GEWEX NEWS

GEWEX is a Core Project of WCRP on Global Energy and Water Exchanges

WCRP World Climate Research Programme | WORLD METEOROLOGICAL ORGANIZATION | International Science Council

Vol. 29 No. 4, November 2018

Trio of Meetings Highlights Potential of the Andes for Continued Research

Three recent meetings—the 1st ANDEX Workshop, 2018 GHP Meeting, and 4th INARCH Workshop—bring attention to the Andes mountain range as a valuable area of research.

Contents

A Balancing Act

Peter van Oevelen
Director, International GEWEX Project Office

Our global community researching climate and weather-related science collaborates on an international level because it offers an opportunity to not only share views, knowledge, and data, but also different perspectives. The community functions through activities such as working groups and projects and is guided, in the case of GEWEX, by its four scientific panels, the GEWEX Scientific Steering Group (SSG), and the Joint Scientific Committee (JSC) of the World Climate Research Programme (WCRP).

During the International GEWEX Open Science Conference in May 2018, a few things became apparent both by observation as well as through the much-appreciated comments of participants and colleagues. Though we did well with the breadth and depth of science and the high quality of presentations, there are a few areas where we can and should do better. Firstly, gender balance can be improved both in conference representation and in our panels and steering group. There are several ways to advance this, and one would be to set targets regarding representation, starting with our panels and steering group and expanding into all activities we organize. A minimum of 30% non-male representation is a launching point. This should be a reflection on the overall balance of our community and is something to be explored and tracked. In addition, our larger events should offer some form of child support or child care facilities at a small or no extra cost to the participant.

A view of the Andes from the Torres del Paine National Park in Chile

Secondly, the geographical balance of participants can be improved. The major barrier here is that the current make-up of the community is primarily driven by national support; hence, participation from lesser-developed countries is low without additional funding. The location of a meeting can also be a deterring factor, as acquiring visas can be a lengthy and in certain cases almost impossible process.

Much of the above can be mitigated by providing financial support for participants to attend events. Establishing specific or targeted funds at the appropriate level could be a good first step. Currently, much of the travel support distributed for our meetings goes to early career researchers and those from lesser-developed countries, and the GEWEX panel and SSG events have similarly distributed funding. I want to note, though, that we very much appreciate the many scientists who are able to participate with their own funding, which enables others to participate!

Although funding is necessary, the very first step is to be aware of these issues and take them into account. Our community exists by virtue of mostly volunteer efforts, and we want to be inclusive when it comes to these concerns. We are open to further suggestions, and invite you to take the above as a call to nominate candidates who will steer us in a more balanced direction. We always have an open call for nominations to our panels and SSG, and you can find more information on our website (*https://www.gewex.org*) or by contacting us via email at *gewex@gewex.org*.

This issue of our GEWEX newsletter has many meeting reports about quite a variety of activities. In the light of the discussion above, I would like to highlight the GEWEX Hydroclimatology Panel (GHP) Meeting, the 1st ANDEX Workshop, and the 4th INARCH Workshop, all held in Chile. One way we do try to engage more regional scientists is through our projects, and we hope that by organizing these meetings in the area, we can entice the South American scientific community to broaden its participation in GEWEX. The 1st ANDEX Workshop was a kick-off meeting to explore the possibility of establishing a Regional Hydroclimate Project (RHP) in South America focusing on the Andean region, a 7000 km long mountain range presenting unique scientific challenges.

To conclude, I thank Dr. Chuck Long for his extensive efforts in safeguarding, managing, and promoting the Baseline Surface Radiation Network (BSRN), as he is stepping down as the BSRN Project Manager. I also thank the National Oceanic and Atmospheric Administration Earth System Research Laboratory (NOAA-ERSL) for giving Dr. Long the opportunity to do this work for the past several years. With that, I welcome Dr. Christian Lanconelli as the new Project Manager and we look forward to working with him.

New Baseline Surface Radiation Network (BSRN) Project Manager

We welcome Dr. Christian Lanconelli as the new Project Manager for the Baseline Surface Radiation Network. Dr. Chuck Long has stepped down as BSRN Project Manager, and we would like to thank him for his service as a dedicated leader and wish him well in his retirement.

Dr. Lanconelli received his degree in physics in 2002 from the University of Bologna and obtained a Ph.D. in atmospheric physics in 2007 at the University of Ferrara, exploring the effects of Earth surface reflectance properties on aerosol direct radiative forcing by combining modeling and measurements approaches. He worked at the Institute of Atmospheric Sciences and Climate (ISAC) of the Italian National Research Council from 2002 to 2015, mainly involved in radiative transfer modeling and solar radiation measurement activities with the principal aim of assessing the effects of both aerosols and clouds on Earth's energy balance.

He was involved in several polar field campaigns and managed the Dome-C Antarctic BSRN station from 2006 to 2015, directing the field campaign, instrument setup and maintenance, and the processing chain from data acquisition to quality-checked data creation and submission. His group hosted the 13th BSRN Workshop in Bologna during September 2014. He left ISAC as principal investigator of a project financed by the Italian National Program for Antarctic Research (PNRA) to determine the radiative regimes over the Antarctic plateau, with particular attention to addressing the surface albedo properties and cloud radiative effect characterizations.

Moving to the Joint Research Centre of the European Commission, he worked in the Quality Assurance for Essential Climate Variables (FP-7 QA4ECV) and Copernicus projects by developing competencies in Monte-Carlo 3D radiative transfer modeling. This was used to assess the fitness for purpose of satellite-derived Essential Climate Variables such as surface albedo and the fraction of absorbed photosynthetically active radiation (FAPAR). The process involves the simulation of surface- and satellite-based radiative measurements over reference scenes, and the application of routine inversion methods in a single-pixel mode to determine their uncertainties in the retrieval of biological (in the case of vegetated surfaces) and physical parameters such as the surface spectral reflectance.

His efforts as BSRN Project Manager will include extending the synergy of BSRN with other networks and its role as a reference for modeling studies as well as calibration and validation activities.

YESS Involvement in Africa

Faten Attig-Bahar[1], Martin Addi[2], Rondrotiana Barimalala[3], Jully Ouma[4], Modathir Zaroug[5], and Gaby Langendijk[6]
[1]University of Carthage, Polytechnic School of Tunisia, Tunisia; [2]Ghana Space Science and Technology Institute, Ghana Atomic Energy Commission, Accra, Ghana; [3]University of Cape Town, South Africa; [4]University of Nairobi Department of Meteorology & IGAD Climate Prediction and Applications Centre (ICPAC), Nairobi, Kenya; [5]Nile Basin Initiative, Entebbe, Uganda; [6]Climate Service Center Germany, Hamburg, Germany

The successful Young Earth System Scientists (YESS) and Young Hydrologic Society (YHS) Early Career Researcher (ECR) Workshop and the 2018 GEWEX Open Science Conference, held in conjunction last May in Canmore, Canada, helped to raise the practical cooperation between the YESS-Africa members and GEWEX activities in the Lake Victoria Basin (LVB) to a new level. Moreover, it enhanced the connection between YESS members and the Global Challenges Research Fund African Science for Weather Information and Forecasting Techniques project (GCRF African SWIFT), leading to the planned joint YESS-SWIFT summer school in July 2019 in Ghana.

Planned GEWEX LVB activities and the YESS-Africa members involved with Victoria Basin research aim to improve the understanding of the climate over the Victoria Basin and enhance its predictability and projections to support decision making in the region. In line with the recent paper published in *Nature Climate Change* by Dike et al. (2018) on "Obstacles facing Africa's young climate scientists," young researchers in YESS acknowledge the opportunities and challenges that they could face in conducting studies. Some difficulties are being addressed over East Africa through the objectives of programs such as the High Weather Impact Lake System (HIWAY). Limited observational data and lack of general resources to support research remain the two main obstacles in studying the LVB.

The YESS community had the opportunity to participate in two GCRF African SWIFT meetings. The first was the advisory board meeting in Nairobi in June 2018, with Jully Ouma and Moses Tumusiime representing YESS-Africa. The second was held in Ghana in September 2018, with Addi Martin of YESS-Africa attending. The former aimed to convey the vision of young researchers in the planning of a summer school on improving science for weather and climate information and forecasting techniques on the continent. The latter discussed the effective role of the YESS community in the planned GCRF African SWIFT Summer School, which will be held in Ghana next year, as a joint SWIFT-YESS event. Martin Addi is nominated to join the GCRF African SWIFT Summer School organizing team, and will be supported by selected members of YESS-Africa. The SWIFT project aims to sponsor up to 30 young scientists in Africa to participate in the summer school.

We look forward to active contributions from ECRs in these initiatives and to research development in Africa.

H3S at the 2018 Fall AGU Meeting

Megan Brown
AGU H3S Chair

The Hydrology Section Student Subcommittee (H3S) of the American Geophysical Union (AGU) successfully completed its "Haiku Your Research" competition on our Twitter account, @AGU_H3S. We had some great submissions, and would like to congratulate the winners, Emily Fairfax, Dom Ciruzzi, Kieran Dunne, James Farrell, and Holly Andrews. Each received a mug inscribed with their haiku.

The Hydrology Section and H3S planned numerous activities and events for the AGU Fall Meeting, which took place from 10–14 December 2018 in Washington, DC. We'd like to thank those who joined us at the Hydrology Section Business Meeting on Tuesday night and the Joint Section Student/Early Career Networking event that took place on Thursday evening, which turned out to be a great interdisciplinary networking opportunity!

Some of our Town Halls, Pop-up Sessions, and Workshops featured alternative science careers, where participants shared food and learned about career opportunities they may not have realized existed:

- Alternative Careers: I Can Do Research There? Research in Places You May Not Expect
- Alternative Careers: Research in Action in Washington, DC

We hosted five Pop-Up Talk Sessions, back in their original format of short lightning talks. These sessions took place Monday through Thursday in the Student and Early Career Lounge from 16:00–18:00. Topics of our Pop-Up Talk Sessions included:

- 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

In addition, we conducted two workshops:

- Outsmart Your Research with Contemporary Technology
- Meet the Experts: Identifying Representative Spatial Scales in Hydrologic Modeling

As always, keep an eye on our Twitter account, @AGU_H3S, for updates and news!

