GEWEX NEWS

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The GDAP Integrated Product

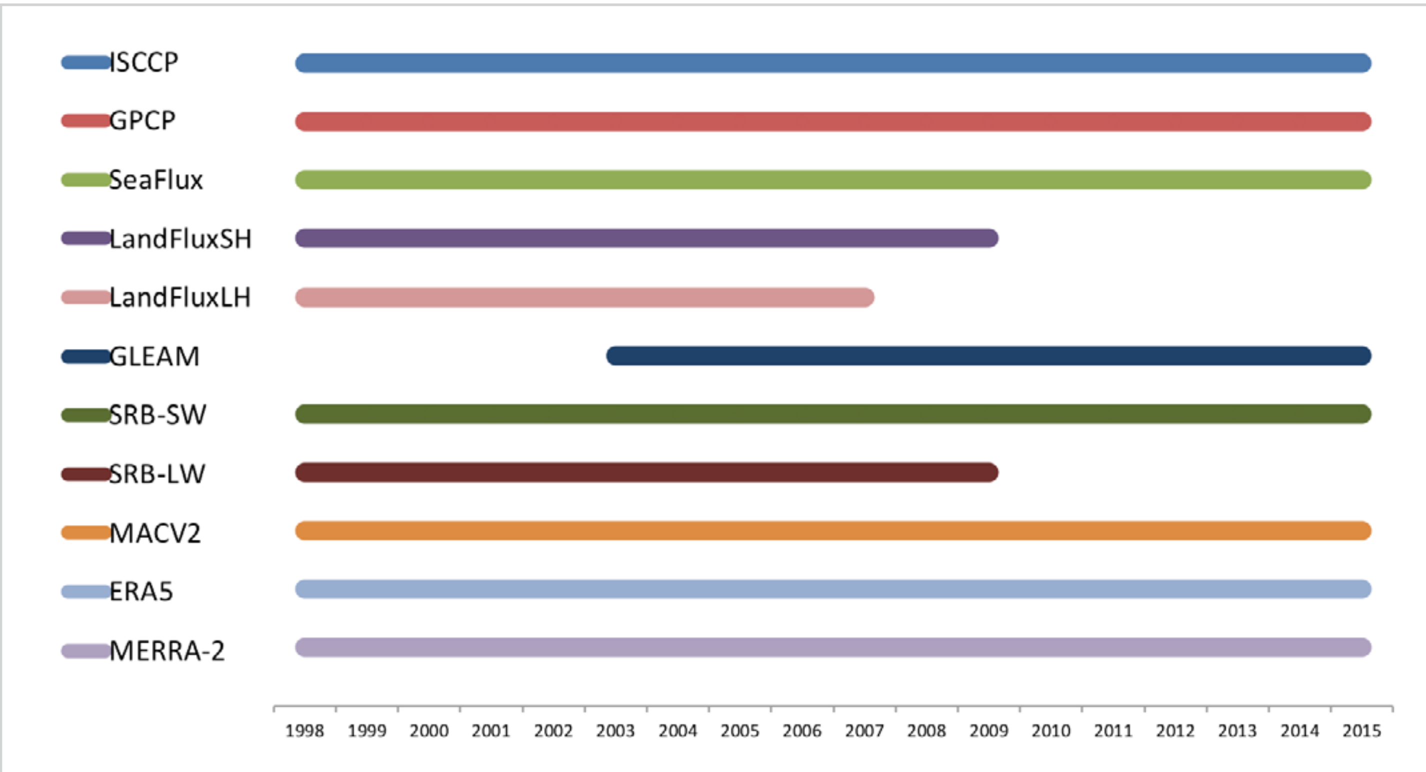

Figure 1 gives an overview of the data availability of the GEWEX Data and Analysis Panel (GDAP)'s Integrated Product, which provides high spatial and temporal resolution products now available for water and energy process understanding. See page 3 for the full article.

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Commentary:
Asia in Focus

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As I am writing this, the Asian Precipitation EXperiment (AsiaPEX) kick-off meeting in Sapporo, Japan is just concluding. The meeting hosted over 50 scientists from more than 10 countries in Southeast Asia and highlighted the unique role GEWEX has and continues to play in bringing together the international research community to conduct collaborative research and experiments in a particular region. GEWEX involvement in the area began in the mid 1990s with the GEWEX Asian Monsoon Experiment (GAME) and was followed by the Coordinated Enhanced Observation Period (CEOP) around the mid 2000s and in early 2010s by the Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (MAHASRI). What these activities have in common is that they were able to establish a local research community that could rally around specific climate research challenges relevant to the region and with the ability to acquire the resources to execute the work. Lasting contributions from these programs are not only measurable in the significant scientific publication output, but also in the establishment of observational sites and networks along with new avenues for data sharing and collaboration. In addition, many of the countries in Southeast Asia now also have the academic and computational resources to perform high-resolution regional modeling. AsiaPEX will expand on this legacy and focus on several key issues in the region with precipitation as the central theme. Among the many interesting presentations given during the workshop, one highlight was the Borderless Radar Information Networking (BRAIN) over South and Southeast Asia, led by Hideyuki Kamimera from the National Research Institute for Earth Science and Disaster Resilience (NIED) in Tsukuba, Japan. This initiative hopes to achieve what the Next Generation Weather Radar (NEXRAD) did for the U.S. and the Operational Weather Radar Network in Europe. A challenge, no doubt, as collaborative infrastructure needs to be established in this area. I hope that this initiative can count on the support of our American and European colleagues from the aforementioned networks to share their experience in making this endeavor a success.

In this edition of the GEWEX newsletter, there are reports from three other Regional Hydroclimate Projects (RHPs). On page 13, the Pannonian Basin Experiment (PannEx) reports on its workshop to build task teams that address environmental needs in the Pannonian Basin. On page 10, Global Water Futures (GWF) describes its 2nd Global Water Futures Meeting, with notable and unique contributions from GWF Indigenous community co-led water research projects across Canada. And on page 9, ANDEX, which, like AsiaPEX, is still in its prospective phase, gives an account of its writing workshop for a scientific plan/white book called "ANDEX–A Regional Hydroclimate Project (RHP) on the Andes. Scientific Context, Challenges and Opportunities". Having attended several of these RHP meetings, what strikes me in particular is the positive energy and a sense of community, both of which are highly motivating and stimulating. I urge anyone who has an interest in these activities and wants to get involved to get in touch! The International GEWEX Project Office can help direct you to the relevant contact person or field any further inquiries you may have.

As a participant in the recent the Global Land/Atmosphere System Study (GLASS) Panel meeting in Boulder, I would like to highlight one activity that I found in particular fascinating: the proposal for the GLASS Land Atmosphere Feedback Observatories (GLAFOs). Volker Wulfmeyer, David Turner, Craig Ferguson and several others propose designing and developing observatories in different climate regions based on the Land-Atmosphere Feedback Experiment (LAFE) setup (Wulfmeyer et al., BAMS 2018, DOI:10.1175/BAMS-D-17-0009.1) in order to make corresponding measurements operational and to refine these by additional instrumentation. Simply put, it will result in a state-of-the-art 3-dimensional characterization of the dynamics and thermodynamics of the atmospheric surface and planetary boundary layer, along with subsurface (soil) and vegetation observations. If the GEWEX RHPs could help in realizing this, I think that would be of tremendous scientific value and interest. Further details will be in the report of the GLASS Panel meeting, which, however, will not be available until the next edition of *GEWEX News*.

Scenes from the AsiaPEX kick-off meeting

Early Career Researchers Review Draft IPCC Sixth Assessment Report

Gaby Langendijk, Marisol Osman and Valentina Rabanal
On Behalf of the YESS Community

Early career researchers are pivotal to the growth and the long-term sustainability of the climate research community. Therefore, it is of great importance that young scientists have the opportunity to engage in major international climate initiatives early onwards to gain experience, enhance their understanding of international initiatives and contribute to the community.

To enable such interactions and opportunities for early career researchers, the Young Earth System Scientists (YESS), the Association of Polar Early Career Scientists (APECS), Past Global Changes-Early Career Network (PAGES-ECN) and the Permafrost Young Researchers Network (PYRN) co-organized a group review of the Intergovernmental Panel on Climate Change's (IPCC) First Order Draft of the Working Group I Sixth Assessment Report (AR6).

