GEWEX QUARTERLY

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

Recap from the 3rd Pan-GASS Meeting

A wave hello from the attendees of our first larger in-person meeting in several years: the 3rd Pan-GASS Meeting, Understanding and Modeling Atmospheric Processes (UMAP 2022). The four themes of the conference touched on organization of shallow and deep convection, surface–atmosphere interactions and the boundary layer, cloud systems and associated processes, and global km-scale modeling of the Earth System. For more on the science covered, see Klocke et al., pg 12.

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Commentary

Peter van Oevelen
Director, International GEWEX Project Office

This edition of the *GEWEX Quarterly* contains the first in-person meeting reports (GEWEX Scientific Steering Group, pg. 13, and 3rd PAN-GASS Meeting, pg. 11) since COVID-19, and I truly enjoyed seeing and engaging with friends and colleagues from around the globe again. No doubt I am not the only one! Certainly, for the new Panel and SSG members, these meetings were a good opportunity to get better-acquainted with whom and how GEWEX runs its business. As part of the Pan-GEWEX meetings, we organized a whale watching tour in Monterey Bay and we were fortunate not just see many sea otters, sea lions, and humpback whales, but also the largest mammal on Earth, the blue whale. Certainly a highlight this year, not counting our science!

With the in-person and hybrid meetings ramping up, I would like to draw attention to the upcoming World Climate Research Programme (WCRP) Open Science Conference, to be held in Kigali, Rwanda, next year from 23–27 October 2023. Registration is expected to open before the end of the year. This conference aims to address the challenges of the Global South in climate change research and how WCRP and its core projects and Lighthouse Activities can help. We look forward to welcoming many of you there, and please let us know if you would like to get involved personally (e.g., through organizing poster clusters or side meetings, workshops, and summer schools).

After the recent 6th Convection Permitting Workshop in Buenos Aires, Argentina, and the Land Surface Modeling Workshop in Oxford, UK, it became clear that current higher spatial resolution models are getting to much more relatable scales, especially for policy and decision makers. These higher resolutions pose a challenge, not the least with the amount of data required and produced, yet they also provide an opportunity to better deal with adaptation, mitigation, and risk. I look forward to seeing the GEWEX community strongly engaged in this direction!

New GEWEX Panel Members

Laura Condon of the University of Arizona is one of two recent additions to the Global Land-Atmosphere System Sudies (GLASS) Panel. Her primary expertise is in integrated hydrologic modeling and large scale groundwater systems, and her research focuses on the role of groundwater surface water interactions in large scale watershed dynamics.

Patricia Lawston-Parker of the University of Maryland/National Aeronautics and Space Administration (NASA) Goddard Space Flight Center joins the GLASS Panel as a member after participating in GLASS activities for several years. Her area of expertise lies in the monitoring and modeling of irrigation water use and its impacts on the water and energy cycles and local land-atmosphere coupling.

Santosh Pingale of the National Institute of Hydrology in Roorkee, India, is a new member of the GEWEX Regional Hydroclimatology Panel (GHP). His research is mainly in water resources and climate change, focusing on hydrologic and groundwater modeling, currently in the Nile region.

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New GEWEX Scientific Steering Group (SSG) Members

Myoung-Hwan Ahn of the Ewha Womans University in Seoul is a new member of the SSG. His background is in radiation and atmospheric physics, a complement to many GEWEX activities, with additional expertise in satellite observations.

Benjamin Lamptey of the West African Science Service Centre for Climate Change and Adapted Land Use joins the SSG with expertise in atmospheric modeling and a background in regional African climate and community.

L. Ruby Leung's research broadly cuts across multiple areas in modeling and analysis of climate and the water cycle, including orographic precipitation, monsoon climate, extreme events, land surface processes, land-atmosphere interactions, and aerosol-cloud interactions. She is currently affiliated with the Pacific Northwest National Laboratory.

New SSG member Maria Piles of the Universitat de València researches microwave remote sensing, retrieval of land biogeophysical parameters, and development of multi-sensor synergistic techniques for applications of ecology, agriculture, forest conservation, and a better understanding of climatic phenomena.

Inaugural GEWEX Ambassadors: Advancing Science and the GEWEX Community

The GEWEX Ambassador is a new position granted to select individuals who have contributed significantly to GEWEX, its achievements, and its community. The distinction honors our colleagues who have made the international GEWEX program possible by giving a notable amount of their time and energy, and who can continue to promote GEWEX in the broadest sense with this very new distinction. There will only be two nominations per year for a 5 year period. The inaugural ambassadors were announced at the second installment of the 34th Session of the Scientfic Steering Group (SSG-34B) in Monterey, California, USA: Claudia Stubenrauch of the Laboratoire de Météorologie Dynamique and Mike Ek of the National Center for Atmospheric Research (NCAR).

Claudia has co-led the GEWEX Cloud Assessment, the first international assessment of 12 state-of-the-art global cloud climatologies from space observations, since 2006. Claudia was also involved in the GEWEX Data and Assessments Panel (GDAP) for over a decade. She is currently leading the GEWEX Process Evaluation Studies (PROES) for Upper Tropospheric Clouds and Convection, with a goal of gaining a better understanding of the interconnection between convection and the properties of outflowing anvils, and in particular to provide observational metrics to probe process understanding.

Mike has long been involved with GEWEX, starting shortly after the program began in 1992. His contributions to boundary layer and land-atmosphere interaction representation in models have been invaluable to many GEWEX projects and panels, from the Project for the Intercomparison of Land Surface Parameterization Schemes (PILPS) to the GEWEX Atmospheric Boundary Layer Study (GABLS) project to the Global Land-Atmosphere System Studies (GLASS) Panel, which he co-chaired from 2015–2020.

We are privileged to be able to honor two great scientists who have contributed so much to GEWEX. Thank you, Mike and Claudia!

In Memoriam: Zheenbek Kulenbekov

Michael Brody
George Mason University, Fairfax, Virginia, USA

Zheenbek Kulenbekov, a central figure in GEWEX efforts to create initiatives in Central Asia, passed away in the month of September. He was a colleague eager to engage and a friend eager to help.

I first met Zheenbek when I was a Fulbright Scholar teaching environmental science at the National University of Uzbekistan in Tashkent during the fall semester of 2017. Fulbright encourages travel within one's region, but it requires an invitation from a host university and a plan for one's time during the visit. A colleague in Bishkek, Kyrgyzstan, introduced me to Zheenbek Kulenbekov in October of that year. He immediately invited me, and I received a small travel grant to go to the American University of Central Asia (AUCA) in Bishkek. So, in December 2017, I arrived in Bishkek for the first time, came to AUCA, and Zheenbek and I met in person.

At the time, Zheenbek was Program Coordinator of Environmental Management and Sustainable Development, Environmental Sustainability Officer, and Program Chair of the Applied Geology Department. That was his title, and he had a lot of serious responsibilities. But among the many things he was trying to do was to build a very strong, masters-level program in the environmental sciences at AUCA. He was always looking for these types of opportunities. Thus began our friendship and collaborations.

Zheenbek started his education in the Soviet system, having received his first diploma from the Faculty of Physics at the Kyrgyz National University in Bishkek. He developed that discipline to do science that was common in that time. Then came the end of the Soviet Union and his world completely changed. Those of us in the West will never be able to understand what people went through to adjust to a new way of living and doing things. Newly independent Kyrgyzstan then and now is not a wealthy country, yet Zheenbek made the transition. He received a Ph.D. in Hydrogeology and Environmental Geology from the Freiberg University of Mining and Technology in Germany. He learned to work in English, his third language.

I remember that first trip to AUCA. I was looking out the window in Zheenbek's office area and saw nothing but clouds and pollution. Mentioning that to Zheenbek, he showed me a publication of his about using a portable air quality monitor to measure particulate pollution in Bishkek. This was a demonstration of his scientific versatility and broad

Participants from the water management conference in June 2019 at a field trip to the Ala Archa National Park in Kyrgyzstan. Zheenbek is pictured in the front row, fourth from the right.

interests in the environment. We began discussing potential ways to work together on environmental sciences at AUCA. Then the following week he came to Tashkent for an international conference on reclamation of marginal arid lands in the Central Asian deserts. He had introduced me to many others in Bishkek and laid the groundwork for my participation on the scientific committee for the Conservation Asia 2018 conference held at AUCA in August of 2018. I received a travel grant to spend the summer of 2018 at AUCA. Although it was a gratifying summer, that was when I first learned about his very serious health issues. In December of 2018, he came to the American Geophysical Union conference in Washington, where we met again, and he was quite open about his health. He organized a conference on management of water resources in Central Asia held at AUCA in June 2019. The proceedings were published as a special issue by Springer.