Global Runoff Data Centre Turns 30

Ulrich Looser
Head, Global Runoff Data Centre (GRDC)

The Global Runoff Data Centre (GRDC) was established at the German Federal Institute of Hydrology (BfG) in Koblenz, Germany, in November 1988, and has reached its 30th year of operation under the auspices of the World Meteorological Organization (WMO).

River discharge data collected by WMO in the framework of the First Global Atmospheric Research Program (GARP) Global Experiment (FGGE) in the 1970s and early 1980s and a compilation of monthly discharge data collected by the United Nations Educational, Scientific and Cultural Organization (UNESCO) constituted the initial dataset of approximately 3500 stations.

The GRDC database of quality controlled "historical" mean daily and monthly discharge data has developed into the most comprehensive global river discharge data archive supporting climate-related programs and projects of the United Nations and their special organizations and the scientific and research communities at large. This valuable collection of river discharge data and metadata currently comprises data for more than 9500 stations from 161 countries with an average time-series length of 43 years.

The exchange of hydrological data and information on a global scale is the principal reason for operating GRDC. It connects national hydrological and hydro-meteorological services, the primary providers of river discharge data and associated metadata, and the scientific research community utilizing this unique data collection. GEWEX Regional Hydroclimate Projects (RHPs) are also taking advantage of these services, as GRDC as has been recognized as one of the global data centers affiliated with the GEWEX Hydroclimatology Panel (GHP) for more than 20 years.

Increasing data supplies and rising numbers of data requests reflect a sound relationship with data providers and users. This is a good basis for looking ahead with confidence to the continued operation of GRDC in a challenging environment. For more on GRDC, visit *http://grdc.bafg.de*.

GEOGLOWS: A Comprehensive GEO Water Initiative

Richard Lawford[1], Angélica Gutiérrez-Magness[2], Bradley Doorn[3], and Jim Nelson[4]
[1]Morgan State University, GESTAR (NASA), Baltimore, MD, USA; [2]NOAA, Silver Spring, MD, USA; [3]NASA, Washington, DC, USA; [4]Brigham Young University, Provo, UT, USA

Water sustainability is a critical issue for the world. Although the demand for water grows continuously, the amount of water recycled through the Earth's atmosphere remains relatively fixed. Climate trends and extremes add uncertainty to the availability of water resources because of shifts in the location, intensity, and timing of wet and drought events.

The Group on Earth Observations (GEO) Global Water Sustainability (GEOGLOWS) Initiative was launched in 2016 to provide a coordination mechanism for GEO projects that use Earth Observations (EO) for improved water resource management. This short review gives an outline of the vision for GEOGLOWS and summarizes some of its recent highlights.

Vision

GEOGLOWS contributes to water resources management by providing decision-makers with data and knowledge, allowing them to make more effective water management decisions and develop better strategies to address climate risks and supply shortages. GEOGLOWS supports the goals of the Group on Earth Observations (GEO) by connecting the demand for sound and timely environmental information to the supply of data and information about the global water system, exploring the science needed to achieve the initiative's goals, and advocating for open data policies and full access to information. GEOGLOWS supports diverse regional water projects and brings them into a global framework where they interact synergistically to improve water sustainability.

As part of GEO, GEOGLOWS contributes to the development of integrated global observation and information systems. It supports the information needs of policy priorities such as the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, the Paris Agreement on Climate Change, and the Aichi Targets of the Convention on Biodiversity.

Structure

At the launch of GEOGLOWS, the program structure shown in Figure 1 was adopted. Some areas of this matrix are well developed, but other aspects, such as Water Scarcity, Climate, Integrated Water Prediction, and Water Use, are in need of further development.

A governance structure was also agreed to at the first annual business meeting held in Tuscaloosa, Alabama. The structure includes a Steering Committee with members from nine countries. Two Steering Committee co-chairs and four working groups were established to serve as GEOGLOWS's main delivery mechanism.

GEO Global Water Sustainability (GEOGLOWS)		
1. Enhancing Global Water Sustainability	**2. Minimizing Basin and Regional Risk**	**3. Essential Water Variable (EWV) Understanding**
Sustainable Development Goals	Integrated Water Prediction	Water Quality
Water Scarcity and Access	Floods	Water Use
Climate	Droughts	Water Cycle Variables [Precipitation, Soil Moisture, Groundwater, Evapotranspiration, Stream Flow, Surface Water Storage (includes Snow Pack)]
Cold Regions	Transboundary Issues (Integrated Water Resources Management)	
	Water-Energy-Food-Environment-Health Nexus	
	Climate Adaptation	
4. Earth Observations, Integrated Data Products and Applications, and Tool Development		
5. Data Sharing, Dissemination of Data, Information, Products, and Knowledge		
6. User Engagement, Capacity Building, and Regional Global Earth Observation System of Systems (GEOSS) Programs		

Figure 1. The thematic structure of the GEOGLOWS Initiative (GEO, 2018).

The GEOGLOWS Working Groups include:

1. Socio-economic issues surrounding water management and crises, and policy linkages (Chair: Rose Alabaster). This group links GEOGLOWS with policy needs and advocates for policies that enable GEOGLOWS to deliver services and data.
2. The science, applications, and product development group (Co-Chairs: Dr. Ashutosh Limaye and Dr. Ed Beighley). It contributes to the development of a global framework for water assessments through user surveys, development of a new hydro fabric, and tools to extract and use global datasets locally.
3. The Essential Water Variables (EWV) and observations group (Co-Chairs: Dr. Jose Romero and Dr. George Huffman). This group leads the GEOGLOWS follow-up to the GEOSS Water Strategy Report in the area of EWVs. It addresses integrated data products, new observational systems, and strategies for data services, including data quality standards and long-term dataset continuity.
4. Data dissemination, portals, and capacity building (Chair: Dr. Jim Nelson). It guides GEOGLOWS strategies and develops services for user support; facilitates the migration of models, tools, and techniques from research to operations; and builds capacity and services in countries and organizations where they are most needed.

Each of the working groups has identified deliverables and projects for achieving their deliverables. The projects with active deliverables are incorporated into the latest version of the GEOGLOWS Work Plan, which can be viewed at *http://earthobservations.org/index2.php*.

At present, the GEOGLOWS Secretariat is staffed until December 2018 on an interim part-time basis.

Scientific Highlights

Streamflow Forecasting: GEOGLOWS has brought together a collaboration of scientists and professionals in the water and hydrologic information sector. By leveraging Earth observations, numerical weather prediction systems, and hydrologic modeling all run on supercomputers at the European Centre for Medium-Range Weather Forecasts (ECMWF) and delivered through cloud services, this partnership is providing daily streamflow forecasts that are relevant and useable for every river in the world. Through an effort led by Brigham Young University (BYU) and Esri, which grew out of the National Oceanic and Atmospheric Administration (NOAA)'s National Water Center in 2015, the ECWMF global runoff forecasts were mapped and routed through a high-resolution stream network in order to produce localized 15-day probabilistic forecasts every day. Partners in this project include BYU, ECMWF, The World Bank, the National Aeronautics and Space Administration (NASA) and United States Agency for International Development (USAID)'s joint project SERVIR, NOAA, and Microsoft Azure. The streamflow forecast is being implemented as a service to facilitate local applications. Forecasts are currently being produced for South Asia, Africa, South America, and North America.

Essential Water Variables: GEOGLOWS is developing a framework for the selection of audiences for the EWVs and a process for choosing and processing EWVs that address inland and coastal waters. Two policy priorities will guide this initial effort of selecting EWVs: the Sustainable Development Goals (SDGs) and the Sendai Framework. Also, the water assessment function that underpins water management and supports links with the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Intergovernmental Panel on Climate Change (IPCC), and the Paris Agreement will be considered.

The selection of a set of EWVs will be based on a multistep, user-driven approach, with the engagement of the communities involved in water assessments and water-related issues in priority policy areas. Communities already engaged in the process of developing EVs where water is an essential element [e.g., the GEO Biodiversity Observation Network (GEO BON) Essential Biodiversity Variables (EBVs), Global Climate Observing System (GCOS) Essential Climate Variables (ECVs), Global Ocean Observing System (GOOS) Essential Ocean Variables (EOVs)] will also be consulted. Synergies and collaborations with other organizations will be pursued to develop criteria, identify data gaps, and create implementation strategies. The Swiss government has shown its support for this effort by providing funding for a 2019 workshop on EWVs.

Contributing Research Projects: As a result of discussions at the NASA Water Applications Program Principal Investigators (PIs) meetings, a number of PIs volunteered to link their projects to GEOGLOWS. A similar opportunity for Centre National d'Études Spatiales (CNES) PIs led to a number of experts volunteering their engagement. These projects will contribute to the science and applications of GEOGLOWS themes and sub-themes, with a large number of NASA and CNES researchers investigating areas such as cold regions, integrated water resource management, water quality, and water cycle variables.

GEOGLOWS also connects data suppliers with users and bridges research and operations. NASA supports GEOGLOWS by providing access to data and the tools needed to achieve environmental sustainability, climate adaptation, and flood and drought risk management.

Reporting and Capacity Development

Reporting in GEOGLOWS is based on periodic written reports, presentations at science conferences, and participation in the annual GEOGLOWS meetings. In May 2017, the first GEOGLOWS business meeting was hosted by the National Water Center in Tuscaloosa, AL where a high-resolution version of the National Water Model is being implemented. The Tuscaloosa meeting consolidated the GEOGLOWS structure, its Terms of Reference, and its research directions. GEOGLOWS held its second annual business meeting at ECMWF in Reading, UK in May, 2018, which allowed more European experts to become active in the GEOGLOWS efforts.

International Linkages

GEOGLOWS provides support for capacity building through project links with the regional GEO structure in the Americas (AmeriGEOSS), Africa (AfriGEOSS), and Southeast Asia (AO GEOSS). GEOGLOWS is developing its linkages with the Committee on Earth Observing Satellites (CEOS) by assisting in planning a CEOS meeting on Freshwater from Space in November 2018.

