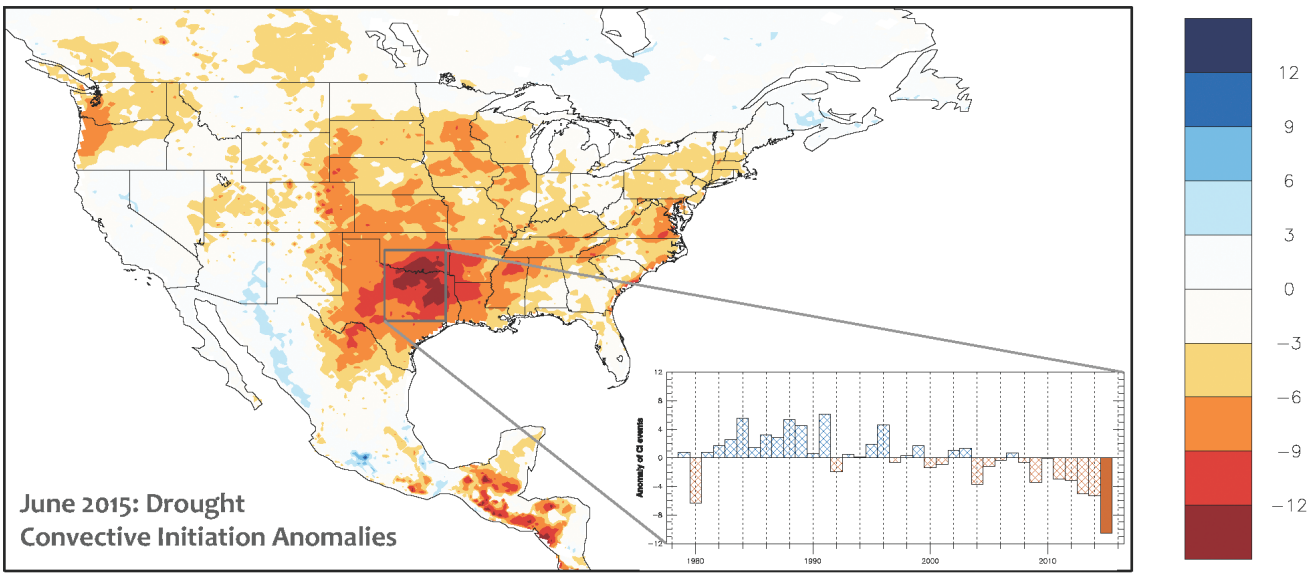
GEWEX NEWS

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

WCRP World Climate Research Programme | WMO | UNESCO | IOC | ICSU International Council for Science

Vol. 27 No. 1, February 2017

GLASS-LoCo Project is Developing Land-Atmosphere Coupling Metrics and Diagnostics



The map above shows the anomaly in surface-triggered convective initiation (CI) events during the summer of 2015 when a heat wave occurred. There are 6-12 fewer days with surface-triggered CI in the build-up and during the heat wave. The inset shows a time series of CI anomalies to put the 2015 heat wave in perspective. Overall, the strong connection between heat waves and surface-triggered convection demonstrates that from a Local Land-Atmosphere Coupling (LoCo) viewpoint, metrics such as the "Heated Condensation Framework" (used here; Tawfik et al., 2015) allow for local-scale processes to be put into the perspective of broader synoptically forced events, such as heat waves. See article by M. Ek et al. on page 9.

Also Inside

Commentary

GEWEX at 30

Graeme Stephens
Co-Chair, GEWEX Scientific Steering Group

The 29th GEWEX Scientific Steering Group (SSG) met during the week of 6-9 February in Sanya, China and was graciously hosted by former SSG member Xin Li of the Chinese Academy of Sciences. This meeting was remarkable for a few reasons. First, it signaled the start of the 30th year of GEWEX and was a reminder to us all that it is time to emphasize the many scientific achievements of GEWEX over the past three decades and to reflect on its vision and path forward into the next decade. Secondly, it was proposed that GEWEX achievements be collected in a review article called "GEWEX at 30." As part of the process for developing this article, inputs and thoughts from past and present GEWEX Panel co-chairs will be collected. The depth and breadth of the excellent work performed by the GEWEX Panels and their various working groups that was presented at the SSG were a remarkable testament to both the current high value and the future potential of information products and scientific outcomes from GEWEX and its future activities.

While there seems to be an ever-growing number of panels and working groups formed outside of the core projects of WCRP, it is the Panel activities of these core projects, and of GEWEX in particular, that are the bedrock of WCRP. This is where the real volunteer work is done, and where process-level understanding is advanced.

A third highlight of the meeting was the exposure the SSG received to the range and scale of the important scientific activities being pursued in China. A major GEWEX initiative centered on the water and energy cycles of the Tibetan Plateau is emerging from these discussions. Presentations to the SSG on future plans for new satellite measurements, both from Korea and China, were given. For the latter, development of a water cycle satellite mission was described and plans for a precipitation measurement mission were discussed. In addition, carbon dioxide measurement highlights from the Chinese TanSat satellite, launched in December 2016, were provided.

The annual GEWEX SSG meeting is an opportunity to take stock, and the 2017 meeting provided a forum to underscore the current challenges confronting WCRP and also assess the evolving nature of GEWEX. The GEWEX Panel activities continue to be shaped by the directions of Earth science research. It is also clear that GEWEX has and will continue to influence the focus and objectives of remote-sensing Earth science and modeling activities. A notable outcome of the China meeting was the development of plans for a new GEWEX Panel on atmospheric processes that will build on existing and new process activities, with a clear objective of aligning with activities of the World Weather Research Programme.

Participants at GEWEX SSG-29 Meeting.

Contents

New SSG Members

We welcome the following new members of the GEWEX Scientific Steering Group (SSG), whose terms began in January 2016. For a listing of all the GEWEX SSG members, see: *http://www.gewex.org/about/organization/*.

Gianpaolo Balsamo

Dr. Balsamo is a senior scientist at the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, United Kingdom. He leads the Coupled Processes Group of the Earth System Modeling section in the Research Department. His scientific interests are surface-atmosphere interactions and their influence on weather and climate.

Michael G. Bosilovich

Dr. Bosilovich is a scientist at the Global Modeling and Assimilation Office of NASA Goddard Space Flight Center in Greenbelt, Maryland. His scientific interests include the Earth's water and energy cycles, global and regional climate variations, extreme weather, the planetary boundary layer, land-atmosphere interactions, influence of data in reanalysis, and Earth system models and the observations needed to improve them.

Branka Ivančan-Picek

Dr. Ivančan-Picek is head of the Research and Development Department at the Meteorological and Hydrological Service (DHMZ) in Zagreb, Croatia. She has many years of experience in research of mesoscale dynamics and forecasting, as well as in the severe weather events interpretation and modeling. Her scientific interests are extreme weather and local phenomena, such as bora winds and heavy precipitation.

Student and Early Career Scientist Events at 2016 AGU Fall Meeting

Allison Goodwell, Niels Claes and Sheila Saia
AGU H3S Members

The American Geophysical Union (AGU) Hydrology Section Student Subcommittee (H3S) was busy hosting several events during the AGU Fall Meeting in San Francisco, California. The day before the Fall Meeting, H3S organized the interdisciplinary track of the Student and Early Career Conference. This provided an opportunity for students and other early career scientists within the AGU community to make social and professional connections before the meeting. The Student Conference featured sessions on the food-water-energy nexus, data visualization, and modeling. Between these, participants mingled and networked through an ice-breaker to help them "find [their]research superpower" as well as a gallery walk that inspired discussion on themes such as mentoring, inclusion and service.

At the AGU meeting, the student-led activities continued with pop-up talks, Hydrologist Bingo and an open-door H3S committee meeting. The pop-ups, which are rapid-fire presentations on a range of topics, fell under themes of "Social Dimensions" and "Water Science." Throughout the week, Hydrologist Bingo gave students the opportunity to meet and start conversations with well-known hydrologists. The Hydrology Business Luncheon and the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) mixer provided prime opportunities to network and fill out bingo cards. During the H3S committee meeting, current members met with other students and young scientists to discuss the focus and mission of the committee and brainstorm ideas for future initiatives.

After the AGU meeting, several students embarked on a morning field trip to Palo Alto to participate in a service event with a watershed monitoring group, Grassroots Ecology (*http://www.grassrootsecology.org*). Students met with volunteers from diverse backgrounds and discussed the links between academic and community efforts to monitor the environment and effectively conduct and communicate science.

Most members of H3S serve on the committee for a 2-year term, and this year's committee includes new and old members of six different nationalities, spread over four continents. Check our twitter feed (@AGU_H3S) for announcements and for activities throughout the year. Questions and suggestions are welcome! Please contact committee chair Niels Claes at *nclaes@uwyo.edu*.