The process began in December 2018, when YESS was invited to join the APECS effort in reviewing the First Order Draft of the AR6. In January 2019, the Early-Career Group released a call for reviewers. During the selection phase, a group of more than 30 Early Career Researchers (ECRs) reviewed the applications, working to form a review team of scientists with different science backgrounds, while also considering their regional and gender balance. Within all the applicants, 32 YESS members were selected to take part in the ECR group review.

After all the reviewers were confirmed, the co-organizers held a training session, where experts from the IPCC, including Sarah Connors, Carolina Vera and Peter Thorne, described the process of how the report is created and how the review is managed. The review phase began after the training session and ended on June 1, 2019. All reviewers were given a subsection of a chapter to review. The lead chairs and subchairs of each reviewed chapter compiled the comments sent by more than 160 scientists from all over the world. The comments were submitted to the IPCC under the group review project.

YESS is grateful to the IPCC for providing this unique opportunity for ECRs to participate in their review process and we congratulate the ECRs who participated in the process. It was a constructive experience for the ECRS, which also provided them the opportunity to contribute their expanding scientific expertise to further enhance the IPCC report.

Article Submissions to *GEWEX NEWS*

Do you have an idea for a *GEWEX News* article on scientific research results or other information related to GEWEX activities? E-mail us at *gewex@gewex.org* with your suggestion. Contributions of 1-2 pages (800-1600 words) are sought, and we require at least one figure or image. The graphic should be sent as a separate, high-resolution file, and not be embedded in your document.

The GDAP Integrated Product

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The GEWEX Data and Analysis Panel (GDAP) has a long history of overseeing and evaluating surface and satellite-based water and energy cycle products. In the Panel's earlier days, it sponsored activities, including: (i) the International Satellite Cloud Climatology Project (ISCCP) that required international collaboration for data acquisition; (ii) the Global Precipitation Climatology Project (GPCP) that required international collaboration for gauge networks used in the analysis; and (iii) the Baseline Surface Radiation Network (BSRN), which relies on voluntary participation across the globe to make high quality down- and upwelling surface radiation measurements. As aerosols, radiative fluxes and turbulent flux products were added to the GDAP sponsored products [Global Aerosol Climatology Project (GACP), Surface Radiation Budge (SRB) and LandFlux/SeaFlux respectively], there grew a sense that the GDAP panel should attempt to put these together in a physically consistent data set that described the core components of the water and energy cycles. While the idea dated back to the early 2000's, it was formally accepted as a GDAP activity at the 2010 GEWEX Science Steering Group meeting in New Delhi, India.

Two parallel efforts were undertaken. The first was to define a common set of ancillary data sets and assumptions, while the second focused on the consistency of geophysical parameters across data sets. Because of the GEWEX focus on process understanding, data sets were re-gridded to 3-hourly, 1-degree (equal area) grids. The integrated product uses the Advanced Very-High-Resolution Radiometer (AVHRR) Global 30 Arc-second Elevation (GTOPO30) for the surface mask and the Moderate Resolution Imaging Spectroradiometer (MODIS) International Geosphere-Biosphere Programme (IGBP) surface characterization. The National Oceanic and Atmospheric Administration (NOAA) Snow and Ocean and Sea Ice Satellite Application Facility (OSI SAF) sea ice are used consistently across all products. The 5th European Centre for Medium-Range Weather Forecasts (ECMWF) ReAnalysis (ERA5) is used for atmospheric water vapor transport terms as there is currently no satellite wind data available. Aerosols come from the Aerosol Comparisons between Observations and Models (AEROCOM) project while atmospheric humidity and temperature are taken from the latest High-resolution Infrared Radiation Sounder (HIRS) climate data record (nnHIRS). The latter is the most significant, and caused significant problems with respect to consistency among the geophysical parameters.

GDAP struggled with the optimal method to homogenize the temperature (including sea surface temperature and T_{2m}) and water vapor structures required to get radiation calculations to validate against Baseline Surface Radiation Network (BSRN) measurements, while simultaneously validating against water vapor and sea flux estimates. While the final integrated product does not solve all problems, it does constitute GDAP's best effort at synthesizing the diverse products, and thus represents far more than a simple collection of individual water and energy parameters, albeit perhaps less than a fully consistent set of parameters at all levels. In addition, as is often the case, products evolve continuously and an integrated product evolves with the individual components. Nonetheless, there is currently an 18-year time series available from 1998–2015 (see Figure 1 on the cover). Where individual products end before 2015, MERRA-2 Re-Analysis data is used as an independent product to complete the data set. The end date is currently determined by ISCCP, although processing is currently underway at NOAA's National Centers for Environmental Information (NCEI). The individual products are described next.

Clouds (ISCCP)

The new ISCCP H-Version used in the integrated product is very similar to the previous D-Version with a finer map grid (1-degree equivalent) and more detailed products, including a globally-merged 0.1 degree, Level 2 (pixel-level) product (Young et al., 2018). The only notable changes from the previous version are a change in the cloud top temperature that divides liquid and ice clouds from 260 K to 253 K, which shifts the statistics for these cloud types, a reduction in summertime cloudiness over Antarctica and Greenland, and a change of the vertical distribution of clouds over the Arctic and Antarctic sea ice related to a better atmospheric temperature structure. Small refinements were also made to the radiance calibrations and the microphysical models used for the cloud retrievals, such as differing liquid water cloud droplet sizes over ocean and land and differing ice particle sizes as a function of optical thickness, as well as accounting for the effects of aerosols, but these did not produce large changes in the overall results.

Aerosols

There are currently no direct observations of aerosol products at 1-degree, 3-hourly resolution. The Integrated product therefore relies on the Max Plank Institute (MPI)–Meteorology, Aerosol Climatology (MAC-V2) for its aerosol product. The product provides monthly climatologies of frequency resolved Aerosol Optical Depth, single scattering albedo and asymmetry factor. It is described in detail in Kinne (2019).

Radiation (SRB)

The Surface Radiation Budget (SRB) project produces surface and top-of-atmosphere shortwave (SW) and longwave (LW) radiative fluxes using many of the GEWEX Integrated products. SRB Release 3.0, using ISCCP DX as the primary input, is described in Stackhouse et al. (2011). For this integrated product version, ISCCP H-Series provide cloud and surface properties and ISCCP nnHIRS provides atmospheric temperature and humidity (Young et al., 2018), SeaFlux (Clayson et al., 2016) and Landflux (Siemann et al., 2018, for sensible heat and McCabe et al., 2016, for latent heat) provide surface and near-surface meteorology, and MACv1 (Kinne et al., 2013) provides aerosol properties. In addition to the input data improvements, several important algorithm improvements have been made since Release 3. These include recalculated SW atmospheric transmissivities and reflectivities yielding a more realistic, somewhat less transmissive atmosphere. The number of SW radiative bands is increased from five to eighteen consistent with Rose et al. (2013). The calculations also now include variable aerosol composition and radiative properties. Ocean albedo and snow/ice albedo are also improved from Release 3 by implementing Jin et al. (2004). Total solar irradiance is now variable, averaging 1361 Wm^{-2} (Kopp and Lean, 2011). The SW now explicitly treats ice and liquid clouds distinctly. Improvements to the LW algorithm from Rel. 3 begin with aligning the algorithm with that used by the Clouds and the Earth's Radiant Energy System (CERES) (Rose et al., 2013). This allows for the use of MAC aerosols, updates the ice cloud properties, and expands the radiative bands by two. Adjustments to the cloud overlap scheme were required to accommodate the new high ice cloud type now provided in ISCCP HX. The surface emissivity now varies according to a monthly climatology based upon Huang et al. (2016), and adjustments to SeaFlux, LandFlux LST and ISCCP HX retrievals were incorporated where necessary for consistency. The LW time series currently ends in 2009 due to the end of the LandFlux land surface temperature time series, so MERRA-2 LW data is also provided for completeness.

Precipitation (GPCP)

The GPCP product used for the GDAP Integrated Product is a slightly modified analysis based on the existing standard GPCP products. The key product is the GPCP Daily product (Huffman et al., 2001), Version 1.3, which, in turn, is driven by the monthly precipitation amounts from each grid of the GPCP Monthly analysis (Adler et al., 2018), Version 2.3. In order to achieve the required three-hour time resolution for the GDAP Integrated product, the GPCP Daily analysis was disaggregated to the required 3-hour time resolution through the use of the 3-hour TRMM Multi-satellite Precipitation Analysis (TMPA) (Huffman et al., 2010). Since the TMPA extends only between latitudes 50N-50S, outside of these latitudes the daily values are not disaggregated. Instead the daily rain rates are repeated every three hours at each grid to fill all the time periods at these higher latitudes. The resulting 3-hour resolution data set at 1° latitude-longitude resolution reflects the daily and monthly amounts of the current, standard GPCP analyses, but with the sub-daily variations provided by the independent TMPA, at least between 50N-50S.

