energy imbalance (EEI) and ocean heat storage, and changes in the surface temperature in response to the changing water-energy fluxes. It was demonstrated that the science community is now providing consistent satellite estimates of the global water and energy fluxes of the planet Earth from the bottom of the ocean to the top of the atmosphere over the last two decades. Observations now provide a consistent and objective picture of the global water and energy fluxes that explain the current Earth energy imbalance at the top of the atmosphere. This observational basis serves as a reference to better understand the subtle imbalances at stake among the Earth water and energy fluxes in the current climate. The challenge of the next decade is to detect, monitor, and understand how climate change modifies these balances in space and time (including EEI), leading to regional consequences that impact ecosystems and human communities. A key aspect to progress on this challenge is to improve the detection, the understanding, and the modeling of cloud changes and their relationship to radiative imbalances at the top of the atmosphere. The emergence of new observational approaches (e.g., mesoscale convective system tracking techniques) along with new modeling tools (e.g., convection-permitting models) shows promise for significant progress in the next decade. The workshop is expected to lead to a set of papers published as a volume of the Space Science Series of ISSI (SSSI) and, in parallel, in *Surveys in Geophysics*.

The GDAP Panel convened on Friday to welcome three new members, Helen Brindley, Maria Hakuba, and Benoit Meyssignac, and offer our warmest thanks to departing co-chair Rémy Roca for his six years of dedicated service. Hirohiko Masunaga was enthusiastically welcomed to succeed Rémy as GDAP Co-Chair. The Panel briefly discussed remaining membership needs, identifying a desire to establish liaisons with the Global Atmospheric System Studies (GASS) Panel and the GEWEX Hydroclimatology Panel (GHP) (Yunyan Zhang currently serves as a liaison to the Global Land-Atmosphere System Studies, or GLASS, Panel), before receiving project updates and conducting new business.

Claudia Stubenrauch summarized new foci of the Upper Tropospheric Clouds and Convection (UTCC) Process Evaluation Studies (PROES) and welcomed continued participation from GDAP members and affiliated scientists. With an eye toward future observing systems, there is an increased focus on analyzing the convective lifecycle and tracking convection using geostationary observations. GDAP and GASS will co-sponsor a convective tracking workshop with the Atmosphere Observing System (AOS) project in the U.S. in 2023 to define the tools required to support convective lifecycle analyses in both satellite observations and global km-scale models (e.g., the DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains model, or DYAMOND). EarthCARE will hold a related "*2nd EarthCARE Modeling Workshop*" in Japan in March 27–29, 2023 that will consider the benefits and challenges of applying satellite simulators to bridge between global km-scale models and satellite observations. Simulators will also play an important role in GDAP's participation in the Warm Rain PROES. A goal of this initiative will be to coordinate modeling and observations to establish warm rain processes and impacts on radiative fluxes.

Participants of the 2022 GDAP Meeting and the ISSI Global Water-Energy Cycle Challenges Workshop

The second phase of the Water Vapor Assessment is concluding and has generated several papers in a special issue of *Atmospheric Chemistry and Physics* (https://acp.copernicus.org/articles/special_issue1118.html). Highlights include a robust assessment of the quality of upper tropospheric humidity products, comparisons of water vapor profiles over stratocumulus and in subsiding regions against GPS radio occultation estimates, analysis of the short-term variability in boundary layer water vapor, and a characterization of the consistency between reference water vapor observations. It was determined that there is no immediate need to initiate a third phase of the Water Vapor Assessment. While a follow-on assessment may be warranted in the future as water vapor data sets continue to evolve, the current state of the field has been sufficiently well-documented in the first two assessments to justify a pause in this activity.

The GDAP Earth's Energy Imbalance (EEI) Assessment continues to advance under the leadership of Benoit Meyssignac and Tim Boyer. The effort addresses the critical need for coordinating independent EEI estimates and establishing their uncertainties on a range of time and space scales. It is encouraging that independent estimates from top-down (satellite-based) and bottom-up (in situ) approaches are converging on annual scales. Several papers are in preparation or review documenting initial findings from the group. A second community workshop to consolidate results and advance new objectives under the EEI Assessment is planned for May 15–18, in Frascati, Italy (https://www.wcrp-esa-eeia-2023.org/).

Ground networks continue to provide important reference observations for anchoring GDAP science. Baseline Surface Radiation Network (BSRN) co-chair Christian Lanconelli presented outcomes from the BSRN meeting held in Vispra, Italy, in June 2022. A highlight from that meeting was the notification that the BSRN was recently approved as a Global Climate Observing System (GCOS) affiliated network. Other new activities within the vibrant BSRN community include defining a new longwave reference standard, establishing best practices for ocean-based radiation measurements, supporting satellite retrievals, and pioneering a suite of value-added products at some network sites. Plans to initiate a satellite working group in BSRN to strengthen the links between space-based and ground-based radiation measurements are ongoing.

