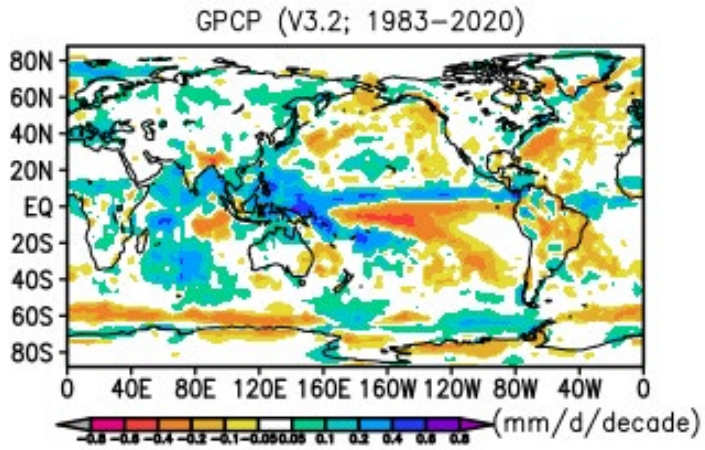

***Figure 3**. Regional trend map (1983–2020). Units are mm/d/decade*

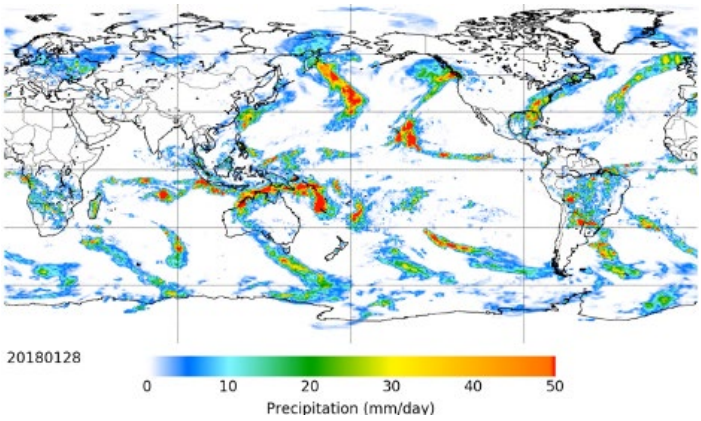

***Figure 4**. An example of GPCP V3.2 Daily (2000–2020) for January 28, 2018*

mission (IMERG; Huffman et al., 2020) Final product and other inputs (e.g., precipitation analysis from infrared sounders in high latitudes), with results adjusted to the Monthly product. Both the Monthly and Daily products also include a Probability of Liquid Phase (PLP) based on a specification using reanalysis surface information.

The GPCP group welcomes feedback from users of these new products while we continue to improve observation-based analysis of global precipitation.

References

**The full list of references can be found at* https://www.gewex.org/gewex-content/uploads/2022/06/Q22022_GPCP_References.pdf.

Adler, R.F., J.-J. Wang, G. Gu, and G.J. Huffman, 2009. A ten-year tropical rainfall climatology based on a composite of TRMM products. *J. Meteorol. Soc. Japan*, 87A, 281–293.

Adler, R., G. Gu, M. Sapiano, J. Wang, and G. Huffman 2017. Global Precipitation: Means, Variations and Trends During the Satellite Era (1979-2014). *Surv. Geophys.*, 38: 679–699, doi:10.1007/s10712-017-9416-4.

Adler, R., M. Sapiano, G. Huffman, J. Wang, G. Gu, D. Bolvin, L. Chiu, U. Schneider, A. Becker, E. Nelkin, P. Xie, R. Ferraro, and D. Shin, 2018. The Global Precipitation Climatology Project (GPCP) Monthly Analysis (New Version 2.3) and a Review of 2017 Global Precipitation. *Atmosphere*, 9(4), 138; doi:10.3390/atmos9040138.

Meeting/Workshop Reports

2021 GEWEX Hydroclimatology Panel (GHP) Meeting

Virtual Meeting
8–9 November 2021

Ali Nazemi and Francina Dominguez
GHP Co-Chairs

In response to the ongoing Covid-19 pandemic, the 2021 GHP Meeting was held fully online through Zoom. This was the second consecutive virtual annual GHP meeting, which provided an opportunity for Panel members and project leaders from across the globe to share and review the status of current and future GHP activities, including: (1) Regional Hydroclimate Projects (RHPs), (2) Cross-Cutting Projects (CCs), (3) Global Data Centers (GDCs) and (4) GHP Networks. While these projects are fully independent, together they provide an integrated understanding of environmental water and energy exchanges at regional scales, from observing and modeling of physical processes to assessing socio-economic impacts. Building on the experience obtained in 2020, the meeting was distributed over two days, each including two sessions divided by a short break. Similar to the 2020 GHP Meeting, each ongoing and envisioned project submitted its presentation(s) and report(s) in advance, so Panel members could review each activity prior to the meeting. As a result, each project could be effectively overviewed and discussed in 10- to 15-minute slots.