Limitations

Many GEOGLOWS activities are done on a volunteer basis and experts sometimes have limited time to deliver on expectations. The EWVs pose a specific challenge because a wide range of experts are needed to address multiple issues for each EWV. Other challenges involve developing processes whereby the many tools available through NASA and other space agencies can be effectively transferred and applied in developing countries. Sustainable information platforms and simple interfaces with existing tools need to be developed and promoted.

How to Get Involved

Some of the expertise and activity of the GEWEX program could contribute to GEOGLOWS by providing a robust scientific basis for GEOGLOWS projects. To discuss opportunities for engaging in GEOGLOWS, please contact Dr. Angélica Gutiérrez-Magness (Co-chair, GEOGLOWS Steering Committee).

References

GEOGLOWS Community, 2018: GEO Global Water Sustainability (GEOGLOWS) Initiative and 2018-2019 Work Plan (as submitted to the GEO Secretariat in February 2018).

Meeting/Workshop Reports

Joint Workshop of the International Surface Working Group and Land Surface Analysis Satellite Application Facility

Lisbon, Portugal
26–28 June 2018

Benjamin Ruston[1], Gianpaolo Balsamo[2], and Isabel Franco Trigo[3]

[1]Naval Research Laboratory, Monterey, CA, USA; [2]European Centre for Medium-Range Weather Forecasts, Reading, UK; [3]Instituto Português do Mar e da Atmosfera, Lisbon, Portugal

On 26-28 June 2018 at the Instituto Português do Mar e da Atmosfera (IPMA) in Lisbon, Portugal, the Joint Workshop of the 2nd International Surface Working Group (ISWG) and 8th Land Surface Analysis Satellite Application Facility (LSA-SAF) meetings were convened. This workshop saw over 15 countries represented by a dynamic, diverse, and engaging group with lively discussions.

The aim of the International Surface Working Group (ISWG) is to gather requirements specific to surface observations to enhance both our understanding and ability to monitor the components of the Earth system, including land, vegetation, snow, ice, and coastal and open waters. The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) Land Surface Analysis Satellite Application Facility (LSA SAF) aims to increase the benefits accrued from satellite data, specifically for terrestrial processes, land-atmosphere interactions, and biospheric applications. One of the target applications of the LSA SAF product is to assess and improve the quality of land surface models.

The meeting sought to combine and coordinate between the Earth System Modeling (ESM) and data assimilation methodologies. The workshop opened with summaries from Numerical Weather Prediction (NWP) centers such as Météo-France, the European Centre for Medium-Range Weather Forecasts (ECMWF), the Korea Meteorological Administration, and Deutscher Wetterdienst covering the current state of ESMs and their corresponding assimilation systems. Presenters also introduced the land surface products distributed and maintained by the EUMETSAT LSA SAF. An excellent brief by Dr. Sujay Kumar [National Aeronautics and Space Administration (NASA) Hydrological Sciences Laboratory] highlighted some of the existing knowledge gaps that persist in this challenging arena, particularly in areas where remaining ESM systematic errors are not well-treated in current data assimilation methods and require further fundamental research before they can be fully addressed.

The following presentations reviewed the current state of Earth surface products and assimilation methodologies, where there is a growing focus on modifications of the number and density of soil and snow levels in ESMs. For example, Tomas Landelius of the Swedish Meteorological and Hydrological Institute (SMHI) reported 14 soil layers and 12 snow layers in their current scheme. At the first ISWG, a call was put out to examine the layering in ESM models to accurately fit the observations, particularly those from the L- and C-bands, such as data from the Soil Moisture and Ocean Salinity (SMOS), Soil Moisture Active Passive (SMAP, L-band), and Advanced Microwave

Participants of the Joint Workshop of the 2nd International Surface Working Group (ISWG) and 8th Land Surface Analysis Satellite Application Facility (LSA-SAF)

Scanning Radiometer-2 (AMSR-2, C-band) satellites. Yohei Sawada from the Japanese Meteorological Agency presented a nice parameter sensitivity study of ESM parameters to the L- and C- band measurements, which addressed another recommendation from the first ISWG. Both Drs. Sawada and Jean-Christophe Calvet (Météo-France) further showed that when trying to address root zone soil moisture, the full soil state can be defined using vegetation parameters in conjuction with surface soil moisture.

Surface temperature is still a critical parameter to aid in the development of accurate Earth System Models (ESMs). The EUSTACE project (*https://www.eustaceproject.eu/*), presented by Elizabeth Good of the Hadley Center of the UK Met Office, is an effort to establish a long-term record (since 1850) of surface air temperature. For the more recent era, Frank-Michel Goettsche (Karlsruhe Institute of Technology) and Benjamin Bechtel (University of Hamburg) demonstrated methods of data reduction that provide parameters to create diurnal land surface temperature, which ESMs can use to simulate realistic variability. Carlos Jiménez of Estellus in France presented efforts to create a well-calibrated multi-decade land surface temperature from microwave data to provide further consistent information for ESMs and many other applications.

The workshop plenary featured actions and recommendations for the community that would further promote the uptake of observational data and Earth System Modeling (ESM). A short European Space Agency (ESA) Climate Change Initiative (CCI) survey was circulated at the meeting, aiming to capture the community's needs regarding land surface temperature data. To participate in the survey, please contact Dr. Good at the Met Office (*elizabeth.good@metoffice.gov.uk*). Furthermore, a survey on L-band usage and plans from the SMOS-Centre d'Etudes Spatiales de la Biosphère (CESBIO) are also being completed. The suggestions are largely ones which would lead to a roadmap for reduction in the bias or systematic errors the ESMs often show with respect to observations. To further investigate these issues, a recommendation was set forth to catalog important events for model study intercomparison, clearly defining the ESM and radiative transfer used for assimilation. Another proposal is to continue parameter error-budget and sensitivity studies, and find the observations and other model parameters which correlate with the root zone soil moisture. Lastly, creation and maintenance of L- and C-band climatologies, along with those for Land Surface Temperature (LST), are critical to ensure the ESM is accurately depicting diurnal and seasonal behaviors.

The presentations and final plenary actions and recommendations will be available on the workshop web page at *http://cimss.ssec.wisc.edu/iswg/meetings/2018/*. Contributions in this and related areas of research are invited for a special issue of the journal Remote Sensing called "Advancing Earth Surface Representation via Enhanced Use of Earth Observations in Monitoring and Forecasting Applications." Finally, the tentative schedule for the next meeting, ISWG-3, is early July in 2019 in Montreal, Canada.

The 2nd GEWEX Convection-Permitting Climate Modeling (CPCM) Workshop

Boulder, Colorado, USA
4–6 September 2018

Andreas F. Prein[1], Roy Rasmussen[1], and Graeme Stephens[2]

[1]National Center for Atmospheric Research (NCAR), Boulder, CO, USA; [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

The 2nd GEWEX Convection-Permitting Climate Modeling (CPCM) Workshop was held from 4–6 September 2018 at the National Center for Atmospheric Research in Boulder, CO. It focused on scientific and technical challenges related to CPCM with a horizontal grid spacing of ≤4 km. These challenges include the model setup, observational datasets, evaluation techniques, computational resources, model inter-comparisons, and the use of convection-permitting simulations in impact research. The workshop's aim was to foster collaborations and synergies to work on this challenging topic as a community.

The international workshop hosted 79 participants from 14 countries who delivered seven keynote presentations, 30 oral talks, and 22 poster presentations. The topics spanned simulating precipitation in current and future climates, land-atmosphere coupling, snow- and cold-region processes, tropical processes, model sensitivities, ensemble simulations, and efforts on global convection-permitting modeling. In addition, two breakout sessions were organized that focused on challenges and opportunities in convection-permitting modeling and on future directions. The recordings of oral presentations and PDFs of the presented posters and slides are available on the workshop website: *https://ral.ucar.edu/events/2018/cpcm*.

Compared to the first GEWEX CPCM workshop in 2016, major advances were made in transitioning from dominantly mesoscale and regional-size model domains towards continental and global-size domains. Larger domains allow for investigating interactions between explicitly simulated mesoscale features such as deep convection and orographic forcing and larger scale processes such as synoptic weather patterns. Capturing these scale interactions has the potential to improve the simulation of downstream weather and climate features and to enhance the skill of subseasonal-to-seasonal prediction. Variable resolution models, such as the Model for Prediction Across Scales (MPAS) and the icosahedral nonhydrostatic (ICON) model, help us to understand these interactions with higher computational efficiency, but more work is needed to evaluate scale aware physics schemes to make these models more robust.

The realistic simulation of land-atmosphere interactions in CPCM is another rapidly growing research area and their importance was highlighted in several presentations. This often demands the inclusion of currently neglected processes in modeling systems, such as dynamic groundwater treatment.

Land-atmosphere interactions can be scale sensitive, which means that their sign and amplitude might be dependent on the model horizontal grid spacing.

Using CPCMs to simulate tropical processes such as tropical convection, monsoonal flows, and tropical cyclones was another area of active research. Significant improvements in simulating these processes were demonstrated when convection was explicitly simulated instead of parameterized. Several presentations identified a high-frequency bias of tropical cyclones in CPCMs. The origin of this bias is so far unknown, but might in part be related to the pre-described sea surface temperatures that do not allow dynamic interaction between the atmosphere and the ocean. Dynamic coupling of CPCMs with high-resolution ocean models was identified as a research priority during the meeting.

Remaining challenges for CPCMs are their high demand for computational resources, their large data output volume, and frequently missing high-resolution observational datasets. Strategies on how to address these challenges, including online model evaluation, advanced data compression, and more open sharing experiences and tools, were discussed.

Concerning the model evaluation, this community realized that reducing model uncertainty is important to gain a more solid understanding of atmospheric processes. Future work should focus on a more systematic, process-oriented model evaluation using high-resolution, high-quality observational data sets in various climate regimes. Observations from the US Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) program were mentioned as potentially providing suitable datasets that could facilitate such an evaluation.

All the above examples clearly indicate that the CPCM community has to reach out to other groups to enhance future advancements in Earth system modeling. There are already existing connections to the numerical weather prediction community, which should continue to be strengthened in the future along with common interests in subseasonal to seasonal weather predictions. Common activities such as the Coordinated Regional Climate Downscaling Experiment (CORDEX) Flagship Pilot Study on "Convective phenomena at high resolution over Europe and the Mediterranean" can help to enhance scientific advancements and can provide frequently missing uncertainty estimates of CPCM simulations.

