GEWEX NEWS

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2018 GEWEX Science Conference | Extremes and Water on the Edge

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8th GEWEX Open Science Conference

Highlights from the 8th GEWEX Open Science Conference

Peter van Oevelen
Director, International GEWEX Project Office

GEWEX held its 8th Open Science Conference from 6-11 May 2018 in Canmore, Alberta, Canada, with over 380 in attendance. Scientists from 40 countries, a third of them female, discussed and presented on issues ranging from mountain and high latitude hydrology to atmospheric and land modeling research and observations. The Conference covered both long-standing and emerging topics and featured the work of more than 200 Early Career Researchers (ECRs). It left us very appreciative of the contributions from our community and the Conference sponsors.

Themes of the Conference mirrored the diverse research of the GEWEX community. The program reflected the science represented by the four core Panels of GEWEX and the two GEWEX-led World Climate Research Programme (WCRP) Grand Challenges on "Weather and Climate Extremes" and "Water for the Food Baskets of the World."

The Conference, organized into seven overarching themes and 26 individual sessions, was designed to cover as wide a gamut of topics on water and energy and climate and weather-related research as possible. This also allowed us to showcase the science performed under the four GEWEX Panels as well as the WCRP Grand Challenges. The GEWEX Global Atmospheric System Studies (GASS) Panel's focus on atmospheric models was shown through contributions in sessions such as "Energy and Water Budget Closure and Advances in Assessment Techniques." The Global Land/Atmosphere System Study (GLASS) Panel's concentration on land surface model development and evaluation was highlighted in sessions such as "Satellite Observations for Climate Extremes, Water Cycle Processes, and Land-Atmosphere Interactions." The GEWEX Hydroclimatology Panel (GHP)'s emphasis on regional hydroclimates was displayed particularly in the session on "Regional Hydroclimate Projects." The GEWEX Data and Analysis (GDAP) Panel's mission of guiding the production and evaluation of global data products as well as its newer direction of conducting analyses was well represented in the session on "Global Energy and Water Cycles, Clouds, and Radiation."

Weather and climate extremes and the food-water-energy nexus, the topics of the two WCRP Grand Challenges, were explored in detail in various sessions. Research on extremes in weather and climate was a popular topic and its session was well attended.

Given the Conference venue in the beautiful town of Canmore, located in the Canadian Rockies, mountainous regions and their hydrology and climate were a focal point, both throughout the Conference and in excursions led by John Pomeroy and the excellent story teller and scientist Bob Sandford. High mountainous terrain, critical for regional water supply and access, is still a frontier due to lack of research infrastructure. Many unanswered questions on weather and climate-related processes in these regions persist. During the Conference, significant steps were made that may lead to a new GEWEX Mountain Initiative to bring together the latest scientific knowledge and models, such as convection-permitting models, and the relevant research communities.

The Early Career Researchers (ECRs) from the Young Earth System Scientists (YESS) (*http://www.yess-community.org/*) group and the Young Hydrologic Society (YHS) (*https://young-hs.com/*) came together to hold the 2018 Joint YESS-YHS ECR Workshop for a three day span before the Conference. Participants discussed creating and disseminating regional information on different spatial and temporal scales, and you can read more about the Workshop on the next page. A white paper detailing outcomes and conclusions will be published in the coming months. A good portion of students and ECRs attending the Conference also entered in the ECR and Student Presentation Competition, and five outstanding researchers came away with prizes, as described on page 4.

The Wednesday night banquet served as an opportunity to wish our departing Scientific Steering Group Co-Chair, Sonia Seneviratne, farewell and to thank her for her many contributions over the four years of her tenure. Her energy will be missed. We would also like to thank the Conference sponsors (*https://www.gewexevents.org/events/2018conference/sponsors/*) for making the event possible and funding the participation of early career researchers and scientists from developing countries. Without their backing, we would not be able to put together such a fantastic event. A great many thanks also to our host institution, the Global Institute for Water Security of the University of Saskatchewan, particularly to John Pomeroy and Chris DeBeer for their fantastic input, support, and contributions.

A conference is only as good as it attendees and their contributions. We thank all who attended for sharing your enthusiasm, your great research, and your willingness to openly discuss and exchange ideas, which helped make the Conference such a success. I also thank the staff of the International GEWEX Project Office, Dawn, Shannon, and Fernande, for their tireless efforts before, during, and after the event. They were a crucial part in making it work smoothly. Thank you!

2018 Early Career Researcher Workshop at the GEWEX Open Science Conference

Canmore, Alberta, Canada
3–5 May 2018

Marisol Osman[1], Caroline Aubry-Wake[2], Carla Gulizia[1], and Gaby Langendijk[3]

[1]CIMA (CONICET/UBA), Universidad de Buenos Aires, Argentina; [2]University of Saskatchewan, Canada; [3]Climate Service Center Germany (GERICS)

On May 3-5, the Young Earth System Scientists (YESS) (*http://www.yess-community.org/*) and Young Hydrologic Society (YHS) (*https://younghs.com/*) held a Joint YESS-YHS Early Career Researcher (ECR) Workshop prior to the 2018 GEWEX Open Science Conference (OSC). The 3-day workshop brought together 40 early careers researchers from 23 different countries for an in-depth interdisciplinary discussion on generating regional information to improve our understanding of weather, water, and climate extreme events. The goal of the workshop was to develop a shared ECR vision on challenges and ways forward to enhance the generation of usable regional information for water, weather, and climate extremes, and the utility of that information for users, decision makers, and other stakeholders. During the three days, the discussions centered on three topics: data sources (conventional and unconventional), scale-interactions, and user needs.

On the first day, after an introduction of the workshop dynamic, the agenda, and the participants, Peter van Oevelen, the Director of International GEWEX Project Office, introduced the role and mission of GEWEX in the international science community. His talk outlined the function of the World Climate Research Programme (WRCP), World Meteorological Organization (WMO), and GEWEX. After lunch, Prof. John Pomeroy, Director of the Global Water Futures program, gave a talk highlighting the importance of combining observations and modeling to gain information on the processes at play in the hydrological world. Drawing from multiple examples of mountain and snow hydrology, Prof. Pomeroy explained how intensive field observations can be used to develop models, to increase our understanding of our study environment, and to predict future changes. We then jumped in a yellow school bus and headed into one of the highlights of the event: a trip to the very frosty Fortress Snow and Climate Observatory. Located in scenic Kananaskis Provincial Park 75 km from

Participants of the Joint YESS-YHS Early Career Researcher Workshop in Canmore, Alberta, Canada

Canmore, the Fortress Snow and Climate Observatory is a state-of-the-art network of automated weather stations to investigate cold region mountain hydrology. Prof. Pomeroy addressed the challenges of establishing and maintaining an observation network, and the importance of such programs for hydrological and climate studies. This field visit was followed by an evening at the Canmore Brewing Company, where the workshop participants socialized and enjoyed tasty beverages.

On the second day, Dr. Graeme Stephens, Co-Director of National Aeronautics and Space Administration (NASA) Jet Propulsion Lab (JPL), USA, gave an impulse talk on the challenges in the science of weather, water, and climate extremes. After that, participants were split into two break-out groups, each moderated by two ECRs, to discuss the workshop topics of data sources and spatial scales for user needs. For the data sources group, the goal was to explore the use of conventional and unconventional data and new technologies to provide better weather, water, and climate data services. The second group's objective was to investigate opportunities to provide the required regional information at appropriate spatial scales for varied user needs. Participants spent the day discussing these issues in the context of water and weather extremes. In these diverse groups, composed of ECRs from different regions, with different expertise and at different stages in their career, the participants brought their own perspective to enrich the proceedings.

To finish the day, we split the attendees in small groups and went for a walk outside to talk about the current state and challenges of the ECR community. We discussed five topics: empowering early career scientists from underrepresented groups, increasing involvement in the global community, raising the scientific profile of the ECR communities, engaging community members in the consolidation of the networks, and developing interdisciplinarity. These conversations pointed out the dual purpose of networks such as YESS and YHS: professional development, helping the transition from student to professional researchers, and promotion of ECRs on an international stage, pushing for a stronger voice and presence of ECRs in the research community.