Recently publish a paper related to GEWEX research?

We are interested in showcasing selected research highlights that feature recent and interesting results relevant to the GEWEX mission. For consideration, please summit your highlight at: *http://www.gewex.org/latest-news/research-highlights/*. If your research qualifies, it will be published on the GEWEX website and may be featured in *GEWEX News.*

Changes in Leadership in GDAP

The new co-chairs for the GEWEX Data and Assessments Panel (GDAP) are Drs. Rémy Roca and Tristan L'Ecuyer.

Dr. Rémy Roca (pictured in the center of the photo at the bottom of the page) is the Director of Research at the Centre National d'Etudes Spatiales (CNRS) Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. His research interests are the physics of tropical climate, tropical meteorology, hydrology, the water and energy cycle, satellite meteorology, remote sensing, mesoscale convective systems and the Megha-Tropiques satellite mission.

Dr. Tristan L'Ecuyer (pictured on the far left of the photo at the bottom of the page) is a Professor in the Atmospheric Radiation and Climate Research Group at the University of Wisconsin-Madison, Wisconsin, USA. His research interests include the Earth's energy balance, cloud-aerosol interactions, climate, satellite remote sensing and ground validation.

Matthew McCabe

Dr. Roca replaces **Dr. Jörg Schulz** (pictured on the far right in the photo below), the Climate Product Manager of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) in Darmstadt, Germany, who served as GDAP chair from 2014–2016 and as vice-chair from 2010–2013. Dr. L'Ecuyer replaces **Dr. Matthew McCabe**, Professor of Environmental Science and Engineering at the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. Dr. McCabe served as vice-chair from 2015–2017 and has been a member of GDAP since 2008.

GDAP Leaders, Current and Past

From left to right: Tristan L'Ecuyer, Chris Kummerow (GDAP Chair from 2007–2010), Rémy Roca, Bill Rossow (Chair of GRP, the precussor to GDAP, from 2001-2007) and Jörg Schulz at the GDAP Meeting in Washington, D.C., in November 2016.

Changes in Leadership in GHP

Joan Cuxart

Jan Polcher

Dr. Joan Cuxart, Senior Lecturer at the University of the Balearic Islands in Palma, Majorca, Spain, joins Dr. Jason Evans as co-chair of the GEWEX Hydroclimatology Panel (GHP). Dr. Cuxart is an atmospheric physicist who specializes in boundary-layer meteorology, with a focus on atmosphere-surface exchanges through numerical modeling and experimental work. Previously he worked as a numerical modeler and researcher at the French and Spanish Meteorological Services.

Dr. Cuxart replaces **Dr. Jan Polcher**, a researcher at the Laboratoire de Météorologie Dynamique du Centre National de la Recherche Scientifique in Paris, France, who co-chaired GHP from 2011–2016. Dr. Polcher has participated in GEWEX for nearly 20 years, and we have benefited enormously from his technical expertise in land-surface and atmosphere interactions and from his commitment to the project itself. He has held many roles in GEWEX, including leader of the African Monsoon Multidisciplinary Analysis Project (AMMA-EU), chair of the GEWEX Modeling and Prediction Panel (GMPP) and the Global Land-Atmosphere System Study (GLASS), and member of the GEWEX Scientific Steering Group. We are grateful for Dr. Polcher's support of GEWEX and look forward to his continued involvement as the co-lead for the new GHP/GLASS crosscutting project, Human Regulation of the Water Cycle, and as the co-lead on the WCRP Grand Challenge on Water for the Food Baskets.

Changes in Leadership in GLASS

Dr. Gab Abramowitz joins Dr. Michael Ek as co-chair of the Global Land/Atmosphere System Study (GLASS) Panel. Dr. Abramowitz is a Senior Lecturer at the Climate Change Research Centre and Australian Research Council's Centre of Excellence for Climate System Science at the University of New South Wales in Sydney, Australia. His research interest is model evaluation in climate science, ecology and hydrology. Currently, his research focuses on two main areas: model dependence in multi-model ensemble climate prediction and the standardization of model evaluation in land-surface research. He replaces **Dr. Aaron Boone**, a research hydrometeorologist at the Centre National de Recherches Météorologiques in Toulouse, France, who served as GLASS co-chair from 2013–2016. Dr. Boone has been involved with GLASS for over a decade and continues his association with GLASS as the ALMIP2 Project co-leader and as liaison to the SoilWat Initiative.

IN MEMORIAM: Piers Sellers

It is with great sadness that we reflect on the recent death of our friend and colleague, Piers Sellers, a climate scientist, former astronaut and eternal optimist, who died on 23 December 2016 at the age of 61. Before Piers went on to achieve fame as an astronaut, he was a scientist at the NASA Goddard Space Flight Center (GSFC) and the leader for a GEWEX project called the International Satellite Land Surface Climatology Project (ISLSCP), where he worked on global climate problems, particularly those involving interactions between the biosphere and the atmosphere, and was involved in constructing computer models of the global climate system, satellite data interpretation and conducting large-scale field experiments in the United States, Canada, Africa and Brazil.

Piers successfully guided ISLSCP until 1996, when he joined the astronaut corps and moved to Houston, Texas. We at GEWEX were thrilled for Piers as we watched him make three space flights from 2002 to 2010 and take six space walks during the assembly of the orbiting laboratory. Piers never forgot his connection with GEWEX and at the 6th International GEWEX Science Conference held in Melbourne, Australia in August 2009, he gave a keynote speech on land-atmosphere interactions.

Piers returned to GSFC in 2011 as deputy director of the center's sciences and exploration directorate and as acting director of its Earth sciences division, where he oversaw scientists researching climate and weather, including the causes and effects of climate change. He made a point of using his experiences as an astronaut to further people's awareness of climate issues.

In January 2016, Piers wrote in the *New York Times*, "What should the rest of us do [about climate change]? Two things come to mind. First, we should brace for change. It is inevitable. It will appear in changes to the climate and to the way we generate and use energy. Second, we should be prepared to absorb these with appropriate sang-froid. Some will be difficult to deal with, like rising seas, but many others could be positive. New technologies have a way of bettering our lives in ways we cannot anticipate. There is no convincing, demonstrated reason to believe that our evolving future will be worse than our present, assuming careful management of the challenges and risks. History is replete with examples of us humans getting out of tight spots. The winners tended to be realistic, pragmatic and flexible; the losers were often in denial of the threat."

In an interview with the *National Geographic*, Piers summed up his life by saying "I won't be remembered as an Einstein, and that's fine—but I tried really hard, and I had fun. The things I've seen, the things that people have allowed me to do, the experiences I've had—I've had a very rich, rewarding life. Most of it has turned out wonderfully."

The Pannonian Basin Experiment (PannEx)

Mónika Lakatos[1], Ivan Güttler[2], Vladimir Djurdjevic[3], Adina-Eliza Croitoru[4], Tamas Weidinger[5], Danijel Jug[6], Branka Ivančan-Picek[7] and Joan Cuxart[8]

[1]Hungarian Meteorological Service, Budapest, Hungary; [2]Meteorological and Hydrological Service, Zagreb, Croatia; [3]Faculty of Physics, University of Belgrade, Serbia; [4]Physical and Technical Geography, Babeș-Bolyai University, Cluj-Napoca, Romania; [5]Department of Meteorology, Institute of Geography and Earth Sciences, Eötvös Loránd University, Budapest, Hungary; [6]Faculty of Agriculture, University of Osijek, Osijek, Croatia; [7]Meteorological and Hydrological Service, Zagreb, Croatia; [8]Department of Physics, University of the Balearic Islands, Palma, Mallorca, Spain

The Pannonian Basin is contained within the larger Danube River Basin and is surrounded by the Carpathian Mountains, the Dinarides and the Eastern Alps, creating an almost closed topographic structure with a very wide central flatland. This configuration makes the Basin an excellent natural laboratory for the study of the water and energy cycles, focusing on the physical processes of relevance. Administratively, the Pannonian Basin is shared among twelve European countries.