Ocean Turbulent Fluxes (SeaFlux)

The SeaFlux product version here is the NOAA Climate Data Record (CDR) v2.0, which is available over the time period from 1988 through near-real time. This version of the data uses GDAP products to the extent possible for ice and ocean masks, radiation, and precipitation. The product and documentation (including a C-ATBD) is available from the NOAA CDR website (*https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00973*). Efforts are still ongoing to continue homogenizing across the backbone SSM/I and SSMIS sensors.

Land Turbulent Fluxes (LandFlux)

The LandFlux project coordinated two interrelated research efforts that sought to: (i) intercompare available long-term gridded surface flux data sets to establish their skill and reliability (i.e., product-benchmarking, Mueller et al., 2013), and (ii) simulate and intercompare a range of evaporation models to identify algorithms appropriate for a global flux product (i.e., model-benchmarking, McCabe et al., 2016; Michel et al., 2016; Miralles et al., 2016). Through these analyses, three models were identified to further the development of LandFlux latent heat flux product. These included, the Priestley-Taylor Jet Propulsion Laboratory model (PT-JPL, Fisher et al., 2008), the Penman-Monteith based Mu model (PM-Mu, Mu et al., 2011), and the Global Land Evaporation: the Amsterdam Methodology (GLEAM, Miralles et al., 2011). The key criteria used for model selection were that they relied on a minimum of forcing variables, had capacity to use remote sensing based observations, and had previously been deployed at the global scale. Simulations covering the period 1984–2007 were produced using a forcing data set that shared commonalities with the other components of the integrated product (see McCabe et al., 2016, for details). A 24-year record of latent heat (LE) flux was produced for global (non-ice covered) land surfaces at 3 hourly, 0.5-degree resolution. These were later upscaled to 1.0-degree to conform with the specification of the integrated product. A thorough assessment against tower-based data, performed across a range of biome and climate zones, highlighted the variable performance of individual models, with no single model consistently outperforming any other. At the global and regional scale, inter-model consistency was largely observed, although with noted biases. Ultimately, of the models assessed as part of the latent heat flux product, GLEAM and PT-JPL represented the schemes that provided the most consistent response over a range of biome and climate types. IP only has GLEAM LH.

GLEAM v3.3a (Martens et al., 2017) evaporation is also included here for continuity, but differs significantly from the GLEAM version used in LandFlux (McCabe et al., 2016) as it includes: (i) a newer data assimilation scheme of satellite-based surface soil moisture, (ii) an updated water balance module that describes the infiltration rates as a function of the vertical gradient in soil moisture and (iii) updated evaporative stress functions that combine the vegetation optical depth and the root-zone soil moisture estimates. More importantly, data are only available at daily resolution and are based on different forcing. The V3.3b uses surface radiation from CERES (Wielicki, 1996), near-surface air temperature from the Atmospheric Infrared Sounder (AIRS, Aumann et al., 2003), and precipitation from Multi-Source Weighted-Ensemble Precipitation (MSWEP, Beck et al., 2017). Moreover, it applies dynamic land cover information based on the MEaSUREs Vegetation Continuous Fields data set (Hansen and Song, 2018) and it covers the entire continental domain spanning the 31-year period 1998–2018 at 0.25-degree resolution. The overlap period between the version of GLEAM used in LandFlux and V3.3a is intended to allow users to examine the differences according to their own research objectives, and determine if the latter GLEAM project meets their requirements for consistency with the remaining GEWEX products.

An independent sensible heat flux product was provided by Siemen et al. (2018) for the period covering 1979–2009. The data was originally produced at hourly, 0.5-degree resolution but is averaged to the common 1-degree, 3-hourly resolution of the Integrated product. The sensible heat flux (H) at the surface within the atmospheric boundary layer (ABL) according to Brutsaert (2005) as follows:

$$H = \rho C_p C_h u_z \Delta\overline{\theta}$$

where ρ is the air density, C_p is the specific heat capacity of air at constant pressure, C_h is the coefficient of heat transfer, u_z is the mean wind speed at a reference height, and $\Delta\overline{\theta}$ is the difference between the potential temperatures at two different reference heights. The variables C_h and u_z are transformed into the aerodynamic resistance (r_a), which is computed as described in Siemen et al., 2018, while $\Delta\overline{\theta}$ used satellite derived Land Surface Temperature (LSP) with T_{2m} derived from ECMWF Interim Re-Analysis (ERA-Interim) developed by Wang and Zeng (2013). After 2009, the sensible heat flux is taken direclty from MERRA-2 Re-Analysis but some overlap is provided as with the Latent Heat Flux to allow users to evaluate the utility of the extended data.

Data Availability

All data is currently being hosted at Colorado State University and is available via anonymous ftp server at: *ftp://rain.atmos.colostate.edu/pub/pbrown/GEWEX_IP_2019/*. The data is archived in 3-hourly data files in NetCDF format. Dr. Paula Brown is the curator of the data and she can be contacted via e-mail at: pbrown@atmos.colostate.edu.

While the data set has just now been completed and it is too soon to discuss the advances that came from it, two things are perhaps already clear. The first is that GDAP's attempt to force consistency between the above products that were all developed independently was ultimately much more difficult than originally anticipated. Nor did we completely succeed in that proposition. The above data are, however, as consistent as possible for an observationally-based data set at this time. The second issue is that the consistency in assumptions, but not the products, meets our ultimate objective to have a data set with 1-degree space and 3-hourly time resolution to begin addressing the interaction between radiation, clouds and the water cycle.

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Evaluation of a New Daily Global Precipitation Data Set by Intercomparison of Extreme Climate Indices

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The evaluation of models requires high-quality data sets of observations at a similar temporal and spatial scale as the model data. For this purpose, a daily global precipitation data set was constructed from the Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data (HOAPS) over ocean and gridded Global Precipitation Climatology Centre (GPCC) data over land (for details on precipitation data sets, see Table 1). The merged data set currently spans 28 years (1988-2015) and is available at 2.5° x 2.5°, 1° x 1° and 0.5° x 0.5° resolution (the latter over Europe). The data sets are referenced under doi: 10.5676/DWD_CDC/HOGP_ddd/V002 (ddd = 250, 100 and 050 for the three resolutions, respectively).

Table 1. Data Sets Used in the Intercomparison

HOAPS	Hamburg Ocean-Atmosphere Parameters and Fluxes from Satellite	Version 4.0	Andersson et al., 2010; Graw et al., 2017
GPCC-FDD	Global Precipitation Climatology Centre Full Data Daily Product	V.2018 (V2)	Schamm et al, 2014; Schneider et al., 2018
TRMM3B42	Tropical Rainfall Measuring Mission 3-hourly precipitation estimates from the TRMM multi-platform algorithm	Version 7	Huffman et al., 2007; Kidd and Huffman, 2011
GPCP-1DD	Global Precipitation Climatology Project's 1° daily global data set	Version 1.3	Huffman et al., 1997
ERA-5	ECMWF Re-Analysis 5		ECMWF website*

*https://confluence.ecmwf.int/display/CKB/ERA5+data+documentation, accessed May 2019

In the past, various intercomparison studies were performed with a focus on patterns of the mean precipitation rate (PR) (see reviews by Kidd and Huffman, 2011; Maggioni et al., 2016; and Tapiador et al., 2017). The general conclusion from these studies is that there is good agreement among global satellite PR data sets, although significant absolute differences are found where PR is high (e.g., at the intertropical convergence zone–ITCZ), and large relative differences at latitudes greater than 40°. In particular, no single method is superior to any other in all regions and under all conditions, as each has its own strengths and weaknesses.