The last time I saw him in person was in late February and early March of 2020. Peter van Oevelen and I were visiting AUCA to consider its potential as a host university for some GEWEX climate workshops. Always thinking about the future, Zheenbek arranged for me to meet AUCA's President. Well, the pandemic intervened, but nonetheless, we held an online workshop at AUCA in October of 2021. And Zheenbek was very active in many of the online activities during that time. Zheenbek was a stalwart. He never stopped. In addition to his efforts with GEWEX, he was also the Central Asian coordinator for the Central Asia Regional Information Network (CARIN). His life was short by our modern standards, but he accomplished so much. And I know he had a good family life. I considered him to be a real friend, not just a really good colleague and scientist. I will miss him, and from what I have been reading in many emails and on social media, many others will also.

YESS involvement in the GEWEX Pan-GASS Meeting, the SRI2022 Congress, and a Recent Commentary Article on Data-Intensive ECR Activities

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

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The 3rd Pan-GASS Meeting was held in Monterey, CA, USA, from 25–29 July 2022 with a wide participation of around 70 early career researchers (ECRs) presenting their research during the meeting. Several ECRs were also invited to act as session moderators. In collaboration with the Atmospheric Radiation Measurement (ARM) program of the U.S. Department of Energy (DOE) and the center of Excellence in Simulation of Weather and Climate in Europe (ESiWACE), the GEWEX Global Atmospheric System Studies (GASS) Panel organized two contests for ECRs to encourage the use of ARM data and the data set of the DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains (DYAMOND), respectively. In addition, a third ECR competition was organized in collaboration with the World Climate Research Programme (WCRP). The YESS community would like to congratulate the awardees for their excellent contributions and presentations. Moreover, our former Executive Committee (ExeCom) member, and currently GASS Panel member representing the YESS community, Carla Gulizia, attended the pan-GASS Meeting, and she was also invited as a panelist in the roundtable "*How to Increase Engagement in WCRP*" during the GEWEX SSG-34b session held at the same venue during 26–27 July.

The YESS community was also well-represented at the Sustainability Research and Innovation Congress 2022 (SRI2022) held from 20–24 June 2022 and hosted by the Future Africa Institute at the University of Pretoria, South Africa (*https://attend.sri2022.org/people/7KEZfPxTnaJ2qh4MP*). SRI2022 featured 700 speakers and 2,000 participants from 100 countries. ExeCom member Faten Attig-Bahar served as one of the program committee members for the congress, and co-hosted and spoke in six different sessions, with topics including the role of women in science and ECRs at the time of the pandemic. YESS officer Valentina Rabanal was also invited as a speaker.

Finally, a group of YESS-members led by former ExeCom-member Shipra Jain recently published a commentary article on the struggle of ECRs to find a balance between data intensive and foundational climate science activities in AGU Advances (*https://doi.org/10.1029/2022AV000676*). The aim of this article is to start a community-wide discussion on this challenge through the following survey: *https://forms.gle/hbWgwKjbiytCdJ9X6*. We invite you to take this short survey, which is open until 15 October 2022.

Attention Student and Early Career Scientists!

Danyka Byrnes[1] and Dan Myers[2]

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As we start the academic year, the Hydrology Section Student Subcommittee for the American Geophysical Union (AGU-H3S, *https://agu-h3s.org*) has an exciting lineup of events and resources to help early career scientists develop professionally, network, and explore.

Grant Writing Workshop: Need help grant writing? This free workshop is happening on October 20, 2022 from 12–2pm EST, in partnership with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). Visit *https://agu-h3s.org/events/* soon for more updates.

Navigating Academic and Non-academic Waters: Missed our summer Cyberseminars about succeeding as a postdoc (August 11) and non-academic jobs (September 8)? Visit *https://www.youtube.com/CUAHSI* to see recordings of these and other workshops.

WaterPOC & AJEDI Resource Database: The Water Researchers of Color (WaterPOC) database contributes to AJEDI efforts by providing a resource of water researchers. Learn more at: *https://agu-h3s.org/waterpoc-database/*. Also, H3S recently made available a database of Accessibility, Justice, Equity, Diversity, and Inclusion (AJEDI) resources for early-career scientists and the broader community. Access and contribute to the database at *https://tinyurl.com/h3s-database*.

Scientific Branding Webinar: Through personal websites and social media, scientists use branding to communicate their research and advance their careers. This webinar will feature a panel of scientists discussing the why and how for developing your brand. Stay tuned into *https://agu-h3s.org/events/* for updates.

H3S Summer Contest: H3S hosted a fun contest to explain your conference abstract using only the 1,000 most common words, with the deadline of September 1st. Visit *https://tinyurl.com/h3s-contest* to read the abstracts and congratulate the winners.

AGU Fall Meeting: Meet H3S at the AGU Fall Meeting in December for a series of Town Halls including "Building Your Network: Collaborating as an Early-Career Hydrologist," "A cross-career stage conversation about AGU Hydrology Section initiatives," and "Successful Proposal Writing for Early-Career Scientists in Atmospheric Sciences" (organized by Atmospheric Sciences Early Career committee). We will also be at the session "Engaging in DEI Initiatives as an Early Career Researcher" and contributing to an informational workshop for Fall Meeting first-timers.

The WCRP Academy Lighthouse Activity

Chris Lennard[1], Angela Maharaj[2], Amy Lovecraft[3], Andrew Charlton-Perez[4], Antonietta Capotondi[5], Ayman Batisha[6], Enrique Sanchez[7], Feba Francis[8], Iréne Lake[9], Luciane Veeck[10], Michael Bosilovich[11], Pablo Borges de Amorim[12], Peter van Oevelen[13], Thando Ndarana[14], Ayman Batisha[15], Clifford Chuwah[16], Qingyun Duan[17], Melissa Hart[18], and Dorcas Kalele[19]

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What is the WCRP Academy?

The World Climate Research Programme (WCRP) Academy Light House Activity is the advisory and coordination arm of WCRP for human capacity development in climate and climate impact research both within and outside WCRP. The Academy was formed in response to WCRP's belief that the provision of climate science training could be made more efficient and sustainable by better connecting providers and consumers of training.

The mission of the WCRP Academy is to equip current and future climate scientists with the knowledge, skills, and attributes required to tackle the world's most pressing and challenging climate research questions. We do this through assessing the requirements for climate research training in various contexts and building enabling mechanisms to facilitate this. The Academy will thus be a hub for climate science training opportunities, a marketplace that connects training providers with scientists who are seeking training (Fig. 1).

Structure and Current Status of the Academy

For the last 2 years, the Academy, like other Lighthouse activities, has developed its science plan (*https://www.wcrp-climate.org/lighthouse-activities/2107-science-plans/2107-Science-Plan-LHA-Academy.pdf*) through a Science Plan Development Team (SPDT) that included GEWEX representation through Peter van Oevelen. With the completion of this task, the leadership layer has recently transitioned to a Steering Group (SG) through an open call for nominations and has representation from some core projects including GEWEX. The author list

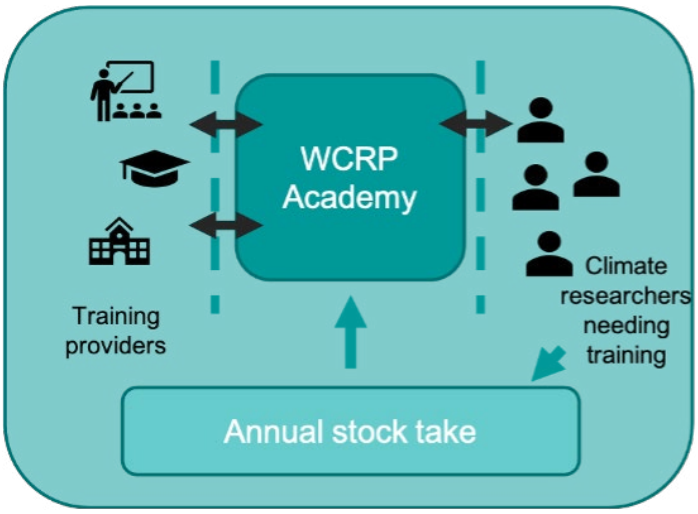


***Figure 1**. Role of the Academy in facilitating training collaborations for climate science researchers.*

of this article includes members of the SPDT in recognition of the work they have done in setting up the Academy science plan as well as the new SG. The SG will direct and oversee the activities of the Academy that will largely take place through three Working Groups (WGs):

1. Stocktake WG, which will regularly survey the climate science training landscape and provides the content for the training hub
2. Identity and Portal WG, which will develop the Academy brand as well as the online training hub/portal
3. Finance WG, which will establish a business model for the Academy to facilitate long-term financial stability and a sustained efficacy and impact.