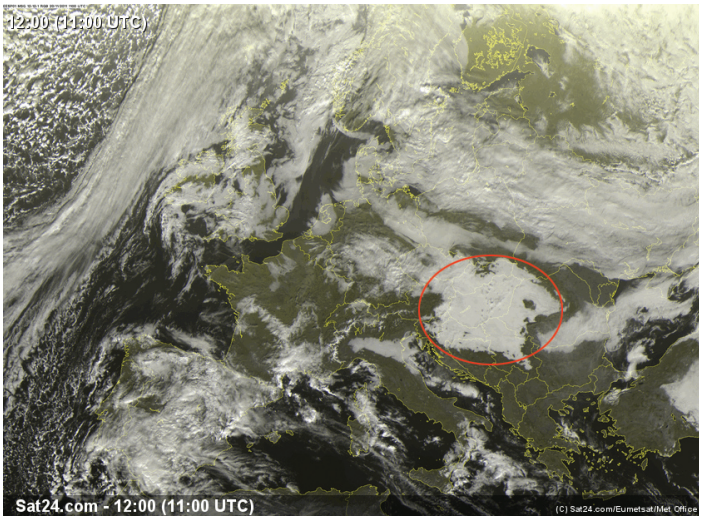
A group of scientists from countries in the Basin have joined together to form the Pannonian Basin Experiment (PannEx) to coordinate research on the climate and environment of this region and address societal impacts related to these important issues. The initiative is working towards becoming a Regional Hydroclimate Project (RHP) under the GEWEX Hydroclimatology Panel (GHP), and will thus adhere to the principles of GEWEX, its Grand Challenges and Scientific Questions.

After the first exploratory meeting in Osijek, Croatia in November 2015, a PannEx International Planning Committee (IPC) was formed to define the main themes of the experiment. The IPC was tasked with developing a White Book and the first version of it was presented to the GHP members at their annual meeting in Gif-sur-Yvette, France, in October 2016. The draft document is available to anyone interested in PannEx. For a copy, send an email to *lakatos.m@met.hu* or *ivan.guettler@cirus.dhz.hr*. Comments on the evolving plan are welcome.

Flagship Questions

PannEx has five Flagship Questions (FQs) addressing well-defined societal issues and three crosscutting actions to address technical and scientific procedures. These will be the foundation for the science and implementation plans required to launch PannEx as an RHP. Both plans will be outlined at the next PannEx workshop in Cluj-Napoca, Romania in 20-22 March 2017 (*https://sites.google.com/site/projectpannex/workshops*).

FQ1 addresses the adaptation of agronomic activities to weather and climate extremes. Agronomy is a very important economic sector in the Pannonian Basin and there is already



The Pannonian Basin (outlined in orange) covered by fog and low clouds.

evidence of change in areas related to climate and socio-economic developments. Severe precipitation events and long-lasting droughts have been increasingly observed, and some phenological changes in crops and orchards have been recorded. In addition, the welfare of livestock during prolonged periods of excessively hot weather is an issue. Monitoring of these events, together with more appropriate water and soil management and plow strategies, is needed. Addressing these issues and developing a better understanding of the relationships between the soil-vegetation system and the rest of the climate system in the Pannonian Basin can be achieved through collaboration between scientists and stakeholders at the local and multinational scales.

FQ2 addresses changes in air quality under different weather and climate conditions. Air quality has improved in the Pannonian Basin over the last two decades due to technological advances in most sources of pollution (vehicles, factories, power plants). Still, under some meteorological conditions, incidences of poor air quality could increase in the future. For example, along the main river valleys, pollutants can be trapped in the atmospheric boundary layer during winter anticyclonic conditions and redistributed by mesoscale circulations. We must further explore the movement of these pollutants, their related chemistry and the impact on humans and ecosystems through enhanced observations and specialized modeling that overcomes the difficulties of accessing the observational data of multiple countries. FQ2 also addresses what actions must be taken to monitor the quality of precipitation and surface and ground water.

The subject of FQ3 is sustainable development. Specifically, how can the Pannonian Basin maintain its current ecosystems in a future where renewable energies must increase substantially? This FQ requires a coordinated effort between countries and energy producers, as well as an assessment of the expected evolution of energy requests. This will foster the preservation of the ecological services, identifying potential threats due to climate change and mitigation strategies to cope with them. Hydropower use in the region is relatively mature, whereas wind and solar energy have room to increase, relying upon good weather forecasts.

FQ4 addresses water management and droughts and floods. It explores how changes in water availability may affect the region, as most of its ground surface is devoted to agriculture. Climate change scenarios for the future indicate that the frequency of extreme events, such as floods and droughts, may increase in the Pannonian Basin due to a warmer climate. This implies that actions must be planned to mitigate the effects of these extremes, such as developing hydrological models at different temporal and spatial scales, improving the water balance observational network and using satellite data and climate model outputs. Short-term warning systems and long-term drought forecasting are two challenges of great societal impact that must be tackled. Managing dams and reservoirs and their effect on the environment is also an important issue.

FQ5 addresses university-level education for meteorology and hydrology in the region. Most areas of expertise are represented in institutions in the Pannonian Basin, but some countries show more specialization in a particular discipline or specialty. Also, collaboration between meteorological services and universities varies largely depending upon the country. We hope that PannEx can promote transnational and transdisciplinary cooperation in research, operations and education by means of establishing summer schools, the exchange of professors and students and the coordination of master's degree courses and Ph.D. activities.

Transversal Crosscutting Actions (CCs)

Three CCs have been defined for PannEx. CC1 is related to data and knowledge rescue and consolidation, aiming to identify and locate already-existing relevant data and equipment and list all pertinent previous research, thus setting a precise starting point for new actions. The goal of CC2 is to improve understanding and representation of process modeling, which affects all FQs. Emphasis will be placed on the analysis of surface water and energy budgets and land-atmosphere interactions, atmospheric chemistry, crop modeling, the study of precipitation systems and hydrological modeling. Observational and modeling experiments involving transnational working groups will be conducted in the Pannonian Basin.

CC3 addresses the development and validation of modeling tools, including listing current activities at numerical weather prediction centers and regional climate modeling centers. Future developments will include the increase of spatial resolution; the use of new observations in the model suite; the convergence of models into a seamless prediction system; the coupling with crop, dynamic vegetation, air chemistry and hydrological models; and optimized post-processing of model outputs.

In summary, the goal of the activities of PannEx, including the initiative's interaction with GHP RHPs and other projects of GEWEX and WCRP, is to enhance Earth system science in the Pannonian Basin and contribute to the overall goal of the scientific community to improve the understanding of the climate system, its predictability and its effect on human activities.

Meeting/Workshop Reports

1st GEWEX SoilWat Initiative Planning Workshop: Advancing Integration of Soil and Subsurface Processes in Climate Models

28–30 June 2016
Leipzig, Germany

Dani Or
Institute of Biogeochemistry and Pollutant Dynamics, Swiss Federal Institute of Technology, Zürich, Switzerland

The Soil and Critical Zone communities have been exploring ways to broaden disciplinary participation in addressing global challenges where soil and subsurface processes (groundwater) play important roles, such as climate change, food security and land and water resources. GEWEX plays a prominent role in quantifying land-atmosphere interactions in various modeling platforms and is a natural partner for fostering interactions between the soil, subsurface and climate communities.

To improve the interactions between GEWEX and the soil and critical zone communities, the workshop was held with the goal of working towards the integration of soil and subsurface processes in current climate models and other research activities within GEWEX. Almost 30 scientists participated in the workshop, where discussions revolved around key issues such as: (i) how soil processes (infiltration, evaporation, soil properties) are represented in land-surface models; (ii) what role plants play in climate models; (iii) how to bridge scales between traditional soil models and representation relevant to climate modeling; (iv) how to effectively incorporate groundwater in models; and (v) how to best integrate the communities.

Among the many suggestions received during the workshop, three related initiatives were pushed to the forefront. The first is an evaluation of pedotransfer functions and functional descriptions for calculation of hydraulic and thermal soil properties in global climate and hydrological models. This is a joint GEWEX and International Soil Modeling Consortium (ISMC) project to conduct an in-depth survey on how key soil physical processes (water and heat flow) are represented in climate and hydrological models. It will focus on the Land Surface Snow and Soil Moisture Model Intercomparison Project (LS3MIP) models, with an emphasis on revisiting the pedotransfer functions used to convert soil properties into hydraulic and thermal parameters. Activities are underway to use new and highly resolved global soil maps (e.g., SoilGrids, *http://www.isric.org/content/soilgrids; s*ee figure on next page) to revise key hydrologic transfer function models and to analyze the impact on predicted hydraulic and thermal properties.

The second inititative is a systematic assessment of the utility of resolved soil maps and sensitivity of climate models to improve the quality and resolution of soil maps (e.g., Dy and Fung, 2016). A systematic SoilParameterMIP will be conducted to evaluate the output of several climate models (their land surface modules) migrating from standard soil maps to the new global SoilGrids. The task will follow the GEWEX LS3MIP protocol for standardized inputs.

The third initiative involves conducting a survey of how groundwater is implemented in climate models and strategies for better incorporation of groundwater in climate models. The initiative will explore producing a global database for historical and current groundwater levels, with the goal of having contributing countries and monitoring authorities commit to submitting their data and possibly creating a global archive of historical groundwater data.

Items discussed during the workshop on the role of soil science in climate research are described below.