The International Satellite Cloud Climatology Project–Next Generation (ISCCP-NG) initiative is also regaining momentum after the pandemic. Project lead Andrew Heidinger indicated that a prototype gridded Level 1 (L1G) data set for the full geostationary ring (GEO-ring) of advanced imagers has been produced for the year 2020 at 0.05 degree and 30-minute temporal resolution. Initial feedback has been positive, and experiments have begun to derive Level-2 (L2) cloud from the L1G prototype. To maximize utility for future applications, however, it will be important to determine whether the current time and space resolution is sufficient for applying modern convection tracking algorithms. ISCCP-NG has been well received by agencies internationally, and the National Oceanic and Atmospheric Administration (NOAA) and European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) have pledged to ensure continued progress. A second international ISCCP-NG workshop is planned for 2023 focusing on gathering feedback regarding the prototype L1G and the development of a corresponding suite of L2 products. GDAP will continue to support the ISCCP-NG project, help coordinate international meetings, report its status to the GEWEX Scientific Steering Group, and advertise the project to the broader cloud science community.

In the next year, it is anticipated that GDAP will initiate new cross-cutting activities with GLASS, GASS, and GHP. The Integrated Product (IP) workshop originally planned for spring 2020 has been resurrected and will serve to kick off a multi-scale, land-atmosphere closure initiative with GLASS and GHP in Toledo, Spain, in spring 2023. The UTCC PROES has bridged GDAP and GASS in the past, and this cross-panel coordination will continue as the activity focuses on understanding cloud, precipitation, and radiative processes over the full convective lifecycle. This activity will leverage significant recent advances in tracking convection in contemporary multi-channel geostationary observations (ISCCP-NG) to output from km-scale models (DYAMOND). To accelerate progress in global hydrologic modeling and process studies, GDAP and GHP will pursue a cross-panel activity starting in 2023 to document the capability of high time and space resolution satellite precipitation data sets to capture rainfall variability and extremes over the areas addressed by current and planned Regional Hydroclimate Projects (RHPs). These data may, in turn, fill an observation gap in regions where ground-based measurement infrastructure is not well established (e.g., Central Asia). Finally, GDAP is seeking to increase the breadth of knowledge on the Panel by adding members with expertise in global ground radar networks, land surface measurements [including land surface temperature (LST)], and ocean-atmosphere fluxes. Nominations are encouraged from individuals with expertise in any of these areas, especially those who complement the gender, ethnic, and geographic diversity of the Panel.

Report on the GEWEX 2022 GLASS Panel Meeting

Monterey, California, USA
28–29 July 2022

Anne Verhoef[1] and Kirsten Findell[2], GLASS Panel Co-Chairs

[1]University of Reading, Reading, UK; [2]Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA

The GEWEX Global Land-Atmosphere System Studies (GLASS) Panel had a very successful Panel meeting during 28–29 July 2022, in Monterey, California, USA. Many of our Panel members were present in person, and most of the remaining ones joined online. Our meeting took place concurrently with the Pan-GASS and Pan-GEWEX Meetings, which meant that there also were opportunities to touch base with the chairs and some members of the other Panels (e.g., via dedicated "speed-dating" sessions). Below we give a summary report for the various GLASS projects (see Fig. 1 and *https://www.gewex.org/panels/global-landatmosphere-system-study-panel/glass-projects/*), followed by an outlook, based on our discussions in Monterey, including those with our rapporteurs from the GEWEX Scientific Steering Group: Bob Su and Gianpaolo Balsamo.

Volker Wulfmeyer provided an overview of the status and recent progress on the **GEWEX/GLASS Land-Atmosphere Feedback Observatories (GLAFO)**. The hierarchical design is fixed, but may be extended with new sensors (e.g., Solar-Induced Fluorescence, or SIF). Two observatories agreed to become a GLAFO: the Ruisdael Observatory in Cabauw, The Netherlands, and the Meteorological Observatory Lindenberg (MOL) of the German Meteorological Service. A new matrix of the required data sets to qualify as a GLAFO has been developed, which includes variables needed to compute key land-atmosphere (L-A) feedback metrics such as two-legged metrics, CTP-HIlow, and the Heated Condensation Framework. Volker demonstrated how GLAFO data can be used to study and improve turbulence parameterizations and presented initial L-A feedback results from the LAFO at the University of Hohenheim and from MOL. Finally, he presented results of machine learning applied to surface flux data with the aim to replace or improve Monin-Obukhov similarity theory.

The **Local Land-Atmosphere Coupling (LoCo) project** update presented by Craig Ferguson covered the four current focal areas of LoCo working group activities. This includes engaging operational numerical weather prediction (NWP) and climate centers to adopt more integrative, process-level metrics, influencing and leading observational advancements in boundary layer profiling, contributing to the design and application of field campaigns, and continuing to expand the scope of LoCo via collaborations and proposals while influencing agency priorities to fund core land-atmosphere related research. Strong opportunities exist for LoCo to contribute to the 3rd ARM Mobile Facility (DOE-AMF3), GLAFO, U.S. Regional Hydroclimate Project (U.S. RHP), and the National Aeronautics and Space Administration (NASA) Earth Venture Suborbital-4 (EVS-4) in the coming years. With regards to ESV-4: NASA will fund approximately five new, $30M, 5-year suborbital and ground campaigns (initial proposal due dates will be next spring). There is a good chance this opportunity could not only leverage, but also enhance and expand existing GLAFO and U.S. RHP plans. There are also strong LoCo connections with the GLASS-GEWEX Hydroclimatology Panel (GHP) cross-cut on irrigation modeling and with assessment and application of the Data and Analysis Panel (GDAP) integrated product.