CPCMs will play a central role in activities that address the GEWEX-led WCRP Grand Challenge on "Water for the Food Baskets of the World." The aim of this Grand Challenge is rendering a more realistic representation of human influences on the water cycle to assess how fresh water availability shifts in some of the major food producing regions of the world due to climate change. This is a unique opportunity for the CPCM community to collaborate and to engage with other groups such as agricultural modelers or hydrologists. Meetings that aim to engage these communities and to strategically plan activities are organized at international conferences such as the American Geophysical Union (AGU) Fall Meeting. Such meetings and future workshops on this topic will be announced through the CPCM e-mail list (*ral-cpcm@ucar.edu*).

The 3rd GEWEX CPCM workshop will be organized together with the 2019 Latsis Symposium on "High-Resolution Climate Modeling: Perspectives and Challenges." It will be held 21-23 August 2019 at ETH Zürich in Switzerland. More information can be found on the symposium website: *http://www.latsis2019.ethz.ch/*. Additionally, there are upcoming sessions that focus on convection-permitting climate modeling at the 2018 AGU Fall Meeting and the European Geosciences Union (EGU) General Assembly 2019. Similar sessions will be continued to be organized in following years.

Participants of the 2nd GEWEX Convection-Permitting Climate Modeling Workshop

15th Baseline Surface Radiation Network (BSRN) Scientific Review and Workshop

Boulder, Colorado, USA
16-20 July 2018

Chuck Long[1], Amelie Driemel[2], and Christian Lanconelli[3]

[1]NOAA ESRL GMD and CIRES, Boulder, CO, USA; [2]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany; [3]European Commission, Joint Research Centre, Ispra, Italy

Seventy-six scientists, station managers, and data users from 24 countries representing 49 different organizations gathered for the 15th BSRN Scientific Review and Workshop held at the Cooperative Institute for Research in the Environmental Sciences (CIRES) in Boulder, Colorado USA from 16–20 July 2018. The workshop was co-hosted by CIRES and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Global Monitoring Division (GMD), and led by Dr. Chuck Long, the BSRN Project Manager, who was ably assisted by a host of other CIRES and GMD personnel. During the meeting, BSRN observations were reviewed, improvements in instrumentation and data reduction methods discussed, data management and quality control issues considered, and ways the data are used by the larger community were examined. In addition, a total of nine new sites were proposed for consideration to join BSRN.

The GEWEX Data and Analysis Panel (GDAP), co-chaired by Rémy Roca and Tristan L'Ecuyer, oversees and gives general guidance to BSRN. The BSRN project consists of volunteers operating stations that measure surface solar and infrared (IR) radiation according to a set protocol, using the highest-quality radiometers. Many stations also make ancillary measurements, such as ultraviolet radiation (UV), photosynthetically active radiation (PAR), and meteorological parameters. A few stations began operating in 1992, and have accumulated over two decades of high-quality data. Up to July 2018, 64 stations have submitted data to the BSRN Archive since 1992, totaling over 10,800 data months.

Dr. Christine Wiedinmyer, the Associate Director for Science at CIRES, opened the meeting, giving a welcome address and a brief overview of CIRES. Then Dr. James Butler, Director of the NOAA ESRL GMD, greeted participants and discussed a brief history of NOAA's Global Monitoring Division, its three research themes and several research applications, and its enduring link to BSRN that began at the network's inception. The presentation underscored the power of partnerships in resolving scientific challenges, most notably in understanding the trends and distributions of surface radiation, clouds, and aerosols.

Chuck Long chaired the opening session and discussed meeting logistics in addition to giving the meeting charge. Items that were noted for discussion during the workshop included forming a committee to review the BSRN Manual, exploring the idea of an "expertise resource" group to share knowledge relevant to all aspects of BSRN, and potentially installing a Deputy Project Manager for succession planning. Finally, Dr. Long announced that he would be retiring and stepping down as BSRN Project Manager. Dr. Christian Lanconelli, currently with the European Commission Joint Research Centre, has been appointed as the new BSRN Project Manager. He previously served as the station scientist for the BSRN Dome-C site in Antarctica, and hosted the 13th BSRN Workshop in Bologna, Italy.

Tim Oakley welcomed the participants on behalf of the Global Climate Observing System (GCOS) Director Carolin Richter. He explained the vision of GCOS, how the program is involved across the whole observing cycle, and the key documents that govern its work. He explained in more detail the pertinent sections of the Implementation Plan and two actions, A11 and A12, which are of direct relevance to BSRN. A11 and A12 are described in the GCOS technical report (GCOS-200).

Tristan L'Ecuyer provided a status report for the GEWEX Data and Analysis Panel. GDAP continues to address its primary charge within WCRP of assessing how sensitive the Earth's climate is to changes in radiative and other forcings through coordinated global and regional observations of energy and water fluxes.

BSRN Archive Status

Dr. Amelie Driemel, Director of the BSRN Archive, reported that the World Radiation Monitoring Center (WRMC) of the Alfred Wegener Institute of Polar and Marine research (AWI) currently contains more than 10,800 monthly datasets from 64 stations (+2000 monthly datasets/5 stations since April 2016). A few stations have closed (Boulder, BOU; Xianghe, XIA; Solar Village, SOV) or face operational problems, and some stations are submitting data again. The archive receives around 140 new data access requests per year, particularly from the renewable energy sector. Current issues within the WRMC are the large number of retiring of station scientists, some of whom do not yet have a successor; the demand for a new BSRN Toolbox developer; and the need to convey to users how to correctly cite BSRN data (Driemel et al., 2018).

Proposed BSRN Stations

Nine new sites were proposed for consideration as BSRN stations.

1. Adriana Gonzalez Cabrera (National Autonomous University of Mexico, UNAM) proposed Selegua, a station belonging to the Mexican solarimetric network located in the southern Mexico near the Guatemalan border, representative of a tropical climate.

2. Ankie Piters (Royal Netherlands Meteorological Institute, KNMI) proposed Paramaribo in Suriname, operated by the Meteorological Service of Suriname (MDS) with KNMI, as a site representative of the tropical rainforest.

3. Luis Suarez Salas (Geophysical Institute of Peru) proposed the Observatory of Huancayo (3,313 m a.s.l.), Peru, representing the Andes mountain region. The observatory, part of the Laboratory of Atmospheric Microphysics and Radiation (LAMAR), includes a meteorological station,

precipitation radar, and a sun photometer that is part of the Aerosol Robotic Network (AERONET).

4. Aaesha Abdulla Alnuaimi presented a site situated within the Dubai Electricity and Water Authority (DEWA)'s Mohammed Bin Rashid Solar Park, a massive solar park under development that is projected to eventually generate 5000 megawatts by 2030.

5. Bryan Fabbri (National Aeronautics and Space Administration, NASA) proposed Granite Island in Lake Superior (Michigan, USA) as a water/ocean BSRN site. NASA Langley is interested in using BSRN and Clouds and the Earth's Radiant Energy System (CERES) measurements with the Great Lakes Evaporation Network (GLEN) evaporation measurements to improve understanding of the Earth's energy budget.

6. Béatrice Morel [Laboratory of Energy, Electronics and Process (LE2P) of the Université de La Réunion] proposed Reunion Island as a water/ocean site in the Southern Indian Ocean. The measurement site is collocated with routine upper-air soundings and basic meteorological instrumentation housing a large variety of atmospheric equipment, including Light Detection and Ranging (LIDAR) instruments, radiometers, and in situ gas and aerosol sensors.

7&8. Carlo Wang (Department of Atmospheric Science of the National Central University of Taiwan, with the Central Weather Bureau, CWB), presented the installation of two BSRN standard sites in Yushan (Mt. Jade, 3,858 m a.s.l.) and Lanyu (Orchid Island, 324 m a.s.l.), representative of mountain climate and the remote Western Pacific, respectively.

9. Dénes Fekete (Hungarian Meteorological Service) spoke about the solar and meteorological measurements at the Budapest-Lőrinc station in Hungary. Currently a wide set of meteorological and radiation instruments is deployed in field, including a Brewer spectrophotometer and spectral visible and near-infrared measurements.

Satellite and Model Studies

One of the key features of high quality data is their reliability to assess the accuracy of satellite products and model calculations.

Laurent Vuilleumier presented a validation study for direct and global ground shortwave (SW) radiation, as derived by the HelioMont (Stöckli, 2013) algorithm from the Meteosat Second Generation (MSG) satellite's Spinning Enhanced Visible and Infrared Imager (SEVIRI) measurements, for different climatic conditions using ground data as a reference over two contrasting European sites. Retrieval of direct normal irradiance (DNI) in clear sky conditions is affected mainly by aerosol uncertainties. In cloudy sky conditions DNI is overestimated, while global horizontal irradiation (GHI) is underestimated in the presence of thick clouds and underestimated for thin clouds. Paul Stackhouse pointed out the critical importance of BSRN in quantifying uncertainties and improving the NASA/GEWEX Surface Radiation Budget (SRB) Fluxes product (*http://gewex-srb.larc.nasa.gov*), and showed the need for BSRN to maintain high calibration standards for long periods of time in order to allow trend and stability analysis. Taiping Zhang, using surface data from BSRN and the Surface Radiation Budget Observing Network (SURFRAD) as a reference, pointed out that the systematic negative bias of clear-sky SW downward fluxes affecting the GEWEX SRB could be partly explained by the systematically lower moisture and aerosol loads as observed at BSRN sites. Then, David Rutan described the use of BSRN data in the validation of NASA's CERES products and the web-based tool for data intercomparison (*https://www-cave.larc.nasa.gov/*). Results show a remarkable agreement between computed and observed fluxes averaged over ocean or land sites. Zhuosen Wang reported the albedo product validation activities for the Moderate Resolution Imaging Spectroradiometer Visible Infrared Imaging Radiometer Suite (MODIS/VIIRS)/Landsat-8/MultiSpectral Instrument (MSI) over SURFRAD/BSRN Sites, and pointed out the importance of following the guidelines drawn up by the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Land Product Validation (LPV) subgroup. He also described a new unmanned aerial vehicle (UAV)-based instrument to catch spectral bidirectional reflectance and albedo (the Multi Angle Imaging Bidirectional Reflectance Distribution Function small Unmanned Aircraft System, MALIBU), developed at NASA's Goddard Space Flight Center. Measurements of albedo taken by MALIBU over the BSRN Table Mountain site in 2016 agreed well with BSRN data. Martin Wild showed that BSRN data have been instrumental in constraining the surface radiation budget shown in the Global Energy Balance diagram in the 5th Intergovernmental Panel on Climate Change Assessment Report (AR5) (Wild et al., 2015). It has been pointed out that significant decadal changes can be inferred from both downward longwave and shortwave BSRN records. Matthias Schwarz dealt with the representativeness of single point observation with satellite/model spatial resolution through a worldwide assessment of the representativeness of monthly surface solar radiation records, using decorrelation lengths (δ), spatial sampling biases (β), and spatial sampling errors (ε) as assessment parameters (Schwartz et al., 2017).