On the third day, the dialogue focused on the main outcomes of the working groups and the consolidation of an ECR perspective to be outlined in a white paper after the workshop.

We had a very inspiring and fruitful ECR workshop and are looking forward to the write-up of our white paper, elaborating on an ECR perspective on regional information, to be published in an international scientific journal. Keep an eye out towards the end of 2018 to hear the results of our discussions!

This workshop was jointly organized by YESS and YHS in close consultation with the GEWEX OSC Organizing Committee and was kindly supported by WMO, WCRP, and GEWEX OSC sponsors. Travel support was provided through direct sponsorship of WMO as well as through the GEWEX OSC and its sponsors.

Winners of the Early Career Researcher and Student Presentation Competition

Top photo, from left: GEWEX Scientific Steering Group Co-Chair Sonia Seneviratne, Andreas Prein, Emily Slinskey, Julián Giles, GEWEX Scientific Steering Group Co-Chair Graeme Stephens, and Liyun Yang.

Early career researchers (ECRs) and students were invited to join a competition during the 8th GEWEX Open Science Conference, where volunteer judges evaluated talks and posters to determine the top five presentations. Over 120 ECRs and students were assessed on the originality of their approach to their research question; the analysis supporting their conclusions; their background knowledge; and the organization, clarity, and effectiveness of their submissions. Participants ranged from students pursuing Master's degrees and beyond to those who received their terminal degree no more than five years ago.

Julián Giles of the Centro de Investigaciones del Mar y la Atmósfera, Mia Gross of the University of New South Wales, and Liyun Yang of Nanjing University were each awarded an iPad. Andreas Prein of the National Center for Atmospheric Research and Emily Slinskey of Portland State University won a waiver granting them free registration to an American Meteorological Society (AMS) meeting of their choice, prizes generously donated by AMS. You can read more on the winners, their presentations at the Conference, and their research interests at *https://www.wcrp-climate.org/future-science-leadership/spotlight-on-early-career-researchers*.

The conference organizers would like to congratulate the winners and thank the many volunteer judges for their time and thoroughness. We would also like to extend gratitude to Joshua Roundy, Mike Ek, and Catherine Michaut, who spearheaded the competition.

Announcements

Dawn Erlich: 24 Years with the International GEWEX Project Office (IGPO)

Paul Try
Former Director, International GEWEX Project Office

Congratulations to Dawn Erlich, the bedrock of GEWEX, as she retires after 24 years with the IGPO. It may be a cliché, but Dawn was the "glue" that held the IGPO together and kept it on track through several Directors and the usual funding struggles. As GEWEX expanded and added projects and committees (too many to count), changing its name and logo, too, Dawn was there steadying the progress. She managed the newsletter, planned meetings and conferences of all sizes, traveled to events across the globe, and found solutions for all of the glitches that occur in a project of this size. At the hub of preparation for these activities, Dawn is well known by many of the over 2,000 scientists participating in the project worldwide. As we Directors from the past and present come up with numerous wild ideas for facilitating and encouraging the progress of GEWEX, Dawn has been the one to provide more pragmatic solutions to help the process.

We hope Dawn will remember her time at the IGPO as rewarding, given the great progress GEWEX has made over her tenure. We also hope we can continue to count on Dawn for some limited support in the future at the IGPO, as her past support has been invaluable to all who have worked with her.

Howard Wheater, Former GEWEX SSG Vice-Chair, Wins Dooge Medal

Professor Howard Wheater, who served as the GEWEX Scientific Steering Group (SSG)'s Vice-Chair from 2010 to 2014, received the 2018 International Hydrology Prize Dooge Medal. The award recognizes those who make fundamental contributions to the science of hydrology. The Dooge Medal was presented to Howard during a ceremony at the World Meteorological Organization in Geneva in early May 2018, "in recognition of his international leadership in hydrological research of scientific excellence, coupled with its translation into policy and practice and application worldwide." Howard most recently served as the Canada Excellence Research Chair in Water Security and Director of the Global Institute for Water Security at the University of Saskatchewan. His efforts have resulted in science that benefits society, giving the field a better understanding of large scale hydrology and hydrological modeling.

New GEWEX Scientific Steering Group (SSG) Co-Chair

We welcome Dr. Jan Polcher as GEWEX SSG Co-Chair, with a term beginning in June 2018. He joins Graeme Stephens to head the SSG.

Dr. Polcher is Directeur de Recherche at the Centre National de la Recherche Scientifique (CNRS) and works at the Laboratoire de Météorologie Dynamique (LMD), part of the Institut Pierre Simon Laplace (IPSL) in Paris. He studied oceanography and theoretical physics in the 1980's in Kiel, Germany. He then moved to Paris to complete a Ph.D. under the supervision of Katia Laval at LMD in 1993. Since then, his main interest lies in climate modeling of the water cycle, particularly land surface processes and their interactions with the atmosphere. He is one of the founding members of the Organizing Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) land-surface model at IPSL and continues to participate in its development. Land-surface modeling was also the reason for his initial involvement in GEWEX, where he led the creation of the Global Land/Atmosphere System Study (GLASS) Panel panel in 1999.

In 2003, Dr. Polcher focused on regional climate problems with the African Monsoon and Multidisciplinary Analyses (AMMA) project. He coordinated the project, which gathered 37 European and 22 African institutions around the objective of enhancing our understanding of the West African Monsoon. AMMA also served to empower the African research community to participate in research on climate change. As chair of the GEWEX Hydroclimatology Panel (GHP), he continued to pursue that aim of enabling communities around the world to come together around regional studies of the water cycle and its sensitivity to climate change by encouraging new regional hydroclimate projects.

In the last few years, he has reunited his passion for modeling with his interest in regional water cycle issues by leading the effort at IPSL to develop a regional climate model based on the same components as those used for the global Earth system model. This effort is currently centered on the Mediterranean region and contributes to the Hydrological Cycle in the Mediterranean Experiment (HyMeX) project. As this region's water cycle is equally controlled by climate fluctuations and human water usage, Dr. Polcher is taking a keen interest in including anthropogenic processes in land surface models. This led him to accept the co-chair position for the WCRP Grand Challenge on Water for the Food Baskets of the World.

Throughout his career, Dr. Polcher has coordinated a number of research projects funded by French and European agencies, supervised or co-supervised 12 Ph.D. theses, and authored or co-authored over 100 papers.

Hydrology Section Student Subcommittee (H3S) Plans for the 2018 Fall AGU Meeting

Megan Brown
AGU H3S Chair

The Hydrology Section Student Subcommittee (H3S) of the American Geophysical Union (AGU) is hosting a few fun activities this summer on our Twitter account, @AGU_H3S, including "Haiku Your Research." We invite you to write a Haiku about your research and tweet it to our account. On Thursday, September 27, 2018 at 2:00 PM Eastern Daylight Time, we will hold a webinar in conjunction with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) (*https://www.cuahsi.org/community/news-events/cuahsi-news-events/*) called "H3S, AGU, and You: Navigating the 2018 AGU Fall Meeting as a student or early career Hydrology Section member." We invite everyone to join us and let us know what you'd like to see at the AGU Fall Meetings and during the year. H3S is currently in the midst of planning numerous activities, both in terms of professional development and social networking, for students and early career scientists at the AGU Fall Meeting from 10–14 December 2018 in Washington, D.C. Our events will take advantage of our Washington, D.C. location and the beginning of AGU's Centennial.

Currently we are planning two workshops at the Meeting, one on the tools of the trade for research and another focused on representative spatial scales for hydrologic modeling. In addition, we will be hosting up to five Pop-Up Talk Sessions, back in their original format of short lightning talks; watch for a call for abstracts in early fall! The topics of our Pop-Up Talk Sessions include:

- Building Communities Through Shared Experiences: Social Dimensions in AGU
- Frontiers in Hydrology: Paths Toward the Next Century in Water Research
- Hydrology for Public Good: Best Practices and Lessons Learned from Community Engagement
- The Role of a Scientist in the 21st Century: Big Ideas for the Next 100 Years and How to Get There
- Bridging Science and Policy for Change: Best Practices

We are also proposing two Town Hall sessions on alternative careers to academia. We hope everyone will join us at our Fall Meeting events. Keep an eye on our Twitter account, @AGU_H3S, for updates and news!