Yijian Zeng provided an overview of the ongoing and emerging **Soils and Water (SoilWat)** activities. The working groups on "pedotransfer functions (PTFs) and land surface parameterization" and "soil thermal properties" are preparing science roadmap papers. The first results of the Soil-Parameter Model Intercomparison Project (SP-MIP) thermal regime analysis show that changes in soil textural maps have a larger effect on soil temperature climatology than changes in hydraulic/thermal PTFs for some land surface models (LSMs), while the opposite is found for other LSMs. The SP-MIP hydrology analysis indicates that differences in treatment of infiltration processes are important to improve our understanding of the impact of soil maps on the hydrological responses, and that interactions between groundwater and soil water are important to consider. There were discussions on the emerging "soil-cloud cascade" initiative, and some preliminary studies are currently ongoing to investigate the cascading effects of different soil maps (and the PTFs) on spatiotemporal distribution (heterogeneity) of soil moisture content, surface temperature, and evaporative fraction, and how all these effects will subsequently impact the convective cloud formation processes.

Nicholas Parazoo introduced the new **Solar-Induced Fluorescence Model Intercomparison (SIF-MIP)** project. The global, multiscale remote sensing of vegetation solar induced fluorescence represents a major breakthrough in our ability to track the response of planetary photosynthesis to environmental change and carbon-climate feedback. SIF-MIP aims to characterize SIF process representation within land models, improve their performance compared to observations, and enable more accurate prediction of carbon-water-energy cycle interactions. Preliminary work focuses on forest locations in North America with well-calibrated SIF spectra. Future work will expand across the global tower network, leveraging forcing data from parallel projects such as the Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project, Phase 2 (PLUMBER2).

Though the **Coupling of Land and Atmospheric Subgrid Parameterizations (CLASP)** is a new GLASS project, the effort began as a U.S.-based Climate Process Team jointly funded by the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Energy (DOE), and NASA. Through GLASS, this project is now extending beyond the

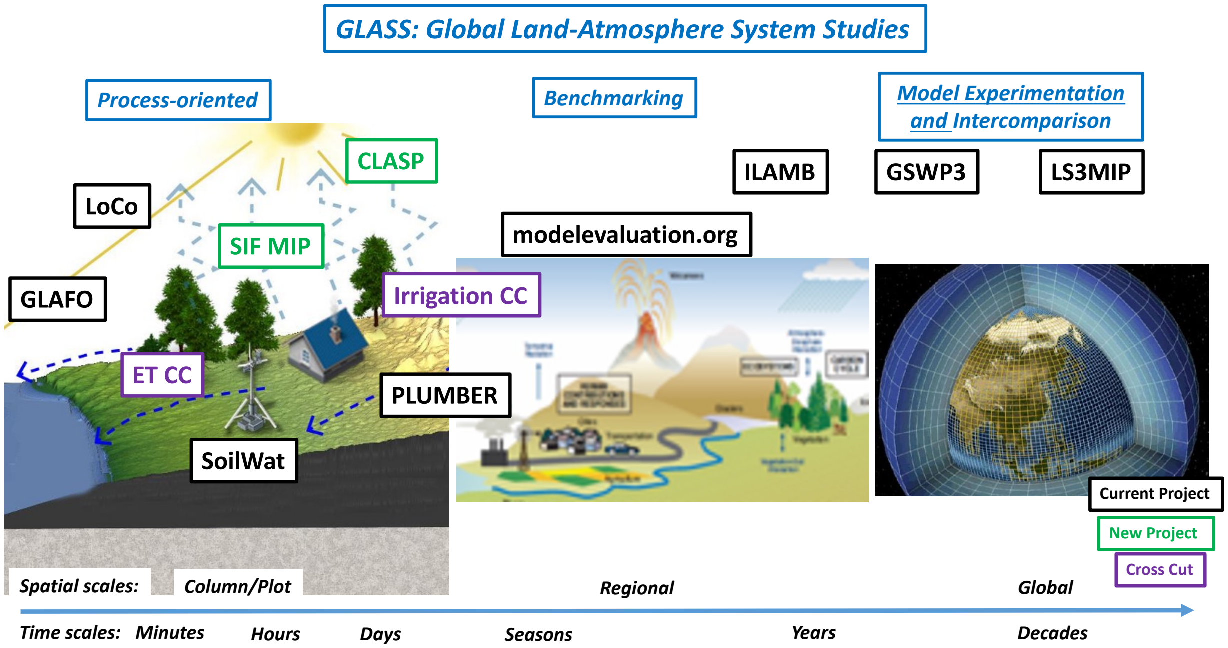

***Figure 1**. Current GLASS projects and the spatio-temporal scales they broadly address*

U.S. to include efforts in Germany and the UK; we hope to continue that international expansion and cross-pollination of ideas and strategies.