Observations and Analysis Studies

This session included BSRN-specific activities related to spreading knowledge and experience within the community in terms of technical solutions, analysis issues, and scientific phenomenology.

Jordi Badosa described how activities carried out at the massively equipped Palaiseau (PAL) station can contribute to improved knowledge for BSRN providers and users, including accuracy of independent radiometric components, aerosol and cloud effects on SW and LW, their predictability for energy production, and performing training activities. Fred Denn dealt with the accuracy of determination of Langley calibration constants (V0) in place for aerosol optical depth (AOD)

Participants at the 15th Baseline Surface Radiation Network Scientific Review and Workshop

assessment, indicating that an average window of 3 months and nearly 20 Langley plots could be appropriate to determine suitable V0s. Nozomu Ohkawara examined the difference between windowed pyrgeometers calibrated by the World Infrared Standard Group (WISG) and the windowless infrared integrated sphere radiometer (IRIS) at high total column water vapor, confirming an underestimation of the WISG of 4-5 Wm^{-2} with respect to the IRIS, as indicated by previous campaigns held at the Physikalisch-Metorologisches Observatorium Davos (PMOD) World Radiation Centre (WRC). Ibrahim Reda confirmed these outcomes by comparing WISG with a set of IRIS and Absolute Cavity Pyrgeometers (ACP) with a certain dependence on integrated water vapor (IWV). Carlo Wang, using data obtained during an extensive pyranometer intercomparison of 12 different models and six manufacturers, showed how well modern instruments performed to compensate for the thermal offset. His results demonstrate that the pyranometer offsets depend on the model/serial number, the ventilation status, and the use of the thermal offset correction method. For some samples, the best performance was obtained by avoiding any correction or ventilation support. Chris Cox continued by describing activities related to improving BSRN site performance in cold climate environments, highlighting the results obtained during the De-Icing Comparison Experiment (D-ICE). Finally, John Augustine presented an assessment of surface radiation trends over the US as determined from seven SURFRAD/BSRN sites over the last 20 years, paying particular attention to describing the SW brightening features.

Working Group Reports

The workshop hosted dedicated Working Group breakouts, and summaries of each are found below.

Infrared Working Group Report (Julian Gröbner). Further comparisons between windowless radiometers such as IRIS, ACP, and the Atmospheric Radiation Measurement (ARM) Program's atmospheric emitted radiance interferometer (AERI) and common network pyrgeometers were conducted in 2017. Results from three different campaigns are consistent with previous studies, which show a good agreement between the windowless radiometers within the uncertainties of the instruments and an underestimation of about 5 Wm^{-2} of the WISG. Based on these results, the Task Team on Radiation References is setting timelines for a modification of the current WISG.

Cold Climate Issues Working Group (CCIWG) Report (Chris Cox). During the 2016 meeting, CCIWG identified three objectives to complete for the Year of Polar Prediction (YOPP) (2017-2019). The first involved updating the archive status of polar BSRN stations, and is only partially completed. Since YOPP is still ongoing, this objective was kept as a priority. The second was the development of a mobile radiometer intercomparison station, which is in progress and of significant interest for CCIWG participants, though funding for the project has yet to be identified. The third goal was to evaluate the state of ice mitigation technology for broadband radiation stations, which was successfully completed through the De-Icing Comparison Experiment (D-ICE) conducted from August 2017–June 2018.

Spectral Working Group Report (Kathy Lantz). This group is tasked with three topic areas: UV broadband radiometry, aerosol optical depth, and photosynthetically active radiation. The Second UV Filter Radiometer Campaign (UVC-II) was held at PMOD WRC from May 25–Oct 3, 2017 with an impressive 75 instruments participating from 37 countries. The results of this effort were summarized by the World Meteorological Organization Global Atmosphere Watch (WMO GAW) 240 report. The Fourth Filter Radiometer Campaign was held at the PMOD WRC in 2015 (Kazadzis et al., 2016). Discussions of the group confirmed the need for a campaign in a location with higher AOD and with longer duration to assess on-site Langley calibration performances.

Proposed Use of BSRN in Solar Renewable Energy Working Group (Enio Pereira). There is a growing demand for quality data to support the development of the solar energy market all over the world. Several opportunities and barriers were discussed during the meeting, varying from questions about uncertainties in the models for surveying solar energy resources, the bankability of solar energy projects, the intermittence and variability of the solar resource, and the short and long term stability of solar energy.

BSRN Manual Review Committee (Gary Hodges). A lunch meeting was held to discuss the formation and scope of a BSRN Manual Review Committee. Gary Hodges has volunteered to lead the effort, along with assistance from Tom Stoffel, and will pursue other volunteers from the BSRN membership to assist. Along with reviewing the manual itself, several

other areas of concern were mentioned for the committee to examine. An example is producing a clear checklist of items that new site proposal presentations should include.

A specific meeting for the Broadband Radiometry Working Group lead by Allison McComiskey was not held formally this year, but relevant topics were discussed in other breakouts and in the plenary sessions at the workshop.

Workshop Wrap-Up

The final session of the Workshop was comprised of BSRN business and discussions. The first item of business was a discussion of the proposed candidate sites. All proposed sites except the Dubai location will be marked as candidate sites on the BSRN Sites map (*http://bsrn.awi.de/stations/maps.html*), and will be designated as full-fledged BSRN sites upon successful acceptance of quality-assessed data files into the BSRN Archive. The Dubai station was temporarily excluded because of its location within a huge photovoltaic power plant, which influences the thermodynamic status of the lower part of the atmosphere, impacting LW downwelling and SW diffuse components. The second matter was discussing the installment of a deputy BSRN Project Manager, as workloads related to management activities have grown and the cost of travel to workshops could be lowered with two potential attendees. The last item addressed was extending the idea of an "expertise resource" group to include a listing of used and currently unwanted BSRN related equipment. This would help BSRN members with issues such as repairs or even upgrading their sites to include upwelling irradiance measurements. While no specific action was taken, it is hoped this discussion might serve as a seed for future conversation and action.

References

Driemel, A., J. Augustine, K. Behrens, et al., 2018. Baseline Surface Radiation Network (BSRN): Structure and data description (1992–2017). *Earth Syst. Sci. Data, 10*, 1491-1501, doi:10.5194/essd-10-1491-2018.

GCOS-200: The Global Observing System for Climate: Implementation Needs. Tech. rep., *World Meteorological Organization*, 2016.

Kazadzis, S., N. Kouremeti, and J. Gröbner, 2016. Fourth WMO Filter Radiometer Comparison (FRC-IV). *GAW Report No. 231*, 65 pp.

Stöckli, R., 2013. The HelioMont Surface Solar Radiation Processing. *Scientific Report MeteoSwiss No. 93*.

Schwarz, M., D. Folini, M.Z. Hakuba, and M. Wild, 2017. Spatial representativeness of surface-measured variations of downward solar radiation. *J. Geophys. Res-Atmos.*, p. 2017JD027261. doi:10.1002/2017JD027261.

Wild, M., D. Folini, M.Z. Hakuba, et al., 2015. The energy balance over land and oceans: an assessment based on direct observations and CMIP5 climate models. *Clim. Dynam.*, 44 (11-12), 3393-3429.

1st ANDEX Workshop

Santiago, Chile
22–24 October 2018

René Garreaud[1] and Germán Poveda[2], ANDEX Co-Chairs

[1]Geophysics Department, Universidad de Chile and Center for Climate and Resilience Research (CR2), Santiago, Chile; [2]Department of Geosciences and Environment, Universidad Nacional de Colombia, Medellín, Colombia

ANDEX, a scientific research program focused on the hydroclimatology of the Andes and a prospective GEWEX Hydroclimatology Panel (GHP) Regional Hydroclimate Project (RHP), held its first workshop in Santiago, Chile, from 22-24 October 2018. ANDEX is aimed at understanding, modeling, and predicting the dynamics of the water and energy cycles over the Andes cordillera, which runs from 10°N to 53°S and cross Colombia, Venezuela, Ecuador, Peru, Bolivia, Chile, and Argentina. More than 60 million inhabitants rely directly on the water resources provided by the Andes, but they are also exposed to a suite of natural hazards imposed by such impressive geography and climate, ranging from very humid conditions near the equator and western Patagonia to the hyper arid conditions in the subtropics. The Andes also face enormous challenges from human encroachment, urbanization, climate variability, climate change, land use changes, and massive deforestation.

The Santiago workshop was hosted by Prof. R. Garreaud and his team from the Geophysics Department of the Universidad de Chile, and received financial support from the World Meteorological Organization (WMO) through the GEWEX program, the Universidad de Chile, and the Center for Climate and Resilience Research (CR2). The meeting took place 10 months after the foundational ANDEX meeting held in Medellín, Colombia, from 4-6 December 2017, where a group of ten scientists summarized the current understanding of the Andean hydroclimate, identified key outstanding questions, and agreed upon the preparation of a White Book. The first ANDEX workshop in Santiago was attended by 27 scientists (the agenda is located at *https://www.gewexevents.org/events/2018-andex-ghp-inarch-meeting/agenda/andex/*), most of them from South American countries. The workshop benefited from the participation of colleagues who shortly after attended the 2018 GHP Meeting in Santiago and the 4th International Network for Alpine Catchment Hydrology (INARCH) Workshop in Portillo. To capitalize on the shared interests of the three groups, a joint ANDEX-GHP-INARCH meeting was held during the morning of October 24 (the agenda is available at *https://www.gewexevents.org/events/2018-andex-ghp-inarch-meeting/agenda/joint-andex-ghp-inarch-meeting/*).