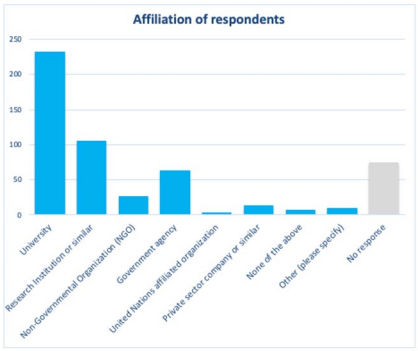
Annual stocktakes are envisaged that map climate science training requirements and climate science training providers. This work is both inward facing, with the aim of consolidating and supporting training activities within WCRP, and outward facing, which will bring together an even broader range of training opportunities. The Academy will also identify training gaps and advocate for those needs to be met.

Using this information, the Academy will facilitate engagement between these communities and serve climate science training needs of the climate science community through an online hub/marketplace. To build this marketplace, the Academy will work with WCRP core activities, other Lighthouse activities, and established climate education providers, including universities.

The Academy's activities will promote lifelong learning opportunities and facilitate global equity in climate science training. To this end, we will prioritize training opportunities for developing nation scientists who are often in regions most vulnerable to climate variability and change.

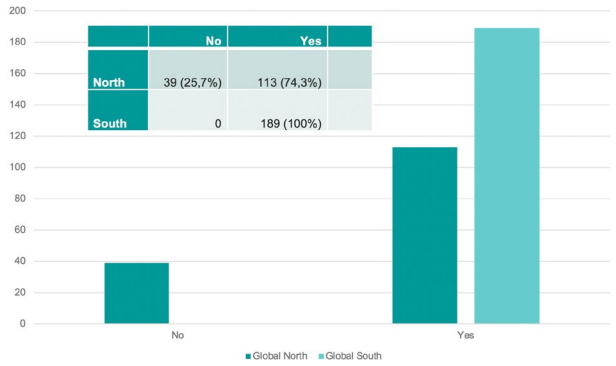
(a)

Survey respondents	
Global North	198
Global South	216
Total	414
Gender	
Man	222
Woman	180
Non-binary	6
Prefer not to say	6
Top 10 respondent countries	
Brazil	50
United States	35
United Kingdom	35
Australia	24
Germany	22
India	21
Nigeria	20
Peru	14
Argentina	14
Norway	11

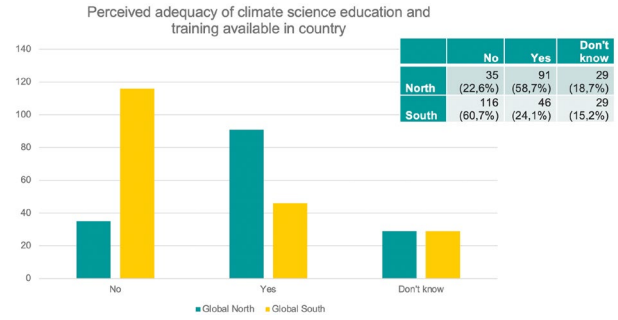


(b) **Would you like access to additional climate science training or education?**

	No	Yes
North	39 (25,7%)	113 (74,3%)
South	0	189 (100%)



(c) **In your opinion, is the climate science training and education available in your country adequate to allow researchers to work effectively on climate change science and associated fields?**



	No	Yes	Don't know
North	35 (22,6%)	91 (58,7%)	29 (18,7%)
South	116 (60,7%)	46 (24,1%)	29 (15,2%)

(d)

Obstacles to the provision of adequate climate science training and education in your country (respondents could choose multiple)	
Financial barriers	112
A lack of local expertise	74
Technical limitations (computer capacity, etc.)	60
Training available but limited to formal studies	58
Limited knowledge of available options	54
Limited face to face training available	47
Limited internet access	41
Limited online training available	39
Language barriers	35
Training not available formally or informally	21
Limited (or no) help for people with disabilities (physical, behavioural, learning etc.)	17
No physical access to educational facilities (due to distance/transport,...)	15
Ethnic group biases	12
Gender biases	7
Disregard for long-term problems	6

***Figure 2**. Preliminary stocktake results showing (a) demographics of respondents, (b) desire for further climate science training, (c) what the capacity for climate science training is in the respondent's country, and (d) perceived barriers to further climate training in Global South respondents.*

The Academy will measure its success by the scope and diversity of the global climate research community that engages with the Academy, as well as its ability to improve global access to high-quality climate science training and professional development without prohibitive costs to the trainee.

Activities of the Academy

In addition to the development of the Science Plan, the Academy has successfully conducted its first climate training stock take survey (*https://www.wcrp-climate.org/academy-survey*), which collected 400 unique responses from WCRP and the broader climate research community across the globe. Early analysis of the results indicates that there is an appetite for additional climate science training in a number of contexts, particularly from respondents from the Global South, where finances, lack of local expertise, and technical limitations pose barriers to further learning (Fig. 2).

Global South respondents expressed greatest need for training in the (higher order) analysis of climate model results, the collection and analysis of observations, and the development and verification of forecasting and prediction systems. More general training required by these respondents included training in coding/programming, science communication, writing academic publications and proposal/grant applications, GIS, and more qualitative methods.

The results of the survey will help the Academy to pinpoint what the community identifies as current gaps and emerging needs. We believe there is tremendous potential for collaboration in the near future with GEWEX and other core programs to see how we may work together to meet these identified needs.

GEWEX and the Academy

In terms of capacity development, the GEWEX community already conducts a number of activities including conferences, workshops, and regional training programs. GEWEX also actively engages in increasing capacity for hydroclimate research in developing countries through training and outreach initiatives to help participants engage in independent research.

These training programs form a natural synergy point for collaboration between GEWEX and the Academy. The Academy presents an opportunity for GEWEX training content to be featured in the Academy online marketplace and be seen by

a much wider audience. This would likely increase the reach and efficacy of the training, particularly in the developing nation context where the need is greatest. The Academy, in turn, would be able to host high-quality climate training material, archive materials for future use, and facilitate ways to scale up training in the longer term.

The Academy hopes in the future to be able to monitor the training and career paths of early career scientists (ECS), thereby improving transparency and accountability around professional development training in the community. Here, another natural synergy between GEWEX and the Academy would be GEWEX outreach programs to ECS where the Academy could assist with identifying groups who have ECS interested in training around GEWEX themes and facilitate these linkages with relevant workshops, summer schools, and conferences.

We also hope to set up or join networks for public and private institutions, learners, and peers to improve networking and career opportunities for early- and mid-career researchers internationally.

Whilst the Academy's inaugural survey was a success, we did identify geographical gaps in our reach, particularly throughout Asia, Southeast Asia, and China. Furthermore, the Academy is also grappling with how it could access and curate training in working languages other than English, and we are keen to be connected to those who provide such training. We would be very interested in being linked to the GEWEX community in these regions to improve their representation in future surveys and training activities.

Within the formal structure of the Academy, we would welcome representatives from the four GEWEX Panels who are interested in capacity building and training to either make themselves available to serve in one of the three Working Groups or consult with the GEWEX representative on the Academy SG as to how to most effectively contribute to the goals of the Academy.

Summary

For the WCRP Academy, with its mission to equip current and future climate scientists with the knowledge, skills, and attributes required to tackle the world's most pressing and challenging climate research questions, it is imperative that collaborations and relationships with core programs such as GEWEX be developed and nurtured to achieve its objectives.

There is tremendous potential for this through current (and future) GEWEX capacity development programs, and within the Academy are a rich set of opportunities for the GEWEX community to engage.

The Academy and GEWEX leadership teams look forward to interacting with the larger GEWEX community as we begin building a marketplace of training opportunities to capacitate climate and climate impact scientists of today and the future.