Nate Chaney provided updates on the status of CLASP's three themes. Two different approaches to parameterizing sub-grid land-atmosphere coupling through modifications of turbulence closure schemes have been implemented and tested by the participating modeling centers. The Cloud Layers Unified By Binormals (CLUBB)-based approach shows weak sensitivity to surface heterogeneity while the Eddy-Diffusivity/Mass-Flux (EDMF)-based approach shows appreciable global impacts. Understanding these differences (and similarities) is an active area of research. On the diagnostics side, there are ongoing efforts to define new metrics to assess the atmospheric response to sub-grid heterogeneity; these include coupling sensitivity scores, evaluating models at sub-daily time scales, leveraging mixing diagrams, and evaluating simulated spatial heterogeneity of land surface temperature. Finally, the Large Eddy Simulation efforts show the key role that surface heterogeneity can play in the development and enhancement of convection due to secondary circulations. Most notably, CLASP work shows that the formation of secondary circulations (and the related enhancement of cloud development) is driven by surface spatial variances and correlation lengths (particularly sensible heat fluxes) rather than spatial means of surface fluxes.

Gab Abramowitz reported that about 90% of the output submissions for the **PLUMBER2** intercomparison are complete and analysis is gathering pace. The driving and evaluation data sets, which involved quality control and gap-filling flux tower data specifically geared towards land model applications, have now been published and are publicly available. Overall, results appear qualitatively similar to those of PLUMBER in terms of the relationship between physically-based models and empirical approaches. However, the breadth of model submissions (including LSMs, ecosystem, and hydrology models), empirical approaches (out-of-sample cluster and regression, long short-term memory, random forest), and ecosystems and conditions involved (170 sites internationally) mean that the potential for data mining to identify the circumstances of poor model performance (and so the potential for model improvement) is greatly improved. While at least two manuscripts are in preparation involving the 40+ co-authors involved in this project, we ultimately hope that the PLUMBER2 data will represent a valuable community resource for process representation improvement over the coming years.

Dave Lawrence reported that the **International Land Model Benchmarking (ILAMB) project** results are featured in the Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC AR6) documenting general improvement in model performance from the Coupled Model Intercomparison Project, Phase 5 (CMIP5) to CMIP6 for most land variables. ILAMB continues to integrate new observational data sets, and is now ingesting 90+ global, regional, and site-level data sets spanning 35 variables across the hydrological, radiation and energy, and carbon cycles as well as land climate/weather forcing variables. These include new data sets developed by members of the GLASS community. ILAMB also continues to evaluate scoring methodologies and is evolving towards a method that gives better bias-to-score correspondence, provides a clearer meaning for the scores, and limits problems related to mass weighting and regional dominance.

Hyungjun Kim reported that several analyses have been carried out on the output of the "Land-hist" experiment connecting the **Land Surface, Snow and Soil Moisture Model**

Intercomparison Project (LS3MIP) and the **Global Soil Wetness Project, Phase 3 (GSWP3)**: i) overview and model benchmarking, ii) long-term balance and variability of the terrestrial water and carbon cycle, iii) land surface simulations of cold processes, and iv) global energy transport by the terrestrial hydrologic cycle. Also, land surface feedbacks on temperature and precipitation in Land Feedback Model Intercomparison (LFMIP) experiments have been investigated.

Some participants of the 2022 GLASS Panel Meeting

Cross-cuts and other efforts: Aaron Boone provided a brief overview of the Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) field experiment and the Determining Evapotranspiration cross-cut (dET CC), which will be pockets of GLASS-GHP collaboration in the years ahead. We also received an update by John Edwards on the Global Atmospheric System Studies (GASS) project called the **GEWEX Atmospheric Boundary-Layer Study (GABLS)**, which has close connections with GLASS. Over the past two decades, the GABLS project has organized four successful intercomparisons of the atmospheric boundary layer. As these have grown in sophistication, interactions with the land have become a key theme. GASS is keen for the project to continue, with close connections to GLASS (e.g., via GLAFO).

GLASS interactions with other WCRP and WMO programs: Kirsten Findell shared the latest on the WCRP Lighthouse Activity "Explaining and Predicting Earth System Change", which she co-leads. Mike Ek provided an update on the Working Group on Numerical Experimentation (WGNE), with priorities on Earth system model development at all time scales and diagnosing and resolving shortcomings. WGNE is interested in GLASS activities related to improving land models in weather and climate models at the process level via studies such as land model benchmarking (e.g., PLUMBER) and land-atmosphere interactions (e.g., LoCo, GLAFO). WGNE activities relevant to GLASS include their 2019 Systematic Error Survey (surface fluxes, surface temperatures, and the diurnal cycle are noteworthy); the WGNE Surface Flux Intercomparison Project will have a future focus on land. WGNE is also keen to know when/whether GLASS will return to land and hydrology data assimilation. Anne Verhoef is the GLASS representative on the Science Steering Committee of the 6th WGNE Workshop on Systematic Errors in Weather and Climate Models, which took place at the European Centre for Medium-Range Weather Forecasts (Reading, UK) in early November 2022.

