GEWEX NEWS

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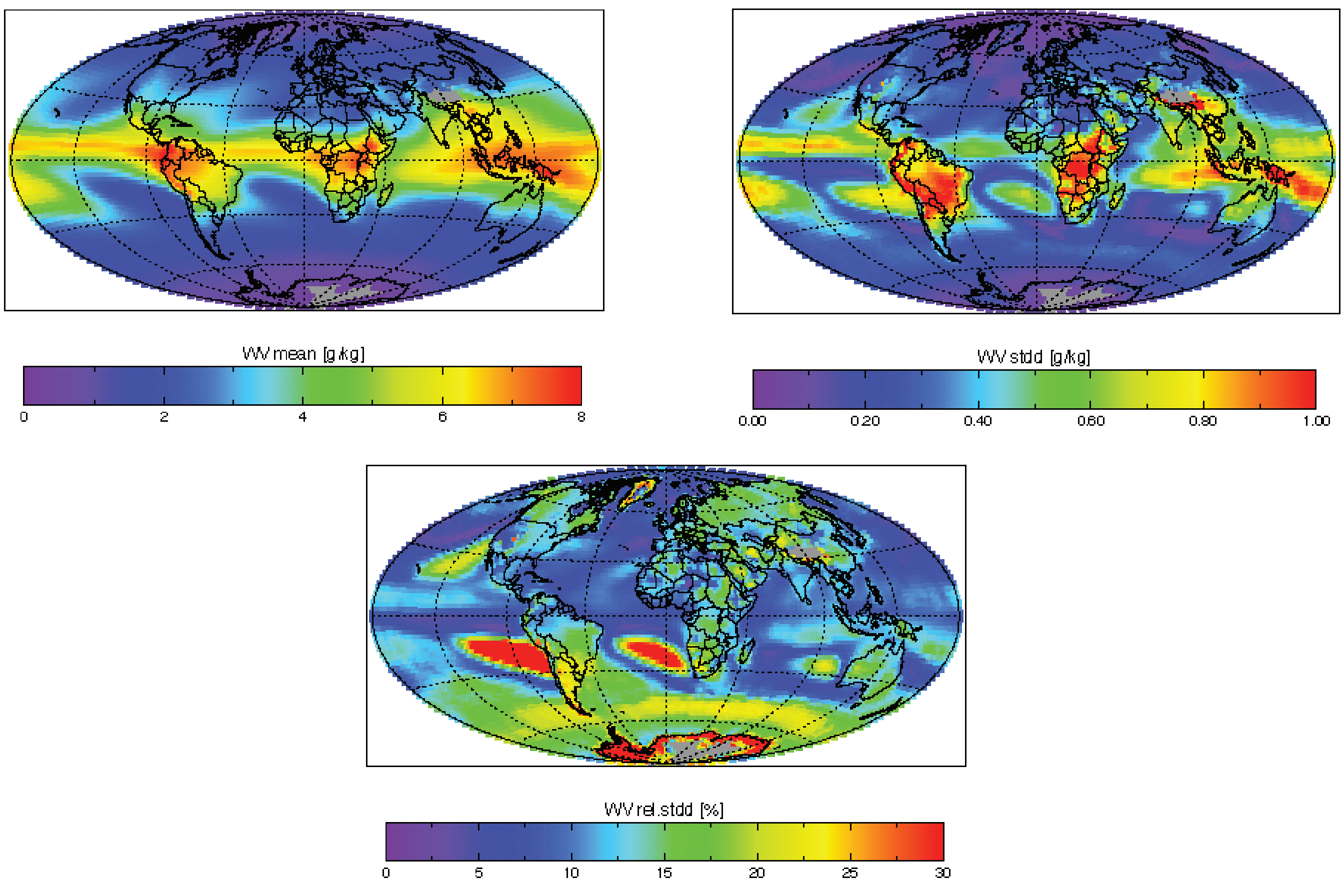
GEWEX Water Vapor Assessment Shows Need for Enhanced Analysis of Stratus Regions



Intercomparison of specific humidity at 700 hPa based upon a common period (1988–2009) and grid (2° longitude and latitude) of five long-term data records. Ensemble mean (top left panel), standard deviation (top right panel) and relative standard deviation (bottom panel). Maxima in differences are found over South America, Central Africa, the poles and off the coast of South America and South Africa in the stratus/subsidence regions. Regionally averaged profiles in the stratus regions and the representation of the top of the planetary boundary layer is obviously different between the data records. See the GEWEX water vapor assessment meeting report by Marc Schröder et al. on page 8.

Also Inside

Commentary

We Still Do Not Understand Our Climate Well Enough!

Peter van Oevelen
Director, International GEWEX Project Office

This month brought forward surprising and disturbing news from Australia, where the Commonwealth Scientific and Industrial Research Organization (CSIRO) is gutting its Climate Division, and over 300 scientists may lose their jobs. This is not a small number, even in the context of scientists worldwide who are working on fundamental climate issues. The rationale behind the decision by CSIRO appears to be related to a shift in focus from understanding our climate and climate change to climate adaptation and mitigation. This is a short sighted and ill-informed decision for two main reasons. First, we do not understand our climate system well enough in a holistic and integrated sense as part of the Earth system. More importantly, the specific drivers of climate change, including the anthropogenic effects, are still not understood. Secondly, we need greater comprehension of the specific drivers than we have now to effectively adapt to or mitigate the effects of climate change. Although many climate scientists do not like to bring up geo-engineering because of this, it is exactly the reason why we should. Without a better understanding of the geophysics and biochemistry involved, the implications of adaptation, and in particular, mitigation measures, can range from being non-effective to catastrophic. I hope that the climate community at large supports our colleagues in Australia and elsewhere where similar sentiments are emerging.