The Baltic Earth Assessment Reports: From BACC to BEAR

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Baltic Earth (*https://baltic.earth*) succeeded the Baltic Sea Experiment (BALTEX) in June 2013, and is currently one of the GEWEX Regional Hydroclimate Projects (RHPs). It strives to coordinate and foster research in an international and interdisciplinary network of institutions and scientists working on regional Earth system issues in the Baltic Sea region. The *BALTEX Assessment of Climate Change for the Baltic Sea Region* (BACC, 2008) was among the first regional assessments that took the Intergovernmental Panel on Climate Change (IPCC) example to the regional level, but with a dedicated bottom-up strategy. No countries were officially involved, only scientists from the region, from different countries and disciplines. The idea was to compile a "*synthesis of material drawn comprehensively from the available scientifically legitimate literature (e.g., peer reviewed literature, conference proceedings, reports of scientific institutes). Studies whose results and conclusions cannot be reconciled with a consensus view but which are of a good scientific and technical standard should be taken into account. The assessment should thus encompass the knowledge about what scientists agree on but also identify cases of disagreement or knowledge gaps*" (*https://baltic.earth/bacc*; BACC II tasks and responsibilities). The assessment was published as a comprehensive textbook with Springer, by more than 80 authors from various disciplines. It is separated into three parts: past climatic changes, possible future climatic changes, and the manifold impacts on terrestrial, freshwater and marine ecosystems of the region. An important aspect already in this early assessment was the close collaboration with the Helsinki Commission (HELCOM), which is an intergovernmental organization to protect the Baltic Sea environment and to give associated scientific advice and recommendations to the contracting partner countries. As such, it acts as a regional science-policy interface. Seven years later, the *Second Assessment of Climate Change for the Baltic Sea Region* (BACC II, 2015) was published, this time with more than 140 authors, and updated content, including new aspects like postglacial climate change, socio-economic aspects of climate change, and drivers of regional climate change, including aerosols and land use. Both assessment reports, published as textbooks, represent excellent archives of the contemporary knowledge of climate change and its impacts in the Baltic Sea region, and are excellent study books on the environment of the Baltic Sea region.

The BEAR Reports: New Scope, New Format

When it was time to come up with an update to BACC II, the format was discussed: should there be a third book, a BACC III, or should the opportunity be taken to realize a primary

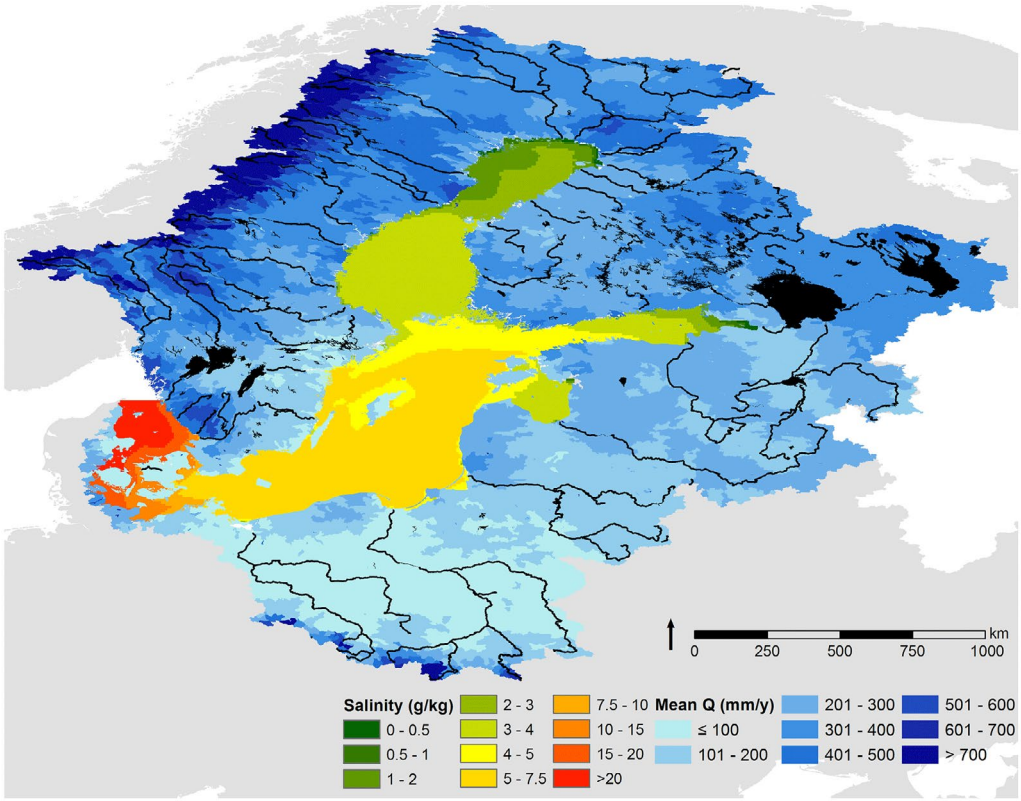

***Figure 1**. The Baltic Sea and its catchment area, with climatological mean salinity (g kg-1) and river runoff (mm yr-1). From Meier et al., 2014.*

goal that was formulated in the birth phase of Baltic Earth: "*It is, however, one important task of the new BALTEX to perform a continuous assessment of scientifically important questions by identifying and defining new Grand Challenges*" (Rutgersson et al., 2012)? This was further elaborated on in the Baltic Earth Science Plan 2017: assessment reports of the state of the current knowledge of specific scientific fields are central products of Baltic Earth. Following the example of the BALTEX (2008) and Baltic Earth (2015) regional climate change assessments for the Baltic Sea basin, the assessment reports should be multi-authored and state the current, consensual knowledge of a specific topic but also identify cases of disagreement, and thus help to pinpoint knowledge gaps requiring further research.

In June 2018, the Baltic Earth Science Steering Group adopted the concept of the "Baltic Earth Assessment Reports" (BEAR): a series of extensive, peer-reviewed papers in a special issue of an international open access journal, providing a state-of-science review on the respective Grand Challenges or topics. An outstanding paper is the summary of the current knowledge on climate change in the Baltic Sea region, an update to BACC I and II. As for the BACC reports, there was a very close collaboration with HELCOM. An international team of scientists from different disciplines (Expert Network Clime, EN Clime: *https://helcom.fi/helcom-at-work/groups/state-and-conservation/en-clime/*) elaborated a comprehensive Climate Change Fact Sheet in 2021, which largely draws from the BACC and BEAR compilations and which wraps together the current knowledge in a very brief and concise way, accessible also to managers and the public (CCFS, 2021).

The ten BEAR papers are available as open access papers in a special issue in *Earth System Dynamics* (*https://esd.copernicus.org/articles/special_issue1088.html*), very briefly summarized here:

- **Salinity dynamics of the Baltic Sea**, Grand Challenge 1 (Andreas Lehmann et al., *https://esd.copernicus.org/articles/13/373/2022/*)

  In the Baltic Sea, salinity and its large variability, both horizontal and vertical, are key factors for the physics but also have large effects on ecosystem processes. This paper is a continuation and update of the BACC II book, published in 2015. Here, the focus is on observing and indicating the role of climate change for salinity dynamics. The dynamics of Major Baltic Inflows (MBI) have been intensively studied, resulting in new information regarding MBI-related meteorological conditions, variability in salinity, and exchange of water masses between various scales. All these processes are coupled with changes in the Baltic Sea circulation dynamics. To arrive at better scenarios for the salinity conditions in the Baltic Sea, we need more studies on factors like the meteorological patterns at various spatial and time scales as well as mesoscale variability in precipitation. Also, updated information on river runoff and inflows of saline water is needed to close the water budget. Furthermore, we have a limited understanding of the water mass exchanges between the

North Sea and the Baltic Sea and within its sub-basins, and the complicated vertical mixing processes. Hence, the response to climate change is highly uncertain.

- **Biogeochemical functioning of the Baltic Sea**, Grand Challenge 2 (Karol Kulinski et al., *https://esd.copernicus.org/articles/13/633/2022/*)

  Recent decades have brought significant changes in the Baltic Sea. Rising nutrient loads from land in the second half of the 20th century led to eutrophication and spreading of hypoxic and anoxic areas. Since the 1980s, the nutrient loads to the Baltic Sea have been continuously decreasing, but this has so far not resulted in significant improvements in oxygen conditions. This assessment reviews the available and published knowledge on the biogeochemical functioning of the Baltic Sea. It covers the aspects related to changes in carbon, nitrogen, and phosphorus (C, N, and P) external loads, their transformations in the coastal zone, changes in organic-matter production (eutrophication) and remineralization (oxygen availability), and the role of sediments in burial and turnover of C, N, and P. It also focuses on changes in the marine CO_2 system, the structure and functioning of the microbial community, and the role of contaminants for biogeochemical processes.