Process Evaluation Study on Warm Rain (PROES-WR)

Kentaroh Suzuki[1], Hanii Takahashi[2,3], and Graeme Stephens[3,4]

[1]University of Tokyo, Kashiwa, Japan; [2]Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, California, USA; [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA; [4]University of Reading, Reading, UK

The GEWEX Process Evaluation Study (PROES) has been launched as a community effort intended to integrate observation-based metrics for a better understanding of key physical processes critical to climate and to improve their representations in numerical weather prediction and climate models (Stephens et al., 2015), thereby advancing the models at their "building-block" level. The PROES concept is developed differently from the vast array of activities now part of model inter-comparison efforts, requiring a more direct engagement with modeling groups and tailored diagnostics from them. PROES activities seek to work directly with model development groups specifically on targeted processes, develop critical diagnostic tools to test them, and collaborate with those groups to address biases that are exposed by the study. Warm rain formation is one such process that governs how cloud water suspended in the atmosphere is converted into precipitation. It thus largely controls cloudiness, a fundamental cloud characteristic determining the radiative effect and significantly impacting our ability to simulate the climate (Golaz et al., 2013). The warm rain process is also a pathway central to aerosol impacts on clouds, or the aerosol indirect effect, a major uncertainty in climate projection that is often "tuned" to reproduce historical temperature evolution in climate models (e.g., Penner et al., 2010; Golaz et al., 2013). The latest PROES will focus on the warm rain process, developing new diagnostic methodologies and providing data to constrain representations of warm rain processes in models.

GEWEX-PROES Warm Rain (PROES-WR)

The warm rain process is typically represented in numerical models through parameterizations for two modes of the water conversion process, i.e., auto-conversion and accretion, which express the water conversion rate in a way that depends on mixing ratios and number concentrations of cloud and rain water. The functional form dictating this dependency, however, is subject to large uncertainty, which is also a major source of uncertainty in estimates of the aerosol indirect forcing. There is a critical need for better constraints on the fundamental uncertainty in model cloud physics, which would lead to more reliable estimates of the aerosol indirect forcing and thus climate projection.

Recent measurement capabilities offered by space-borne active and passive sensors within the A-Train satellite constellation enable the simultaneous observation of clouds and precipita-

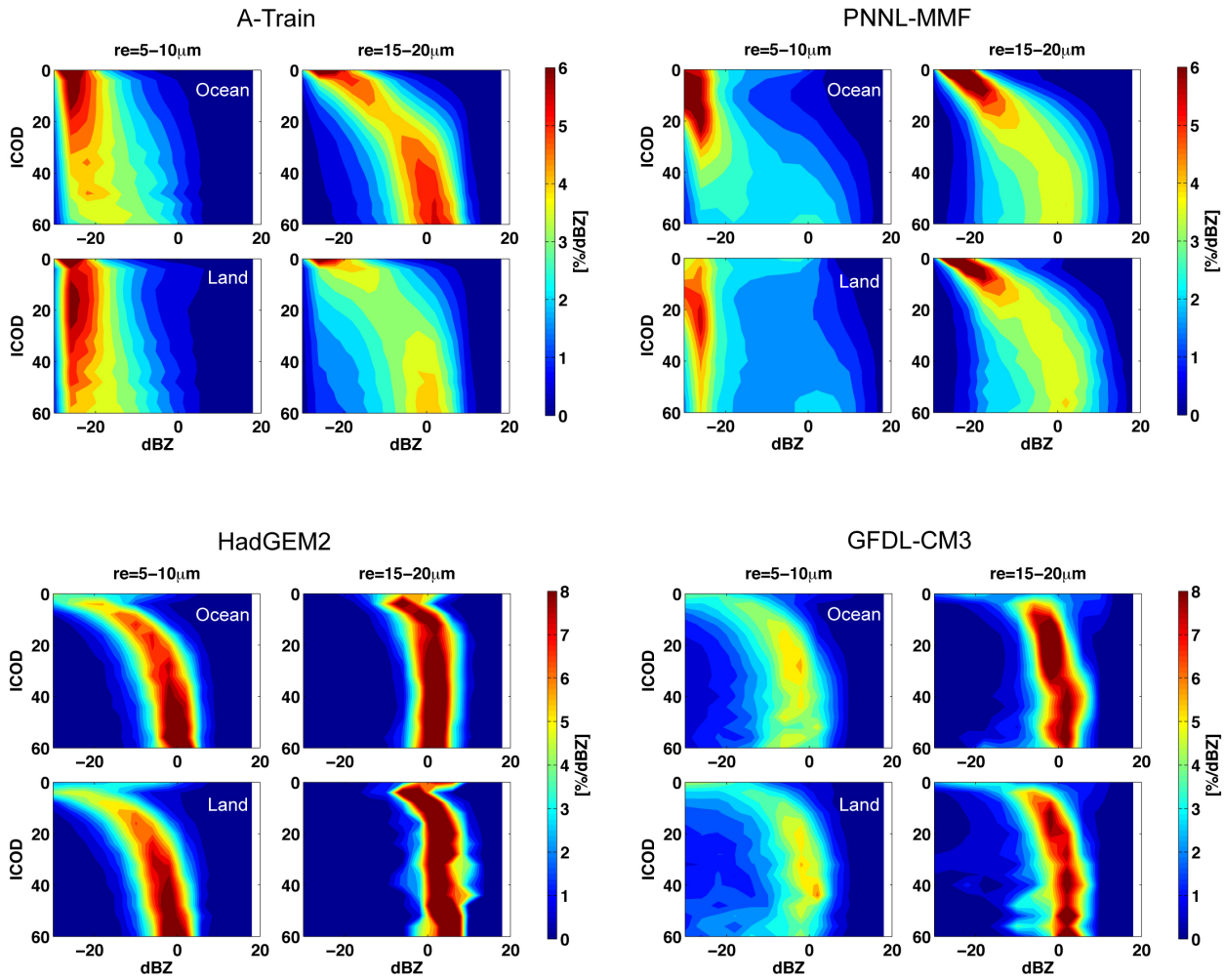

Figure 1. *The probability density function (color shading in the unit of %/dBZ) of radar reflectivity (abscissa) normalized as a function of in-cloud optical depth (ICOD) increasing downward (ordinate), which is further classified according to different ranges of cloud-top particle sizes (5-10μm and 15-20μm) and separately shown over ocean and land. The statistics are compared between A-Train satellite observations, the Pacific Northwest National Laboratory's Multi-scale Modeling Framework (PNNL-MMF) model, the Hadley Centre Global Environment Model version 2 (HadGEM2), and the Geophysical Fluid Dynamics Laboratory Coupled Model (GFDL-CM3) (adapted from Suzuki et al., 2015, and Takahashi et al., 2017).*

tion, which provides unprecedented information about the cloud-to-precipitation water conversion process on the global scale. Motivated by this recent progress in satellite observations, the GEWEX PROES Warm Rain (PROES-WR) initiative aims to develop new diagnostic methodologies that specifically probe the warm rain process parameterizations exploiting multi-sensor satellite observations, and then serve as observation-based metrics to constrain model representations of the process. The methodologies combine multiple satellite observables of cloud and precipitation to construct particular statistics that "fingerprint" the warm rain process.

PROES-WR Metrics

Fig. 1 shows an example of statistics depicting how vertical microphysical structure tends to transition from non-precipitating to precipitating types when vertical profiles of radar reflectivity (the primary observable from CloudSat) are represented in the form of the probability density function normalized as a function of cloud optical depth, a major Moderate Resolution Imaging Spectroradiometer (MODIS) observable, and further classified according to cloud-top particle size, another key MODIS observable (Suzuki et al., 2010). The figure also highlights an important difference of the microphysical transition over land compared to over ocean, which can be traced to different updraft velocities, implying a significant impact of dynamics on microphysics (Takahashi et al., 2017). The corresponding statistics obtained from some of the global climate models enabled by the Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package (COSP) satellite simulator (Bodas-Salcedo et al., 2011) are also shown in Fig. 1. The model-satellite comparisons in this form expose the propensity of models for producing rain too efficiently, even when the cloud-top particle size is small (Suzuki et al., 2015; Jing et al., 2017). The model biases thus identified can be further traced back to uncertainty in formulations of cloud microphysical parameterizations (Suzuki et al., 2015), implying that the satellite-based statistics are able to serve as a reference to constrain the model cloud physics. The statistics depicted in

Fig. 1 are one of the primary metrics that will be developed in PROES-WR to evaluate global models against satellite observations.