On a different topic, the 28th meeting of the GEWEX Scientific Steering Group (SSG) was recently hosted by our SSG co-chair Sonia Seneviratne at the Swiss Federal Institute of Technology in Zürich (ETHZ). I thank ETH and in particular Sonia and her staff for their excellent support.

The meeting began with presentations from the SSG co-chairs on the state and direction of GEWEX. Two new SSG members were welcomed, Dr. Nathalie de Noblet-Ducoudré (France) and Dr. German Poveda (Colombia, who unfortunately could not attend). Drs. Siegfried Schubert (USA), Paul Poli (France), Xin Li (China) and Minghua Zhang (USA) have completed their terms on the SSG and were thanked for their guidance and expertise. New members will be confirmed after the World Climate Research Programme (WCRP) Joint Scientific Committee (JSC) meeting on April 25–26.

The majority of main GEWEX activities are in very good shape; however, there is an issue related to the leadership and continuation of the Global Atmospheric System Studies (GASS) Panel. Details of the implementation plan for the WCRP Grand Challenge on Changes in Water Availability are being honed and will be presented at the JSC meeting in April. The scientific presentations by the GEWEX Panels showed the incredible breadth and depth of their activities. In particular, the GEWEX Hydroclimatology Panel (GHP) is well on track after its reorganization in 2010–2012. Several new Regional Hydroclimate Projects (RHPs) have been initiated (Hydrology of the Lake Victoria Basin in Africa, HyVic, and the Australian Energy and Water Exchanges, OzEWEX), as well as new crosscutting activities such as mountain snow and ice hydrology and atmospheric interactions (Alpine Research Catchment Hydrology, INARCH) and sub-daily precipitation (INTENSE). New initiatives include alpine precipitation (MOUNTerrain) and the incorporation of the human dimension in land-atmosphere and hydrological modeling, in collaboration with the Global Land Atmosphere Panel (GLASS). A special thank you goes to Dr. Jan Polcher, whose term as co-chair of GHP is ending this year. He will be succeeded by Dr. Joan Cuxart, whom we warmly welcome. Jan has been involved in GEWEX in one capacity or another for 20 years, and we are very grateful for his amazing efforts and hope that he will continue to be engaged in GEWEX activities.

The other GEWEX panels are successfully continuing their efforts and at this meeting in particular, the cross collaboration activities were discussed between the the panels and other programs. For example, the collaboration with the integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) has strengthened, and to highlight the importance of this, a memorandum of understanding was signed by the leadership of WCRP and iLEAPS. Furthermore, activities such as the Monsoon Panel, a joint project with CLIVAR, warrants further attention, as developing a coherent "transboundary" monsoon science-driven activity continues to be challenging.

Overall, the SSG meeting proved to be very successful and we can look to the future with confidence.

Contents

New GEWEX 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/.*

Nathalie de Noblet-Ducoudré

Dr. de Noblet-Ducoudré is a research scientist at the Laboratoire des Sciences du Climat et de l'Environnement. Her research interests are biosphere and atmosphere interactions; the role of land dynamics in the climate system (managed ecosystems and natural dynamical behavior; wetlands), modeling terrestrial ecosystems; and interactions between climate, managed ecosystems, and socio-ecological systems.

Germán Poveda

Dr. Poveda is a professor in the Department of Geosciences and Environment at the Universidad Nacional de Colombia in Medellín, Colombia. His research interests are land surface-atmosphere-ocean feedbacks, climate variability and climate change in the tropical Americas, multiscale processes in hydrology, and linkages between climate change and human health.

MERRA-2 Data Set Now at the GES DISC

The NASA Global Modeling and Assimilation Office and the Goddard Earth Sciences Data and Information Services Center have a new version of the Modern Era Retrospective-analysis for Research and Analysis data set (MERRA-2).

MERRA-2 includes the use of observation-based precipitation data as forcing for the land surface parameterization. The data set also includes the assimilation of aerosol information based upon the off-line "MERRAero" data set that was integrated using meteorological fields from MERRA. The MERRA-2 aerosol variables are included in additional file collections. MERRA-2 also includes a mass balance over glaciated land surfaces and several surface variables have additional daily statistics written in a separate file collection.

More detailed information on MERRA-2, including documentation and access to data and services, is available at: *http://disc.sci.gsfc.nasa.gov/datareleases/merra_2_data_release.*