The Role of Plants in Climate Models

Adaptation of plants and plant communities to the soil and cross-correlations between soils and plants are not currently included in plant functional types. Modelers are starting to consider whether biomes are better suited for modeling the role of vegetation than plant functional types. Whatever approach is used, the hydraulics of plants need to be incorporated in climate models.

Scale Issues

One obvious obstacle for land-surface models is their need for input with a relatively high spatial resolution (less than 1 km). Generating rainfall at that resolution is currently not feasible. This problem is particularly relevant in landscapes with vegetation patterns and drainage networks that have scales smaller than the smallest resolution that climate models can handle, which must be greater than 10-25 km. A critical hydrological scale is the distance between the watershed and the river corridor. Most rivers have many hierarchical tributaries within their subcatchments, creating a hierarchy of such length scales, with the smallest ones having a strong effect on the generation of river discharge. Some combination of a stochastic treatment of the atmosphere paired with a deterministic approach to the soil and vegetation domain seems inevitable.

For land and vegetation models, the deeper subsurface can become important if aquifers create teleconnections between areas of infiltration and upwelling that may be tens or hundreds of kilometers apart. For these areas, hydrogeological features also need to be included in regional and global models.

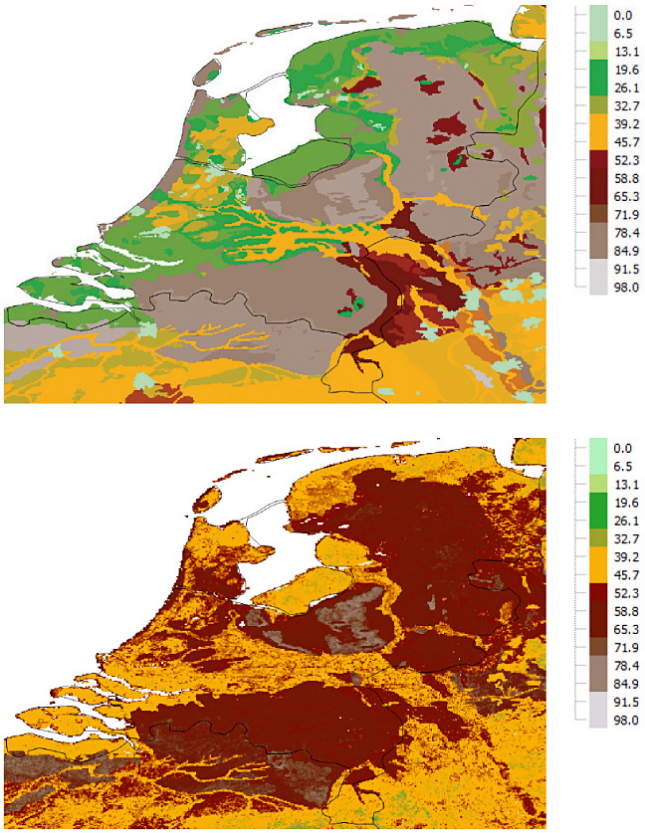
The soil science community should be able to identify and address some of the interesting problems that occur at the 25-km scale. These include: interflow, snow redistribution, soil-plant interactions (the influence of plants on soil properties and the adaptation of plants to the soil), soil thermal behavior (relevant for energy partitioning) and albedo modification (e.g., biological crusts covering arid soils). In addition, the climate modeling community has a huge demand for continuous soil moisture data.

Modeling

In order to focus the debate in the coming years and the research it will hopefully generate, we need to be specific: (i) What is the purpose of the modeling effort? (ii) What are the spatial and temporal scales of the model(s) we want to work on? (iii) What is the necessary or desirable level of model complexity? (iv) What are the spatial and temporal resolutions we are striving for? (v) What accuracy is needed, and what accuracy can be achieved given the available input data?

With respect to model complexity and accuracy, the parameter uncertainty is such that we cannot expect overly complex models to be constrained to a degree that makes their predictions reliable.

In general, the soil hydraulic properties will be approximated using proxy data. The pedotransfer functions that are used for the conversion to soil hydraulic properties were mostly developed for humid climates and do not work in more arid regions.



An illustrative example of two maps of sand content percentage in the top soil in The Netherlands based on the Harmonized World Soil Database (HWSD) that is used in many land surface models (top) and the new SoilGrids (1 km, bottom). These maps are taken from a recent report from Wageningen (HiHydroSoil: A High Resolution Soil Map of Hydraulic Properties, April 2016, by Froukje de Boer; http://www.futurewater.eu/2015/07/soil-hydraulic-properties/*). The example illustrates potential differences in using high-resolution soil maps to improve description of soil properties in land surface models.*

An atmospheric model needs a soil and vegetation model that delivers the following: (i) accurate values of the absorbed, emitted and reflected radiation; (ii) sensible and latent heat fluxes in the correct proportion and (iii) correct values for roughness and drag.

In addition, a soil model needs to incorporate the exchange of water with the groundwater, in view of the teleconnections that aquifers can establish and the increasing importance of groundwater recharge in areas where groundwater is pumped for domestic, agricultural and industrial use. Groundwater data of several countries, including China, are not stored in a central, global repository.

It is not clear how well current approaches can be modified to meet these demands. The best strategy appears to be to improve available models, while at the same time exploring alternative approaches. The use of Richards' equation at scales much larger than the Darcian scale for which it was developed was discussed. According to one view, there is no viable alternative to Richards' equation, even though it was acknowledged that a formal upscaling of Richards' equation leads to a similar equation, but with effective parameters that are hysteretic in nature, and which can only be quantified if the special variation and cross-covariances of the local parameters were known and obeyed limiting restrictions. It was noted that using a Darcy-based equation (like Richards' equation), which describes flow as driven by a potential gradient, to compute fluxes in areas of multiple square kilometers is not realistic. According to another view, these limitations are arguments to depart from the Darcian framework and search for an alternative approach that tackles soil water and possibly heat flows at the desired scale directly. Models should be transferable to other catchments or regions, depending on the scale, with minimum or no calibration.

From a survey by ISMC regarding the expectation of the modeling consortium, the following are pertinent to the SoilWat Initiative: (i) a classification to structure the existing populations of soil models is desired; and (ii) model input should be standardized, including the minimum information required to achieve adequate predictions.

Societal Aspects

Five shared socio-economic pathways (SSPs) were developed by the International Committee on New Integrated Climate Change Assessment Scenarios (ICONICS, O'Neill et al., 2015) and these are sustainability, middle of the road, regional rivalry, inequality and fossil fuel development.

The role of water in these scenarios is not yet well established. Groundwater recharge and irrigation appear to be particularly difficult to capture. Our community has the knowledge to contribute here but has not yet been involved.

Planned Activities

- Establish a survey of existing soil models. The ISMC website currently lists over 30 models with descriptions.

- Survey the pedotransfer functions that are used in global climate models.
- Carry out a sensitivity analysis.
- Set up a soil parameter MIP.
- Seek or develop a modeling case study in which several soil models are run to model fluxes (of mass and energy) that are relevant for climate models. This could be developed into a MIP, or become part of a MIP that is already running. Joining existing MIPs has the strategic advantage of connecting with the climate science community.
- Establish a global database for historical and current groundwater levels.

Summary

The workshop was successful in galvanizing interaction between the communities and highlighted the commitment and interest in finding ways to cooperate for improving soil and subsurface processes in climate models and informing the soil communities of climate model capabilities and opportunities. A perspective paper will be written to clarify the needs, objectives and future directions of the GEWEX SoilWat Initiative. A second GEWEX-SoilWat planning workshop is planned in 2017 to report on progress and discuss items not addressed at this workshop, such as soil and plant processes and human interactions.

References

Dy, C.Y., and J.C.H. Fung, 2016. Updated global soil map for the Weather Research and Forecasting Model and soil moisture initialization for the Noah Land Surface Model. *J. Geophys. Res. Atmos.*, 121:8777-8800. doi: 10.1002/2015JD024558. *http://onlinelibrary.wiley.com/doi/10.1002/2015JD024558/abstract?campaign=woletoc*.

O'Neill, Brian C., et al., 2015. The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environ. Change*. In press, doi:10.1016/j.gloenvcha.2015.01.004.

Resources

Soil maps at various resolutions (90 m to 1 km) on global and continental scales are available at the International Soil Reference and Information Centre (ISRIC, *http://www.isric.org/*).

Five quantitative SSPs were developed by ICONICS (*https://www2.cgd.ucar.edu/research/iconics*; *https://www2.cgd.ucar.edu/research/iconics/background*). These SSPs are available at: *https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about*. The International Institute for Applied Systems Analysis (IIASA) and the National Center for Atmospheric Research (NCAR) developed population and urbanization scenarios for each of the SSPs. For GDP, three alternative interpretations of the SSPs by the teams from the Organization for Economic Cooperation and Development (OECD), IIASA and the Potsdam Institute for Climate Impact Research (PIK) have been developed.