Scope of PROES-WR

The PROES-WR intends to extend this type of model diagnostics analysis to multiple global models, including state-of-the-art climate models and next-generation global cloud-resolving models, to expose their biases in representations of the warm rain process and to help improve the models at the fundamental process level. Eight different modeling groups are engaged in this effort and some have already provided simulated observations that are currently being analyzed. The "process-oriented" model constraint will also be contrasted against "top-down" requirements on model performance, such as reproducing historical climate warming, to explore how the process-level model constraint impacts the macroscopic aspect of global climate and how error compensations inherent in climate models manifest themselves when the particular "building block" of the model is constrained.

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Meeting/Workshop Reports

Aerosol-Cloud-Precipitation Interactions: Analysis of Satellite- and Ground-Based Data, and of Cloud-Resolving Modeling, in the ACPC Initiative

Boulder, Colorado, USA
3–6 April 2018

Johannes Quaas[1], Daniel Rosenfeld[2], Meinrat Andreae[3], Graham Feingold[4], Ann Fridlind[5], Michael P. Jensen[6], Ralph Kahn[7], Philip Stier[8], Kentaroh Suzuki[9], Sue van den Heever[10], Minghuai Wang[11], Bethan White[12], and Rob Wood[13]

[1]University of Leipzig, Germany; [2]Hebrew University of Jerusalem, Israel; [3]Max Planck Institute for Chemistry, Mainz, Germany; [4]NOAA, Boulder, USA; [5]NASA Goddard Institute for Space Studies, New York, USA; [6]Brookhaven National Laboratory, Upton, USA; [7]NASA Goddard Space Flight Center, Greenbelt, USA; [8]University of Oxford, UK; [9]University of Tokyo, Japan; [10]Colorado State University, Fort Collins, USA; [11]Nanjing University, China; [12]Monash University, Melbourne, Australia; [13]University of Washington, Seattle, USA

The goal of the Aerosols Clouds Precipitation and Climate (ACPC; *www.acpcinitiative.org*) initiative is to improve the understanding of the mechanisms by which aerosol perturbations may modify clouds and precipitation, and to quantify the impact these modifications may have on climate, particularly from the process to cloud field scale. The approach combines detailed observational studies with large eddy simulations and cloud-resolving and cloud-system-resolving models. Following the continued progress of activities defined and discussed in a series of previous meetings (e.g., Quaas et al., 2017), the ACPC group gathered at the University of Colorado, Boulder, U.S., from 3–6 April 2018.

At earlier meetings, the ACPC group defined two climatically important cloud regimes to study, deep convection and marine boundary layer clouds, and formed specific sub-groups to define research objectives and roadmaps. The sub-groups at this meeting reviewed topics ranging from pilot studies for tracking convective cells and data analysis using an objective cell-tracking algorithm for the deep convection regime to developing testable hypotheses for shallow clouds and conducting a joint investigation of warm rain processes from satellite data for cloud system resolving modeling. In both regimes, specific strategies were chosen that aimed at detecting and attributing signatures of aerosol effects on cloud and precipitation properties, using a combination of modeling and analysis of observations.

For the deep convective regime, the coastal region of Houston, Texas, U.S. was selected to potentially distinguish between deep convection influenced by aerosol emissions from the city and its surrounding industry, and others, in the vicinity, that are not.

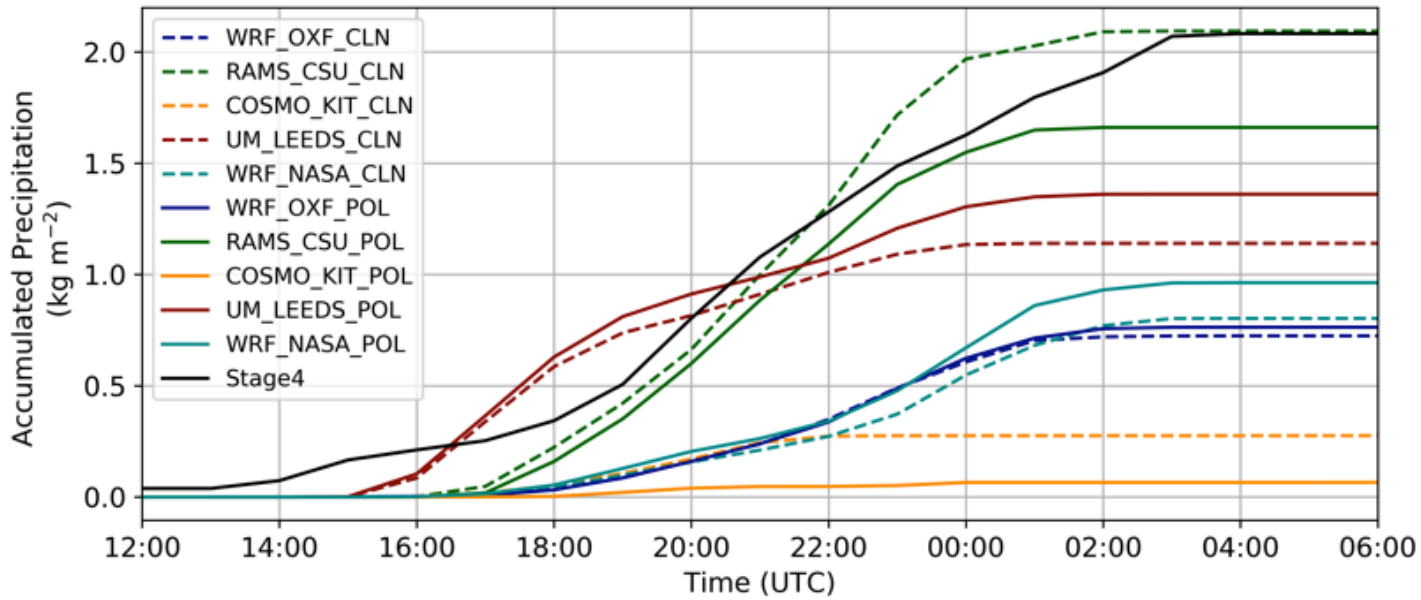

***Figure 1**. A time series of the accumulated precipitation obtained from five of the different modeling frameworks being utilized to conduct the "clean" (dashed lines) and "polluted" (solid lines) numerical experiments. The solid black line is the accumulated precipitation obtained from the National Center for Environmental Prediction (NCEP)'s Stage IV quantitative precipitation estimate (QPE) multi-sensor product (figure produced by Max Heikenfeld and Peter Marinescu).*

This coastal, urban area experiences convection throughout the year with a significant peak in occurrence during the summertime months when onshore flow of moist air over the warm land surface enhances convective initiation and propagation. In terms of observations, a strong focus was put on the analysis of polarimetric radar data, with complementary observations of aerosols, thermodynamics, and lightning. The methods already identified at the 2017 meeting have been refined in several ACPC pilot studies for application to tracking convective cells using polarimetric radar observations and identifying how processes (such as the microphysics in the updraft shafts) are affected by various drivers. A chief conclusion of the tracking pilot study is that operational weather radar observations can only poorly resolve the rapid evolution of target convective cells, strongly motivating efforts to deploy research-grade radars with adaptive scanning strategies. To optimize the strategy for an observational identification of aerosol-convection interactions from rapid-scanning instruments, radar forward simulations from a regional model simulation (Tatarevic et al., 2018) were also performed. The chief conclusions of the forward-simulation study are that radars should optimally be located less than 30 km away from the target for microphysical retrievals, and that a network of three Doppler radars nearer than 10 km to the target would be optimal for vertical wind retrievals. Finally, four years of operational weather data were analyzed using an objective cell-tracking algorithm. Results indicated the seasonality, locations, frequency, and lifetime of typical isolated cells in the Houston coastal region. On the basis of these and other results, and on the basis of the ancillary observational information gathered by the ACPC group, a proposal was submitted to the U.S. Department of Energy's Atmospheric Radiation Measurement Facility (DOE ARM) shortly after the Boulder workshop to deploy instrumentation to observe the variability of convective cloud properties under varying aerosol conditions in the Houston area. The proposed campaign, which also benefits from existing operational meteorological, air quality, and lightning networks, includes the yearlong deployment of a research-grade polarimetric radar; detailed surface-based cloud, aerosol, and precipitation measurements; and regular radiosonde profiling.