Ocean Salinity and the Water Cycle: Recent Progress and Future Challenges

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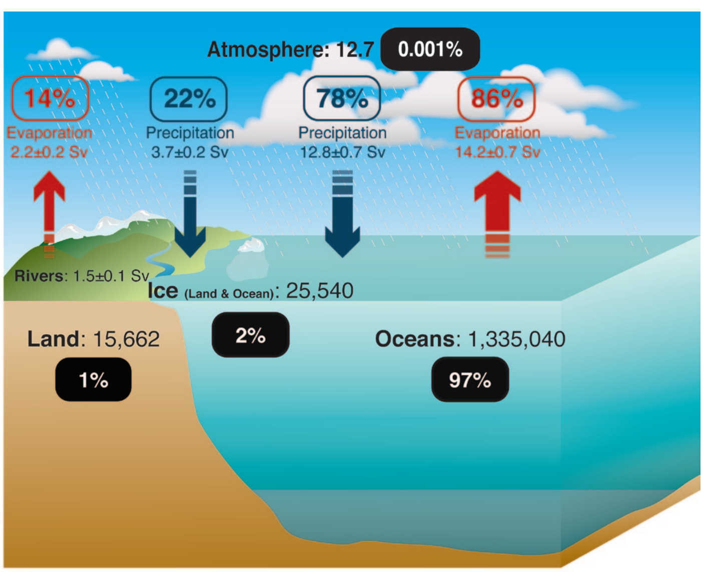
The exchange of freshwater between the ocean, land and atmosphere—the global water cycle—is one of the fundamental cycles of the Earth's climate system. It is necessary for life and hence of prime significance to our existence. The recent alteration of the global water cycle related to climate change has already had serious consequences on the environment, economy and society (Huntington, 2006; Zhang et al., 2007; Willett et al., 2007). These changes are manifested as extremes such as droughts, heavy rainfall and floods that claim thousands of lives and cause billions of dollars of damage annually (Gillings and Hagan-Lawson, 2014). Today 80% of the global population is at risk of shortages in freshwater due to changing precipitation patterns and depletion of freshwater reservoirs (Vorosmarty et al., 2010). Water availability is projected to become scarcer over the next few decades (Arnell et al., 2013). Predicting the changes in the Earth's water budget is therefore crucial to stakeholders and policymakers who must make informed decisions in water and energy management, agriculture, urban development and infrastructure.

Although it is common to focus on the terrestrial element of the water cycle, the largest reservoir of the world's water supply is the ocean, which is about 97% of the Earth's water. The ocean supplies more than 75% of the evaporated and precipitated water in the global water cycle (Schmitt, 2008; Gimeno et al., 2012; Rodell 2015—see figure on page 4). Clearly, to successfully predict the future of the global water cycle, we need to understand the changes in its largest component—freshwater in the oceans, including its storage and transport, as well as exchanges with the atmospheric, terrestrial and cryospheric elements of the water cycle. Building upon discussions from a workshop held in October 2015 in Hamburg, Germany (*https://for1740.zmaw.de/Salinity-and-Freshwater-Changes-in-the-Ocean-Con.3078.0.html*), the following is a brief overview of the consensus of the research community on the oceanic water cycle and its key variables.

One of the challenges in characterizing the amount of freshwater entering the ocean via precipitation and river runoff or leaving the ocean via evaporation is the difficulty in directly measuring these fluxes. Current estimates of air-sea freshwater fluxes suffer from large uncertainties both on regional and global scales (Josey et al., 2013). One way to improve the estimates of oceanic freshwater fluxes is to use variations in ocean salinity as an additional constraint, given salinity's sensitivity to the transport of freshwater in and out of the ocean and availability of accurate salinity measurements over the globe. By definition, the rate of salinity change is maintained by a balance between forcing, such as surface freshwater fluxes (as well as river runoff and sea ice melt/freeze), and oceanic advective and diffusive salt fluxes, associated with ocean currents and mixing. Generally, ocean fluxes are very effective in compensating for the changes imposed by the atmospheric freshwater flux; thus, a more promising way to infer meaningful estimates of surface fluxes is to combine salinity variations in conjunction with ocean fluxes using the salinity equation (Vinogradova and Ponte, 2013; Köhl et al., 2014). However, on sufficiently long time scales (e.g., 30+ years) and large spatial scales (e.g., greater than 1000 km), changes in surface salinity can potentially be used as a direct proxy of the changing water cycle, including its amplification in a changing climate (Pierce et al., 2012; Durack et al., 2012; Skliris et al., 2014; also Vinogradova and Ponte, 2013 for review). Further investigation is needed to determine whether there are other time scales, spatial scales or regions where salinity can be used as an effective indicator for changes in the water cycle.

Recent use of salinity as an indicator to monitor the water cycle and ocean circulation was made possible by advances in the salinity observing system. Although research cruises have been collecting salinity data since the nineteenth century, only recently has the research community been able to have a broad synoptic view of global salinity fields from three-dimensional sampling by the network of Argo arrays. This network has provided near-global coverage since 2005 (Roemmich et al., 2009) and global high resolution spaceborne measurements of sea-surface salinity derived from the NASA Aquarius/SAC-D



Water cycle schematic: reservoirs are represented by solid boxes (10^3 km^3), fluxes are represented by arrows. 1 Sv=10^6 m^3/s. Sources: Baumgartner and Reichel (1975), Schmitt (1995), Trenberth et al. (2007), Schanze et al. (2010), Rodell et al. (2015). Graphics by Paul Durack.

mission (2011–2014; Lagerloef, 2012), the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission (2009–present; Reul et al., 2014) and the Soil Moisture Active Passive (SMAP) mission; launched in January 2015. In addition to sea-surface-salinity measurements with high spatial and temporal resolution, oceanographers are now able to use new tools to understand salinity variability in the upper few meters of the oceans (Ward et al., 2014) in order to monitor air-sea interaction and close the gap between satellite and in situ measurements.

As a result of this progress in the observing system, a tremendous number of studies have emerged, transforming our understanding of the ocean water cycle, heat and freshwater transports, and their coupling to the ocean and climate system. Collectively, the research community has identified a number of new frontiers in the field of ocean salinity, including the use of salinity as a predictor of rainfall in various terrestrial regions; constraining fluxes of carbon dioxide (Salisbury et al., 2015), ocean heat and freshwater (Köhl et al., 2014; Vinogradova et al., 2014) and transport of atmospheric moisture (Liu and Tang, 2005); and monitoring river plumes, tropical storms and high wind events. The importance of salinity has been emphasized in a wide range of processes affecting ocean dynamics, including changes in sea level height (Llovel and Lee, 2015; Durack et al., 2014), inter-ocean water exchange (Gordon et al., 2015), propagation of the planetary and tropical instability waves (Lee et al., 2012) and mesoscale variability in ocean fronts (Kao and Lagerloef, 2015) and eddies (Bryan and Bachman, 2015).