Since RHPs represent the pursuits and collaborative activities of a science community and need to be driven by the interests and efforts of a core group through institutional resources, the ANDEX workshop in Santiago gauged the level of interest in such a GEWEX RHP and assessed whether the level of scientific activity currently underway or planned would be

sufficient to make it a candidate for an RHP. Specifically, the Santiago meeting aimed to:

- Review the status of the ANDEX White Book
- Identify overarching themes and major scientific questions
- Provide a first approach to an implementation plan

Meeting Outcomes

The first day of the meeting was devoted to reviewing the status of the ANDEX White Book, a document envisioned at the Medellin foundational meeting that now involves the contributions of 30 scientists. The objectives of the White Book are to summarize the scientific knowledge and recent advances in Andean hydroclimatology and to identify major gaps in our understanding. The White Book contains the following eight topical chapters:

1. Geographical Context
2. The Hydroclimate of the Andes
3. Climate and Environmental Change
4. High Impact Events
5. Cryosphere of the Andes
6. Observations and Data
7. Science Underpinning Sustainable Development
8. Actions and Challenges

The lead authors presented the status of their respective chapters, showing substantial progress of about 75% completion with some differences among chapters. The group intends to send out the first drafts of the White Book chapters for review in June 2019. During the rest of the first day and into the next morning, diverse colleagues from the region (Jhan Carlo Espinoza, Francina Dominguez, Paola A. Arias, and Jorge Molina), as well as colleagues working outside the region who are involved in Andes-related research, gave presentations on their efforts: Joan Cuxart and Jason Evans of GHP; Thomas Condom from the Glacier and Water Resources in the Tropical Andes: Indicators of Changes in the Environment (GREAT ICE) project in France; Kate Halladay, reporting on convection permitting modeling from the UK Met Office; and Ana P. Barros from Duke University, USA, working on climate-vegetation linkages.

Most of the second day of the meeting was devoted to identifying critical gaps in Andean-related hydroclimate research and pinpointing how these gaps hinder the advance of operational activities in the region (e.g., weather and flood forecasts, climate prediction, etc.). To facilitate this task, participants were split into two groups whose main results were summarized in a plenary session at the end of the second day. An action list emerged from this activity, as summarized below:

- It is imperative to create an updated and comprehensive list of scientists involved in Andean-related research (ANDEX-list). Likewise, we should create an ANDEX website and start uploading content and news to promote community involvement.
- There is a general sense that critical observations in the Andean highlands are lacking. While this is undoubtedly so (e.g., just 10 radiosonde stations near or at the Andes), many research projects have installed new observing systems, as well public and private measurement networks. Therefore, there is an urgent need to create an inventory of hydroclimate observational platforms along the Andes. To this end, a survey on projects and resources will be sent to the ANDEX-list within the next few weeks. Once completed, the survey result will be conveniently displayed in a dynamic map on the ANDEX website.
- The observational survey will ask the responsible researcher about the possibility of sharing station data. If possible, the data will be made available on the ANDEX website. CR2 has enough expertise and technical resources to lead this task. Likewise, freely available information (e.g., weather reports and climate data) will be ingested in the already-available CR2 Climate Explorer.
- The need to develop an ANDEX atmospheric reanalysis was suggested by both groups as another science-enabling product. A high-resolution, fully consistent, long-term atmospheric dataset will benefit the broader community, permitting the description of regional-scale circulations and the forcing of hydrological and vegetation models. Likewise, we also propose a characterization of Andean basins along the whole cordillera, including geomorphological features, soil and land-use characteristics, and human-dimension indices.
- Completion of the ANDEX White Book is a top priority. The first draft is expected in May 2019, which may coincide with a small meeting of the core ANDEX scientists in Quito, Ecuador. After that, it should be sent out to the larger community in June 2019 for feedback, with a final version ready by the end of 2019. In addition to summarizing what is currently known about the Andes hydroclimate, the White Book also needs to make explicit the gaps in our knowledge. This will be the starting point for an ANDEX implementation plan.

In addition to generating these action items, the subgroups contributed to and complemented the overarching ANDEX questions, which were presented by Prof. G. Poveda at the joint ANDEX-GHP-INARCH meeting on Wednesday morning. These questions are:

1. What are the dynamical feedbacks between the Andes and the processes involved in the hydrologic cycle over the Andes (water vapor, precipitation, evapotranspiration, sublimation, soil moisture, infiltration, groundwater, and river flows) at a wide range of spatial and temporal scales, for average and extreme conditions? Among those processes the following were highlighted: water vapor sources and pathways, precipitation recycling, low-level jets and atmospheric and aerial rivers, the Bolivian High anticyclone, the Madden-Julian Oscillation (MJO), tropical easterly waves, and El Niño Southern Oscillation (ENSO). Among the most important extreme events the following

Participants of the 1st ANDEX Workshop

were identified: intense storms, mesoscale convective systems, floods, droughts, cold spells, hail storms, lightning, fires, Zonda winds, and landslides.

2. What are the physical dynamics of processes involved in the surface energy budget over the Andes across a wide range of spatial and temporal scales?
3. How does the dynamical coupling between 1 and 2 operate across the Andean altitudinal, latitudinal, and longitudinal gradients and from glaciers to deserts?
4. What is the influence of the cryosphere on the surface hydrologic cycle of the Andes, and what is the influence of the atmospheric hydrologic cycle on the Andean cryosphere?
5. What are the current and future human impacts from water diversion and pollution, deforestation, land use and land cover, and climate change on processes and variables involved in water and energy budgets over the Andes?
6. How should these impacts be dealt with from a water (and other life support systems) management perspective?
7. How will the current and future water and energy budgets along the Andes affect ecosystem services, water supply, hydropower generation, food production and food security, natural hazards, and human health?
8. What is the effect of the Andes on pollution in urban valleys and what are the risks for human health?

Summarizing, we are positive that the first ANDEX workshop fulfilled the expectations of the Andean scientific community, as well as the GHP and INARCH communities, in terms of gathering a larger group of highly interested scientists willing to move this initiative forward. On this basis, our timeline for the next few years includes:

- Presentation of ANDEX activities during the 31st Session of the GEWEX Scientific Steering Group (SSG-31), to be held in Geneva, Switzerland: 25 February to 1 March 2019
- Creation of a Logo: March 2019
- Completion of the list of scientists and institutions working on the ANDEX overarching questions and main themes: March 2019
- Creation of a web presence: beginning in April 2019
- Completion of the ANDEX White Book first draft: May 2019 (Quito Meeting)
- Definition of ANDEX governance structure: May 2019 (Quito Meeting)
- ANDEX session at the AGU Fall Meeting: December 2019
- Definition of Scientific Program (Observations and Modeling): March 2020
- ANDEX Open Science Conference: April 2020
- ANDEX Implementation Plan: June 2020

We feel that ANDEX is moving forward and envision it becoming a recognized GEWEX Regional Hydroclimate Project within the next 3 years, a period during which we must translate the ANDEX overarching questions into a concrete implementation plan of a long-due and much-needed research program focused on the world's longest mountain range.

2018 GHP Meeting within the ANDEX-GHP-INARCH Workshop

Santiago, Chile
24–26 October 2018

Jason P. Evans[1] and Joan Cuxart[2], GHP Co-Chairs

[1]Climate Change Research Centre, University of New South Wales, Sydney, Australia; [2]University of the Balearic Islands, Palma, Majorca, Spain

The 2018 GEWEX Hydroclimatology Panel (GHP) Meeting, held from 24-26 October in Santiago, Chile, was organized by René Garreaud with the local support of the Center for Climate and Resilience Research and the Faculty of Physical and Mathematical Sciences at the Universidad de Chile. GHP panel members and action representatives discussed the current status of the three GHP components: Regional Hydroclimate Projects (RHPs), Crosscut actions (CCs), and Data Centers (DCs). Scientists from across South America also gathered to discuss future directions of regional research that could be unified under ANDEX, a new hydroclimate research program for the Andes led by Germán Poveda and René Garreaud. INARCH presented its recent activities in alpine research catchments, clearly showing synergies with work being proposed in ANDEX. The workshop was an excellent opportunity to tighten the links between GHP, INARCH, and ANDEX.

During the meeting, the status of some ongoing activities was reviewed. Two current RHPs, the Hydrological cycle in the Mediterranean Experiment (HyMeX) and Baltic Earth, respectively studying the Mediterranean Basin and the Baltic Sea region, are progressing steadily and generating new actions for the coming years. The Changing Cold Regions Network (CCRN) has completed its run as a successful RHP, providing a solid basis for the new Global Water Futures (GWF) initiative. GWF expands the scope of CCRN to cover seven major river basins in Canada and the USA, and has been granted RHP status. PannEx, the Initiating RHP centered in the Pannonian Basin in Europe, continues to develop in the preliminary phase after finalizing its white book and science and implementation plans. Two other Initiating RHPs, the Australian Energy and Water Exchanges program (OzEWEX) in Australia and the Hydrology of Lake Victoria Basin project (HyVic) in Eastern Africa, have stalled in their progress towards full RHP status. Those involved in the projects are commended on their efforts to date, and it is hoped that they can continue in some fashion into the future. The running Crosscut projects–the International Network for Alpine Catchment Hydrology (INARCH) on mountain hydrology, the Intelligent use of climate models for adaptation to non-Stationary hydrological Extremes (INTENSE) on sub-daily precipitation, and Precipitation Near 0ºC in a changing climate–report very significant advances. The current actions in global Data Centers are described for the Global Runoff Data Centre (GRDC) on river discharge data and the Global Precipitation Climatology Centre (GPCC) on precipitation data.