On the cloud system resolving modeling side of our two-pronged model-observational approach, the investigation on deep clouds has made substantial progress. A summer season case study of isolated convective cells developing under onshore flow conditions in the Houston region was identified using a combination of ground-based weather radar and satellite remote-sensing observations. An extensively tested case study specification and experiment design were developed (van den Heever et al., 2017). This included realistic bimodal aerosol profiles representing clean versus polluted conditions in the Houston area, derived from airborne in situ measurements obtained during NASA's Deriving Information on Surface conditions from the Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) field campaign. Six different modeling groups from Germany, England, Israel, and the U.S. are contributing to the modeling study, thus highlighting the international collaborations facilitated by ACPC. Some emerging results about the aerosol-perturbation impact on the convection were identified across models (e.g., shifts in precipitation intensity). However, substantial differences between the models' base state and response to aerosol perturbations remain, as is evident from Figure 1 above. The chart demonstrates not only variations in the magnitude of the precipitation response to the aerosol perturbations, but also variations in the aerosol-induced trends. Once fully analyzed, the results of this investigation are to be published in the peer-reviewed literature.

With regard to shallow clouds, the group decided to shift the geographical region of interest from the Southeast Pacific to the Southeast Atlantic Ocean. Recent field campaigns in this area (Zuidema et al., 2016), including Cloud-Aerosol-Radiation Interactions and Forcing (CLARIFY-2016), DOE ARM Layered Atlantic Smoke Interactions with Clouds (LASIC), and the NASA Observations of Clouds above Aerosols and their Interactions (ORACLES), provide new insights, and motivate a number of modeling studies within as well as outside the ACPC group. On the basis of science performed by several teams participating in ACPC, a few testable hypotheses have emerged. On the one hand, model research has shown that the cloud adjustments to aerosol-radiation interactions (also called the semi-direct effect) may lead to a net increase in low-cloud liquid water path (a net negative effect on the radiation budget; Stjern et al., 2017). Due to strong solar absorption by biomass burning aerosol (BBA) in the Southeast Atlantic region, a combination of modeling and observations may allow researchers to investigate and test this hypothesis. On the other hand, large eddy simulations suggest a strong microphysical impact of free tropospheric BBA mixed into the boundary layer on cloud persistence and the life cycle of liquid water path in the stratocumulus-to-cumulus transition over the Southeast Atlantic (Yamaguchi et al., 2017; Zhou et al., 2018). These large eddy simulations disagree on the impact of entraining BBA on the transition, but differences in the model set-ups used may be important. The group now plans to coordinate studies with ongoing work for the Southeast Pacific, its former area of focus, to identify trajectories along the cloud-system life cycle derived from regional models to drive reference large eddy simulations. In combination with the field campaign measurements and satellite observations, the aim is to corroborate or falsify the described hypotheses.

Considerable insight into co-variation of aerosols, clouds, and precipitation can be gleaned from satellite retrievals. With regards to liquid-water clouds, the droplet number concentration, N_d, is a key parameter, central to the quantification of effects of aerosol perturbations on cloud properties. However, the retrieval of N_d from satellite data is prone to uncertainties, and in this regard it was a major achievement of the ACPC group to produce a comprehensive review that quantifies these uncertainties and proposes avenues towards better measurements (Grosvenor et al., 2018).

A new initiative in the shallow clouds group is the joint investigation of warm rain processes from satellite data. The idea is to combine a suite of existing methodologies developed for analyzing satellite data to probe the process and its susceptibility to aerosols in an attempt to integrate different approaches of process-oriented analysis. This includes the warm rain from radar reflectivity vs. cloud optical depth joint histogram (Suzuki et al., 2010), the probability-of-precipitation metric (Wang et al., 2012), and the warm rain occurrence fraction (Mülmenstädt et al., 2015).

A follow-up workshop is planned for 24–26 April 2019 at Nanjing University in China. The ACPC group welcomes interested researchers to join the activities.

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Joint WCRP Grand Challenge on Weather and Climate Extremes/GEWEX GDAP Workshop on Precipitation Extremes

DWD, Offenbach, Germany
9–11 July 2018

Lisa Alexander[1], Rémy Roca[2], Sonia Seneviratne[3], Andreas Becker[4], Ali Behrangi[5], Steefan Contractor[1], Felix Dietzsch[4], Markus Donat[1], Robert Dunn[6], Hayley Fowler[7], Chris Funk[8], Adrien Guérou[9], Rainer Holmann[4], Pierre Kirstetter[10], Katharina Lengfeld[4], Maarit Lockhoff[4], Hirohiko Masunanga[11], Heewon Moon[3], Caroline Muller[9], Marc Schroeder[4], Udo Schneider[4], Yukari Takayabu[12], V. Venugopal[13], Martin Werscheck[4]

[1]University of New South Wales, Sydney, Australia; [2]Laboratoire d'Etudes en Geophysique et Oceanographie Spatiales, Toulouse, France; [3]ETH Zürich, Zürich, Switzerland; [4]Deutscher Wetterdienst, Offenbach, Germany; [5]University of Arizona, Tucson, USA; [6]Met Office, Exeter, UK; [7]Newcastle University, Newcastle upon Tyne, UK; [8]US Geological Survey/University of California Santa Barbara, Santa Barbara, USA; [9]Centre National de la Recherche Scientifique, Toulouse, France; [10]University of Oklahoma Advanced Radar Research Center/NOAA National Severe Storms Laboratory, Norman, USA; [11]Nagoya University, Nagoya, Japan; [12]University of Tokyo, Tokyo, Japan; [13]Indian Institute of Science, Bangalore, India

The WCRP Grand Challenge (GC) on Weather and Climate Extremes and the GEWEX Data and Analysis Panel (GDAP) held a joint workshop on "Precipitation Extremes" at Deutscher Wetterdienst (DWD) in Offenbach, Germany from 9-11 July 2018. The workshop objectives were to:

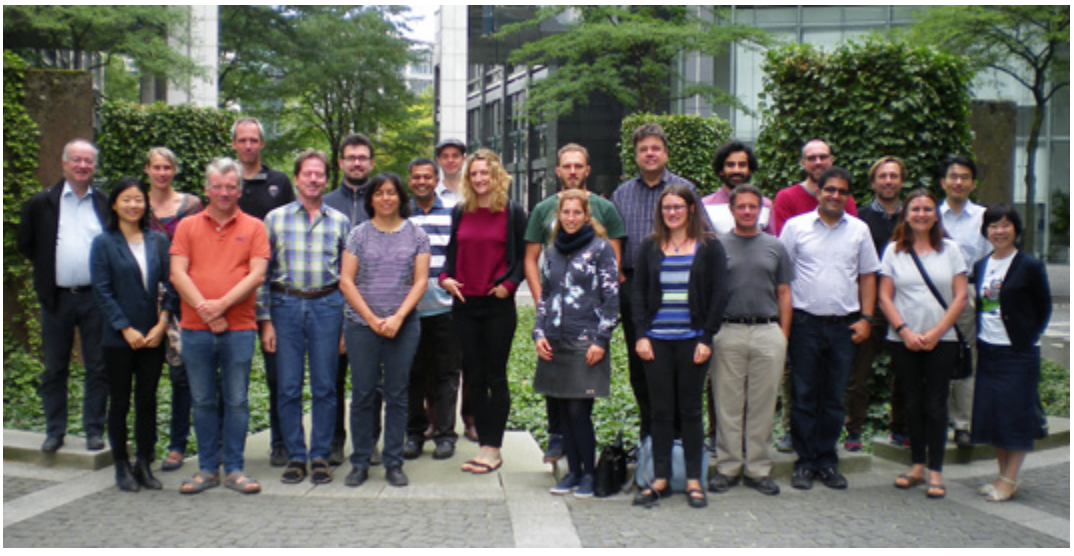
- Identify the form of a new International Precipitation Working Group (IPWG)/GEWEX Precipitation assessment chapter on extreme precipitation, including the selection of chapter leads and other contributors
- Finalize a best practice guidance document for the WCRP Extremes GC on data use for assessing precipitation extremes, including the consideration of satellite-based measurements
- Integrate the efforts of the remote sensing community in the literature on precipitation extremes that will be assessed for the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6)

The workshop had 23 invited participants, bringing together experts from the communities addressing climate-scale perspectives in extreme precipitation observations to identify gaps and agree on common goals for future work.