- **Natural hazards and extreme events in the Baltic Sea region**, Grand Challenge 3 (Anna Rutgersson et al., *https://esd.copernicus.org/articles/13/251/2022/*)

  A natural hazard is a naturally-occurring extreme event that has a negative effect on people and society or the environment. Here, we summarize existing knowledge about extreme events in the Baltic Sea region with a focus on the past 200 years as well as on future climate scenarios. The events considered here are the major hydro-meteorological events in the region and include windstorms, extreme waves, high and low sea levels, ice ridging, heavy precipitation, sea-effect snowfall, river floods, heat waves, ice seasons, and drought. We also address some ecological extremes and the implications of extreme events for society (phytoplankton blooms, forest fires, coastal flooding, offshore infrastructure, and shipping). Significant knowledge gaps are identified, including the response of large-scale atmospheric circulation to climate change, and the occurrence of marine heat waves and small-scale variability in precipitation.

- **Sea level dynamics and coastal erosion in the Baltic Sea region**, Grand Challenge 4 (Ralf Weisse et al., *https://esd.copernicus.org/articles/12/871/2021/*)

  Processes contributing to sea level dynamics and coastal erosion in the Baltic Sea include the still ongoing viscoelastic response of the Earth to the last deglaciation, contributions from global and North Atlantic mean sea level changes, or contributions from wind waves affecting erosion and sediment transport along the subsiding southern Baltic Sea coast. Other examples are storm surges, seiches, or meteotsunamis, which primarily contribute to sea level extremes. Such processes have undergone considerable variation and change in the past. For example, over approximately the past 50 years, the Baltic absolute (geocentric) mean sea level has risen at a rate slightly larger than the global average. In the northern parts of the Baltic Sea, due to vertical land movements, relative mean sea level has decreased. Processes contributing to Baltic sea level dynamics and coastline change are expected to vary and to change in the future, leaving their imprint on future Baltic sea level and coastline change and variability.

- **Human impacts and their interactions in the Baltic Sea region**, Grand Challenge 6 (Marcus Reckermann et al., *https://esd.copernicus.org/articles/12/871/2021/*)

  We present an inventory and discussion of different human-induced factors and processes affecting the environment of the Baltic Sea region, and their interrelations. Some are naturally occurring and modified by human activities (i.e., climate change, coastal processes, hypoxia, acidification, submarine groundwater discharges, marine ecosystems, non-indigenous species, land use and land cover) and some are completely human-induced (i.e., agriculture, aquaculture, fisheries, river regulations, offshore wind farms, shipping, chemical contamination, dumped warfare agents, marine litter and microplastics, tourism, and coastal management), and they are all interrelated to different degrees. We present a general description and analysis of the state of knowledge on these interrelations. Our main insight is that climate change has an overarching, integrating impact on all of the other factors and can be interpreted as a background effect, which has different implications for the other factors.

- **Global climate change and the Baltic Sea ecosystem: direct and indirect effects on species, communities and ecosystem functioning**, Baltic Earth topic (Markku Viitasalo and Erik Bonsdorff, *https://esd.copernicus.org/articles/13/711/2022/*)

  Climate change has multiple effects on Baltic Sea species, communities, and ecosystem functioning through changes in physical and biogeochemical environmental characteristics of the sea. Associated indirect and secondary effects on species interactions, trophic dynamics, and ecosystem function are expected to be significant. We review studies investigating species-, population-, and ecosystem-level effects of abiotic factors that may change due to global climate change, such as temperature, salinity, oxygen, pH, nutrient levels, and the more indirect biogeochemical and food web processes, primarily based on peer-reviewed literature published since 2010.

- **Coupled regional Earth system modeling in the Baltic Sea region**, Baltic Earth topic (Matthias Gröger et al., *https://esd.copernicus.org/articles/12/939/2021/*)

  Nonlinear responses to externally-forced climate change are known to dampen or amplify the local climate im-

pact due to complex cross-compartmental feedback loops in the Earth system. These feedbacks are less well represented in the traditional stand-alone atmosphere and ocean models on which many of today's regional climate assessments rely [e.g., the Coordinated Downscaling Experiment - European Domain (EURO-CORDEX), the North Sea Region Climate Change Assessment (NOSCCA), and BACC II]. This has promoted the development of regional climate models for the Baltic Sea region by coupling different compartments of the Earth system into more comprehensive models. Coupled models more realistically represent feedback loops than the information imposed on the region by prescribed boundary conditions and, thus, permit more degrees of freedom. This article reviews recent progress on model systems that allow two-way communication between atmosphere and ocean models; models for the land surface, including the terrestrial biosphere; and wave models at the air–sea interface and hydrology models for water cycle closure.

- **Atmospheric regional climate projections for the Baltic Sea region until 2100**, Baltic Earth topic (Christensen et al., *https://esd.copernicus.org/articles/13/133/2022/*)

  The Baltic Sea region is very sensitive to climate change; it is a region with spatially varying climate and diverse ecosystems, but it is also under pressure due to a high population in large parts of the area. In this overview paper, recent climate projections from 12.5 km horizontal resolution atmosphere-only regional climate models from EURO-CORDEX are presented. These projections strengthen the conclusions from previous assessments, including a strong warming, in particular in the north in winter. Precipitation is projected to increase in the whole region apart from the southern half during summer. Consequently, the new results lend more credibility to estimates of uncertainties and robust features of future climate change.

- **Oceanographic regional climate projections for the Baltic Sea until 2100**, Baltic Earth topic (Meier et al., *https://esd.copernicus.org/articles/13/159/2022/*)

  In this study, recently-performed scenario simulations for the Baltic Sea including marine biogeochemistry were analyzed and compared with earlier published projections. Specifically, dynamical downscaling using a regionally-coupled atmosphere–ocean climate model was used to regionalize four global Earth system models. However, as the regional climate model does not include components representing terrestrial and marine biogeochemistry, an additional catchment and a coupled physical–biogeochemical model for the Baltic Sea were included. The scenario simulations take the impact of various global sea level rise scenarios into account. According to the projections, compared to the present climate, higher water temperatures, a shallower mixed layer with a sharper thermocline during summer, less sea-ice cover, and greater mixing in the northern Baltic Sea during winter can be expected.

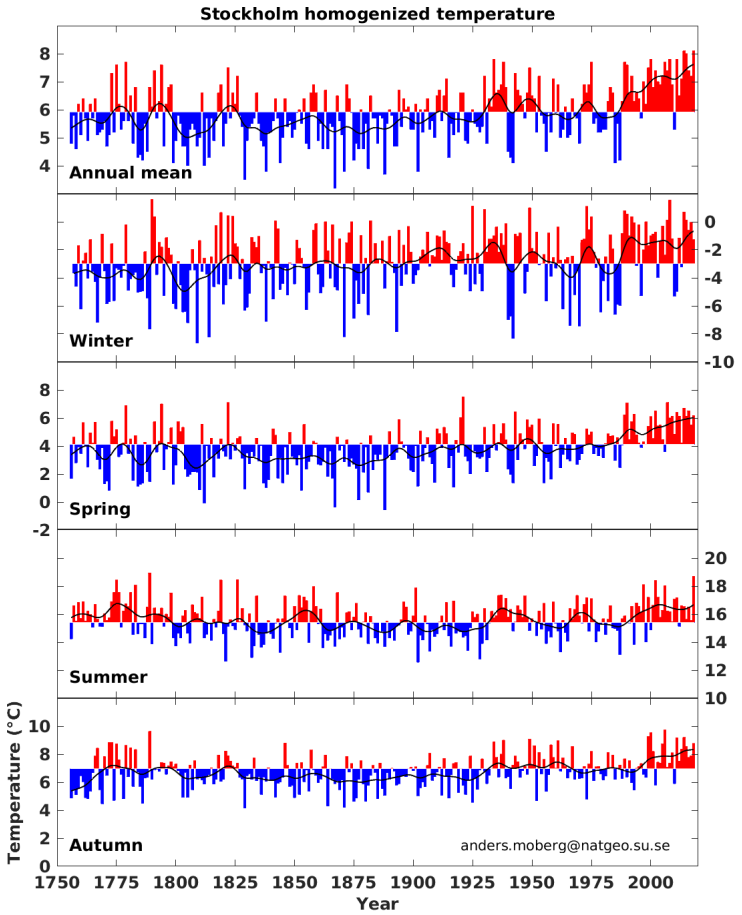

***Figure 2**. Homogenized annual and seasonal mean temperature in Stockholm during 1756–2018. Each colored bar shows the mean temperature, in red or blue, depending on whether the temperature is above or below the reference period 1961–1990. The black curve represents smoothed 10-year mean temperatures. Source:* https://bolin.se/data/stockholm-historical-temps-monthly *(last access: 17 February 2022); Anders Moberg, Stockholm University, Sweden.*

  Both the frequency and the duration of marine heat waves will increase significantly, in particular in the coastal zone of the southern Baltic Sea (except in regions with frequent upwellings). Nonetheless, due to the uncertainties in the projections regarding regional winds, the water cycle, and the global sea level rise, robust and statistically-significant salinity changes could not be identified.