New initiatives are also being proposed. The Third Pole Environment (TPE), a research program focused on water, ice, air, ecology, and human processes and their interactions in the Third Pole region, may organize a joint action with GEWEX on ***Water Security in the Third Pole***. This proposal may see this TPE initiative become an RHP in due course. A study of the hydroclimate of the Andean region, ***ANDEX***, may take the form of an RHP in the near future. Another initiative being led from Japan is focused on the hydroclimate of monsoon regions of south and southeast Asia. The WCRP "Water for the Food Baskets of the World" Grand Challenge includes a focus over the great plains of the USA with a proposed regional climate experiment at convection permitting resolution to examine the role of agriculture in the region's climate. This effort may also form part of a prospective RHP over the ***Western USA*** which continues to be discussed. The intention for this initiative is to develop into a RHP in the next year. A Crosscut on ***Water Management in Models*** will explore how to deal with anthropic action in numerical models and is being pursued jointly with GLASS, the GEWEX Panel on the Global Land/Atmosphere System Study. Another on ***Determining Evapotranspiration*** is in the early discussion stages with a workshop likely to be held in a year's time. Other actions are being explored, but are not yet to the point of being proposed formally to the Panel.

While existing RHPs produce consistent science advances, and a number of "prospective" RHPs continue to progress toward formal RHP status, it is recognized that not all initiatives will reach full RHP status despite being successful in collaboration and capacity building activities relevant to GEWEX. It is also recognized that upon completion, RHPs often have a great network of scientists that may continue collaboration and capacity building activities, such as workshops and summer schools. In order to keep these scientific communities engaged with GEWEX, a new GHP activity, GHP Networks, is being proposed. These Networks are required to maintain collaboration and capacity building activities relevant to GEWEX science, and are offered the opportunity to be directly involved in Crosscut projects and other GEWEX initiatives.

The conclusions of the meeting will be presented for approval to the GEWEX Scientific Steering Group at its 31st meeting in early 2019.

Participants of the 2018 GEWEX Hydroclimatology Panel Meeting

Recent INARCH Activities and the 4th INARCH Workshop

Santiago and Portillo, Chile 24–26 October 2018

John W. Pomeroy[1], James McPhee[2], and Chris DeBeer[1]

[1]Centre for Hydrology and Global Institute for Water Security, University of Saskatchewan, Saskatoon, Canada; [2]Department of Civil Engineering, Faculty of Physical and Mathematical Sciences, Universidad de Chile, Santiago, Chile

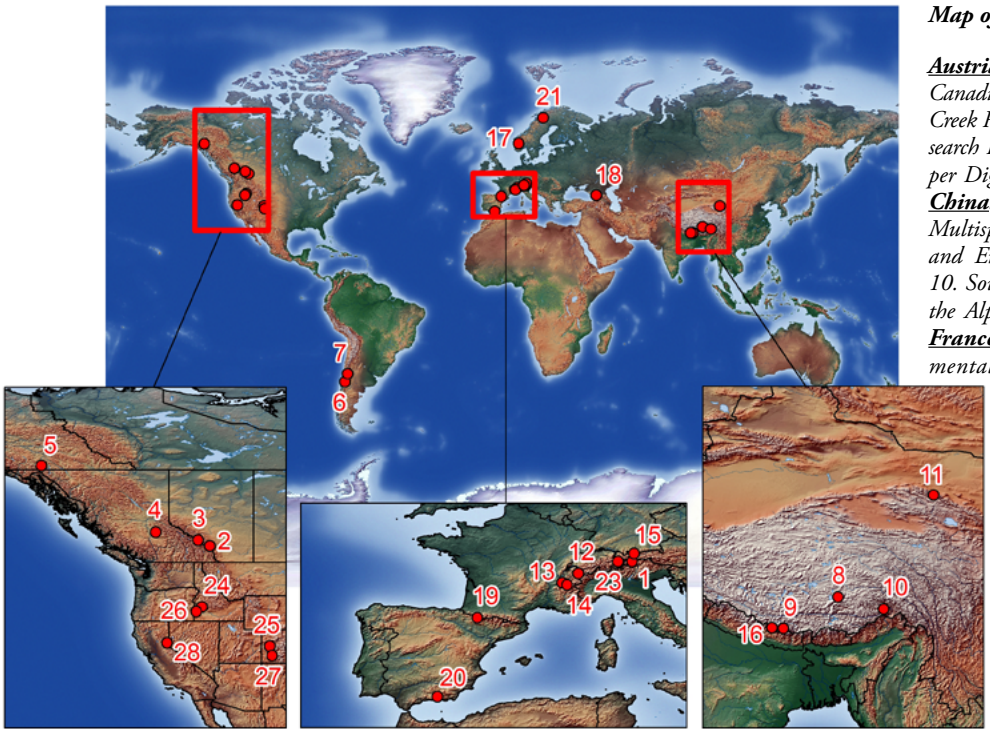
INARCH and Its Recent Activities

The International Network for Alpine Research Catchment Hydrology (INARCH) is a crosscutting project of the GEWEX Hydroclimatology Panel (GHP) with the objectives to better understand alpine cold regions hydrological processes, improve their prediction, diagnose their sensitivities to global change, and find consistent measurement strategies. INARCH is formulated around addressing five core questions: (1) How do varying mountain measurement standards affect scientific findings around the world? (2) What control does changing atmospheric dynamics have on the predictability, uncertainty, and sensitivity of alpine catchment energy and water exchanges? (3) What improvements to alpine energy and water exchange predictability are possible through improved physics, downscaling, data collection, and assimilation in models? (4) Do existing mountain model routines have global validity? and (5) How do transient changes in perennial snowpacks, glaciers, ground frost, soil stability, and vegetation impact alpine water and energy models?

In just three years, INARCH has made exceptional progress towards addressing these questions and achieving its goals. This year, the team has grown with the inclusion of new members and research sites in Norway, Russia, Spain, and the USA. Moving forward, INARCH will be developing synthesis papers and other products as outputs of the network and contributing to initiatives beyond GEWEX, such as Future Earth, the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC), the United Nations Educational, Scientific, and Cultural Organization (UNESCO)'s International Hydrological Programme (IHP), and the United Nations at large through its International Water Action Decade: Water for Sustainable Development, 2018–2028.

Over the past year, there have been several notable areas of activity and progress. John Pomeroy (Canada) and Danny Marks (USA) served as guest editors for an INARCH special issue of Earth System Science Data (ESSD, *https://www.earth-syst-sci-data.net*), covering Hydrometeorological data from mountain and alpine research catchments. The aims of the issue and links to published and in-discussion papers can be found at *https://www.earth-syst-sci-data.net/special_issue871.html*. The issue closed on 30 September 2018, and 19 papers were contributed from around the world, with several more coming into the discussion phase; however, new papers that contribute to this special issue are still welcome by ESSD and will be handled by the special editors if the contributing authors request it.

INARCH convened a special session on Observing and modeling the mountain water cycle using alpine research catchments at the GEWEX Open Science Conference held in Canmore, Alberta, Canada, on 7–10 May, 2018. It addressed topics on:



Map of Current INARCH Mountain Research Basins

***Austria**: 1. Open Air Laboratory (OpAL); **Canada**: Canadian Rockies Hydrological Observatory - 2. Marmot Creek Research Basin; 3. Peyto Glacier; 4. Quesnel River Research Basin; 5. Wolf Creek Research Basin; **Chile**: 6. Upper Diguillín River Basin; 7. Upper Maipo River Basin; **China**: 8. Nam Co Monitoring and Research Station for Multisphere Interactions; 9. Qomolangma Atmospheric and Environmental Observation and Research Station; 10. Southeast Tibet Observation and Research Station for the Alpine Environment; 11. Upper Heihe River Basin; **France**: 12. Arve Catchement; 13. Col de Porte Experimental Site; 14. Col du Lac Blanc Experimental Site; **Germany**: 15. Zugspitze Basin and Schneefernerhaus Research Station; **Nepal**: 16. Langtang Catchment; **Norway**: 17. Finse Alpine Research Centre; **Russia**: 18. Djankuat Research Basin; **Spain**: 19. Izas Research Basin; 20. Guadalfeo Monitoring Network; **Sweden**: 21. Tarfala Research Catchment; **Switzerland**: 22. Dischma Research Catchment; 23. Weissfluhjoch Snow Study Site; **USA**: 24. Dry Creek Experimental Watershed; 25. Grand Mesa Study Site; 26. Reynolds Creek Experimental Watershed; 27. Senator Beck Basin Study Area; 28. Sagehen Creek, Sierra Nevada*

a) convection permitting modeling and high resolution satellite data, b) use of big data techniques and large computers and models, c) hybrid downscaling techniques [e.g., such as the Intermediate Complexity Atmospheric Research (ICAR) model], d) other observational datasets, and e) recent completed field efforts [such as the WMO Solid Precipitation Intercomparison Experiment (SPICE) project on measurement of snow]. The session included eight oral presentations and 11 poster presentations. Dr. John Pomeroy and Dr. Chris DeBeer (Canada) were local organizers for the GEWEX Conference, and Dr. Pomeroy and Bob Sandford also led a tour group to the hydrological apex of the Rocky Mountains: the Columbia Icefield in Banff National Park. Full details on the conference are found at *http://www.gewexevents.org/events/2018conference/*.

The second GEWEX Convection-Permitting Climate Modeling Workshop was held at the National Center for Atmospheric Research (NCAR) Mesa Lab in Boulder, Colorado, USA on 4–6 September, 2018. The meeting was hosted by Roy Rasmussen (USA) and focused on scientific and technical challenges related to convection-permitting climate modeling (horizontal grid spacing ≤4 km). These challenges include model setup, observational datasets, evaluation techniques, computational resources, model intercomparisons, and the use of convection-permitting simulations in impact research. The 3-day workshop's aim was to foster collaborations and synergies to work on this challenging topic as a community, one that includes INARCH. There were oral and poster sessions, several invited talks on key topics, and multiple opportunities for discussions and networking. More information, including an agenda and presentations, can be found at *https://ral.ucar.edu/events/2018/cpcm*.