The general consensus of the ocean research community is that there is strong evidence of changes in the ocean water cycle over the period of observational coverage (see figure on next page). The ocean water cycle is projected to continue its amplification in a warming world, and ocean salinity is an essential independent variable that can be used to monitor and understand these changes. The main recommendation is thus not only to maintain, but also to enhance the existing remote and in situ water cycle observing systems. For the ocean monitoring components, this can be achieved by increasing measurement resolution, accuracy and coverage, especially in near-coastal and high-latitude regions, and by including satellite measurements of all key components of the global water cycle, such as ocean salinity, soil moisture, mass/gravity, precipitation, atmospheric water vapor and cryospheric observations. The next challenge is to reconcile available information across the broad water cycle research community, and to strengthen the crosscutting research efforts that link the oceanic, atmospheric and terrestrial components of the global hydrological cycle, using a synergistic approach to couple it with other fundamental Earth cycles, such as energy and carbon.

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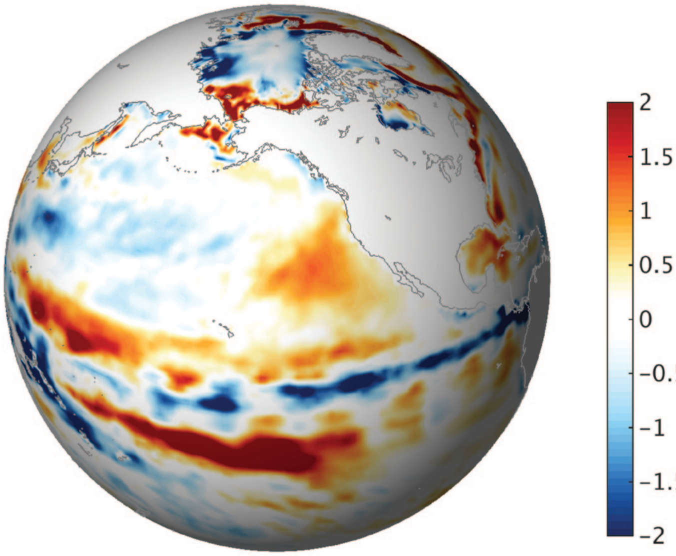

Changes in freshwater over the oceans—surface heat flux and freshwater flux (E-P-R)—in the last two decades (mm/d) based on Estimating the Circulation and Climate of the Ocean (ECCO) ocean state estimation (Forget et al., 2015). The blue (negative) values imply that since 1993, the ocean is getting more freshwater, while the red (positive) values mean that the oceans are losing freshwater. Notice general "drying" of the subtropics, including the U.S. coast, and "wetting" of the tropics (e.g., Intertropical Convergence Zone, Western Pacific Warm Pool) and parts of the Arctic Ocean. Graphics by Nadya Vinogradova.

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Meeting/Workshop Reports

Land Modeling "LandMIP" Workshop

ETH, Zürich, Switzerland
28–29 October 2015

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In the context of the 6th Phase of the Coupled Modeling Intercomparison Project (CMIP6) that is being planned within the World Climate Research Programme (WCRP), the climate modeling community will conduct several new land-related Model Intercomparison Projects (MIPs), also referred to as "LandMIPs" (Seneviratne et al., 2015). These include the Land Surface, Snow and Soil Moisture MIP (LS3MIP) and the Land Use MIP (LUMIP), both endorsed by the CMIP6 Panel (*www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6*). This represents the first time that dedicated and comprehensive land climate experiments (with offline land and coupled land-atmosphere set-ups) will be conducted within the CMIP framework, in addition to the long-standing Coupled Carbon Cycle Climate Model Intercomparison Projet (C4MIP), which also considers land-related carbon feedbacks (e.g., Friedlingstein et al., 2006). In parallel to these efforts, the Intersectoral Impact MIP (ISI-MIP, *www.isi-mip.org*; e.g., Warzawski et al., 2014) has provided and is presently conducting extensive offline impact model experiments, which share several commonalities with the land models used in Earth system models.

Questions addressed within these land-based experiments are wide-reaching and include:

- What is the the land use change forcing on climate?
- How does the land surface state (soil moisture, snow or vegetation initialization) affect predictability?
- What are the hydrological, terrestrial carbon and surface energy responses and feedbacks to climate change?
- What are the spatial patterns of trends, extremes and impacts?
- How does human interference on the land surface affect these trends and impacts?
- Can we trust, benchmark and improve the models that are used to map these processes?

In preparation for these new modeling initiatives, and to allow coordination of the respective experimental set-ups, a dedicated GEWEX and Climate and Cryosphere (CliC) Project-sponsored Land Modeling "LandMIP" workshop was organized at ETH Zürich (*http://iacweb.ethz.ch/events/landmip/programme.html*). This workshop provided for the first time an interface between the broad spectrum of land modeling communities involved in the LS3MIP, LUMIP and ISI-MIP experiments to foster exchange and develop synergies. It should be noted that these projects themselves build upon several previous and ongoing initiatives, such as the Global Soil Wetness Project (GSWP, Dirmeyer et al., 2006); SnowMIP and SnowMIP2 (e.g., Essery et al., 2009); the Land-Atmosphere Coupling Experiment (GLACE, Koster et al., 2004, 2010); GLACE-CMIP5 (Seneviratne et al., 2013); Land-Use and Climate, IDentification of Robust Impacts (LUCID, Pitman et al., 2009; de Noblet-Ducoudré et al., 2012), LUCID-CMIP5 (Brovkin et al., 2013); WaterMIP (Harding et al., 2011); and Earth System Model SnowMIP (ESMSnowMIP). Representatives of the Global Carbon Project (GCP) Trendy Experiment (Sitch et al., 2015; Le Quéré et al., 2015) and the developers of land reanalysis products and forcing data sets for land modeling experiments also attended the workshop.