Looking ahead, there are clearly strong synergies between GLASS projects, as well as with activities in other GEWEX Panels and the wider WCRP community. These synergies can and should be leveraged to address current land model limitations, and to improve understanding and modeling capabilities. For example, discussions with GDAP representatives in Monterey focussed on the need to ensure that modeling systems are able to ingest remote sensing *observables* (e.g., SIF, optical spectra, brightness temperature, land surface temperature, etc.) as land data assimilation efforts move forward. Additionally, we want to strengthen our focus on the representation of heterogeneity in LSMs, via CLASP and GLAFO, and the new related initiatives on "soil-cloud cascades": a collaboration between CLASP, SoilWat, GLAFO, and members of the GDAP and GASS communities. This desire links well with the new GEWEX-wide "km-scale modeling" and "mesoscale organization of convection" themes.

We also discussed the importance of land-atmosphere interactions at diurnal and sub-diurnal scales; we aim to address this issue through GLAFO, CLASP, and in collaboration with GABLS. We agreed that to improve diurnal predictions, we need to replace Monin-Obukhov with a more suitable theory. Moreover, we need to continue to strive for full ecosystem process representation in our models, i.e., 3-D connections between groundwater, soil water, roots, vegetation, and the atmosphere (through water, heat, and CO_2 fluxes). This may result in cross-project activities (SIF-MIP/SoilWat/CLASP/GLAFO/ILAMB), ideally with an initial focus on the watershed scale. Here we need to strengthen our links with GHP (and together nurture our ET and irrigation CCs) and GDAP (considering suitable satellite data streams such as the Gravity Recovery and Climate Experiment, or GRACE). These envisaged activities fit well with the GEWEX regional-scale stores and fluxes themes. With this in mind, we would also welcome an increase in our current efforts on surface water, with an emphasis on lakes and reservoirs. This is also relevant to land surface heterogeneity, organization of convection, the dET and irrigation CCs, RHPs, the GEWEX km-scale theme, and the NASA Surface Water and Ocean Topography (SWOT) satellite launch. In all our efforts, we need to make best use of **existing observatories and observations** through joint project consolidation efforts, such as those data relating to the Southern Great Plains Observatory, GLAFOs, LIAISE, and the Tibetan plateau.

The GLASS Panel looks forward to an in-person meeting in August 2023 at the University of Hohenheim, and to gathering with the wider GEWEX and WCRP communities at the WCRP Open Science Conference in October 2023.

Summary of the ANDEX Executive Committee Meeting

Buenos Aires, Argentina
4–6 September 2022

Jhan Carlo Espinoza[1] and Mariano Masiokas[2]
[1]Institut de Recherche pour le Développement (IRD)-France/Peru; [2]Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales (IANIGLA), Mendoza, Argentina
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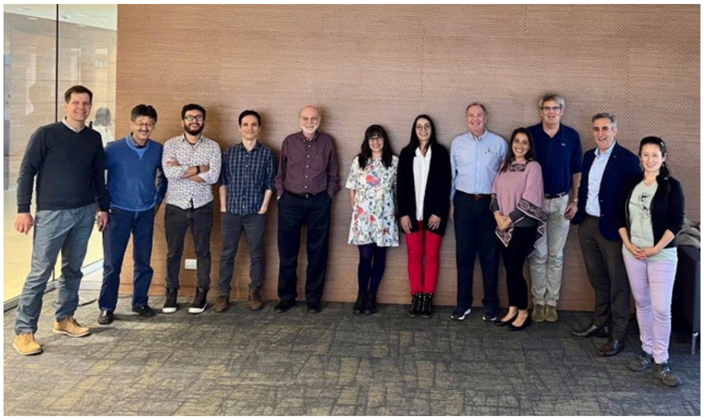


Participants of the ANDEX Executive Committee Meeting at the University of Buenos Aires

Between September 4 and 6, 2022, the Scientific Committee of the regional hydroclimatic program for the Andes (PHR-ANDEX) met in the city of Buenos Aires, Argentina, to define its implementation plan for the coming years. The meeting was held at the University of Buenos Aires (UBA).

ANDEX aims to improve our understanding and prediction of climate and hydrology along the Andes mountain range, involving actors from all Andean countries. ANDEX was created in 2018 with the support of GEWEX, a core project of the World Climate Research Program (WCRP).

During the meeting, we defined the major "scientific challenges for the Andes" and measures to strengthen the resilience of Andean countries to climate change. We identified two priority issues: 1) improving water security for Andean populations, and 2) reducing the risks associated with high impact climate events in the Andes. Confronting these challenges requires tools and solutions based on scientific evidence to address the impacts associated with climate variability and change, as well as current and future environmental changes.

In addition, we defined the main disciplinary teams, the transversal lines of work, and the integrative services aimed at contributing to the solution of the previously-mentioned scientific challenges. To this end, ANDEX seeks to integrate biophysical and social scientists, as well as non-academic partners, to co-produce information and tools to improve the resilience of the countries in the region. By establishing a hydroclimatic community of practice for the Andes, ANDEX will promote regional collaboration and the exchange of data, tools, and best practices. Ultimately, ANDEX aims to generate key scientific evidence to guide climate change adaptation actions in the different sectors of this vast mountainous region.

ANDEX will hold its next meeting in 2023 in Lima, Peru. Previously, the ANDEX scientific committee met in Medellin, Colombia (2017); Quito, Ecuador (2018); and Santiago de Chile (2019).