Rather than validating the long-term or monthly means of the daily HOAPS-GPCC data set, we present an intercomparison of two precipitation-relevant Expert Team on Climate Change Indices (ETCCDI's) that are indicative of precipitation extremes (Peterson and Manton, 2008; Zhang et al., 2011; *www.wcrp-climate.org/etccdi*). The HOAPS-GPCC data set was compared with two observation-based data sets, TRMM3B42 and GPCP-1DD. Finally, ETCCDI's were computed for each of ten ensemble members of ECMWF's most recent reanalysis, ERA-5, which were averaged and included in the intercomparison. A comparison with ETCCDI calculated from the ERA-5 ensemble mean precipitation rate (not shown) yielded relatively minor, but systematic differences.

The simple daily intensity index (SDII) is the mean PR of all days within a year, with PR ≥ 1 mm or in other words, the SDII is the mean PR on rainy days. Maps of the SDII of 2014 from HOAPS-GPCC, TRMM3B42, GPCP-1DD and ERA-5 are shown in Figure 1 on the next page. The patterns found in all four panels are very similar, with high SDII over the ITCZ and the Atlantic and Pacific storm tracks. Over land, HOAPS-GPCC yields the highest SDII over South America, central Africa and India. Panel B looks very similar, although TRMM systematically finds higher SDII over ocean and somewhat smaller values over land (particularly over central Africa). The differences between HOAPS-GPCC and GPCP (Panel C) are smaller and more random—at least over ocean. In contrast, several land regions show strong, systematic deviations, which is noteworthy because GPCP is calibrated against GPCC. The largest differences, found over Africa, can be attributed to the scarcity of stations, but this cannot be said for the southeastern United States. The ERA-5 ensemble mean (Panel D) displays similar patterns to HOAPS-GPCC, but with a large negative bias of the global mean of 2.8 mm/day. The global mean biases of GPCP and TRMM with respect to HOAPS-GPCC are 0.7 and 0.4 mm/day, respectively, in 2014.

The index R20mm represents the number of days in a year when PR ≥ 20 mm/day and is shown for HOAPS-GPCC in Panel A of Figure 2, on the next page. The ITCZ and the Pacific and Atlantic storm tracks yield the largest number of days with heavy precipitation. Over land, northern South America (Amazon region) has by far the wettest days, followed by Indonesia and Central Africa. The difference plots between R20mm of the three remaining data sets on the one hand, and HOAPS-GPCC on the other, are shown in Panels B-D. HOAPS-GPCC is in agreement with both TRMM and GPCP, although TRMM yields higher R20mm than HOAPS-GPCC over most of the ITCZ and the western North Atlantic. ERA-5 shows R20mm is almost a factor of two smaller over South America, Central Africa and Indonesia, but is otherwise in agreement with the observations.

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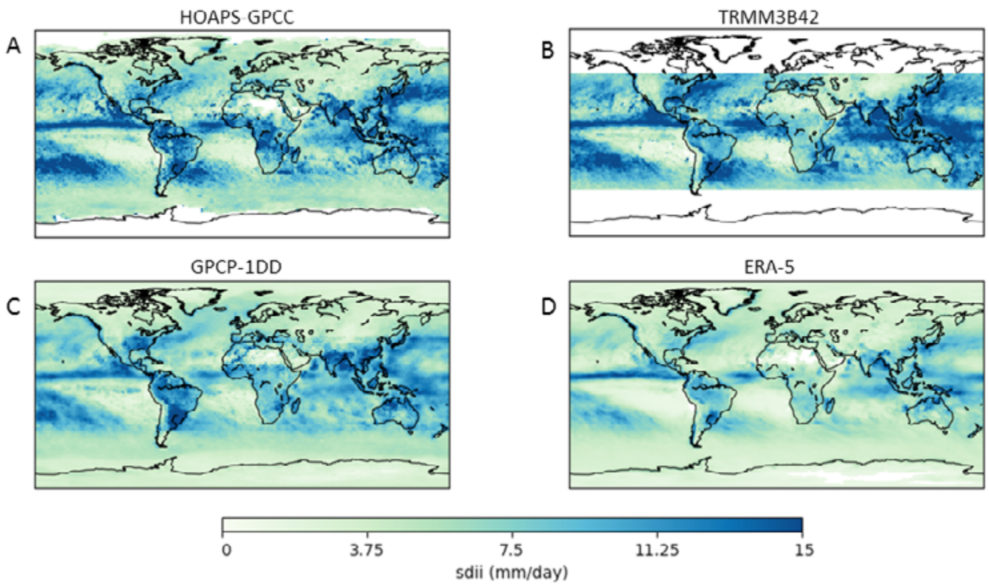

***Figure 1**. Simple daily intensity index (SDII) of the year 2014 from daily PR from (a) HOAPS-GPCC, (b) TRMM, (c) GPCP and (d) mean SDII of ten ERA-5 ensemble members.*

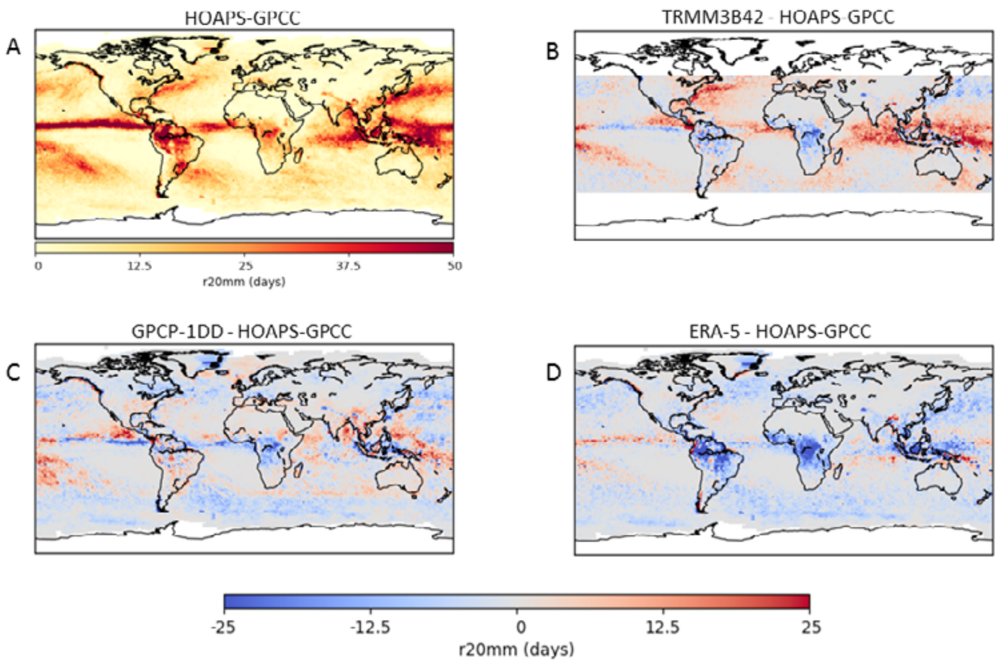

***Figure 2**. Comparison of R20mm (number of days in 2014 when PR ≥ 20 mm/day) between four data sets: (a) R20mm of HOAPS-GPCC, (b) R20mm difference of TRMM3B42 – HOAPS-GPCC, (c) R20mm difference of GPCP – HOAPS-GPCC and (d) difference of ERA-5 ensemble mean R20mm – HOAPS-GPCC.*

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Meeting/Workshop Reports

Third ANDEX Workshop

Quito, Ecuador
21–24 April 2019

Germán Poveda[1] and René Garreaud[2]
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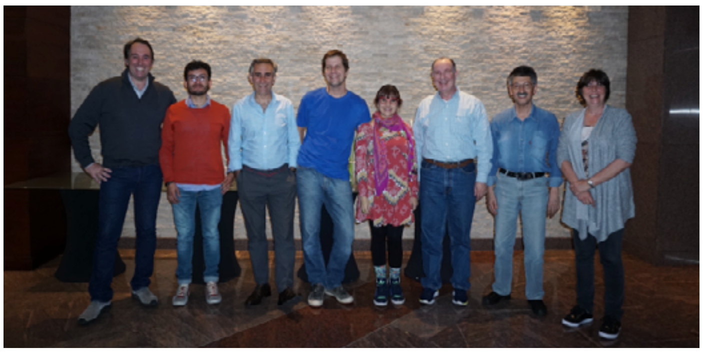

Participants of the 3rd ANDEX Workshop in Quito. Left to right: P. van Oevelen, J.C. Espinoza, R. Garreaud, M. Masiokas, P.A. Arias, G. Poveda, J.D. Pabón and F. Vervoort