ERA-Interim is a global atmospheric reanalysis from 1979 that is continuously updated in real time. It is available from the European Centre for Medium-Range Weather Forecasts (ECMWF; *http://www.ecmwf.int/en/research/climate-reanalysis/era-interim*). The system includes a 4-dimensional variational analysis with a 12-hour analysis window. The spatial resolution of the data set is approximately 80 km on 60 vertical levels from the surface up to 0.1 hPa.

GLASS Science Panel Meeting

3–5 October 2016
Gif-sur-Yvette, France

Michael Ek[1], Gab Abramowitz[2] and Aaron Boone[3]
[1]NCEP Environmental Modeling Center, College Park, MD, USA; [2]Climate Change Research Centre, University of New South Wales, Sydney, Australia; [3]CNRM, Météo France, Toulouse, France

The Global Land/Atmosphere System Study (GLASS) Science Panel Meeting was held at the Université Paris-Saclay Centre/National de la Recherche Scientifique (CNRS) with 17 Panel members and guests attending. Community activities under the three GLASS Panel elements were reviewed, including: (i) land model benchmarking to improve understanding and representation of land-surface processes; (ii) understanding of land-atmosphere interaction and feedbacks; (iii) data model fusion; and (iv) crosscutting activities.

Local Land-Atmosphere Coupling (LoCo) Project

LoCo, which is led by Joseph Santanello, has reached its 10-year anniversary. The LoCo Working Group (WG) has 15 members and many of them are early career scientists. Its focus is on accurately representing the relationship between soil moisture, precipitation and coupling strength in models (e.g., Dirmeyer and Halder, 2016). To have the proper understanding and related model improvements, it is necessary to carefully examine and quantify the full series of interactions (i.e., links in the chain) at the process level, including boundary layer feedbacks. The WG is tackling the development of quantitative process-based metrics and diagnostics of land-atmosphere (L-A) coupling (see figure on the cover) that can be applied to observations as well as to models across scales, where many studies and publications from the WG in recent years have concentrated on various metrics, models and applications.

Field campaigns have been a point of emphasis, including the enhanced sonde at the Department of Energy (DOE) Southern Great Plains (SGP) site (Craig Ferguson, Joseph Santanello, Pierre Gentine) in summer 2015, improved soil moisture and co-located L-A measurements from the DOE Atmospheric Radiation Measurement Program (ARM; Joseph Santanello), New York State Mesonet (Craig Ferguson) and the Land-Atmosphere Feedback Experiment [LAFE; Volker Wulfmeyer, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA)] at SGP in summer 2017. The LoCo WG is suggesting that the Coupled Model Intercomparison Project-6 (CMIP6), via Global Soil Wetness Project Phase 3, and the Land Surface, Snow and Soil Moisture Model Intercomparison project (LS3MIP) include an increased set of L-A variables in the standard output of participants. LoCo has the closest links with the GEWEX Atmospheric Boundary Layer Study (GABLS) and the GLASS-GABLS Diurnal Coupling Experiment (DICE), due to the inherent importance of the boundary layer and model development in each. In the future, LoCo

will continue to follow and broaden the science of LoCo and WG participation, synthesize what we have now in terms of metrics and message, and engage and entrain the operational and model development communities. See the LoCo website (*http://www.gewex.org/loco*). Paul Dirmeyer also provides a synthesis of the project at *http://cola.gmu.edu/dirmeyer/Coupling_metrics.html* and the LoCo coupling metrics toolkit by Ahmed Tawfik is available at *http://www.coupling-metrics.com*.

Protocol for Analysis of Land Surface Models (PALS)

Gab Abramowitz reviewed the PALS Project, a web application designed for automated evaluation and benchmarking of land-surface models (LSMs). PALS hosts experiments that include: (i) data sets required to force or constrain a model for a particular experiment; (ii) model outputs uploaded by users (who run their models locally), including ancillary files; and (iii) automated analyses of model outputs, compared with evaluation data products, other models and empirical benchmarks. The first-generation PALS site had around 250 users from more than 60 institutions, and was used for the LSM Model Intercomparison Project (MIP) "PLUMBER," described below. The second-generation PALS system is in testing and development and will be more flexible, with user-defined benchmarks. Structured to allow the original PALS analysis suite, it will also integrate other existing packages, such as International Land Model Benchmarking Project (ILAMB, in Python) or the NASA Land Validation Toolkit (LVT, in Fortran), with use of a relatively simple wrapper. With all source code public on GitHub and coding structures built for team development, the future aim for PALS is to get the second-generation system functioning and adopted by the community as its own project.

PALS LSM Benchmarking Evaluation (PLUMBER) Project

Gab Abramowitz also summarized the PLUMBER project, an LSM MIP using the PALS system, designed to highlight the importance of benchmarking over traditional evaluation; that is, defining performance expectations a priori. In defining benchmarks before model simulations are performed, we can help answer the question of whether a group of models is performing well or not, as opposed to simply identifying which models perform better or worse than others. To achieve this, PLUMBER used two first-generation LSMs and three empirically based models (testing out-of-sample) as a way to set performance expectations. Results for sensible and latent heat flux were compared at 20 flux tower sites across nine International Geosphere-Biosphere Programme (IGBP) vegetation types, using eight different performance metrics. The key result from the original PLUMBER paper (Best et al., 2015) was that despite clearly performing better than older LSMs, current generation LSMs as a whole were not utilizing the information available in their input data about latent and sensible heat fluxes. The second paper by PLUMBER participants (Haughton et al., 2016) investigated whether or not this result was because of methodological flaws in the original PLUMBER experiment (i.e., whether lack of energy conservation in flux tower data, time scale of analysis, diurnal biases, poor LSM initialization, metric value aggregation or site choices might have been responsible for the original result). The paper concluded that the most plausible explanation for the result was a shared weakness among LSMs, noting that the mean of all participating LSMs did not show a radical improvement in performance (suggesting that LSM error correlation is high). Follow-on LSM benchmarking studies are continuing.

International Land Model Benchmarking (ILAMB) Project

David Lawrence provided an update on the ILAMB Project and its goals to develop internationally accepted LSM evaluation experiments; promote the use of these benchmark experiments; support the design and development of open source benchmarking tools; and strengthen links among experimental, remote sensing and climate modeling communities in the design of new model tests and new measurement programs. ILAMB is mainly led and funded through the U.S. DOE Regional Climate Modeling Program. It is integrated with all the land MIPs in CMIP6 (LUMIP, LS3MIP, C4MIP) and will serve as one of the land analysis packages for CMIP6 and related MIPs. In the future, ILAMB will continue to be augmented with new metrics introduced by international collaborators, and will be utilized in CMIP6 assessments, including assessments of LS3MIP land-only simulations. Collaboration with PALS is under discussion.

Global Soil Wetness Project Phase 3 (GSWP3)

Hyungjun Kim outlined the status of GSWP3, a global offline LSM MIP with meteorological forcing at 0.5 degree developed specifically for this project. It will also be used for the Land Surface, Snow and Soil moisture Model Intercomparison Project (LS3MIP) and SoilWat (both described below). The "fast-track" phase of initial simulations using a preliminary version of the forcing data is complete, as is analysis with the ILAMB package. The goal was to test the forcing within a subset of the LSMs in order to identify any issues (which, in turn, could result in changes or updates to the input forcings), a critical step as the model simulations should have the best possible forcing data as inputs. Significant effort has been expended on refining the forcing data (due to be frozen in May 2017). GSWP3 is also tied in with LS3MIP under its offline component, LMIP (which is endorsed as part of CMIP6). While GSWP3 simulations will run off the 0.5-degree forcing grid, LS3MIP model output is intended to match coupled simulations as closely as possible and so will run on each coupled model's grid. In order to remain consistent with CMIP6, a long-term retrospective GSWP3 experiment (EXP1) starts in 1850, with prescribed land-use and land-cover changes derived from the Land Use Harmonization (LUH) data set. Results submissions are due mid-2017, and GSWP3 land reanalysis fields are expected to be released in late 2017.

Hyungjun Kim and Sonia Seneviratne provided additional updates on LS3MIP, part of the CMIP6 experiment suite to assess land-surface, snow and soil moisture feedbacks on climate variability and climate change. It focuses primarily on the physical system with two phases: LMIP (offline) and LFMIP (coupled, with feedbacks), including coordinated SnowMIP model intercomparisons, while carbon cycle and vegetation dynamics are covered in more depth by CMIP complements

C4MIP and LUMIP respectively (more on LUMIP below). A detailed description of the protocol was published by van den Hurk et al. (2016).