- **Climate change in the Baltic Sea region: A summary**, Baltic Earth topic (Meier et al., *https://esd.copernicus.org/articles/13/457/2022/*)

  This study is an update of BACC II published in 2015 and focuses on the atmosphere, land, cryosphere, ocean, sediments, and the terrestrial and marine biosphere. Based on the summaries of the recent knowledge gained in paleo-, historical, and future regional climate research, we find that the main conclusions from earlier assessments still remain valid. However, new long-term, homogenous observational records, such as those for Scandinavian glacier inventories, sea-level-driven saltwater inflows, so-called Major Baltic Inflows, and phytoplankton species

distribution, and new scenario simulations with improved models, such as those for glaciers, lake ice, and marine food webs, have become available. In many cases, uncertainties can now be better estimated than before because more models were included in the ensembles, especially for the Baltic Sea. With the help of coupled models, feedbacks between several components of the Earth system have been studied, and multiple driver studies were performed, e.g., projections of the food web that include fisheries, eutrophication, and climate change. New data sets and projections have led to a revised understanding of changes in some variables such as salinity. Furthermore, it has become evident that natural variability, in particular for the ocean on multidecadal timescales, is greater than previously estimated, challenging our ability to detect observed and projected changes in climate.

Prospects for the Future

In addition to assessment reports on the various Baltic Earth grand challenges and topics, Baltic Earth organizes conferences, workshops, and educational events like summer and winter schools. As of the 4th Baltic Earth Conference in Jastarnia, Poland, in June 2022, the first phase of Baltic Earth is slowly coming to a close and will be terminated after 11 years with the 5th Baltic Earth Conference in June 2024 in Latvia. The two years between the two conferences will be used to analyze the research gaps specified by the BEAR reports and to elaborate an updated Baltic Earth Science Plan with the goal of a pragmatic way forward: research goals that are timely and feasible. The discussions are just beginning, and the outcomes will define a new Baltic Earth phase.

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Meeting/Workshop Reports

Understanding and Modeling Atmospheric Processes: 3rd Pan-GASS Meeting

Monterey, CA, USA
25–29 July 2022

Daniel Klocke[1], Sandrine Bony[2], and Shaocheng Xie[3]

[1]Max Planck Institute for Meteorology, Hamburg, Germany; [2]Laboratoire de Meteorologie Dynamique (LMD/IPSL), Paris, France; [3]Lawrence Livermore National Laboratory, Livermore, CA, USA

Atmospheric processes from the micro- to meso-scale shape the world we live in by influencing the global water and energy exchanges. The 3rd Pan-Global Atmospheric System Studies (GASS) Meeting (https://www.gewexevents.org/meetings/3rd-pan-gass-meetingunderstanding-and-modeling-atmospheric-processes/) was held to review progress in the understanding and modeling of atmospheric processes, identify pressing issues and opportunities, and organize activities in the international research community to advance this understanding. The meeting was supported financially and through local organization by the U.S. Department of Energy's Lawrence Livermore National Laboratory.

After scientific discussions had largely retreated to the virtual world over the past two years, the community was eager to exchange again with colleagues in person. For some of the early career scientists, it was the first time they met some of their colleagues face-to-face and experienced the international collaboration that is so important to the field.

The conference was organized along four themes, which reflected current and future directions of activities in the GEWEX GASS Panel. Those themes were (i) organization of shallow and deep convection, including the underlying processes, their dependence on environmental conditions, their representation in numerical models, and their role in extreme events, large-scale circulation, and cloud feedbacks; (ii) surface–atmosphere interactions and the boundary layer, including the role of mesoscale processes in air–sea coupling, the role of land–atmosphere coupling in predictive skill, surface and orographic drag, and atmospheric boundary layer over land, ocean, and ice; (iii) cloud systems and associated processes (microphysics, physics, dynamics, radiation): convective systems, including shallow/deep transition, precipitation intensity and variability, scale-awareness and transition from parameterized to resolved convection, mixed-phase clouds, cirrus, and fog, polar clouds and planetary boundary layer processes, and radiative transfer; and (iv) towards global km-scale modeling of the Earth System: strengths and challenges; innovative approaches for high-performance comput-

ing, data analysis, and visualization; and science in support of the World Climate Research Programme (WCRP)'s Lighthouse Activity on Digital Earths. Around 200 participants from the international community participated through oral presentations, posters, and vivid discussions during breakout groups. For more information, including conference presentations, posters, and discussion summaries, see *https://www.gewexevents.org/meetings/3rd-pan-gass-meetingunderstanding-and-modeling-atmospheric-processes/*.

An important part of Pan-GASS meetings are breakout groups to discuss the progress of ongoing projects or the launch of potential new initiatives. Current GASS projects and activities, whose members met during the conference to discuss results and next steps, were the GEWEX Upper Tropospheric Clouds and Convection Process Evaluation Study (UTCC PROES), the Impact of Initialized Land Temperature and Snowpack on Sub-Seasonal to Seasonal Prediction (LS4P) project, the Diurnal Cycle of Precipitation (DCP) project, and the GEWEX Aerosol Precipitation (GAP) initiative. New activities of the community were discussed, such as one based on the EUREC4A field campaign (with a modeling intercomparison on the representation of the mesoscale organization of convection with an additional focus on air-sea fluxes), one based on shallow convective momentum transport, and another on global km-scale models. Similarly, an activity on the Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE) field campaign is planned, with a focus on convective clouds during arctic cold-air outbreaks using nudged climate model runs to be able to compare directly with observations. the Lagrangian large eddy simulation (LES)/single column model (SCM) approach.

Other relevant community activities discussed during the meeting include 1) the WCRP Global Precipitation Experiment (GPEX) project, which will be a multi-year project targeting the improvement of precipitation prediction using an integrated observation and modeling strategy; and 2) the World Meteorological Organization's Year of Polar Prediction (YOPP) site intercomparison project, which is a coordinated, international process-based model evaluation project based on high-frequency, multi-variate observations at select Arctic and Antarctic supersites during the YOPP. Nudged climate simulations that could make the comparison between simulations and observations easier were also discussed.

In order to guide future GASS activities, three overarching questions were formulated from the meeting's discussions:

1. How do the micro- to meso-scale atmospheric processes control global water and energy exchanges?
2. What controls cloud phase and precipitation?
3. What controls the mesoscale organization of convection?

Implementation plans for the discussed topics are being prepared to help answer the above-listed questions, and interested scientists are invited to get involved and contribute to the activities.

Highlights of the GEWEX SSG-34

Monterey, CA, USA
26–27 July 2022

Xubin Zeng[1], Jan Polcher[1], and Peter van Oevelen[2]
[1]GEWEX Scientific Steering Group Co-Chair; [2]Director, International GEWEX Project Office

GEWEX held the 34th session of its Scientific Steering Group (SSG) through two in-person meetings: SSG-34A from 3–5 May 2022 in Paris, and SSG-34B from 26–27 July 2022 in Monterey, California. This was the first in-person session since January 2020 (for SSG-32) due to COVID-19. While SSG-34A focused more on the discussions about the new GEWEX Science Plan and other strategy documents to align with WCRP's new priorities in anticipation of Phase IV (2023–2032) of GEWEX, SSG-34B emphasized the interaction with funding agencies and other programs. As the full report will be prepared later as a WCRP Publication (e.g., see last year's report at *https://www.gewexevents.org/wp-content/uploads/GEWEX-SSG33-report_V2.pdf*), here we provide a few highlights only.