ANDEX is a prospective Regional Hydroclimate Project (RHP) of the GEWEX Hydroclimatology Panel (GHP). It aims to improve our understanding and prediction of climate and hydrology along the Andes cordillera. Three regional meetings have been held with the goals of identifying the research community, constructing a scientific agenda and defining preparatory implementation steps. The first meeting took place in Medellín, Colombia, from 4–6 December 2017. The main outcome of this meeting was to define a White Book with chapters focused on diverse hydroclimatic aspects of the Andes cordillera:

Chapter 1. Introduction
Chapter 2. Geographical Context of the Andes
Chapter 3. Hydroclimate of the Andes
Chapter 4. Cryosphere of the Andes
Chapter 5. High Impact Events in the Andes
Chapter 6. Observed and Projected Hydroclimatic Changes in the Andes
Chapter 7. Observations and Data in the Andes
Chapter 8. Science Underpinning Sustainable Development of the Andes
Chapter 9. Challenges and Opportunities

The first ANDEX scientific workshop was held in Santiago, Chile, from 22–26 October 2018, and partly consisted of the joint ANDEX-GHP-International Network for Alpine Catchment Hydrology (INARCH) meeting. Scientists from all three events joined to discuss subjects of common interest, enhancing transregional scientific collaboration on mountainous terrain topics in manner consistent with the overall objectives of GHP. The first ANDEX workshop aimed specifically to: (1) review the status of the ANDEX White Book; (2) identify overarching themes and major scientific questions; and (3) provide a first approach to an implementation plan.

The third meeting was held in Quito, Ecuador, from 21–24 April 2019, bringing together the lead authors of different chapters of the ANDEX White Book (R. Garreaud, G. Poveda, J.C. Espinoza, M. Masiokas, P. Arias, J.D. Pabón) and representatives of the International GEWEX Project Office (Peter van Oevelen and Fernande Vervoort). The main objective of this meeting was to assess the advancement of the White Book, entitled "*ANDEX–A Regional Hydroclimate Project (RHP) on the Andes. Scientific Context, Challenges and Opportunities*". After an in-depth review on the status of the White Book, a timeline was defined with the first version of the book chapters prepared for peer-review on September 1, 2019. Other issues and further implementation steps were discussed during the Quito meeting, including:

1. Submission of a session proposal to the American Geophysical Union (AGU) Fall Meeting 2019, entitled "The Hydro-climate of the Andes: Current Understanding and Future Challenges", convened by René Garreaud, Germán Poveda, Mathias Vuille and Ana P. Barros. The proposal was approved (session ID#: 78709) and 25 abstracts were received. Session details can be seen at *https://agu.confex.com/agu/fm19/webprogrampreliminary/Session78709.html*.
2. The planned submission of a session proposal to the 2020 European Geosciences Union (EGU) meeting
3. Discussion of initial ideas on setting up an ANDEX Open Scientific Conference for 200–300 participants in austral spring 2020
4. Design and construction of the ANDEX webpage and logo
5. Definition of the governance structure of ANDEX. The participants decided to start with a small coordinating and planning committee of dedicated individuals who will lead alongside the current co-chairs, G. Poveda and R. Garreaud. During the implementation phase, the final governance structure will be defined.
6. Submission of several chapters of the White Book as review papers to high-impact journals
7. Status of the ANDEX survey (*https://es.surveymonkey.com/r/XMHPRRM*). Responses are still welcome! If you would like to take the survey, please contact R. Garreaud (rgarreau@dgf.uchile.cl).

The general consensus among the participants after this third workshop is that ANDEX is advancing at a good pace towards its establishment as a full GEWEX RHP. Ever since its inception in 2017, the ANDEX core group has identified and engaged a broad, diverse research network of scientists working in the seven Andean countries and relevant groups in North America and Europe. The ANDEX White Book will contain our current knowledge of the water and energy cycles along the Andes, and will conduct an in-depth analysis to identify the many gaps hindering our capacity to diagnose, model and predict the hydroclimate along this formidable mountain range. This will constitute a sound basis towards an implementation plan to be developed in the 2020–2025 timeframe.

Second Annual Open Science Meeting of the Global Water Futures RHP

Saskatoon, Saskatchewan, Canada
15–17 May 2019

John Pomeroy and Chris DeBeer
Centre for Hydrology and Global Institute for Water Security
University of Saskatchewan, Saskatoon, SK, Canada

Much of the world's population is dependent upon water from cold regions, which are at the forefront of global warming and undergoing rapid change and an increase in the occurrence of extreme events. Finding solutions for how to best forecast, prepare for, and manage water futures in the face of dramatically increasing risk is a global imperative. The Global Water Futures (GWF; *www.globalwaterfutures.ca*) Program is a Canadian-led GEWEX Regional Hydroclimate Project (RHP) that funds over 165 professors from 15 Canadian Universities in 45 GWF projects and core teams, and works with hundreds of partners from across Canada and internationally. The overarching goal of GWF is to deliver risk management solutions developed from leading-edge water science and supported by innovative decision-making tools to manage water futures in Canada and other cold regions. The focus of GWF is on: (1) improving disaster warning and developing forecasting capacity to predict the risk and severity of extreme events; (2) predicting water futures through the use of Big Data and improved numerical models to assess changes in human/natural land and water systems; and (3) informing adaptation to change and risk management through governance mechanisms, management strategies, and policy tools and guidance.

GWF focuses on major river basins in Canada and the United States, and key ecological, climatological, and physiographic regions (see map below) that are representative of the scientific and societal issues faced globally and especially within cold regions where snow, ice, and frozen soils dominate water processes. Canadian landscapes, ecosystems and the water environment are at the forefront of climate change. River basins are challenged by increasing water demands, high nutrient loads, warming temperatures, altered patterns of rainfall, snowfall, snowmelt and freeze-thaw cycling, glacier loss and permafrost thaw, and changes in river flow regimes. Much of Canada is warming 2-3 times faster than the rest of the world, which is leading to profound changes to its cold region hydrology, water management and aquatic ecosystems. Climate change has increased the severity and frequency of extreme events, leading Canada to experience an unprec-

Figure 1. Map of the GWF Canadian RHP geographic study domain across Canada and parts of the USA. GWF focuses on eight major river basins spanning across the country. Core observational, and climate and hydrological modeling components of the program focus on all of these basins.

edented series of disasters in recent years—2001–2004 Prairie droughts, 2013 Alberta/BC floods, 2013 Toronto flood, 2016 Fort McMurray wildfire, 2017 BC and New Brunswick floods, 2017-2018 British Columbia fires, and 2016–2019 flooding in Quebec, Ontario and New Brunswick. These disasters have caused damages approaching CDN$30B. As a result, federal disaster payments are overspent by an order of magnitude. In addition to global warming-induced changes, water management also impacts remote river basins used for hydroelectric power generation. Infrastructure developments such as dams, hydroelectric generation, diversions and irrigation networks, along with industrialization and urbanization, have altered the natural water cycle. Pollution from population growth, industrialization, and agriculture has degraded water quality in many regions resulting in hundreds of drinking water advisories for rural Indigenous communities in Canada. The implications of human-driven changes and their interactions with the natural environment have not been adequately understood and characterized.

Participants of the 2nd GWF Annual Open Science Meeting take part in a Round Dance to mark the end of the day of Indigenous cultural learning at Wanuskewin Heritage Park on 15 May 2019. Photo credit: Wanuskewin Heritage Park

GWF is developing a number of important international linkages and expanding its scientific activities beyond Canada to address these issues globally. As a GEWEX RHP, the GWF is also an expanded follow-on project from the Changing Cold Regions Network RHP (CCRN; 2013–2018; *www.ccrnetwork.ca*) and the Mackenzie GEWEX Study (MAGS; 1996–2005 *http://www.usask.ca/geography/MAGS/index_e.htm*). GWF closely interacts with the International Network for Alpine Research Catchment Hydrology (INARCH; *http://www.usask.ca/inarch/*), a GEWEX crosscutting project. In May 2018, GWF helped host the 8th GEWEX Open Science Conference in Canmore, AB, Canada—the first time the GEWEX Conference was held in Canada. A memorandum of understanding has been signed between GWF and the Chinese Academy of Sciences and the Third/Three Pole Environment Initiative—a proposed RHP under GEWEX. Other key linkages include the Sustainable Water Futures Programme of Future Earth and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) International Hydrological Programme (IHP), and the UN through its International Water Action Decade: Water for Sustainable Development, 2018–2028. GWF has formal linkages to the World Meteorological Organization (WMO) and is co-leading a *High Mountain Summit* to be held in Geneva, Switzerland in late October 2019. Major areas of international collaboration and support with GWF involve a focus on high mountain and cold regions, and GWF is currently developing plans and allocating funds for a planetary water prediction (PWP) effort with a focus on these regions globally. This involves collaboration with countries in the Americas, Asia and Europe, to develop, support, test, and apply coupled climate–hydrology–water quality–water management models globally with an emphasis on river basins where high mountain water supplies feed lowland water demands and ecosystem needs.