New GLASS Projects

New projects include the Land Use Model Intercomparison Project (LUMIP) led by David Lawrence in collaboration with the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS), where LUMIP is one of the CMIP6 satellite MIPs and therefore is integrated with all CMIP6 activities (Lawrence et al., 2016). LUMIP aims to further advance understanding of the impacts of land-use and land-cover change (LULCC) on climate, and is a follow-up to the previous GLASS project called Land Use and Climate–Identification of robust impacts (LUCID). LUMIP includes a two-phase experimental design where phase one features idealized coupled and land-only model simulations designed to advance process-level understanding of LULCC impacts on climate, as well as to quantify model sensitivity to potential land-cover and land-use change. Phase two LUMIP experiments focus on quantification of the historic impact of land use and the potential for future land management decisions to aid in mitigation of climate change.

Also new is the GEWEX Soils Initiative (SoilWat), presented by Dani Or. The goal of SoilWat is to examine how soil processes are represented in land-surface models and how to bridge scales between traditional soil models and representation relevant to climate modeling, including the effective incorporation of groundwater models. Following the first GEWEX-SoilWat planning workshop from 28-30 June 2016 in Leipzig (see workshop report on page 7), the LSM community is being surveyed about existing treatment of soils, soil maps, groundwater databases and handling in models.

Other GLASS Projects Reviewed

Additional programs reviewed included the Project for the Intercomparison of Land Data Assimilation Systems (PILDAS), presented by Sujay Kumar. The PILDAS initiative is being reinvigorated and is expected to help in the development of best practices in land data assimilation systems for the optimal exploitation of the information content of remote sensing data.

Aaron Boone summarized the status of the African Monsoon Multidisciplinary Analysis (AMMA) Land Surface Intercomparison Project-Phase 2 (ALMIP2). The project is nearing completion, having sought to improve understanding and modeling of key surface vegetation and hydrological processes over West Africa (e.g., large rooting depths, near-surface aquifers, soil crusting, lateral transfer processes and strong runoff variability). A number of ALMIP2 papers were submitted in 2016 for the ALMIP2 special collection. Possible future work for ALMIP2 includes expanding LoCo studies to the AMMA region. Pere Quintana Seguí provided links with the GEWEX Hydroclimatology Panel (GHP) such as land-atmosphere data sets that will help in process-level studies in the Hydrological Cycle in the Mediterranean Experiment (HyMeX).

The new Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) Project was presented by Martin Best. LIAISE could involve GHP, GLASS, and GABLS, as well as iLEAPS. There is a relevant session to LIAISE at the European Geophysical Union Meeting in April on the changing Mediterranean environment.

As GLASS liaison, Paul Dirmeyer provided updates on the joint GEWEX-Climate and Ocean: Variability, Predictability and Change (CLIVAR) Sub-seasonal to Seasonal (S2S) Project where there is a potential contribution of the land to predictability on S2S timescales, and on the WCRP-World Weather Research Programme (WWRP) Monsoon Panel where land-atmosphere interactions are important within monsoons. Joseph Santanello, GLASS representative to the WCRP Modeling Advisory Council (WMAC), noted the GLASS contributions in promoting model development and coordination across WCRP. Similarly, Mike Ek, GLASS representative to the Working Group on Numerical Experimentation (WGNE), also brought up the importance of GLASS activities for data assimilation and process-level improvement to model physical parameterizations.

Finally, possible future process-level studies on snow (SnowMIP, as presented by Gerhard Krinner) and permafrost (presented by David Lawrence) could involve GLASS collaborations with iLEAPS, the Climate and Cryosphere (CliC) Project, and with other GEWEX Panels as partners.

References

Best, M.J., G. Abramowitz, H. Johnson, A.J. Pitman, A. Boone, M. Cuntz, B. Decharme, P.A. Dirmeyer, J. Dong, M. Ek, V. Haverd, B.J.J. van den Hurk, G.S. Nearing, B. Pak, C. Peters-Lidard, J.A. Santanello Jr., L. Stevens and N. Vuichard, 2015. The plumbing of land surface models: Benchmarking model performance. *J. Hydrometeorol.*, 16, 1425-1442. doi: http://dx.doi.org/10.1175/JHM-D-14-0158.1.

Dirmeyer, P.A., and S. Halder, 2016. Sensitivity of surface fluxes and atmospheric boundary layer properties to initial soil moisture variations in CFSv2. *Weather Forecast.*, 31, 1973-1983. doi: 10.1175/WAF-D-16-0049.1.

Haughton, N., G. Abramowitz, A.J. Pitman, D. Or, M.J. Best, H.R. Johnson, G. Balsamo, A. Boone, M. Cuntz, B. Decharme, P.A. Dirmeyer, J. Dong, M. Ek, Z. Guo, V. Haverd, B.J. van den Hurk, G. S. Nearing, B. Pak, C. Peters-Lidard, J.A. Santanello Jr., L. Stevens and N. Vuichard, 2016. The plumbing of land surface models: Why are models performing so poorly? *J. Hydrometeorol.*, 17, 1705-1723. doi: 10.1175/JHM-D-15-0171.1.

Lawrence, D.M., G.C. Hurtt, A. Arneth, V. Brovkin, K.V. Calvin, A.D. Jones, C.D. Jones, P.J. Lawrence, N. de Noblet-Ducoudre, J. Pongratz, S.I. Seneviratne and E. Shevliakova, 2016. The Land Use Model Intercomparison Project (LUMIP) contribution to CMIP6. Rationale and experimental design. *Geosci. Model Dev.*, 9. doi: 10.5194/gmd-9-2973-2016.

Tawfik, A.B., P.A. Dirmeyer and J.A. Santanello, 2015. The Heated Condensation Framework. Part I: Description and Southern Great Plains Case Study. *J. Hydrometeorol.*, 16, 1929-1945. doi: http://dx.doi.org/10.1175/JHM-D-14-0117.1.

van den Hurk, B. et al., 2016. LS3MIP (v1.0) contribution to CMIP6: the Land Surface, Snow and Soil moisture Model Intercomparison Project–aims, setup and expected outcome. *Geosci. Model Dev.*, 9, 2809–2832, *http://www.geosci-model-dev.net/9/*. doi: 10.5194/gmd-9-2809-2016.

2nd INARCH Workshop

17–19 October 2016
Grenoble, France

John Pomeroy[1], Vincent Vionnet[2] and INARCH Colleagues

[1]Centre for Hydrology and Global Institute for Water Security, University of Saskatchewan, Canada; [2]Snow Research Center, CNRM, Météo France/CNRS, Saint Martin d'Hères, France

The International Network for Alpine Research Catchment Hydrology (INARCH) is a crosscutting project of the GEWEX Hydroclimatology Panel (GHP) and its objectives are 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? (5) How do transient changes in perennial snowpacks, glaciers, ground frost, soil stability and vegetation impact alpine water and energy models?

INARCH has a network of well-instrumented mountain research basins that INARCH members maintain. All of these research basins have hydrometeorological, cryospheric and hydrological observations at multiple scales over multiple years and some have snow, glacier, hydrological and atmospheric models run at various scales. Observations are embedded near the headwaters of larger river basins that supply water for vast downstream populations. The following figure shows a map of INARCH mountain research basins. Mount Lebanon has been proposed as a new research basin.

INARCH has linkages to GHP crosscutting projects on precipitation phases and mountain precipitation, as well as to the Changing Cold Regions Network (CCRN), a Regional Hydroclimate Project. INARCH is seeking stronger connections with the Global Cryosphere Watch and the World Meteorological Organization Solid Precipitation Intercomparison Experiment (WMO-SPICE) and the Third Pole Environment (TPE) initiative. INARCH contributes to the UNESCO-International Hydrological Programme (IHP) efforts to gauge climate change impacts on snow, glaciers and water resources within the framework of the IHP-VIII (2014-2021), and has linkages with the International Commission for Snow and Ice Hydrology (IAHS-IUGG). INARCH also contributes to the Mountain Research Initiative led from Bern, Switzerland.

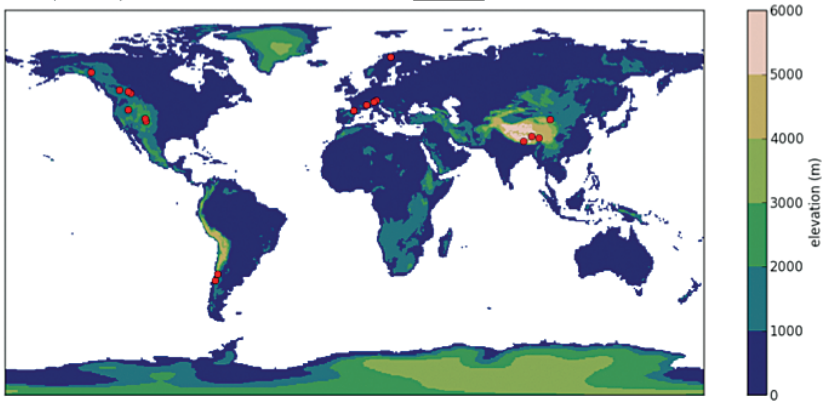
Over the last two years, INARCH has contributed to several conferences and workshops, such as the 2015 American Geophysical Union Fall Meeting, where INARCH organizers chaired an oral and poster session on Improved Understanding and Prediction of Mountain Hydrology through Alpine Research Catchments. INARCH also participated in the WCRP International Conference on Regional Climate, CORDEX 2016, with a presentation by Richard Essery (UK) on observations and downscaling for alpine hydrological modeling and through several other INARCH participants, including Ethan Guttman (USA), Kabir Rasouli (Canada) and Deborah Verfaillie (France). John Pomeroy gave a general presentation on INARCH at the 6th Third Pole Environment Workshop and Joseph Shea, Maxime Litt (Nepal) and Walter Immerzeel (The Netherlands) gave talks or poster presentations.