As part of the groundwork for the meeting, the organizers prepared a range of satellite-based, ground-based, and reanalysis datasets in the same format and on the same grid so that these could be compared and assessed at the workshop. Preliminary investigations performed by participants during the event were promising, highlighting both discrepancies and convergences between datasets.

In order to meet the workshop objectives, participants prepared an outline for a journal special issue on the topic of precipitation extremes and remote sensing datasets. The purpose of this special issue is to address the three main workshop objectives and inform the broader research community of these efforts. Lead authors for publications of the special issue were agreed upon and submission of the articles is planned for December 2018. We expect as an outcome that satellite-based products may be more extensively used in the climate extremes community, and in addition, the remote sensing community may identify avenues for future product development dedicated to extremes research. A community-based guidance document will also be developed on the use and reliability of datasets for assessing precipitation extremes targeted primarily at aiding global climate model evaluation.

The group endorsed the outcomes of the workshop as contributing to key goals of WCRP GC on Extremes, GDAP, and the joint effort on precipitation by GDAP and IPWG.



Participants of the Precipitation Extremes Workshop

Annual GLASS Science Panel Meeting

Canmore, Alberta, Canada
3–4 May 2018

Michael Ek[1], Gab Abramowitz[2], and the GEWEX GLASS Panel[3]

[1]The National Center for Atmospheric Research, Boulder, USA; [2]Climate Change Research Centre, University of New South Wales, Sydney, Australia; [3]For more information on the GLASS Panel members, visit *https://www.gewex.org/panels/global-landatmosphere-system-study-panel/glass-panel/*

The Global Land/Atmosphere System Study (GLASS) Science Panel Meeting was held prior to the 8th GEWEX Open Science Conference at the Coast Canmore Hotel and Conference Centre in Canmore, Alberta, Canada from 3–4 May 2018, with 21 panel members and guests attending (six remotely). As in previous meetings, community activities under the three GLASS Panel elements were reviewed: (1) land model benchmarking to improve understanding and representation of land surface processes, (2) land-atmosphere interaction and feedbacks, and (3) the role of land surface in predictability, as well as associated GEWEX projects and related crosscut activities.

LoCo

The Local Land-Atmosphere Coupling (LoCo) project and working group (WG) updates were presented by Joe Santanello. LoCo science, modeling, and observational advances made over the last year include publishing a *Bulletin of the American Meteorological Society* overview article in June 2018, convening Land-Atmosphere (L-A) sessions at the American Geophysical Union and American Meteorological Society meetings, producing numerous WG publications across an array of L-A focal areas, launching field campaigns focused on L-A interactions (Land-Atmosphere Feedback Experiment, LAFE; August 2017) and irrigation (Great Plains Irrigation Experiment, GRAINEX; summer 2018), pushing to improve planetary boundary layer (PBL) observations in the 2017 National Research Council (NRC) Decadal Survey, and providing input to the U.S. Climate Modeling Summit on advancing L-A coupling metrics in global climate models (GCMs). Much progress has been made over the last decade on developing and applying a range of integrated metrics across scales (Fig. 1 on the next page), and producing public resources such as the LoCo Metrics "Cheat Sheets" (*http://cola.gmu.edu/dirmeyer/Coupling_metrics.html*) and Coupling Metrics Toolkit (CoMeT; *http://www.coupling-metrics.com*). As the broader atmospheric and hydrological/land surface communities continue to learn the importance of integrated, quantitative diagnostics in model development, LoCo will continue to grow and play a pivotal role in delivering metrics and approaches to improving L-A understanding and prediction.

PLUMBER, PALS, and Land Data Assimilation

Martyn Clark led a discussion on the next phase of the land model benchmarking experiment called Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project-2 (PLUMBER2), which will have a greater process-oriented focus. The goal is to ask all participants to run their models for a larger number of sites and to provide much more comprehensive model output, such as all states, fluxes, and parameter values. More model output will allow us to reconstruct model parameterizations (e.g., by plotting fluxes against states) and hence figure out why different models behave differently. More sites will enable us to examine the data in different ways, and understand model behavior under different environmental conditions. This experiment will greatly improve our insight into land model weaknesses. As part of PLUMBER2, a land data assimilation (DA) component will be introduced where model-run variants employing assimilation of remote sensing data will be encouraged and later used to assess the utility of remote sensing data towards model benchmarking. The PALS web application used for the original PLUMBER experiment is transitioning to a new, more flexible workflow and architecture at *https://modelevaluation.org* ("PALS2"). Creating new and more varied analyses, PALS2 will support public community participation in the analysis of the new process-oriented PLUMBER2 experiment. It also allows use of observational datasets for analyses that are not downloadable by users, potentially removing a barrier to better integration of the land-surface modeling and data collection communities.

GSWP3 and LS3MIP

Hyungjun Kim gave an update on the status of the Global Soil Wetness Project Phase 3 (GSWP3) and the Land Surface, Soil-moisture, and Snow Model Intercomparison Project (LS3MIP). The GSWP3 forcing dataset has been updated in response to community feedback, and the official version has been tested carefully and packaged for release. LS3MIP had a kick-off meeting in September 2017 with participants from 15 institutions where nine modeling groups reconfirmed their contributions. A wiki has been set up to share feedback and up-to-date information (*https://wiki.c2sm.ethz.ch/LS3MIP*). Also, Hyungjun is acting as a liaison between the GLASS and Coupled Model Intercomparison Project (CMIP) communities to expand Climate and Forecast (CF) metadata conventions to cover variables newly requested by LS3MIP. Some technical features to be incorporated in CMIP6, including data requests, are still being adjusted.

ILAMB and LUMIP

David Lawrence discussed the International Land Model Benchmarking version 2 (ILAMBv2) package that is currently being utilized by several modeling centers. The ILAMB metrics protocol is documented in Collier et al., 2018. New datasets continue to be added, including some for GEWEX-related quantities including snow depth, permafrost extent, and evaporative fraction. A diurnal cycle metrics package is under development. Focus over the next year will be to implement more process-oriented metrics including metrics on

snow thermal insulation, snow-albedo feedbacks, soil carbon turnover times, and potentially dry-down responses. ILAMB continues to prepare for CMIP6 results and will be applied to the LS3MIP land-history simulations. Dave also provided updates on the Land Use Model Intercomparison Project (LUMIP) and the Land-Use Harmonization version 2 (LUH2) dataset. This recently-released dataset describes land use and land management for the years 850 to 2100. LUMIP is mainly on hold at this stage until model simulations start to become available in 2018 and 2019. A "LandMIPs in CMIP6" workshop is planned for October 2018 in Toulouse, France. Groups have begun to register their interest in analyses of the LUMIP simulations at the LUMIP webpage (*https://cmip.ucar.edu/lumip*).

Joint Projects and Crosscut Activities

GASS

John Edwards, GLASS liaison to the GEWEX Global Atmosphere Systems Studies (GASS) Panel, considered several areas of common interest shared between GLASS and its sister panel. Two continuing GASS projects of particular interest are (1) the Clouds Above the United States and Errors at the Surface (CAUSES) project, which is concerned with identifying the deficiencies in models that lead to a prevalent warm bias in the central U.S. in summer and has led to four papers this year, e.g., Morcrette et al., 2018; and (2) the GEWEX Atmospheric Boundary Layer Study phase 4 (GABLS4), which is concerned with the simulation of the diurnal cycle in summer on the Antarctic Plateau and the role of the stable boundary layer. Potential projects of particular interest to GLASS concern the modeling of fog, the representation of momentum drag, and the influence of the initial state of the land surface and the snow pack on seasonal forecasts.