GWF recently held its Second Annual Open Science Meeting in Saskatoon, which was organized and hosted by the University of Saskatchewan (USask) and Wanuskewin Heritage Park (*https://wanuskewin.com/*). With over 500 attending, 282 poster and oral presentations and six keynote plenary presentations, this was the largest water science meeting ever held in Canada. The meeting was open to all members and affiliates of the GWF Program, its extended community of partners, and others wanting to connect. It included many exciting, informative, and unique events and activities meant to review and better link together GWF's technical and scientific advancements, while promoting further development and training of early career researchers, Indigenization and decolonization of GWF in the spirit of reconciliation, and engagement with partners and stakeholders.

The meeting was notable and unique for including significant contributions throughout from GWF Indigenous community co-led water research projects across Canada, and an Indigenous cultural sharing and learning exchange held at Wanuskewin Heritage Park. This involved local community Elders and members, Wanuskewin interpretive staff, and the Office of Indigenous Initiatives at USask, who shared knowledge of the history, culture, spirituality and worldview of the Indigenous Peoples of the region. Attendees divided into groups and moved through various activities, including a Powwow with traditional dancers and drummers; a tour of ongoing archaeological excavations at the Park; sampling of Walleye—a traditional food for the Cree People in the Saskatchewan River Delta region—and stories of the changing environment of the Delta; knowledge exchange on Bison hide processing and its cultural importance; and a showcasing of Indigenous art, crafts, medicines and ceremonial artifacts. The meeting also included a keynote presentation from the Chief of the Federation of Sovereign Indigenous Nations—a Treaty and Inherent Rights organization that represents 74 First Nations, and over 160,000 Indigenous People—on water issues facing Indigenous Nations.

Parallel thematic sessions focused on: (i) climate and hydrology, (ii) human dimensions and hydro-economics, (iii) ecosystems and water quality, and (iv) modeling advancements. These sessions revealed the remarkable range and quality of research being undertaken across GWF and fostered collaboration, synthesis and discussions on research impact with partners and users. Plenary sessions featured keynote talks by high-level scientists and leaders on key issues relevant to GWF, linking with each of the themes covered in parallel sessions. Plenaries also included highlights of some of the research accomplishments from the GWF Program, and provided an opportunity for several rounds of lightning talks—2-minute short summaries to draw attention to individual posters. A banquet plenary by David Grimes, President of WMO, provided a valuable insight into international atmospheric and hydrological initiatives. A poster and networking session included over 200 posters and provided excellent opportunities for fostering discussion. Achievements noted at the meeting were the outcomes of the first national flow-forecasting workshop and progress towards a national water forecasting system; a national multi-scale, multi-physics coupled meteorological-hydrological-water management-water quality modeling system. Prototypes of the system are providing physically based river basin predictions that include the impact of climate and land use change and water management, and include full representation of the cryosphere. Modeling components, such as water quality and hydro-economics, are showing great promise for future coupling.

The meeting provided many opportunities for students and young professionals, and was an excellent venue for networking. Prior to the meeting, there was a one-day series of professional development workshops for building writing skills and strengthening communication and knowledge mobilization abilities. The GWF Young Professionals (YP) organization also had their annual meeting and networking social to highlight the year of YP activities and introduce new executives into the membership.

On the evening prior to the meeting, a public outreach event was held at the Roxy Theatre in Saskatoon, which included an overview of the GWF Program, a keynote presentation on existing and emerging water issues, and the challenges facing the Canadian Prairie Provinces. In addition, there was a panel discussion with question and answer forum that included a diverse group of water experts who shared their knowledge and expertise. This was a well-attended and positive transdisciplinary event, and provided an opportunity to showcase GWF and what it is doing in response to global water challenges and local societal concerns.

Moving forward there are high expectations of the GWF Program and many ambitious goals to achieve. This meeting, in general, showed that our program is largely on track, with a tremendous amount of energy and excitement for the delivery of new results and the many significant advancements being accomplished. More information on the meeting, including a list of presentations and abstracts, and photographs from the various events is available on the GWF website (*https://gwf.usask.ca/news-events/meetings.php*). We look forward to our 2020 Annual Open Science Meeting, which will be jointly hosted by the University of Waterloo and Wilfrid Laurier University in Waterloo, Ontario next spring. This will be open to all who wish to connect with GWF. Please see our website (*www.globalwaterfutures.ca*) and Twitter (@GWFutures) for more information or contact us if you would like to become involved with the program.

NOAA/OAR Bedrock-to-Boundary Layer (B2B) Workshop

Boulder, Colorado, USA
23–24 April 2019

Kirsten Findell
National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL); Global Land/Atmosphere System Study (GLASS) Panel Co-Chair

About 30 NOAA scientists attended the NOAA/Oceanic and Atmospheric Research (OAR) sponsored Bedrock-to-Boundary Layer (B2B) Workshop. The workshop concept emerged out of the recognition that the broad set of scientific problems around observing and modeling land-atmosphere interactions is larger than any one NOAA laboratory can tackle. The workshop co-organizers, Dave Turner, Earth System Research Laboratory (ESRL)/Global Systems Division (GSD), and Tilden Meyers, Air Resource Laboratory (ARL)/Atmospheric Turbulence and Diffusion Division (ATDD), believe that the collective expertise, wisdom, and observational and modeling toolkits distributed across NOAA labs could give the agency the ability to make great strides in the field, if done collaboratively. Such efforts could lead to improvements in process understanding that could translate into improved modeling and forecasting capabilities.

NOAA representatives from GFDL, the National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC), ARL/ATDD, the National Severe Storms Laboratory, the Great Lakes Environmental Research Laboratory (GLERL), and the four ESRL divisions [Global Modeling Division (GMD), Physical Sciences Division (PSD), Chemical Science Division (CSD), and GSD] were present. Two scientists from the National Environmental Satellite, Data, and Information Service (NESDIS) attended and shared their perspectives on satellite resources relevant to land and the planetary boundary layer that might be beneficial to this community. Jin Huang from the Climate Program Office (CPO) and Mark Vincent and Jordan Dale from the Office of Weather and Air Quality (OWAQ) also attended.

Objectives of the B2B Project include: connect members of the broader NOAA/OAR community who are working on issues related to land-atmosphere interactions; establish communications between observationalists and modelers to help both groups understand the needs of the other; and prepare a vision for a NOAA-driven field campaign at a series of locations in different climatological regimes that would be "shovel-ready" should funding opportunities become available.

Follow-up phone calls with the workshop attendees are expected, ultimately leading to a white paper detailing "A Multi-Lab Integrated Observation and Modeling Approach to Understanding Land-Atmosphere Interactions: A Bedrock-to-Boundary Layer (B2B) Approach" to be shared with OAR program managers and lab directors. There is clearly a lot of overlap between the research objectives of this group and those of the GEWEX/GLASS community, although the focus of the B2B group is skewed towards shorter time-scales than that of the GLASS panel. We look forward to communication and collaboration between the GLASS and B2B communities.