An INARCH special issue in *Journal of Earth System Science Data* is now open for submissions until 30 September 2017 on the topic of "hydrometeorological data from mountain and alpine research catchments." Contributions from openly available, detailed meteorological and hydrological observational archives from long-term research catchments at high temporal, well-instrumented mountain regions around the world are being prepared and at least 16 submissions are expected from the INARCH Project by the special issue co-editors, John Pomeroy (Canada) and Danny Marks (USA).

The 2nd INARCH Workshop was held at the Institut des Géosciences de l'Environnement (IGE) in Grenoble, France, and provided an opportunity for scientists to explore and discuss specific issues in mountain snow and ice hydrology

INARCH: International Network for Alpine Research Catchment Hydrology

Canada – Canadian Rockies, BC & Yukon;
USA – Reynolds Creek, ID; Dry Creek, ID; Senator Beck, CO, Niwot Ridge, CO.
Chile - Upper Maipo & Upper Diguillín River Basins, Andes,
Germany – Schneefernerhaus & Zugspitze;
France – Arve Catchement, Col de Porte & Col du Lac Blanc;
Switzerland – Dischma & Weissfluhjoch;
Austria - OpAL Open Air Laboratory, Rofental
Spain – Izas, Pyrenees;
China – Upper Heihe River, Tibetan Plateau,
Nepal – Langtang Catchment, Himalayas
Sweden – Tarfala Research Catchment



Current INARCH mountain research basins.

highlighted in the first INARCH workshop held in October 2015. Sixty scientists from the USA, Canada, Chile, China, France, UK, Switzerland, Austria, Germany, Italy, Lebanon and Norway attended the workshop. The Local Organizing Committee of Vincent Vionnet [Météo France, Centre National de Recherches Météorologiques-Centre d'Etudes de la Neige (CNRM-CEN)], Isabella Zin (IGE), Jean-Emmanuel Sicart (IGE) and Delphine Six (IGE) arranged the workshop and a field tour to the nearby Mount Blanc area.

The workshop focused on the following topics: (i) atmospheric downscaling for mountain snow and ice hydrology modeling; (ii) availability and suitability of observations from mountain observatories and discussion of the INARCH special issue; and (iii) sensitivity of the cryospheric and hydrological response of mountain catchments to various representations of a changing climate.

The workshop fieldtrip visited research sites in the Aiguille du Midi (3842 m), near Chamonix. Christian Vincent (IGE) described the scientific activities of the CryObs-Clim Observing System, Thomas Condom (IGE) outlined the experimental rain gauge network and related scientific activities, and Florence Naaim Bouvet (IRSTEA) presented the Taconnaz avalanche path and associated protection. The group visited the Le Tour hydrometric station and learned about snow measurement techniques and hydrological issues in the Alps (Vincent Vionnet, Samuel Morin and Isabella Zin). At the confluence of the Arve and Arveyron d'Argentière, they were shown flood defenses, saw the sediment transport station at Pont des Favrands and heard about water quality issues.

The 2nd INARCH workshop had 42 oral and poster presentations covering high mountain environments from North and South America, Africa, Europe and Asia. The topics covered downscaling meteorological models for mountain snow and ice hydrology, modeling the cryospheric and hydrological response of mountain catchments under present and future climate and mountain observatories and links between INARCH and other research programs. Discussions on downscaling, observatories and future directions are summarized next.

Downscaling Discussion

The discussion focused on developing a toolbox or set of guidelines for downscaling. It was agreed that the product should be end user specific (e.g., operational forecasts, 1-3 month water supply forecasts and climate predictions) and the role of statistical versus dynamical methods for various end uses was discussed, including what tools are suitable for each use case. Reoccurring downscaling topics discussed include the following:

- Statistical downscaling of larger-scale regional climate models (RCMs) may be unsuitable for driving physically based snow models where co-occurrence of wind, humidity, temperature and radiation fields with precipitation events control snow regimes, precipitation phase, blowing snow and melt.

- Atmospheric model failure. INARCH recognizes the need for carefully applied bias corrections, but promotes the improved physical representation of atmospheric models in mountain environments. INARCH will interact with the atmospheric modeling community to make its members aware of performance issues in mountain environments. INARCH will promote the assimilation of mountain observations in atmospheric models and the use of mountain data sets in assessing model performance through multi-objective analysis.

- Physical models are never perfect. INARCH can quantify the impact of resolution increase on predicted surface variables (i.e., the diurnal temperature and precipitation cycle). The project will promote dynamical downscaling of atmospheric models but will assist in developing empirical, statistical or simpler dynamical downscaling at scales less than several kilometers.

- Ask questions that Global Climate Model (GCM) and RCM tools can answer. (Just because we want it doesn't mean we can have it.) What is the appropriate scale for evaluation of models given our catchment scales?

Participants at the 2nd INARCH Workshop.

- Specify the questions we ask of GCM and RCM models based on results from our snow and ice models and sites. What is the likelihood of warming and precipitation change that will cause a certain result?

- Ensure that RCMs better incorporate land surface feedbacks in mountain regions and test using observatories.

Observatories Discussion

It was agreed that INARCH sites are valuable for climate change documentation and model verification. The discussion was centered around the following questions.

- How do measurement standards affect scientific findings? The transition from point to continuous spatial measurements opens up new dimensions.

- How do changing atmospheric dynamics affect mountain snow and ice hydrology?

- How well do improved model physics represent mountain snow and ice hydrology and what is the global validity of snow and ice hydrology models?

- Do uncertainties overwhelm models?

- What is the role of transient change in vegetation and the storage of water, snow and ice in enhancing or dampening climate impacts?

- Are INARCH sites valuable for GCM and RCM intercomparison studies? Data sets need to be published (DOI) and well documented on the INARCH website.

One outcome from the discussion was that the Project should compile data for model testing of the sensitivity of snow and ice to climate change in various alpine climates. Models driven by perturbed meteorological observations can be used to do this via virtual basins and mountains. Comparisons, such as the North American Cordillera and Mediterranean, are underway.

Future Directions

The *ESSD* special issue on INARCH will continue to receive submissions until September 30th. Other journals will be approached for a special INARCH issue on mountain snow and ice hydrology that includes references to downscaling, processes and diagnosis of climate change impacts. Updates to the INARCH website (*http://www.usask.ca/inarch/)* will include a downscaling toolbox with a link to methods, as well as metadata for catchments and links to DOI data. A technical document is planned with UNESCO on "Best Practices in Instrumenting Mountain Research Catchments," as is a policy-relevant publication with UNESCO on "Risks to World Water Security from Changing Mountain Snow and Ice Hydrology."

The workshop concluded with a formal statement highlighting the upcoming special issue and the development of the downscaling toolbox for the INARCH website, as well as attempts by INARCH to calculate the impacts of climate change on mountain hydrology sensitivity, transient vegetation cover and hydrological and cryospheric storage.

3rd National OzEWEX Workshop

14–15 December 2016
Canberra, Australia

Simon Walker[1], Seth Westra[2] and Albert VanDijk[1]
[1]The Australian National University College, Canberra, Australia; [2]The University of Adelaide, Adelaide, Australia

The 3rd National Australian Water and Energy Exchange Research Initiative (OzEWEX) Workshop was held at the Australian National University in Canberra. Scientists and policy makers from Australian universities, government and private sectors attended the workshop. OzEWEX is an Initiating-phase GEWEX Regional Hydroclimate Project.

Prof. Albert van Dijk, OzEWEX Chair, opened the workshop and introduced the new OzEWEX Co-Chair, Assoc. Prof. Seth Westra from the University of Adelaide. Prof. van Dijk presented an overview of new OzEWEX initiatives, including a community data catalogue (*http://ozewex.org/data-set-catalogue/*) and the Australian Climate and Water Summer Institute (*http://ozewex.org/first-ozewex-summer-institute/*). The OzEWEX submission to the National Research Infrastructure Roadmap was discussed, including the need to maintain and strengthen national collaboration, data and model infrastructure.