One of the main outcomes of the workshop was the identification of the potential for stronger synergies and exchanges between communities that could be fostered through better coordination among projects and common experimental protocols. In particular, in order to allow comparisons across experiments and to have an extensive set of reference experiments within CMIP6, it was agreed that four forcing data sets for historical offline (LMIP) simulations within LS3MIP should be considered for the time period 1901–2012 or later. These are: (i) the GSWP3 (*http://hydro.iis.u-tokyo.ac.jp/GSWP3/*), which is linked to the 3rd Phase of the Global Soil Wetness Project that is coordinated within the GEWEX Global Land-Atmosphere System Study (this forcing data set is also being used by ISI-MIP2); (ii) the merged Climatic Research Unit and National Centers for Environment Prediction atmospheric forcing data set (CRU-NCEP, *http://dods.extra.cea.fr/data/p529viov/cruncep/readme.htm*; see also Wei et al., 2014) to establish a link to the Global Carbon Project, Trendy experiment and C4MIP; (iii) the updated version of the Princeton forcing data set (Sheffield et al., 2006) used in several publications, as well as within ISI-MIP2; and (iv) the WATCH-Forcing-Data-ERA-Interim (WFDEI) data set (Weedon et al., 2014) merged with the WATCH forcing data set over the time period 1901–1978 (Weedon et al., 2011), which is also used by ISI-MIP2.

The comparison of different data sets allows the consideration of uncertainties linked to atmospheric input in the experiments. These can be potentially large (e.g., Sheffield et al., 2012; Trenberth et al., 2014). On the other hand, the forcing data sets are not fully independent, an issue that would also deserve a better assessment in the future.

Additional important outcomes of the workshop include:

- The LMIP simulations coordinated by LS3MIP will serve as a reference for the evaluation of land models used in LUMIP, while offline land modeling experiments with modified land use will be coordinated by LUMIP.

- The spin-up for the carbon cycle in the offline LMIP experiments will follow the LUMIP protocol.
- Added coordination of the CMIP6 output request of the LS3MIP and LUMIP experiments will be fostered.
- Further coordination between the LS3MIP and LUMIP experiments is ensured through the development of the overview articles on these experiments for an upcoming CMIP6 special issue in *Geoscientific Model Development*. Additional exchanges are planned with other CMIP6 experiments, in particular C4MIP and the Detection and Attribution Model Intercomparison Project (DAMIP).
- Important links to the impact community were identified through connections to the ISI-MIP Project (similar set-up, common forcing data sets, some common models). Much can be gained from more intensive collaborations, both with respect to the integration of human water use or agricultural modules in land surface models, as well as regarding the transfer of experience on the experimental design and the relevance of the processing of atmospheric forcing data sets for impact simulations.
- Given the useful exchanges, a possible follow-up LandMIP meeting will be organized in the course of the CMIP6 cycle to present first results and coordinate analyses of the CMIP6 land-based experiments.

Related parallel meetings occuring during the workshop included a short session on the GEWEX SoilWat Initiative (Or et al., 2015) that focused on soil and subsurface modeling, and a back-to-back workshop by the ISI-MIP community on 28–30 October.

The LandMIP workshop illustrated how large and vibrant the research community on land modeling is, especially when the numerous areas it is related to are considered (i.e., encompassing land climate, land cover, land use, hydrological, agricultural and impact modeling). Numerous shared interests and challenges were identified, emphasizing the need for more exchanges across the whole community working in this area.

Acknowledgments

The authors thank CliC and GEWEX for their endorsement and support of the LandMIP workshop, and in particular, Gwenaelle Hamon for her support on the workshop's first version of the web page. Barbara Aellig, Richard Wartenburger, Edouard Davin, Lukas Gudmundsson and Rene Orth coordinated the local organization of the workshop, and Andrea Alessandri, Mathias Hauser, Martin Hirschi, Vincent Humphrey, Quentin Lejeune, Ruth Lorenz, Heewon Moon and Martha Vogel contributed to the meeting logistics and took notes during the workshop.

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5th GEWEX Water Vapor Assessment Meeting

Madison, Wisconsin
4–5 November 2015

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The primary objective of the GEWEX Water Vapor Assessment (G-VAP) is to quantify state-of-the-art water vapor products for use in climate applications, and thus support the selection process of suitable water vapor products to be used by the GEWEX Data and Assessments Panel (GDAP) in the production of globally consistent water and energy cycle products. The G-VAP Plan, science questions and list of available water vapor records are available on the G-VAP website at: *http://gewex-vap.org*.