GEWEX Panels are all proactive in organizing or planning exciting new activities, with a few examples provided here.

- The Global Land-Atmosphere System Studies (GLASS) Panel has launched a project on the modeling of solar-induced chlorophyll fluorescence (SIF) in land models (SIFMIP) as a bridge to better understand the coupling of energy and water cycles to the carbon cycle, and initiated another project on the Coupling of Land and Atmospheric Subgrid Parameterizations (CLASP).
- The GEWEX Hydroclimatology Panel (GHP) has engaged heavily with scientists in different continents to explore and develop regional hydroclimatological projects, and has proposed a Crosscutting Project on flooding, which has not received much attention in Earth system modeling.
- The Global Atmospheric System Studies (GASS) Panel has been efficient in completing, continuing, and initiating projects, and is expected to launch new initiatives soon that are related to shallow and deep convection and their organization/aggregation, as well as other topics.
- The GEWEX Data and Analysis Panel (GDAP) is in the process of developing a new strategy in helping the data and user community: instead of labeling "GEWEX data sets", GDAP will try to develop the GEWEX criteria for satellite data sets (related to the energy and water cycles) to meet through data assessment and analysis.

GEWEX has made good progress in integrating Process Evaluation Studies (PROES) into the existing Panel structure. These PROES are intended to integrate observation-based metrics to understand key physical processes in climate and to improve weather and climate models at their fundamental process levels. Now two such PROES, the GEWEX Aerosol Precipitation (GAP) initiative and the PROcess Evaluation Study on Upper Tropospheric Clouds and Convection (UTCC-PROES), will join the GASS

Participants at the second half of the 34th session of the GEWEX Scientific Steering Group

Panel for reporting and closer interactions, and at the same time, they will continue to interact with other Panels (e.g., GDAP).

GEWEX is proactively interacting with all five WCRP Light House Activities (LHAs). Some of the LHAs have already published articles in GEWEX Quarterly to introduce their activities and possible collaborations with GEWEX. For instance, the Digital Earth LHA and GEWEX have a substantial collaboration in km-scale modeling of the global atmosphere and land (that requires the modeling of the 3-D movement of water).

GEWEX SSG Co-Chairs Jan Polcher and Xubin Zeng are leading the WCRP tiger teams on (energy, water, and carbon) Cycles and the Global Precipitation Experiment (GPEX), respectively. Representing WCRP, GEWEX also interacts with the World Meteorological Organization (WMO) Hydrology efforts.

The GEWEX vision starts with observations, as observations lead to better understanding of the Earth system and help improve climate/weather modeling and prediction, thereby providing the scientific underpinnings of climate services. Therefore, GEWEX organized a Space Agency Roundtable discussion forum involving representatives from the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the European Space Agency (ESA), the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the Centre National d'Etudes Spatiales (CNES), the Japan Aerospace Exploration Agency (JAXA), and Copernicus (the European Union's Earth observation program). Instead of giving Power Point presentations, these agency representatives were invited to briefly provide their perspectives on each common question, followed by general discussion. One question was: what should the top priorities be for space programs for the energy and water cycles and their coupling to the carbon cycle? Numerous ideas, concerns, and questions were shared, e.g., how can we better plan and support satellite observation continuity and development of new technology? How can we enhance the use of satellite data for science and applications?

GEWEX also held a panel discussion on engagement with the Global South in WCRP activities. One key point from this discussion was that scientific expertise is more important than running models or processing huge data sets in helping the South. Furthermore, it is crucial for the South to develop its own initiatives and priorities (with assistance from the North), rather than for the North to develop initiatives for the South. Besides international partnership, innovative approaches are also needed to sustain the scientific expertise through the support of governments in the South.

WCRP Joint Scientific Committee Chair Detlef Stammer attended the SSG-34B meeting in person, providing an update on various WCRP activities, including the WCRP Open Science Conference to be held in Kigali, Rwanda, in October 2023 (https://www.wcrp-climate.org/wcrp-osc23). During this Conference, WCRP will also launch the GPEX initiative and its African component.

WMO Science and Innovation Department Director and Chief Scientist Jürg Luterbacher also came to the meeting in person, providing an update on the WMO organizational structure with some focus on the WMO Hydrology initiative, including its current call for small proposals.

A major outcome of the SSG-34B is the establishment of the GEWEX Ambassador Award to honor colleagues who have contributed a significant amount of their time and energy to GEWEX and who can continue to promote GEWEX in the broadest sense. With a history of over 30 years of improving understanding of the global water and energy cycles, GEWEX named Claudia Stubenrauch from the Laboratoire de Météorologie Dynamique (LMD-IPSL) and Michael Ek from the National Centre for Atmospheric Research (NCAR) as the first recipients. Colleagues have already begun to call them Her Excellency Claudia and His Excellency Mike!

As this was the first in-person meeting after Graeme Stephens stepped down as the SSG Co-Chair, GEWEX presented Graeme with a gift and heart-felt appreciations with a "top eight list of things we remember when we think of Graeme" –from his good accent to his vision on big picture considerations such as satellite missions and major initiatives, and from his easy-going personality to his legacy of finishing the *Bulletin of the American Meteorological Society* article on the first 30 years of GEWEX.

The Eighth Aerosols-Clouds-Precipitation and Climate (ACPC) Workshop

Virtual Meeting
9–14 May 2021

Michael Jensen[1], Minghuai Wang[2], Daniel Rosenfeld[3], Matthew Christensen[4], Andrew Gettleman[5], Jiwen Fan[4], Philip Stier[6], Meinrat O. Andreae[7,8], Graham Feingold[9], Sue van den Heever[10], Ralph Kahn[11], Johannes Quaas[12], Kentaroh Suzuki[13], Bethan White[14], and Rob Wood[15]

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The Aerosols-Clouds-Precipitation-and-Climate (ACPC; *http://www.acpcinitiative.org*) initiative convened its eighth annual (virtual) workshop from 9–13 May 2022 to discuss progress towards understanding the role of aerosol perturbations on clouds and precipitation. The event was organized into two broad themes aligned with the two ACPC working groups, aerosol effects on low clouds (focusing on "natural laboratories"; Christensen et al., 2022) and aerosol effects on deep convective clouds [focusing on the TRacking Aerosol Convection interactions ExpeRiment (TRACER); Jensen et al., 2022]. During each session, participants discussed updates on ongoing research activities and roadmaps, and participants from around the globe presented their progress, using a hierarchy of modeling and observational approaches.

The low-cloud sessions took place over two days with longer talks followed by an interactive poster session. The first day focused on studies involving warm rain physics, cloud morphology, and aerosol-cloud interactions (ACI) in stratus and stratocumulus clouds. Talks included a new adiabatic fraction retrieval from satellite (X. Lu), 1D-wavelet analysis using European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5 (ERA5) data (X. Zhou), a fine and coarse aerosol analysis of warm rain (F. Liu), and a new entrainment analysis (T. Su). Z. Zhang presented a new parameterization of aerosol effects based on probability of precipitation and cloud droplet number concentration. Modeling studies provided new theoretical understanding of the role of warm rain processes (Z. Liu) and meteorological factors (R. Samson) in the timing of the transition from stratus-to-cumulus.

Through the coordinated efforts of ACPC, we recently published a review paper on natural laboratories and experiments (Christensen et al., 2022). This thread was picked up on day two where we heard a new roadmap being considered on marine cloud brightening (G. Feingold) as well as observational studies of polluted cloud tracks (V. Toll), impacts of shipping regulations on radiative forcing using machine learning (D. Watson-Parris, T. Yuan), and trajectory modeling (P. Manshausen) approaches. Modeling volcanic aerosol impacts on clouds from Hawaii showed a surprising decrease in liquid water path and cloud fraction when the emissions were on (D. Grosvenor), but the opposite occurred for simulations of the Holuhruan volcano (M. Haghighatnasab).

Group discussions pointed out the important role of the radiative effect of changes in cloud coverage caused by increased aerosol concentration. Studies have generally showed that it can be large, but we essentially do not know by how much. There is a methodological challenge in defining cloud fraction for estimating aerosol effects on cloud fraction, requiring either a satellite (observation) simulator for models or a threshold approach in the observations. Furthermore, cloud detection threshold differences across studies are vast. Another key area of research is to focus efforts on the timescale of ACI, as it is critical to constraining microphysical and macrophysical processes in clouds, and the quantifiable effects of aerosols appear to change over time as clouds and aerosols co-evolve. Finally, there was consensus that models and observations need to be combined better to make significant advances in aerosol-cloud interactions.