Participants of the Buenos Aires meeting:

- Jhan Carlo Espinoza–Co-chair of ANDEX, Institut de Recherche pour le Développement (IRD)-France/Peru
- Mariano Masiokas–Co-chair of ANDEX, Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales (IANIGLA), Argentina, and Pontificia Universidad Católica del Perú
- Paola Arias–Universidad de Antioquia, Colombia
- Jorge Molina–Universidad Mayor San Andrés, Bolivia
- Daniel Pabón–Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), Guayaquil, Ecuador
- René Garreaud–Universidad de Chile, Chile
- Isabel Moreno–Universidad Mayor de San Andrés, Bolivia
- German Poveda–Universidad Nacional de Colombia, Colombia
- Silvina Solman–Universidad de Buenos Aires, Argentina
- Anna Stewart–Inter-American Institute for Global Change Research, Uruguay
- Alejandro Martinez–Universidad de Antioquia, Colombia
- Peter J. van Oevelen–International GEWEX Project Office, Fairfax (VA), USA
- Jan Polcher–Co-chair GEWEX, Institut Pierre Simon Laplace (IPSL)-France
- Hugo Berbery–University of Maryland, USA/Argentina

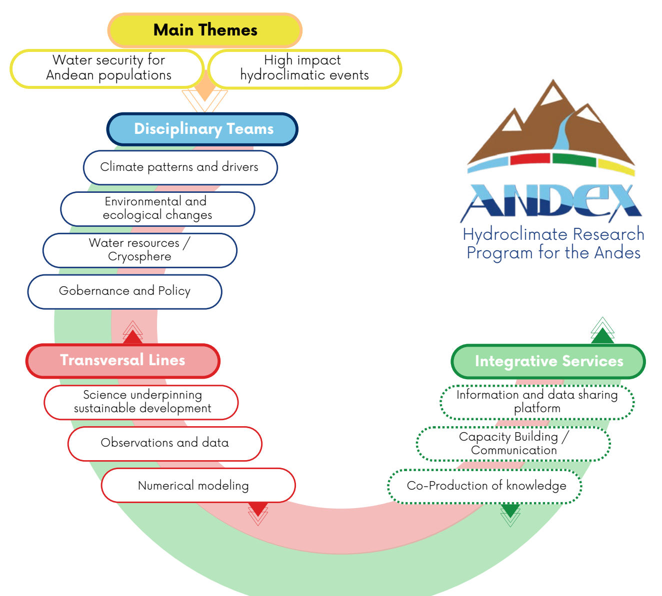


***Figure 1**. ANDEX structure, showing the main themes of the program (in yellow), the disciplinary teams (in blue), the transversal lines of work (in red), and the integrative services (in green)*

Convection-Permitting Modeling in South America and Beyond: A Summary of the 6th Convection-Permitting Modeling Workshop

Buenos Aires, Argentina
7–9 September 2022

Andreas F. Prein[1], Lluís Fita[2], Maria Laura Bettolli[3], and Roy Rasmussen[1]

[1]National Center for Atmospheric Research (NCAR), Boulder, CO, USA; [2]Centro de Investigaciones del Mar y la Atmósfera (CIMA), UBA-CONICET, CNRS IRL 3351 IFAECI, IRD, Buenos Aires, Argentina; [3]Departamento de Ciencias de la Atmósfera y los Océanos (DCAO), UBA-CONICET, CNRS IRL 3351 IFAECI, IRD, Buenos Aires, Argentina

The sixth installment of the Convection-Permitting Modeling (CPM) Workshop series was held in hybrid format between September 7–9, 2022 at the University of Buenos Aires, Buenos Aires, Argentina and online. The workshop attracted 70 in-person and 49 online participants from 19 countries. The six oral, seven panel, and two poster sessions focused on topics including advances in km-scale climate modeling, simulating extreme weather events, coordinated modeling efforts, and connections to impact research. South American km-scale modeling efforts and challenges in performing high-resolution climate modeling in the Global South were particularly emphasized. The workshop brought together members from different communities including the ANDEX project (*https://www.gewex.org/project/andex/*), the Coordinated Regional Climate Downscaling Experiment Flagship Pilot Study (CORDEX FPS) South America group (*http://cordexfpssesa.at.fcen.uba.ar/*), the Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations – Clouds, Aerosols, and Complex Terrain Interactions (RELAMPAGO – CACTI, *https://sites.google.com/illinois.edu/relampago/home*) group, and the South American Affinity Group (SAAG, *https://ral.ucar.edu/projects/south-america-affinity-group-saag*). This year's workshop also featured the 1st Convection-Permitting Climate Modeling School (*http://www.cima.fcen.uba.ar/cpCMSchool2022/*) that occurred on Saturday, September 10, 2022.