Prof. Andy Pitman of the University of New South Wales discussed the potential for broader collaboration in Australia across climate, hydrology and land surface sciences and how these research fields can do more to attract funding. Dr. Richard Thornton and Dr. Michael Rumsewicz from the Bushfire and Natural Hazards Cooperative Research Centre then gave a talk on the importance of connecting applied research with policy decision-making and converting it into action.

The first of two parallel sessions for day one of the workshop was entitled "Observation networks and enhancing data sharing" and included talks on topics such as a network for observing surface fluxes of water and carbon across Australia and national computational infrastructure data collections. The second parallel session focused on "Community modeling and data assimilation systems," and included a project proposal by Dr. Martin DeKauwe (Macquarie University) on how continental-scale vegetation models could be improved through a better understanding of the behavior of Australian Eucalypts.

Mr. Nadeem Samnakay (Murray-Darling Basin Authority) talked about the importance of community collaboration in environmental decision-making. Dr. Pauline Grierson from the University of Western Australian presented the unique hydrology of the Pilbara region in Western Australia and how modern observations (under 100 years) often do not capture the full range of variability in the system (e.g., severe extremes that are seen in the geologic record).

On the second day of the workshop, Prof. Rob Vertessy (University of Melbourne/Australian National University) talked about the strengths of collaborative science research collectives,

Valentin Heimhuber receiving the MSSANZ student poster prize from MODSIM president Dr. David Post.

and the potential for OzEWEX to help in facilitating scientific collaboration in Australia. Dr. Helen Cleugh (Commonwealth Scientific and Industrial Research Organization) discussed the importance of understanding how different components of the Earth system will likely respond to a changing climate and what Australia could do to ensure it is prepared for this.

The first parallel session of the second day was devoted to collaborative research that addresses Australia's climate and water challenges. The session also included two project proposals. The first proposal was presented by Dr. Anthony Kiem of Newcastle University who outlined the need for the collection and analysis of more paleoclimate data across the Australian continent. Dr. Michael Leonard of the University of Adelaide proposed a framework for identifying compound events to assist in planning and decision-making related to climate change. The second parallel session concerned unified and diversified streamflow prediction and presented the latest methods and techniques for modeling a range of hydrological processes.

Poster sessions sponsored by the Modeling and Simulation Society of Australia and New Zealand (MSSANZ) were held during lunches. The winner of the 2016 MSSANZ Student Poster Prize was Valentin Heimhuber (University of New South Wales) for his poster on the use of satellite data for assessing environmental flows.

All in all, the workshop was a great success and we look forward to a productive year for OzEWEX in 2017. Below is the summary of the first OzEWEX Summer Institute.

Australian Climate and Water Summer Institute

OzEWEX ran its first Australian Climate and Water Summer Institute from 5 December 2016 to 20 January 2017. This event provided a fellowship grant to a select number of the best students in Australia, giving them a unique opportunity to work closely with peers and experts from academia and government agencies to enhance climate and water information and its practical applications. The program involved a two-week "boot camp" followed by four weeks of project planning and implementation. During the boot camp, participants visited various government agencies to attend talks and receive training in the most up-to-date data and tools used in Australian climate and water science. Following two weeks of excursions and training, participants then self-organized into small groups to develop projects across four broad themes:

- Drought Assessment—spatially measuring water resources and the environmental and agricultural impacts of drought
- Water Sharing and Environmental Flows—water use and the benefits of environmental flows across the Murray-Darling Basin at present and under future scenarios
- Flood Risk and Emergency Response—spatial flood risk mapping and prediction from remote sensing and the national Digital Elevation Model (DEM), routing river flows at the national scale
- Water Cycle Data Integration—new observation networks and remote sensing, data discovery and data assimilation

Under these themes, students were encouraged to pursue ambitious ideas towards new applications of climate and water data to better assist decision-making. Through presentations, the students were given full insight into topics ranging from environmental flows to cyclone risk assessment, and from seasonal streamflow forecasting to drought impacts.

Among the many highlights from the first Summer Institute were the opportunities to hear about the latest research from government agencies. For example, Dr. David Weldrake (Murray-Darling Basin Authority) showed how the MDBA has used Geoscience Australia's Water Observations from Space (WOfS) product alongside river gauge data to estimate the relationship between river flow and flood plain inundation across various regions of the Murray-Darling Basin.

Participants were also provided opportunities to apply some of the latest tools and data sets currently used by Australian government agencies in decision-making for climate and water issues. Finally, the Institute allowed these young scientists to build connections with senior researchers in the Australian climate and water research space.

Thanks to the great attitude of the fellows and the generous assistance of the Summer Institute Consortium of government and research organizations and their staff, the very first OzEWEX Summer Institute was a resounding success.

The alumni of the 2016/2017 Australian Climate and Water Summer Institute.

GEWEX/WCRP Calendar

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

20–22 March 2017—3rd PannEX Workshop—Cluj, Romania

28–29 March 2017—GEWEX Upper Tropospheric Clouds and Convection Process Evaluation Study Meeting—New York, NY, USA

29–31 March 2017—Joint ESA-Baltic Earth Workshop on Remote Sensing Applications in the Baltic Sea region—Helsinki, Finland

31 March 2017—GABLS Meeting—Delft, The Netherlands

31 March–7 April 2017—Arctic Science Summit Week 2017— Prague, Czech Republic

2–6 April 2017—Aerosols, Clouds, Precipitation and Climate (ACPC) Workshop—Bad Honnef, Germany

3–7 April 2017—38th Session of WCRP Joint Scientific Committee—Paris, France

18–21 April 2017—Third A-Train Symposium—Pasadena, CA, USA

23–28 April 2017—EGU General Assembly 2017—Vienna, Austria

2–4 May 2017—Climate Prediction Application Science Workshop 2017—Anchorage, AK, USA

15–16 May 2017—GLASS Meeting—Tokyo, Japan

15–19 May 2017—Workshop on Frontiers in Ocean-Atmosphere Exchange: Air Sea Interface and Fluxes of Mass and Energy—Cargèse, France

16–19 May 2017—Hydrology Delivers Earth System Sciences to Society (HESSS4)—Tokyo, Japan

17–19 May 2017—Global Soil Wetness Project-3 (GSWP3)–Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) Workshop—Tokyo, Japan

20–25 May 2017—Joint Japan Geoscience Union–American Geophysical Union Meeting—Tokyo, Japan

6–8 June 2017—Clouds, their Properties and their Climate Feedbacks-What have we learned in the satellite era?—New York, NY, USA

19–23 June 2017—5th WGNE Workshop on Systematic Errors in Weather and Climate Models—Montreal, Canada

22–23 June 2017—8th GTN-H Coordinating Panel Meeting—Montreal, Canada

22–23 June 2017—13th GRDC Steering Committee Meeting—Koblenz,
Germany

27–29 June 2017—4th International Conference on Energy and Meteorology—Bari, Italy

4–7 July 2017—10th HyMeX International Workshop—Barcelona, Spain

10–12 July 2017—TPE-CSTP-HKT Joint Conference—Kunming, China

10–14 July 2017—International WCRP/IOC Conference on Regional Sea Level Changes and Coastal Impacts—New York, NY, USA

10–14 July 2017—Workshop on the Future of Cumulus Parameterization—Delft, The Netherlands

18 July 2017—SMAP Weather Focus Session—Moss Landing, CA, USA

19 July 2017—1st International Surface Work Group Meeting—Monterey, CA ,USA

10–24 August 2017—7th International Workshop on Catchment Hydrological Modeling and Data Assimiliation (CAHMDA-VI)—Xi'an Shanxi, China

28 August September 2017—38th Conference on Radar Meteorology—Chicago, IL, USA

11–14 September 2017—5th iLEAPS Science Conference—Oxford, UK

18–22 September 2017—COSPAR 2017—Jeju, Republic of Korea

25–28 September 2017—CFMIP Meeting on Clouds, Precipitation, Circulation, and Climate Sensitivity—Tokyo, Japan

9–13 October 2017—GHP-TPE Workshop—Kathmandu, Nepal

9–13 October 2017—WGNE-32—Exeter, UK

25–26 October 2017—7th GVAP Workshop—Leicester, UK

13–17 November 2017—5th International Conference on Reanalysis (ICR5)—Rome, Italy

13–16 November 2017—IWA World Water Congress and Exhibition—Buenos Aires, Argentina

GEWEX NEWS

Published by the International GEWEX Project Office

Peter J. van Oevelen, Director
Dawn P. Erlich, Editor
Shannon F. Macken, Assistant Editor

International GEWEX Project Office
c/o USRA
425 3rd Street SW, Suite 940
Washington, DC 20024 USA

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