Day 1

The first day of the meeting was kicked off by reviewing the progress of ongoing networks, CCs, and RHPs. After a brief welcome by the co-chairs, the existing networks were reviewed. Networks aim at maintaining collaboration and capacity for activities relevant to GHP science objectives. PannEx, previously an initiating RHP, has now evolved into a thriving network. During 2021, the network published a special issue with 14 contributions on understanding of Earth system processes over the Pannonian Basin. The team was also awarded funding for a new project on micrometeorological measurements and analyses. The Panel is pleased with the progress made despite Covid-19 restrictions and suggested more interactions with other GHP projects, such as Third Pole Environment-Water Sustainability (TPE-WS). The Panel regretted to see the sunset of the Australian Energy and Water Exchanges research initiative (OzEWEX). The Panel suggested reaching out to other colleagues in the region to maintain this space for engaging the Australian community with GEWEX.

CCs are global efforts focused on knowledge syntheses around GEWEX Science Questions relevant to GHP. They encourage collaboration between GHP projects, other GEWEX Panels, and broader World Climate Research Programme (WCRP) activities. The Transport and Exchange Processes in the

Participants of the 2021 GHP Meeting

Atmosphere over Mountains Experiment (TEAMx) CC aims at improving the current understanding of exchange processes in the atmosphere over mountains and how these processes are parameterized in climate models. TEAMx progressed well and organized a workshop with nearly 200 participants. While the activities of TEAMx are mainly concentrated in the Alps region, their focus is on processes and therefore have global relevance. The Panel noted the exceptional opportunity for knowledge sharing between TEAMx and other RHPs and CCs. The International Network for Alpine Catchment Hydrology (INARCH) is entering its second phase. INARCH submitted its draft activity proposal, which is due to be reviewed by the Panel. One key focus of INARCH's second phase will be on human-water interactions in mountainous regions and downstream areas. So far, the activity includes 29 operational research sites in 14 counties. The Panel is very satisfied with how the second phase of INARCH is developing and suggested more interactions with relevant CCs and RHPs.

After a short break, ongoing RHPs were discussed. RHPs are generally large, multidisciplinary projects, developed for improved understanding of the physical processes that affect water and energy exchanges within a region. The two ongoing RHPs are mature projects that involve a large group of active researchers with strong ties to stakeholder groups, which create exceptional opportunities toward addressing the impacts of changing hydroclimatology on human activities and the environment. Global Water Futures (GWF) continues to be a flagship for a top-down RHP with clear contributions to the science, practice, and policy-making of water futures in Canada. The Panel is pleased to see how GWF is expanding to include Indigenous knowledge and views on water. In addition, GWF has become a truly global effort through collaboration with other RHPs and CCs. Unlike GWF, Baltic Earth operates as a bottom-up network of collaborating scientists. It reported major progress on dissemination of the project results through a comprehensive special issue on the past, current, and future of the Earth system in the Baltic region, along with producing fact sheets for stakeholders and policy makers. The Panel also discussed the second phase of the Hydrological cycle in the Mediterranean eXperiment (HyMeX). It is envisioned that a young generation of researchers will lead the new phase of HyMeX, which will serve more as an umbrella for understanding the regional response to climate change and the associated impacts on users and stakeholders. The new HyMeX team has submitted two proposals and been actively involved in the Land Surface Atmosphere Interactions over the Iberian Semi-Arid Environment (LIAISE) campaign.

The meeting continued with the introduction of two new Panel members. Rowan Fealy from Maynooth University of Ireland is actively involved with research on the use of Artificial Intelligence in observing and modeling land surface processes. Anna Sörensson from the University of Buenos Aires of Argentina is heavily involved with the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), particularly in terms of linking global to regional climate change. The Panel welcomed the two new members and noted their potential contributions, particularly as a part of GHP contributions to the new WCRP Lighthouse Activities (LHAs) and the Regional Information for Society (RIfS) core project. Day 1 concluded with discussion on the two prospective CCs, namely Precipitation over Mountainous Terrain (MOUNTerrain) as well as the Flood CC. These efforts are particularly relevant to the My Climate Risk LHA and RIfS. MOUNTerrain has started recruiting team members through a special issue and plans for a kickoff workshop in the fall of 2022. The Flood CC will look at a wide spectrum of challenges around understanding flooding processes from observation to model development to socio-economic impact assessments. It published its first GEWEX Quarterly article and has started to build a community around the topic.