A central theme of discussion was the generation of climate change scenarios with km-scale models. The large computational costs of such simulations makes sampling future climate uncertainties difficult and several approaches were presented to address this challenge. Direct downscaling of global or coarser-resolution regional climate models to km-scales is historically the most common approach and is applied in CORDEX and its Flagship Pilot Studies. The CORDEX Flagship Pilot Study on Convection over Europe and Mediterranean (FPSCONV, *https://www.hymex.org/cordexfps-convection/wiki/doku.php*) was highlighted with more than 20 multi-model, multi-physics decadal-long current and future climate change projections. Key results from this activity include the systematic improvement of extreme precipitation events at km-scales, a reduction of future uncertainties in projected changes of future extreme rainfall, and a systematic larger increase of heat extremes with narrower uncertainties compared to coarser-resolution models. The UK Met Office uses a single model approach for generating transient 100-year long km-scale climate change scenarios and downscale multiple members of their global model.

An alternative approach to directly downscaling global climate model data is the Pseudo Global Warming (PGW) method. For the PGW method, historic reanalysis data is perturbed with climate change deltas derived from climate change projections to generate future scenarios. The benefit of this method is that biases from the driving model do not affect the km-scale modeling results and that future changes can be more easily attributed to forced climate change since the effects of natural climate variability are small. Two criticisms of PGW methods are that they cannot produce new sequences of events in future climates and are thought to not capture systematic changes in future weather patterns. Concerning the latter, novel results over the western U.S. and Europe show that the PGW approach is able to also capture dynamical changes in the climate system that are comparable to directly downscaling General Circulation Model data. The PGW approach will also be applied in the generation of 4 km future climate change scenarios over South America, which are performed by the SAAG. While most PGW simulations were so-far performed in mid-latitudes, one study applied it to the tropical Atlantic. In tropical environments, imbalances in the lateral boundary conditions of PGW simulations have to be adjusted to avoid the generation of artificial waves. Interestingly, 2 km grid spacing simulations with the Consortium for Small-scale Modeling (COSMO) model were able to realistically simulate tropical clouds, including shallow convective clouds. Additionally, the 2 km model was able to simulate the Intertropical Convergence Zone (ITCZ) convection realistically and projects changes that are different compared to coarse-resolution global model projections.

A special application of the PGW method is used in the generation of event storylines. Multiple presentations focused on storylines related to tropical cyclones, derechos, floods, and extreme snowfall events and showed how events would change if they would re-occur under future climate conditions or assess how historic climate change changed an event that occurred under present climate conditions. The presentations showed how storyline simulations are very helpful in improving our understanding of how processes change due to climate change. Furthermore, they are very helpful in working with stakeholders who experienced a specific event and, therefore, can better relate with its changes in the future.

Novel insights were presented from coupled km-scale climate simulations. For instance, km-scale simulations that were coupled to a high-resolution ocean model more realistically simulated cyclones in the Mediterranean and snow bands in the Baltic Sea. Improving our land-surface model capabilities was highlighted as an urgent need. For instance, the lateral flow of shallow groundwater is an important process that has to be captured in km-scale models to allow realistic simulations in, e.g., the Amazon, where water level depths are peaking 4 months after the rainy season. Also, the lack of deep root representation (plants in the Amazon have roots that reach 18 m deep) in some models was highlighted as a deficiency. The high rates of precipitation recycling in the western Amazon were also highlighted and understanding the potential local and remote effects of deforestation were mentioned as key challenges. Km-scale models could also have large benefits for simulating glaciers along the Andean cordillera. Lastly, including the human impact on the water cycle in our models was highlighted as being critical.

In-person participants of the 6th CPM workshop

Global km-scale modelers presented research on improving the representation of convection at km-scales by implementing scale-aware convection parameterizations, which resulted in improved simulation of tropical convection, east African waves, and Numerical Weather Prediction (NWP) forecasts over Germany. Technical developments such as GridTools for Python (GT4Py) were also presented, which allows fairly easy setup and optimization of km-scale models on heterogeneous high-performance computers.

The typical large domain sizes, longer integrations, and larger ensemble sizes produced by km-scale models require a paradigm shift in how data is shared and analyzed. Existing platforms such as the Joint Analysis System Meeting Infrastructure Needs (JASMIN) system (*https://jasmin.ac.uk/*) were presented, which allows researchers to perform analysis at the location of the data rather than downloading data sets to local servers. Cloud storage and computing solutions were mentioned as a future solution but are currently often prohibitive due to the costs and unsure long-term accessibility of data.

Besides making km-scale modeling data more accessible, another major theme of the workshop was how to make the data more usable and results more impactful. The World Meteorological Organization (WMO)'s strategy for climate service delivery was highlighted, which includes four steps: 1) identify and engage users and understand their needs, 2) co-design the service that fulfills their needs, 3) deliver the product, and 4) evaluate and improve the products. Developing relationships with users was identified as a worthwhile effort that can take years of continuous work. Strategies of how to make km-scale modeling research more visible in national and international climate assessments were also discussed. Additional topics of discussion included the involvement of the CPM community in the next Intergovernmental Panel on Climate Change (IPCC) report, the usability of the CPM data for the impact and stakeholder communities, and new frameworks such as "multiple lines of evidence". A stronger focus on impacts, adaptation, and vulnerability as well as changes in urban environments in the next IPCC cycle are opportunities for contributions from the km-scale modeling community.