INARCH 4th Annual Workshop

Most recently, the 4th INARCH Workshop was held by the Faculty of Physical and Mathematical Sciences at the Universidad de Chile and the Hotel Portillo, Chile, high in the Andes Mountains. Twenty four scientists from Chile, Argentina, the USA, Canada, Spain, and France participated in the workshop. Local organizers included James McPhee, Thomas Shaw, and Yohann Videla (Universidad de Chile, Santiago, Chile), while John Pomeroy and Chris DeBeer (University of Saskatchewan, Saskatoon, Canada) also helped plan the workshop.

The meeting focused on reviewing activities, progress, and plans towards INARCH's overall objectives and research questions relating to alpine hydrology. A number of topics were reviewed and discussed, including field observations, catchment data, and emerging methods; snow and glacier hydrology, and climate change; model simulation and data assimilation, big data, and remote sensing; and linkages with various organizations, such as Future Earth's Sustainable Water Futures Programme, the World Meteorological Organization, IHP, the Canadian-led Global Water Futures (GWF) Project, the US-proposed western USA regional hydroclimate project (RHP), and the recently-initiated ANDEX, an RHP for the Andes. An important outcome of the workshop was the development of plans for several key publications based around the INARCH research questions, which will contribute towards the IPCC and its sixth assessment report. The workshop agenda and copies of presentations are available on the INARCH website at *http://www.usask.ca/inarch/index.php*.

Workshop Discussions and Statements

Early discussions focused on field observational practices and the potential for standardization of approaches. Participants agreed that it is not practical or possible to standardize snow measurements around the world, due to inherent variation in snow processes and snowpack characteristics in different environments. However, reporting of uncertainties should be standardized, and stratified landscape sampling techniques should be employed, whereby the landscape is disaggregated into representative types or relatively homogeneous landscape units. This helps to reduce the variance in snow depth and snow water equivalent (SWE) within a landscape unit, improves the confidence of the fit of the SWE distribution, and reduces the necessary field sampling. Best practices for temporal frequency are monthly surveys during the winter accumulation season, and weekly surveys during the spring melt season.

Another key point that emerged in discussions following presentations on snow, glaciers, and climate change was that there is some concern as to how we move towards modeling approaches based on big data, artificial intelligence, and neural networks. We must continue to develop and apply physics-based modeling approaches to capture process interactions and non-linear or unexpected changes in system behavior and response. Further, there is an advantage to predictive modeling in cold regions, as the spatial variability of precipitation inputs (SWE) are better characterized or known than for rainfall, and the timing of snowmelt can be calculated from physically-based relationships from standard meteorological variables and predicted well in advance, whereas rainfall rate prediction is relatively uncertain.

The following statements were developed at the workshop:

- INARCH has identified the importance of the changing high mountain water cycle to global initiatives such as GEWEX, ANDEX, GWF, and the Third Pole Environment (TPE) program and is contributing to a WMO High Mountain Summit and initiative. INARCH supports the idea of an International Year of Snow and Ice and also a year devoted to Mountain Prediction.
- INARCH has published invaluable mountain catchment hydrometeorological datasets from around the world through a special issue of Earth System Science Data with 19 articles. It has expanded to 28 catchments with contributions from 45 scientists based around the world.
- INARCH has identified dramatic snowpack decline and glacial retreat in the Andes and Patagonia as issues of global concern with some of the highest rates of glacial ablation in the world, due to both sublimation and melt. Global warming has influenced mountain mega-droughts in South America, causing hydrological shortages downstream. Complications in glacial modeling due to high

sublimation rates, debris cover, and the occurrence of penitent surfaces require physically-based energy balance techniques for glacier hydrology in the Andes. Mining impacts on some of these glaciers are further accelerating ablation through direct disturbance and dust. An increasing number of glaciers are now debris-covered and so techniques to calculate icemelt under debris are needed in hydrological models. International and national mountain hydrology research programs should prioritize research in the Andes to address these problems.

- The advent of large-area, high resolution atmospheric models at 4 km or less now permits more confident meteorological drivers for advanced snow and glacier hydrology models in complex mountain terrain. The performance of these high resolution atmospheric models needs to be assessed at point and areal scales and spatial datasets for such assessments and for bias-correction should be assembled. Global application of these products to mountains is necessary. High resolution snow and ice hydrology models, including hillslope hydrology processes, require development to take advantage of the more accurate alpine precipitation products that will result.

Participants at the 4th INARCH Meeting

- There is tremendous potential to assimilate high resolution remote sensing products such as snow depth from airborne Light Detection and Ranging (LiDAR) instrumentation, albedo, grain size, and impurities from hyperspectral sensors and visible snowcovered area from multiple platforms into advanced snow hydrology prediction models, and some examples of this are occurring. Efforts are needed to demonstrate how more mountain ranges around the world can be measured by these products and how the outputs can be used together to improve snow prediction models.
- INARCH has quantified the sensitivity of mountain snow hydrology regimes around the world using cold regions hydrological models of virtual alpine basins, driven by reanalysis data, and has shown that decoupling of the snow and hydrological regime with warming is most severe for temperate winter climates with winter precipitation maxima as typified by Mediterranean alpine environments. The results show the controls of both temperature and vapor pressure in determining the sensitivity of mountain snow hydrology to warming. This approach should be extended to examine the sensitivity of mountain glacier hydrology to global warming.
- INARCH continues to examine the performance of alpine snow models in simple alpine environments by comparison of model outputs to diagnostic measurements in INARCH catchments. The next step should be to examine model performance in extreme alpine environments that are more typical of alpine landscapes.

Future Directions

The next major activity for INARCH is to co-organize and contribute to the WMO High Mountain Summit in Geneva, October 2019. Professor Pomeroy is co-chair of the Summit. The Summit is being co-organized with the World Bank Group (WBG)–Global Facility for Disaster Reduction and Recovery (GFDRR), the Food and Agriculture Organization (FAO) of the United Nations, the Mountain Partnership Secretariat, IHP, the Mountain Research Initiative (MRI), the International Association of Cryosphere Sciences (IACS), the International Association of Hydrological Sciences (IAHS), the Chinese Academy of Sciences (CAS)'s TPE program, and has the strong support of Switzerland, Austria, Canada, France, Spain, Italy, and other member nations. The High Mountain Summit seeks to foster international and regional inter-agency collaboration across sectors, scales, and actors by leveraging existing and planned initiatives and projects. This will provide integrated climate service delivery functions along the value chain, addressing the need for reliable information on water and hazard management precipitated by accelerated changes in high mountain cryosphere and ecosystems. The summit objective is to inform and therefore promote sustainable mountain development, and many INARCH participants will attend and contribute. Further information is available at *https://highmountainsummit.wmo.int/en*.

INARCH will continue to build linkages with other GEWEX cross-cuts and RHPs. Of particular importance are ties with the proposed and/or initiating Third Pole Environment cross-cut for the Hindu-Kush-Himalaya region and extended mountain ranges in Asia, the western USA RHP and Water for the Food Baskets of the World initiative, the ANDEX RHP for South America and the Andes, and the Global Water Futures Program in Canada. INARCH members will be well-represented at the upcoming Fall Meeting of the American Geophysical Union in Washington, D.C., in December, as well as the Future Earth–Water Futures session on mountains and climate change in Bangalore, India, in September 2019, and the WMO High Mountain Summit in Geneva in October, 2019, where these links will be further developed. An INARCH meeting is planned for early in 2020.

In Memoriam: Dr. Raymond Arritt

19 September 1957 – 14 November 2018

Dr. Arritt at the recent GEWEX Convection-Permitting Climate Modeling Workshop II in September 2018

Dr. Raymond Arritt, a longtime contributor to GEWEX, passed away on November 14, 2018. As professor of agronomy at Iowa State University, he studied the intersection of meteorology, climate, and agriculture, capturing the effects of a changing climate on the land surface and land management. He ran the Iowa Environmental Mesonet, a collection site and repository for current and historical observations of climate and weather.

Dr. Arritt received his Bachelor's and Master's degrees from the University of Virginia, and completed his Ph.D. in atmospheric science at Colorado State University under Roger Pielke, Sr. He accepted a position as assistant professor at Kansas State University's Department of Physics and Astronomy and moved to Iowa State University in 1993. He remained at Iowa State in the Department of Agronomy, and was promoted from associate to full professor in 2000. He was an investigator in projects involving downscaling seasonal forecasts and examining the relationship between biofuels and the hydrological cycle, and contributed to the North American Regional Climate Change Assessment Program among many other projects. His interest in precipitation extremes and soil moisture made him an invaluable member of the GEWEX community, as did his focus on the human dimension of climate change.

Dr. Arritt had a wonderful sense of humor that, combined with his intellect and his warm personality, made him a highly regarded colleague as well as an excellent collaborator and contributor to many of our meetings. We had great plans to work together on better linking climate modeling, hydrological modeling, and agricultural modeling in the Midwestern United States, the region he so intimately knew and understood. The GEWEX community lost a dear friend and he will be greatly missed. We wish his family strength during this difficult time.

GEWEX/WCRP Calendar

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

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

8–9 December 2018—Impact of Initialized Land Temperature and Snowpack on Sub-seasonal to Seasonal Prediction (ILSTSS2S) Kickoff Workshop (by invitation only)—Washington, D.C., USA

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

12 December 2018—AGU Side Meeting on Water for the Food Baskets of the World Grand Challenge—Washington, D.C., USA

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

31 January – 1 February, 2019—5th OzEWEX Workshop: Water in the Anthropocene—Canberra, Australia

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

25 February – 1 March, 2019—UCP2019: Understanding Clouds and Precipitation—Berlin, Germany

25–28 March 2019—CMIP6 Model Analysis Workshop—Barcelona, Spain

24–26 April 2019—Aerosols, Clouds, Precipitation, and Climate (ACPC) Initiative Meeting 2019—Nanjing, China

15–17 May 2019—Annual Science Meeting of the Global Water Futures Program—Saskatoon, Canada

20–24 May 2019—12th Hydrological Cycle in Mediterranean Experiment (HyMeX) Workshop—Split, Croatia

19–21 June 2019—12th International Precipitation Conference (IPC12) and the Soroosh Sorooshian Hydrometeorology Symposium—Irvine, California, USA

15–19 July 2019—Paracon International Workshop on Convection Parametrization and GASS Project Side Meeting—Exeter, UK

GEWEX NEWS

Published by the International GEWEX Project Office

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*