Day 2

The second day of the annual GHP meeting was dedicated to the review of prospective RHPs, current GDCs, and prospective joint CCs between GHP and the Global Land-Atmosphere System Studies (GLASS) Panel. The day kicked off with a review of the prospective RHPs. The Regional Hydrology Program for the Andes (ANDEX) demonstrated significant progress, including a white paper consisting of published manuscripts and its science plan, which is currently with the Panel for review. The Asian Precipitation Experiment (AsiaPEX) also had a fruitful year, running a conference session and publishing a review paper. The science plan of AsiaPEX is currently under preparation and will be submitted in 2022. TPE-WS also demonstrated significant progress, publishing high-quality papers and data sets as well as setting up new observational transect sites. The project plans to submit its science plan in 2022. The Panel was pleased to see the significant developments made around the United States-RHP

(US-RHP), given that it is still in its beginning stages. The US-RHP benefits from a dedicated leadership team, which is taking an inclusive and comprehensive approach to build this RHP from the bottom up. A strong affinity group with a wide range of sub-groups has been holding regular meetings and the leadership team has presented the project idea at major conferences. It has set a realistic timeline for applying to initiating RHP status in 2022. The Central Asia initiative, a collaboration between the SysTem for Analysis, Research and Training (START) and the National Aeronautics and Space Administration (NASA), is a prospective RHP also showing significant progress in building a regional community. It had its first workshop in 2021, and is planning for a hydrological modeling workshop in 2022.

GDCs collect and distribute hydrologically relevant data and are an integral part of GHP activities. The Global Precipitation Climatology Centre (GPCC) is well-connected to the other GHP and GEWEX activities. Steady and significant progress was reported related to precipitation data from both near real-time and non-real time data sources. The Global Runoff Data Centre (GRDC) focuses on acquisition, harmonization, and storage of global historical river discharge data, and has also demonstrated noteworthy progress as new data are continuously added into the system. Discussions occurred around the International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE) and how this GDC can collaborate with similar initiatives outside GHP and GEWEX.

GHP also includes two prospective CCs, i.e., Determining Evapotranspiration (dET) as well as the Irrigation CC. These are joint initiatives between the GHP and GLASS Panels. dET focuses on advancing the understanding and determination of evapotranspiration across scales. It experienced a fruitful year as the second ET workshop was held online in February, which led to shaping the working groups. The activity has also benefited from the successful LIAISE campaign, which will result in comprehensive data support for informing ET studies. The dET leadership also had some discussions with AmeriFlux on potential avenues for collaboration. The Irrigation CC focuses on intercomparison of irrigation algorithms in current Earth system models and had its first workshop online in early November 2021. Discussions led by Josh Roundy, GLASS-GHP liaison, identified other potential joint activities between the GLASS and GHP Panels, most notably around the GEWEX Land-Atmosphere Feedback Observatory (GLAFO), a network of measurement sites sampling the atmospheric boundary layer and upper surface.

While the 2021 annual GHP meeting enjoyed focus and effectiveness in the discussions and remained quite targeted during both days, it became very clear that such online meetings cannot deliver the spirit of previous in-person GHP meetings–something that was greatly missed by the Panel and projects' leads. We are pleased to announce that next GHP meeting will be held in-person in late July 2022 during the Pan-GEWEX conference in Monterey. We very much look forward to this upcoming meeting.

High-Resolution Climate Modeling and Hazards: A Summary of the 5th Convection-Permitting Modeling Workshop

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The fifth installment of the Convection-Permitting Modeling (CPM) Workshop series was held online between September 7–14, 2021. The workshop was organized by Japan Meteorological Business Support Center (JMBSC) Disaster Prevention Research Institute, Kyoto University (DPRI), Meteorological Research Institute (MRI), and the National Center for Atmospheric Research. A total of 139 participants from 28 countries took part in seven live sessions and online poster presentations. The fifth CPM workshop had the theme "High-Resolution Climate Modeling and Hazards", and the main focus of the workshop was on simulating mesoscale processes and extreme events with CPMs at local to global scales and the use of high-resolution climate models for hazard and impact assessments. Recent advancements were discussed in CPM simulations and wind, flood, and other hazard modeling; ensemble and high-resolution climate modeling activities; computational and data volume challenges; and how to facilitate interactions between interdisciplinary communities.

It is important to assess the impacts of climate change on extreme natural hazards such as strong winds, water-related hazards, and hazards from other aspects of the hydrological cycle due to their significant socio-economic costs. However, hazard assessments are difficult on regional scales because of the small-scale nature of hazards (less than 10–500 km), which currently cannot be resolved in General Circulation Models (GCMs). Although the general impact of climate change on natural hazards has been largely addressed and discussed, the latest assessments from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report (AR6) highlight that quantitative hazard assessments at regional to local scales are still limited.

In recent years, projections for assessing regional climate at high resolution using CPMs and their projections have become increasingly important to address this research gap. CPM-based simulations of extreme precipitation and heavy snowfall have made significant progress in reproducing extreme weather events on the regional or national scale. Coupled atmosphere-ocean-wave models are also being developed and are expected to be used to better understand coastal and other hazards. In addition, CPMs have facilitated great progress in improving projected future climate change impacts on extreme events such as river and storm surge impact assessments.

So far, most CPM simulations are performed on regional scales. There is an increasing interest in running global CPMs for climate change assessments. It is hoped that such models will provide novel insights into climate change impacts on