Fifth PannEx Workshop

Novi Sad, Serbia
3–5 June 2019

Ivan Guettler
Croatian Meteorological and Hydrological Service (DHMZ), Zagreb, Croatia

Professor Branislava Lalić of the Faculty of Agriculture, University of Novi Sad, hosted the 5th Pannonian Basin Experiment (PannEx) Workshop, where almost 50 scientists from Serbia, Romania, Hungary, Croatia, Germany, Italy and Spain presented their research on monitoring and modeling the hydroclimate systems in Europe and the Pannonian Basin. The primary focus of the workshop was on building PannEx task teams to address the environmental needs in the Pannonian Basin. Mónika Lakatos, the PannEx Chair, opened the meeting with an overview of the current progress of the PannEx initiative, which was followed by presentations on the following topics:

1. Micrometeorological observations in Serbia, Hungary and Croatia in vineyards, orchards and lakes, and the general role of the Pannonian Basin peripheral topography on the rest of the Basin.
2. Urban climate studies in Serbia and Romania based on observational studies of present climate and historical reconstructions of late 19th century climate.
3. Regional climate modeling simulations related to the European branch of Coordinated Regional Downscaling Experiment (EURO-CORDEX) simulations and those performed jointly by members of the PannEx community.
4. Topics pertaining to the forestry, ecosystem services, plant protection and climate smart agriculture, including desertification, soil suitability assessments and agrometeorological issues.
5. Weather impacts on human health and comfort and relevant processes in Serbia and Hungary.

All of these topics were further elaborated in almost 20 posters with many examples of collaboration between research groups from the Pannonian countries.

During the workshop the PannEx International Planning Committee and Task Team leaders' met. The newly appointed PannEx Secretary, Professor Danijel Jug of the University of Osijek, was present and is coordinating efforts to expand the PannEx community presence, both in the virtual and real world. Plans were discussed for the next PannEx Workshop, which is to be held in June 2020 at the Centre for Agricultural Research at the Hungarian Academy of Sciences in Martonvásár, Hungary.

The final day of the workshop was focused on presentations and discussions by each of the nine PannEx Task Teams:

1. Agroclimatological and Agrobiological Systems
2. Energy Production
3. Special Observations and Data Analysis
4. Ecosystem Services
5. Urban Climate and Air Quality
6. Outreach and Education
7. Micrometeorology and Agronomical Process Modeling
8. Water Balance at the Basin Scale
9. Modeling from Climate to Flash Floods

All Task Teams are steadily growing, and new members are welcomed.

Participants of the 5th PannEx Workshop

New Research Roadmaps for ACPC Initiative: Volcanic and Ship Aerosol Laboratories and TRACER Observations

Nanjing, China
24–26 April 2019

Johannes Quaas[1], Minghuai Wang[2], Daniel Rosenfeld[3], Meinrat O. Andreae[4,5], Matthew Christensen[6], Michael P. Jensen[7], Philip Stier[6], Kentaroh Suzuki[8], Sue van den Heever[9] and Rob Wood[10]

[1]University of Leipzig, Leipzig, Germany; [2]Nanjing University, Nanjing, China; [3]Hebrew University of Jerusalem, Jerusalem, Israel; [4]Max Planck Institute for Chemistry, Mainz, Germany; [5]Scripps Institution of Oceanography, UCSD, La Jolla, California, USA; [6]University of Oxford, Oxford, UK; [7]Brookhaven National Laboratory, Upton, USA; [8]University of Tokyo, Tokyo, Japan; [9]Colorado State University, Fort Collins, Colorado, USA; [10]University of Washington, Seattle, Washington, USA

Participants to the Aerosols-Clouds-Precipitation-and-Climate (ACPC; *acpcinitiative.org*) met in Nanjing, China to discuss progress in understanding the role of aerosol perturbations in clouds and precipitation. The primary aim of ACPC is to achieve a better understanding of process-scale to regional-scale aerosol-cloud interactions, where most of the effort is invested in analysis of observational data from field campaigns and satellites, and of simulations from large eddy to cloud system-resolving scales. Current ACPC studies are guided by two roadmaps with a focus on shallow marine clouds and deep convective clouds (e.g., Quaas et al., 2018).

For shallow marine clouds, the focus is primarily aimed towards recent field campaigns in the south eastern Atlantic Ocean (e.g., Zuidema et al., 2016). Several modeling groups are now using these field observations for interpretation with the help of large eddy to regional-scale modeling approaches. One emerging result is the importance of the boundary layer response to smoke overlying stratocumulus clouds. Lagrangian approaches applied to both large eddy simulations and satellite observations were shown to be advantageous for characterizing the lifecycle of stratocumulus clouds and the development of an observed Pocket of Open Cells (POC). Much discussion was spent on the interpretation of statistical relationships that relate to cloud droplet number concentration, Nd, and cloud liquid water path, L, from satellite data. Recent studies have arrived at opposite conclusions (Michibata et al., 2016; Gryspeerdt et al., 2019; Rosenfeld et al., 2019). The consensus at the meeting was that the analysis of aerosols emitted from sources that are external to the atmosphere system, such as volcanoes, can be very useful in assessing causality in aerosol impacts on clouds and precipitation. New results were presented from a satellite-data analysis of ship tracks in the south eastern Atlantic Ocean region that supported earlier findings of analyses of volcanic aerosols and ship tracks (e.g., Toll et al., 2017).

For deep convective clouds, the study of the clouds that was conducted in the vicinity of Houston, Texas produced several interesting outcomes. Previous ACPC discussions concluded that polarimetric radar is a key observational resource for assessing aerosol impacts on cloud microphysics and dynamics (Fridlind et al., 2019). In light of this, the ACPC group strongly contributed to the proposal for a deployment of the Atmospheric Radiation Measurement (ARM) mobile facility and additional instrument resources in the Houston region. The proposal, TRacking Aerosol Convection Interactions ExpeRiment (TRACER), led by ACPC steering committee member Mike Jensen, was selected in 2018 and will see the deployment of the ARM facilities from April 2021–April 2022, with an intensive observations period between June and September 2021. Several additional observations will join this effort, with notably contributions from additional radar instruments, as well as local networks in Houston.

ACPC modeling groups have performed cloud-system resolving simulations from the model intercomparison project with a defined simu-

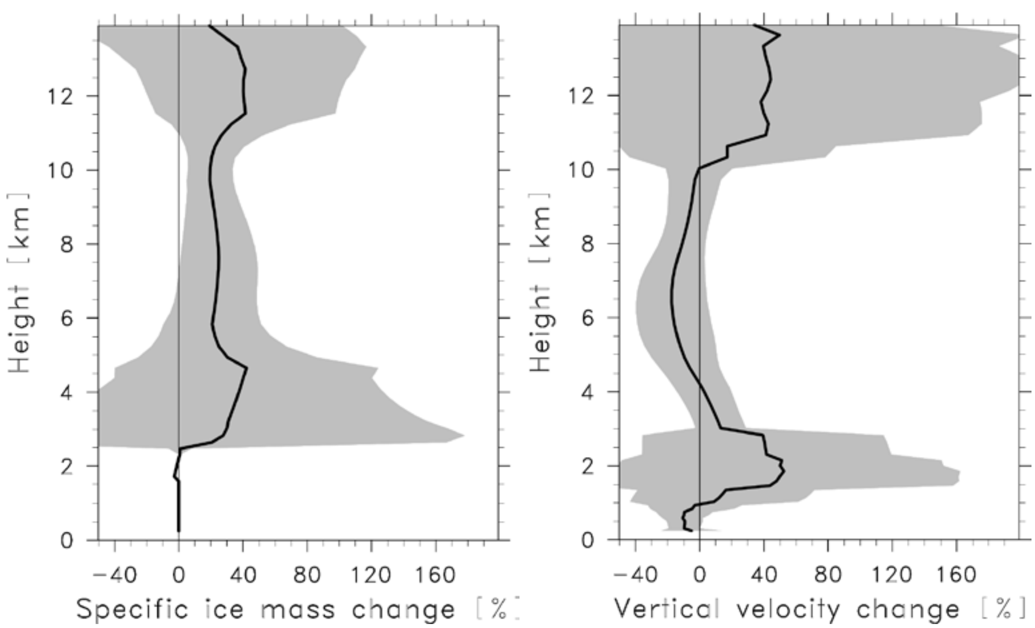

Figure 1. *Results from the Houston case model intercomparison project. Differences between high-aerosol and low-aerosol simulations as temporal mean, domain-average for the multi-model mean (line) and standard deviation (shading). Results are smoothed vertically. Left: specific ice mass as relative difference. Right: vertical velocity. Figure adapted from van den Heever et al. (2019).*

lation protocol. Publications are upcoming. Two primary results are presented in Figure 1. A considerable response of deep convective clouds to the prescribed perturbation of the aerosols in the simulation pairs (with low and high aerosol concentrations) is found. This is despite the fact that the cloud fields in the simulations are rather different between the models, with no model ideally matching the observations. Also, the response of the average surface precipitation flux response differs substantially between the models and in some cases show opposite signs. However, the cloud microphysics respond systematically in different models. An example is the strong increase in upper tropospheric cloud ice mass. Large uncertainties remain regarding the magnitude and signal of effects and a thorough model evaluation and improvement is needed after the TRACER campaign. Similar results were obtained for cloud dynamics (Figure 1), where the models mostly agree on a characteristic shape of the vertical motion changes in response to aerosols (increase in lower and upper troposphere; decrease in middle troposphere), albeit with varying magnitude.