The deep convective cloud (DCC) sessions focused on progress on the ACPC roadmap (Jensen et al., 2021) and research activities on the impacts of marine aerosols; the importance of aerosol type, composition, and size distribution on DCC processes including ice microphysics; and interactions of local processes with the large-scale circulation. The workshop ended with the planning of TRACER-focused modeling activities and future directions.

With the TRACER campaign ongoing, new measurements and long-term analyses were presented, providing fodder for a discussion of future ACPC modeling studies. A plan was developed to follow a similar philosophy to the previous ACPC model intercomparison project (MIP; Marinescu et al., 2021). Several "golden cases" selected from TRACER will be simulated over a similar diversity of environmental conditions (thermodynamic, aerosol), including models with different levels of complexity. Analysis of the existing MIP results focused on examining aerosol effects on the evolution of hydrometeor characteristics and microphysical processes of convective cells and found that among the models, liquid phase response to aerosols is mostly consistent whereas the ice phase responses are highly variable (S. Saleeby).

An entire session was dedicated to the impact of marine aerosols. Zamora and Kahn (2020) demonstrate a method for quantifying aerosol-cloud interactions from satellite observations controlling for co-varying meteorology. This methodology enabled the determination of the aerosol type responsible for the observed cloud property changes. Satellite data was also used to enable investigation of the contrasting impact of fine and coarse

aerosols on DCC and lightning (Pan et al., 2021). Studies demonstrated that the deep layer of marine ice nucleating particles (INPs) associated with atmospheric rivers can play a significant role in affecting orographic mixed-phase clouds and precipitation in the western U.S. (Lin et al., 2022).

To explore how local aerosol effects interact with the large-scale circulation, a numerical set-up that resolves clouds in high resolution while accounting for large-scale circulation and thermodynamic feedbacks was presented (G. Dagan). This work emphasized the importance of examining aerosol effects on DCC life cycle, particularly anvil clouds, which have long-lasting radiative impacts.

The DCC sessions wrapped up with a discussion of potential future research directions, including the impact of different aerosol size distributions, composition, and type. Further, a focus on ice microphysics, anvil radiation impacts, and the effects of urbanization and climate warming were defined as topics of interest.

During the ACPC scientific steering committee (SSC) meeting, Daniel Rosenfeld, a founding member of ACPC, stepped down from his role as co-chair, and Michael Jensen was selected to serve as a new co-chair. In addition, four new SSC members were elected: Guy Dagan, Jiwen Fan, Andre Gettleman, and Franziska Glassmeier. The next ACPC meeting is planned for April 2023, and a hybrid meeting format is proposed, including both a physical meeting and a virtual component. All colleagues interested in ACPC topics are cordially invited to join the initiative.

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Global Water Futures Meets Online for 2022 Annual Open Science Meeting– Knowledge to Action

Virtual Meeting
16–18 May 2022

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Global Water Futures (GWF), a GEWEX North American Regional Hydroclimate Project (RHP), held its fifth Annual Open Science Meeting online over three days (16–18 May 2022), with a central theme of "Knowledge to Action". The meeting had 490 registrants and was well-attended throughout. There were multiple plenary sessions with keynote speakers, high-level panels, Indigenous-led sessions, parallel scientific sessions with oral presentations and lightning talks, poster presentations, and virtual social events. Parallel scientific sessions included 59 oral presentations and 71 posters. All the sessions are available for viewing on the meeting page at https://www.gwf2022.com/.

Throughout the three-day meeting, the theme of Knowledge to Action was integral in the presentations, discussions, and outcomes. Plenary keynote talks featured diverse perspectives on each day's theme: Towards Managing and Governing Water Futures, Water-related Risk Reduction, and Harnessing Data and Knowledge to Improve Water Practice. These set the context for the high-level panels to explore issues in detail, focusing on some specific questions. High-level panels addressed topics including i) Water Governance in a Changing Future; ii) the Canada Water Agency–Towards Innovative Water Management; iii) Extreme Events and Impacts in 2021; iv) Risk Reduction including Human, Ecological, and Economic Elements; v) Advancing Water Management with Science and Models; and vi) Using New Sensors and Datasets to Improve Water Management. The first day of the meeting featured a plenary session called "Our Waters", led and organized by Indigenous partners, which included a set of videos and panel discussions to share and learn about several water bodies in Canada (Redberry Lake, Grand River, and the Saskatchewan River Delta), the communities around them, and the issues they face through the eyes of Indigenous youth, Elders, and community members. Scientific presentations and posters addressed how research is being applied in practice or for potential practical applications.

Of specific relevance to GEWEX, GWF has made substantial advances in continental-scale modeling through the work of our Core Modeling and Forecasting team. These were summarized on the third day of the meeting in the plenary session, Harnessing Data and Knowledge to Improve Water Practice. GWF

has moved towards a model-agnostic framework where model components can be interchanged and run at a continental scale.

GWF has also been leading a focal examination of the 2021 extreme heat, drought, wildfires, storms, and flooding across Canada that broke numerous records and caused extensive damage and societal impacts. A panel was convened at the meeting on day two to discuss progress in understanding and diagnosing these events, and how to better manage and adapt to future extremes. Carrying out these types of focused examinations of single or multiple extreme events through interdisciplinary collaboration was an approach started in the earlier Changing Cold Regions Network RHP for western Canada, and is encouraged for all RHPs to better understand, predict, and manage the increasing occurrence of such events around the world.

GWF2022 Conclusions

Global Water Futures has amassed a large amount of knowledge through research and is working with many collaborators, including Indigenous partners, to better work across knowledge systems and within the uncertainty of our water futures in Canada.

Over the past five years of the program, we have completed laboratory, theoretical, fieldwork, and community research activities as well as modeling, visualization, sensor, and tool development. We have helped develop the first national water prediction models for Canada. We continue to synthesize research findings through workshops, sectoral meetings, model applications, and publications. We need to continue these synthesis activities in collaboration with our research partners while continuing our communication and outreach through regional and sectoral science discussions and custom knowledge translation applications. This is timely, given the extreme water–energy events experienced across Canada in 2021. The record-breaking heat, drought, rainfall, melt, and wildfires experienced were not only of immense magnitude, but also remarkable persistence and national impact.

Several key messages emerged over the course of the meeting:

- The importance of **collaborative and reciprocal partnerships**. Partnerships between disciplinary experts, partnerships with Indigenous and other communities, governments, organizations, and businesses to **reduce the disconnects** between disciplines, sectors, urban/rural and upstream/downstream contexts, knowledge systems, languages, and scientific information versus public information needs
- The importance of **open minds and active listening** as part of knowledge mobilization. Engagement starts at the conceptualization of research and needs to be continued throughout, listening to concerns and ideas and working collaboratively to generate solutions.
- The importance of **working across knowledge systems**, harnessing **process knowledge and quantitative and qualitative data**, developing **holistic and community-informed models**, and **reconnecting and reconciling** with each other, and with the environment
- The importance of **co-developing water governance systems** in Canada using multiple knowledge systems and braiding Indigenous and current colonial mechanisms
- The importance of better and more extensive **measurement and prediction systems**
- The recognition that we are **not ready** for the water-related climate change impacts that we will continue to experience and that we need a different way to **proactively manage water-related disasters** and **reduce risk**
- The recognition that in mitigating water-related risks, we need **solutions that account for biophysical, social, cultural, political, and economic contexts** while **ensuring that risk is not displaced** to other types, groups, places, ecosystems, or times
- The recognition that **vulnerability to water-related risks is interwoven with issues of social and environmental justice**
- The recognition that the **Canada Water Agency** can be a critical catalyst towards achieving our sustainable and equitable water future, as long as it is given the requisite agency and mandate to act effectively and does so within a collaborative governance structure
- The recognition that there are many **opportunities to learn** from success stories, both within Canada (e.g., Manitoba's Collaborative Leadership Initiative) and internationally (Aotearoa's water future)
- The recognition that the **tremendous knowledge, data, and tools** developed in Global Water Futures need to be **preserved and made accessible for current and future generations** as they seek solutions for a more sustainable and equitable water future for Canada.

Ultimately, the climate crisis is the water crisis and we need partnerships to create innovative, equitable, and sustainable solutions. All voices need to be at the table and we need creativity, imagination, intentionality, and transformative thinking to lead us towards more sustainable water futures.

GEWEX QUARTERLY

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