GHP

Craig Ferguson, GLASS liaison to the GEWEX Hydroclimatology Panel (GHP), reported on current GHP activities and plans. Notably, there are three tentative Regional Hydroclimate Projects (RHPs), the Hydroclimate Research Program

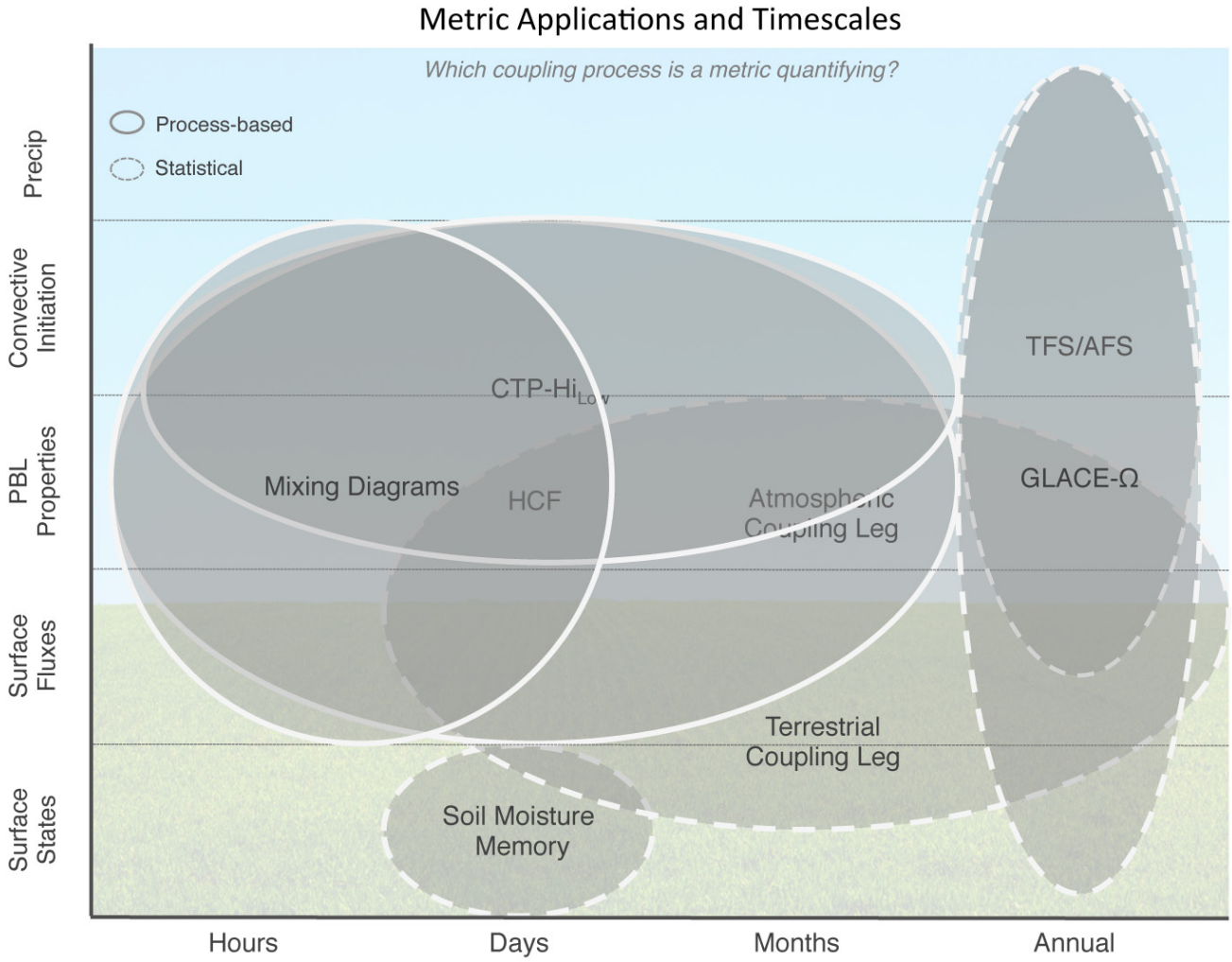


Figure 1. *LoCo metrics across temporal scales (x-axis), relationship to the LoCo process-chain connecting soil moisture to precipitation along the y-axis, and statistical vs. process-based nature of each (elliptical outlines). Green background shading indicates land surface related states and fluxes, while blue indicates PBL and atmospheric variables.*

Participants at the GLASS Meeting

for the Andes (ANDEX), the Land-surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) project (discussed below), and a potential U.S. RHP, all responsive to the World Climate Research Programme's GEWEX-led Grand Challenge on Water for the Food Baskets of the World. The fully-active HyMeX and initiating PannEX RHPs also have research thrusts in isolating the role of land and water management on local climate predictability. The proposed GHP crosscut on Water Management in Models would serve to support and coordinate modeling aspects of this work. GLASS is particularly well-positioned to contribute to the development, implementation, and evaluation of water management representation in land models following the PALS/PLUMBER benchmarking framework.

Aaron Boone gave an update on the potential GHP RHP called LIAISE, noting that one of the biggest challenges facing environmental science is understanding future changes in the terrestrial water cycle and the subsequent impact on water resources. In particular, climate projections predict that the Mediterranean region will be a so-called climate change "hotspot" during the twenty-first century. The LIAISE project seeks to address the challenges posed by modeling semi-arid regions with a field campaign in 2020 that will bring together ground-based and airborne measurements with modeling studies to lead to an improved understanding of processes such as soil moisture, evapotranspiration, and precipitation through atmospheric coupling and the subsequent feedbacks to the Mediterranean atmospheric boundary layer and basin hydrology, including aspects like streamflow and instances of human influence such as irrigation and water extraction methods. In 2018, a workshop was held in January at the University of Barcelona with members of the Spanish research community, and the status of the project was presented during the HyMeX Workshop (May 2018, Lecce, Italy). Currently, the core members of the LIAISE science team are seeking funds to complete the campaign. It is anticipated that this project will lead to several GLASS-GASS-GHP community experiments.

Pere Quintana Seguí, liaison to the GLASS Panel from the GHP RHP Hydrological cycle in the Mediterranean Experiment (HyMeX), reported that the HyMeX Drought and Water Resources Science Team (HyMeX DWR) is working on an enhancement to the studies of drought at the Mediterranean scale, gathering data that covers the entire region in order to better understand drought and drought-related mechanisms in this area. HyMeX DWR is investing in land-surface modeling and remote sensing to improve knowledge of the continental water cycle, including the impacts of irrigation. The LIAISE field campaign, which was discussed at the HyMeX workshop in May, will study land-surface processes in semi-arid areas and the impact of irrigation on both the atmospheric boundary layer and hydrology.

SoilWat

Anne Verhoef gave a summary of the GEWEX Soil and Water Initiative (SoilWat) Pedotransfer Functions (PTF) activity, which relates to testing and improving soil hydraulic and thermal properties in land-surface models (LSMs). Activities so far involve testing the effect of (1) different PTFs and hydraulic models (Mualem-van Genuchten vs. Brooks-Corey) on water flow simulation and (2) different hydraulic functions and PTFs and thermal functions (and related thermal PTFs) on the energy and water balance, the soil (surface) temperature, and soil moisture content. Model runs were conducted with Hydrus-1D for 14 years (2001-2014) with half-hourly data from Avignon, France for a bare soil profile, with various land model thermal equations implemented in Hydrus-1D for this exercise. Thermal conductivity was also compared with measured values. Large differences were found between the various LSMs, both for the hydraulic and thermal functions and for the fluxes, but less so for the state variables (for the thermal runs). These results will be described in a journal publication. The community plans further activities, including the creation of a global map of thermal parameters. Matthias Cuntz reported on another SoilWat activity, the Soil Parameter Model Intercomparison Project (SP-MIP), which is assessing the influence of soil parameters on the variability of LSMs, where SP-MIP follows LS3MIP conventions as closely as possible. Currently, eight modeling groups have committed, half of which have already started or even finished the experiments, while the other half are scheduled to complete their runs this summer.