In summary, some of the key messages from this workshop are:

- The km-scale modeling field is continuing to increase its capabilities concerning domain size, ensemble size, complexity, and integration lengths. It has made the transition from a purely research focus to generating information that is valuable to impact researchers and stakeholders. Building connections and collaborations with users has been highlighted as important to ensure the usability of km-scale model output, but it was also noted that building such relationships can take years.
- Coupling km-scale atmospheric models with other Earth system components, such as ocean models, and advancing capabilities of existing components, such as sub-grid-scale convection and cloud schemes, lateral groundwater flow models, and improved representations of vegetation, are promising to reduce biases. Also, the addition of the human impact on the water cycle in climate change projections was highlighted as an urgent research need.
- A large variety of techniques is being developed to produce regional km-scale model projections, including direct global model downscaling, various PGW approaches, and storyline methods. Each of these approaches offer unique benefits and have some shortcomings. Research is underway that intercompares these different methods.
- The increasing data volume from km-scale models is creating inequalities in data accessibility, particularly for researchers in the Global South. Initiatives have started to reduce these inequalities by allowing researchers to analyze the data at the storage location.

Hosting the workshop in South America and the successful acquisition of multiple sources of funding assistance [NCAR, Instituto Panamericano de Geografía e Historia (IPGH), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), GEWEX, Universidad de Buenos Aires (UBA), Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL IFAECI) and Fondo para la Investigación Científica y Tecnológica (FONCyT)] facilitated the participation of scientists across the continent (58% of in-person attendees). This proved vital to highlight research activities carried out in the region and to incorporate new perspectives and intercontinental collaboration opportunities, which are often lacking in international meetings.

More information on the 6th CPM workshop can be found on the workshop website under *http://www.cima.fcen.uba.ar/cpcmw2022/index.php*. The organization of the 7th CPM workshop has already started, which will be held as a hybrid event on August 29–31, 2023 in Bergen, Norway. Please subscribe to the CPM email list (*ral-cpcm@ucar.edu*) for more information.

GEWEX/WCRP Calendar

For the complete Calendar, see http://www.gewex.org/events/

18–21 February 2023—9th International Conference on Flood Management (ICFM9)—Tsukuba, Japan

27–29 March 2023—1st LIAISE Conference and Determining Evapotranspiration CrossCut Workshop—Lleida, Spain

27–29 March 2023—ICCP-GSRA Workshop 2023 and 2nd EarthCARE Modeling Workshop—Shizuoka, Japan

27–31 March 2023—International Baltic Earth Winter School for Young Scientists on "Earth System Science for the Baltic Sea Region"—Warnemünde, Germany

16–21 April 2023—5th Committee on Space Research (COSPAR) symposium—Singapore

1–5 May 2023—35th GEWEX SSG (SSG-35) Meeting (*by invitation only*)—Lima, Peru

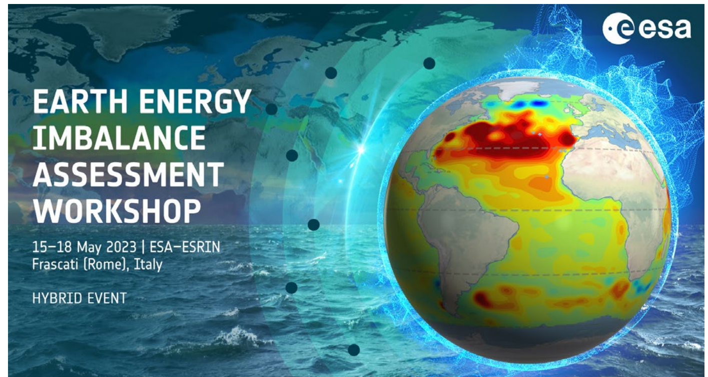
15–17 May 2023—2023 Global Water Futures (GWF) Annual Science Meeting—Saskatoon, Saskatchewan

15–18 May 2023—Earth Energy Imbalance Assessment Workshop—Frascati (Rome), Italy

3–7 July 2023—Berlin Summit to Advance Climate Science and Service—Berlin, Germany

29–31 August 2023—7th Convection-Permitting Climate Modeling Workshop—Bergen, Norway

23–27 October 2023—WCRP Open Science Conference 2023—Kigali, Rwanda, and Online



The European Space Agency, in the context of the "FutureEO - Earth Observations Science for Society" Programme, and the World Climate Research Programme are organizing the Earth Energy Imbalance Assessment Workshop. This event will take place from 15th through 18th of May 2023, hosted as a hybrid meeting at ESA-ESRIN, Frascati (Rome), Italy. The aim of the workshop is to engage a wide community with expertise in radiometric remote sensing, satellite altimetry, space gravimetry, ocean in situ measurements, and ocean reanalysis to assess and intercompare estimates of Earth's energy imbalance and their time variability and uncertainties. To find out more or to submit an abstract, visit https://www.wcrp-esa-eeia-2023.org/.

IMPORTANT DATES
Abstract Submission Deadline: 24 February 2023
Registration Deadline: 28 April 2023 at 12:00

Abstract submission is now open for 40 science sessions and over 40 poster clusters that bring together a broad range of topics under three conference themes: Advances in Climate Research, Human Interactions with Climate, and Co-produced Climate Services and Solutions. Submit your abstract at https://wcrp-osc2023.org/call-abstract.

GEWEX QUARTERLY

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