During the meeting, the ACPC initiative acquired new impetus in its organization (Minghuai Wang took responsibility as a new co-chair, along with Dan Rosenfeld, and replaces Johannes Quaas), and in its science. Two new working groups were formed, one with a focus area on the analysis of cloud and precipitation responses to volcanic and ship aerosols emissions and the other on the analysis of observations, models, and model-data synergy in the TRACER region of interest. The former group will be co-led by Matthew Christensen and Andrew Gettelman and the latter, by Mike Jensen, Scott Collis and Jiwen Fan.

The next APCP workshop is planned for April 2020 and will be held jointly with the TRACER campaign team. The ACPC group welcomes interested researchers to join their activities.

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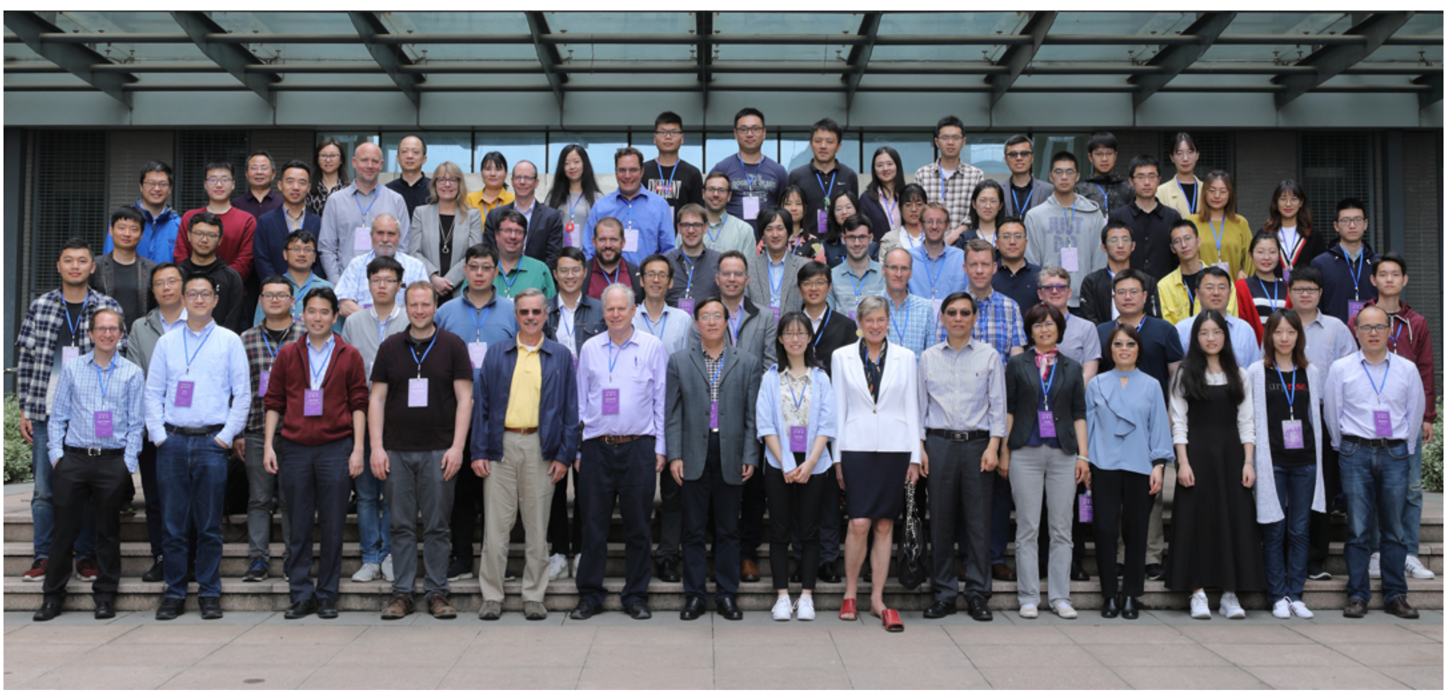

Figure 2. *Participants of the ACPC Workshop at the School of Atmospheric Sciences, Nanjing University, China*

GEWEX/WCRP Calendar

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

8–12 September 2019—International Mountain Conference—Innsbruck, Austria

8–13 September 2019—Ph.D. and Post-Doctorate Summer Research School: Observing and Modeling the Arctic Environment–Climate Processes, Prediction and Projection—St. Petersburg, Russia

8–14 September 2019—Postgraduate Course and International Seminar: Integrating Global Change Knowledge to Decision-Making Processes—Santa Fe, Argentina

9–11 September 2019—Committee on Earth Observation Satellites (CEOS), World Meteorological Organization (WMO)-Global Space-based Inter-Calibration System (GSICS) Workshop on an SI-Traceable Space-based Climate Observing System—London, UK

9–13 September 2019—European Meteorological Society (EMS) Annual Meeting 2019—Copenhagen, Denmark

9–13 September 2019—Soil Moisture Validation and Application over Highlands Workshop—Fairbanks, Alaska, USA

11–13 September 2019—Data Assimilation Working Group Meeting—Boulder, Colorado, USA

15–20 September 2019—Advanced Training School on Remote Sensing/Earth Observation: Applications of Remote Sensing in the Baltic Sea Region—Võru, Estonia

17–19 September 2019—5th Conference on Modeling Hydrology, Climate and Land Surface Processes—Lillehammer, Norway

23 September 2019—United Nations Secretary General's Climate Action Summit—New York, New York, USA

23–25 September 2019—Second International Conference on Our Climate–Our Future: Regional Perspectives on a Global Challenge—Berlin, Germany

24–27 September 2019—Future Earth Water Future Conference: Towards a Sustainable Water Future—Bengaluru, India

24–27 September 2019—Working Group on Numerical Experimentation (WGNE) Meeting—Offenbach, Germany

30 September–4 October 2019—Cloud Feedback Model Intercomparison Project (CFMIP) 2019 Meeting on Clouds, Precipitation, Circulation, and Climate Sensitivity—Mykonos, Greece

1–3 October 2019—Water Isotopes and Climate Workshop—Boulder, Colorado, USA

7–9 October 2019—African Climate Risks Conference—Addis Ababa, Ethiopia

7–9 October 2019—GEWEX Hydroclimatology Panel (GHP) Crosscuting Project (CC) Workshop: Determining Evapotranspiration—Sydney, Australia

8–9 October 2019—Hydrology of the Baltic Sea Basin: Observations, Modeling, Forecasting—St. Petersburg, Russia

10–11 October 2019—2019 GEWEX Hydroclimatology Panel (GHP) Meeting—Sydney, Australia

14–18 October 2019—International Conference on Regional Climate (ICRC)-Coordinated Regional Climate Downscaling Experiment (CORDEX) 2019—Beijing, China

21 October–1 November 2019—Institute of Advanced Studies in Climate Extremes and Risk Management—Nanjing, China

22–25 October 2019—Atmospheric Circulation in a Changing Climate—Madrid, Spain

29–31 October 2019—High Mountain Summit—Geneva, Switzerland

4–8 November 2019—4th Symposium of the Committee on Space Research (COSPAR): Small Satellites for Sustainable Science and Development—Herzliya, Israel

7–13 December 2019—World Climate Research Programme (WCRP) Climate Science Week at the American Geophysical Union (AGU) Fall Meeting 2019—San Francisco, California, USA

7 December 2019—WCRP-AGU Joint Early Career Researcher Workshop—San Francisco, California, USA

8 December 2019—WCRP 40th Anniversary Symposium at AGU Fall Meeting—San Francisco, California, USA

9–13 December 2019—AGU Fall Meeting 2019—San Francisco, California, USA

12–16 January 2020—100th American Meteorological Society Meeting—Boston, Massachusetts, USA

27–31 January 2020—Thirty Second Session of the GEWEX Scientific Steering Group (SSG)—Pasadena, California, USA

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