The 5th G-VAP meeting was hosted by the Space Science and Engineering Center at the University of Wisconsin. Attendees included participants from research institutes and universities (Colorado State University, Freie Universität Berlin, Lille University of Science and Technology, Vanderbilt University, University of Wisconsin), weather services [Agencia Estatal de Meteorología, Danish Meteorological Institute, Deutscher Wetterdienst, U.S. National Oceanic and Atmospheric Administration (NOAA)], the in situ measurement community and space agencies [European Space Agency (ESA), European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)]. Presentations from the meeting and the minutes are available at: *http://gewex-vap.org/?page_id=529.*

During the meeting, results from the last workshop were reviewed and feedback was received from GDAP. There was a discussion of data releases by G-VAP and data sets that are either already used within the assessment or are on the candidate list. Additional data sets were also introduced that had not previously been considered but could still be included. Updates were given on G-VAP activities and related work, together with proposals on how to proceed in finalizing the World Climate Research Programme report on G-VAP. The relevance of information content analysis was emphasized and a proposal on how to consistently handle uncertainties was provided. Highlights of the 183 GHz Workshop held in June 2015 were also presented (see the workshop report in the November 2015 issue of *GEWEX News*). Finally, recommendations, including a new schedule for G-VAP, were presented and discussed.

The figure on page 1 shows results from the intercomparison of specific humidity at 700 hPa from the long-term data records of the U.S. National Climatic Data Center Climate Forecast System Reanalysis (CFSR), the European Centre for Medium-Range Weather Forecast Reanalysis (ERA-Interim), the Japanese 55-year Reanalysis (JRA-55), the Modern-Era Retrospective Analysis for Research and Applications (MERRA) and the nnHIRS reanalysis. The ensemble mean is shown in the top left panel with the standard deviation in the top right panel and the relative standard deviation on the bottom, relative to the ensemble mean. Maxima in differences are found over South America, Central Africa, the poles and off the coast of South America and South Africa, in the stratus/subsidence regions. When looking at regionally averaged profiles in the stratus regions, the representation of the top of the planetary boundary layer is obviously different between the considered data records. Adding Global Positioning System Radio Occultation (GPS-RO) data to the analysis is envisaged, but this will not fully elucidate the true profile due to super refraction. Workshop participants came to the consensus that stratus regions should be a focus for a region of future analysis.

The figure below illustrates extreme precipitation events that are connected to extreme supply in water vapor. Global climate models indicate that the increase in such events will be dramatic (i.e., of the order 10–30% over the next 70 years, depending upon the region). In order to observe such events, the time-to-detect needs to be analyzed. A mandatory input is the uncertainty of the observational data record for the extreme percentile. Uncertainties for the Atmospheric Infrared Sounder (AIRS) and Infrared Atmospheric Sounding Interferometer (IASI) are shown as a function of precipitable water vapor (PWV). The fractional error is a function of PWV. Thus, the time-to-detect for the extremes is significantly larger than in the 25th–75th percentile range.

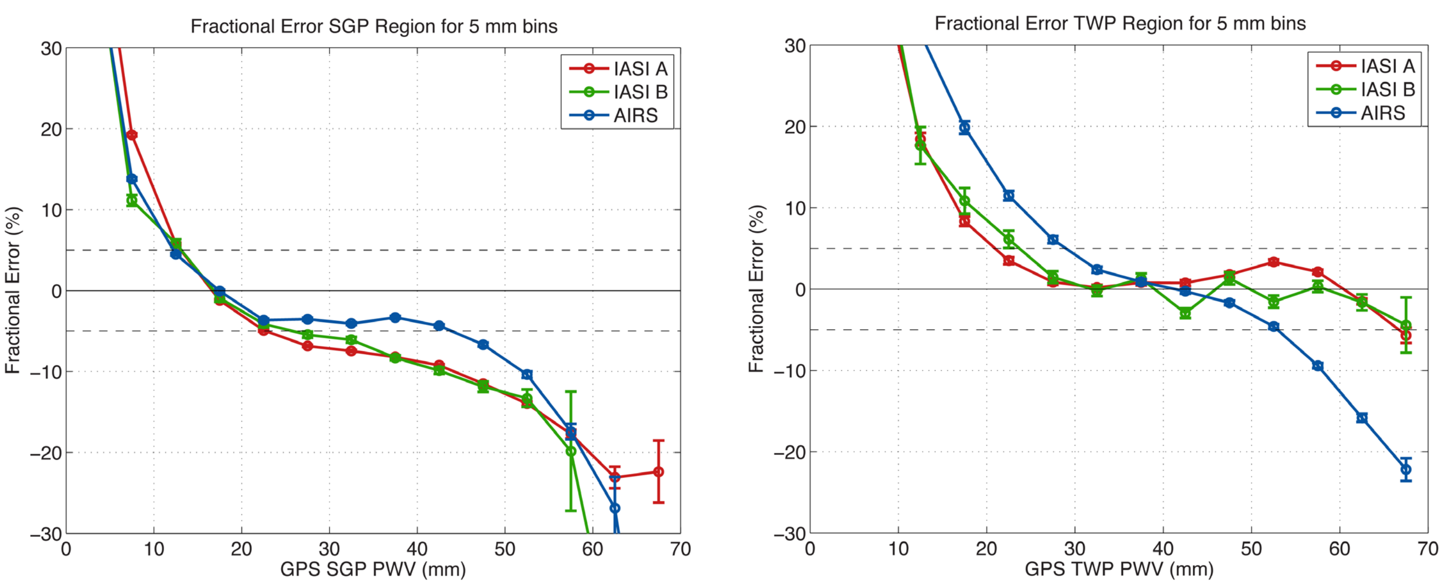
Outcomes of the 5th G-VAP Meeting include:

- A timeline for freezing and finalizing the G-VAP data archive and releasing collocated data using a common grid.
- A timeline for drafting the WCRP report on G-VAP. Sectional reports are to be finalized in March 2016 and a preliminary draft submitted to GDAP in April 2016. The final draft to GDAP is due in August 2016.
- Plans for continuing G-VAP beyond the acceptance of the WCRP report on G-VAP. Participants have expressed their willingness to support G-VAP in the future.