Urban Effects in Land Models

Mathew Lipson presented an overview on including urban effects in land models, i.e., the Project for Intercomparison of Land Surface Parameterization Schemes (PILPS)-Urban, the first (offline) urban land model intercomparison project (Best and Grimmond, 2015). The urban representations providing most benefit were an appropriate urban bulk albedo, radiation reflections within street canyons, separate roof and street canyons, and urban vegetation. However, simpler urban

models performed similarly well for the scales of weather and climate models, so new and more complex processes should not be included unless it can be demonstrated that they provide additional benefits. The Single-column Urban Boundary Layer Inter-comparison Model Experiment (SUBLIME) was also reviewed, where urban land model runs with and without boundary layer interactions were made over central London for two days; submissions are complete and the first results will be presented at the International Association for Urban Climate (ICUC) conference in August 2018. Also discussed was a suggestion to run PLUMBER-style experiments for many urban flux sites that differ in their urban characteristics, with a potential to use the new PALS2 framework. Future foci include urban boundary layer theory, observations and modeling, and human behavioral drivers and impacts (e.g., Barlow et al., 2017).

S2S

Paul Dirmeyer updated the Panel on Subseasonal to Seasonal (S2S) efforts relevant to GLASS. The International S2S Prediction Project (*https:www.s2sprediction.net*) is coming to the end of its original 5-year mandate for global operational centers to produce S2S hindcast and forecast data sets. A proposal for a second 5-year phase, which would have a much stronger emphasis on the role of land surface in S2S prediction, was submitted to WMO in February 2018. Three core questions relevant to GLASS research are proposed: What is the impact of the observing system on land initialization and S2S forecasts? How well are the coupled land-atmosphere processes represented in S2S models? How might anomalies in land surface states contribute to extremes? In the U.S., the National Oceanic and Atmospheric Administration (NOAA)'s S2S Task Force, comprised of investigators funded by the NOAA Climate Project Office, includes two projects with direct GLASS relevance, one led by Trent Ford (Southern Illinois University) and the other by Zhichang Guo (George Mason University). A sister NOAA-supported effort called SubX is similar to the S2S Prediction Project except that it includes research/climate models, enforces greater consistency among models to promote multi-model ensemble studies, and is somewhat better at saving output variables relevant to land-atmosphere interactions. Lastly, the annual U.S. Climate Modeling Summit featured a workshop on land-atmosphere interactions, which was an opportunity to educate U.S. agency leadership at the six U.S. climate modeling centers and their funding agencies about the scientifically-established impact of land surface feedbacks on climate. The U.S. modeling community is now more aware and highly interested in GLASS-led activities and scientific progress, and is exhibiting some momentum to encourage enhanced efforts toward L-A-related model assessment and development.

Other

Paul Dirmeyer and Mike Ek attended the World Climate Research Programme (WCRP) Monsoon Panel side meeting during the May 2018 GEWEX Open Science Conference, where understanding and modeling land-hydrology processes are key in representing monsoon circulations. Eleanor Blyth talked about synergies between GEWEX and the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) and "Future Earth", including possible collaborations. In particular, PLUMBER2 should include carbon fluxes in addition to energy and water, with a joint workshop on land surface modeling to be held in Oxford in 2020 focusing on the impact of carbon dioxide on water use efficiency. Mike Ek briefed the Panel on liaison activities with the WMO Working Group on Numerical Experimentation (WGNE) and the WCRP Modelling Advisory Council (WMAC). WGNE is interested in improving global weather and climate models and WMAC coordinates high-level aspects of modeling across WCRP. GLASS presence in these groups focuses on improving land modeling and land-atmosphere interaction, particularly land data assimilation in the case of WGNE. Kun Yang noted the high spatial heterogeneity of land properties and the associated uncertainties in specifying parameters used in land model parameterizations. To address this challenge, he suggested that it is perhaps time to promote methods for deriving land parameters and calibrating land surface models through satellite remote sensing and data assimilation (e.g., Yang et al., 2016; Pinington et al., 2018). This and other related activities should be explored further as possible areas to increase collaboration with the GEWEX Data and Analysis Panel (GDAP).

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Nominations Open for 2018 Data and Modeling Prizes

The World Climate Research Programme (WCRP), together with the World Weather Research Programme (WWRP) and the Global Climate Observing System (GCOS), is awarding two prizes for notable achievements in model and data development. The "WCRP/WWRP International Prize for Model Development" has been awarded since 2014 for outstanding contributions to model development by WCRP and WWRP. In 2016, the "WCRP/GCOS International Data Prize" was established by WCRP and GCOS to reward climate or Earth system data that has had a tangible impact on the community.

The WCRP/WWRP International Prize for Model Development will be awarded to an early- to mid-career researcher for an outstanding contribution to model development for the Earth System, its components, and their coupling. Candidates should be within the first ten years of their career as measured by receipt of a Ph.D. or highest qualification; made a significant contribution to the development of a model with a demonstrable impact on the model results; and engaged with the wider community through achievements such as publications, editorships, organizing/convening activities, operational implementation, or strong engagement in national and international modeling programs.

The WCRP/GCOS International Data Prize is awarded annually to an early- to mid-career researcher for his or her outstanding contribution to the Earth system science community. The Prize may honor achievements in data product generation, data management, data preservation, data monitoring, and other data relevant activities. In particularly successful cases, the establishment of standards or infrastructure for global data repositories may be considered for eligibility. Candidates should be within the first ten years of their career as measured by receipt of a Ph.D. or highest qualification; made a significant contribution to the provision of climate or Earth system data, preferably with a visible impact on and by studies based on said data; and have visible achievements within the wider community as demonstrated through publications, editorships, organizing or convening activities, and/or strong engagement in community efforts for data provision, standardization, and utilization.

Together, these two prizes for notable achievements in model and data development aim to recognize and foster research activities in their respective fields, as well as stress their mutual interdependence.

Nominations are now open for 2018, and the deadline is **1 October 2018**. For details, see each respective announcement page:

- **WCRP/WWRP International Prize for Model Development 2018:** *https://www.wcrp-climate.org/wmac-activities/ipmd-2018*
- **WCRP/GCOS International Data Prize 2018:** *https://www.wcrp-climate.org/wdac-activities/idp-2018*

GEWEX/WCRP Calendar

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

27–31 August 2018—NASA JPL Center for Climate Sciences Summer School 2018— Pasadena, California, USA

3–7 September 2018—EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2018—Budapest, Hungary

4–6 September 2018—2nd GEWEX Convection-Permitting Climate Modeling Workshop—Boulder, Colorado, USA

4 September 2018—4th PannEx Workshop: The ELTE Meeting—Budapest, Hungary

10–19 September 2018—Potsdam Summer School 2018: The Skin of the Earth - The Earth Surface System—Potsdam, Germany

17–19 September 2018—International Conferences on Subseasonal to Decadal Prediction—Boulder, Colorado, USA

24–26 September 2018—8th Third Pole Environment (TPE) Workshop—Gothenburg, Sweden

1–5 October 2018—SPARC General Assembly—Kyoto, Japan

16–18 October 2018—IV International Conference on El Niño Southern Oscillation: ENSO in a Warmer Climate—Guayaquil, Ecuador

22–26 October 2018—2018 ANDEX/GHP/INARCH Meetings—Santiago and Portillo, Chile

22–23 October 2018—GEWEX UTCC PROES Workshop—Paris, France

13–16 November 2018—2018 WCRP Workshop: The Earth's Energy Imbalance and Its Implications (EEI)—Toulouse, France

26–29 November 2018—2018 GEWEX Data and Analysis Panel (GDAP) Meeting—Lisboa, Portugal

10–14 December 2018—2018 AGU Fall Meeting—Washington, D.C., USA

6–10 January 2019—99th Annual AMS Meeting—Phoenix, Arizona, USA

25 February – 1 March, 2019—GEWEX SSG-31—Geneva, Switzerland

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Peter J. van Oevelen, Director
Shannon F. Macken, Editor

International GEWEX Project Office
c/o USRA
425 3rd Street SW, Suite 605
Washington, DC 20024 USA

Tel: 1-202-527-1827
E-mail: gewex@gewex.org
Website: *http://www.gewex.org*