Recommendations, in particular on the provision of uncertainty information as a function of total amount and on enhanced quality analysis in stratus regions, are provided in the minutes of meeting at: *http://gewex-vap.org*.

The next meeting is tentatively planned at the Headquarters of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) on 22–23 September 2016.

GVAP Results



Fractional error in percent as a function of precipitable water vapor (PWV) observations with GPS at the Atmospheric Radiation Measurement (ARM) Program Southern Great Plains (left) and Tropical Western Pacific (TWP)-Darwin (right) stations. Results are shown for the National Aeronautics and Space Administration Atmospheric Infrared Sounder (AIRS) Version 6 and EUMETSAT Infrared Atmospheric Sounding Interferometer (IASI) Version 6 applied to MetOp-A and MetOp-B data. The dashed horizonal line marks 5% fractional error.

OzEWEX 2015 Workshop

Broadbeach, Queensland, Australia
2 December 2015

Albert van Dijk[1], Gab Abramowitz[2], Luigi Renzullo[3], Christoph Rüdiger[4], Dongryeol Ryu[5], Seth Westra[6], and Marta Yebra[1]

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The second OzEWEX national workshop was a great success, with well over a hundred participants and many inspiring presentations and stimulating discussions. It was held during the biannual International Congress on Modeling and Simulation (MODSIM2015) and made use of the one-day break in the conference schedule. The workshop was organized under the joint auspices of GEWEX, the Hydrological Ensemble Prediction Experiment (HEPEX) and the Modeling and Simulation Society of Australia and New Zealand (MSSANZ). Registration was free thanks to generous support from the European Union Project, EartH2Observe–Global Earth Observation for Integrated Water Resource Assessment, the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO), the Australian National University (ANU), the Bureau of Meteorology (BOM) and the Research Council Centre of Excellence for Climate System Science. Participants explored the theme "Spatial Hydrology: Observation, Modeling and Forecasting" in plenary sessions and three parallel discussion sessions. The proceedings, including abstracts and presentations, are available at: *http://ozewex.org/workshop2015/program/*.

In the plenary, Prof. David Maidment (University of Texas at Austin) introduced the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) and its first National Flood Interoperability Experiment. In July 2015, CUAHSI organized a summer school on the use of national data sets and high performance computational infrastructure. There was much enthusiasm from the meeting participants to pursue a similar activity through OzEWEX. Dr. Jaap Schellekens (Deltares) presented the status and plans of the EartH2Observe Project-Global Earth Observation for Integrated Water Resource Assessment. The substantial progress the project has already made is impressive, including the freely available global hydrological model ensemble, which includes an Australian contribution. Prof. Howard Wheater (University of Saskatchewan) provided a perspective from Canada's Changing Cold Regions Network, a GEWEX Regional Hydroclimate Project. The large-scale high-resolution climate modeling undertaken in the network led to considerable interest for a similar continental modeling exercise in Australia. Finally, Prof. Eric Wood (Princeton University) explored closing the global water cycle using long-term climate data records.

In the three parallel sessions, participants presented and debated the following topics of specific interest to OzEWEX through ongoing activities in the different working groups (WGs).

Observing Hydrology at Different Scales

Organized and chaired by the Observational Data WG, this daylong session explored future observation opportunities and how government agencies are pursuing Earth observation data. Invited speakers were chosen to engage the community in these developments and to discover what observational needs should be addressed with a higher priority for the near future. Three different subtopics were explored.

1. Emerging technologies for plot-to-regional scale measurement, including the ongoing development of the Australian National Cosmic Ray Soil Moisture Monitoring (CosmOz) Network and plans to use the technology for regional mapping of soil moisture. Airborne drones have been used in hydrological applications and the OzFlux flux tower network has furthered the understanding of water and energy in Australia.
2. New developments in data and computation infrastructure, such as the National Computational Infrastructure and Geoscience Australia Data Cube infrastructure. Much progress has been made in providing free access to high quality national Earth observation data assets and products.
3. New and existing Earth observation capabilities. Examples of uses of the global hydrological data products through the EartH2Observe Project were shown, and some long-term, global scale Earth observation programs were presented, both from a data perspective and a policy perspective.

Discussion focused on the need for high-resolution data and models. Australia has a unique opportunity to support the validation or evaluation of Earth observation missions and hydrological modeling, with several monitoring networks providing a wide range of observations at many sites (e.g., OzFlux, CosmOz, OzNet). The infrastructure of these sites is showing signs of aging and will require support to be maintained. Finally, Australia will be chairing the Committee on Earth Observation Satellites in 2016 and the ways in which OzEWEX could support this role were discussed.

Attributing Changes in Natural Hazards to Climate and Other Causes

In 2015, the Trends and Extremes WG focused on bringing together a climatic change special issue reviewing historical and projected climatic changes to climate-affected Australian natural hazards, such as floods, droughts, coastal extremes, heatwaves, bushfires, wind and hail. In this session the preliminary outcomes of those reviews were summarized, along with recommended research priorities. Discussion focused on the following topics:

1. Socio-economic factors that play a significant role in the risk of natural hazards (e.g., flood risk is worse if people build and live on flood plains). These were deliberately excluded from the special issue to retain a focus on the haz-

ard rather than the risk, although it is an important issue that may be considered in the future.

2. A unified approach to attribution of impacts. This is not possible until we have a unified approach to describing the hazard, or a better understanding of what we do and do not know about it. This point emerged in several of the reviews. Examples included the need for clarity on the difference between flood risk and hazard, around the different definitions of drought (e.g., whether the concept of socioeconomic drought is useful), and the distinction between sea level rise and multi-decadal or multi-centennial variations in sea level, storm surge and tide.

3. A common message and list of research questions. These could help ensure that the limited research funds are deployed strategically to maximize science outcomes for understanding future changes to Australian natural hazards. Information on what is necessary to address those questions, along with tasks and likely resources required, would be provided alongside that message.

During 2016, the WG will finalize the special issue and begin implementing the recommendations with a focus on specific and achievable outcomes within a 1-year timeframe.

Characterizing Errors in Models and Observations

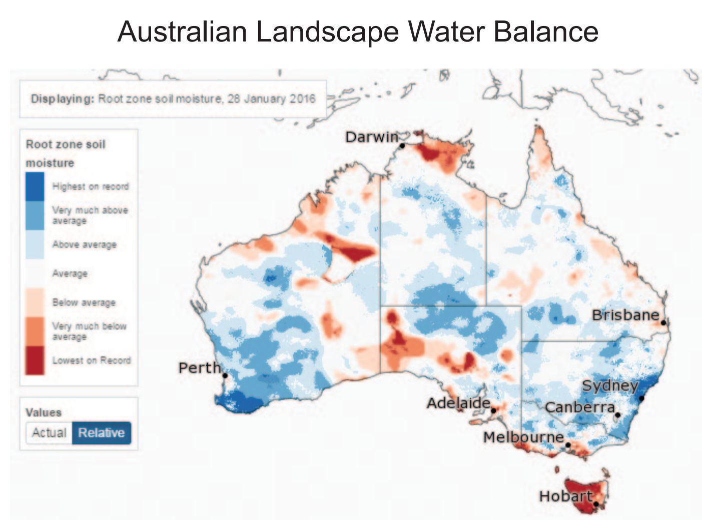
In an effort organized by the Data Assimilation (DA) WG, participants explored spatial and temporal error characterization and the evaluation of models and data products against verification data. Progress in the OzEWEX Soil Water Estimation and Evaluation Project (SWEEP) was presented. The session can be best described as "beyond root-mean-square (RMS) and correlation," as presenters described the pros and cons of these two commonly used metrics for model and data evaluation, often in the context of soil moisture data assimilation. Discussions focused on topics such as: is the use of triple colocation and variants a suitable approach to derive spatially explicit error estimates of observations for assimilation? Is quantifying bias more important than random error in models? Is the common practice of "bias correction" in data assimilation inappropriately named, as it suggests models are less biased than observations? Is correlation an appropriate metric for evaluating time series of soil moisture data, particularly as modeled and observed estimates often differ in terms of meaning and units? Correlation mainly shows a product's ability to identify rain-driven peaks in the time series, but are other metrics (e.g., mean and RMS error) still needed for a comprehensive performance assessment? Is there such a thing as ground "truth" for soil moisture when there is such a large disparity in scale between the surface observations and the remote sensor instantaneous field-of-view? Is it useful to explore alternative spatial information sources as indirect measures of model performance (e.g., land surface temperature to "evaluate" soil moisture)?

Multi-Objective Data Assimilation in Hydrological Models

This session, which was also organized by the DA WG, focused on the need for and the challenges of assimilating multiple observations, usually with differing spatial and temporal characteristics, into hydrological models. A common challenge to multi-objective and spatial data assimilation is the representation of model prediction error variance, and particularly covariance. In spatial DA, this means the spatial correlation of errors across a geographic region of interest, while in multi-objective DA, it is the correlation of errors between data sets (e.g., multiple soil moisture data sets from sensors operating on similar principles). The discussion focused on issues rather than solutions to the challenges of characterizing model prediction error covariance. These included ignoring off-diagonal (covariance) terms in the prediction error matrix, which can lead to underutilization of observations. This becomes increasingly pronounced as the modeling spatial resolution increases relative to the observation resolution. Ensemble representation of model uncertainty (i.e., the probability density of the model state) will struggle with the low-number statistics problem as the state variables increase in dimensionality. Inferring error covariance from a 10–100 member ensemble can result in artifacts (spurious or long-range correlations) in the matrix. The increased dimensionality of state variables (>10^7 cells) creates greater computational challenges and numerical instability when inverting such large matrices. The meeting participants agreed that a lot can be learned from the atmospheric and oceanographic DA communities, especially around lower dimensional representations or data, regularization and localization. A potential new OzEWEX activity may examine alternative approaches to multi-objective assimilation based in a synthetic experiment constructed with observations, such as those from the Soil Moisture Active Passive Experiment (SMAPEx) field validation campaigns.

Water Cycle Processes in Land Surface Models

Presentations in this session were organized by the Model Evaluation and Benchmarking WG, and focused on the role of vegetation response to water availability in the Community Atmosphere Land Exchange (CABLE) model and other land



Example of up-to-date, on-line national water information that has recently become available through the Bureau of Meteorology's Australian Landscape Water Balance website (www.bom.gov.au/water/landscape/).

surface models. Josh Larsen (University of Queensland) presented an idea for a regional OzEWEX project in the Surat Basin (Queensland), where there is great uncertainty of the impact of irrigation, land clearing and coal seam dewatering on groundwater, surface water and surface-atmosphere exchanges. Discussion in this session broadly involved observational and structural constraints in land surface modeling. Questions debated included: does calibration of land surface models typically result in overfitting, in the sense that results are metric, variable and calibration data set dependent? To what extent does the tendency for parameters to calibrate to unreasonable values represent physical inconsistencies in land surface models? The role of multiple independent data sets, metrics, variables, timescales and equifinality was discussed. The nature of the Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project (PLUMBER) land surface model comparison was also mentioned, particularly in the context of water-limited conditions, and which aspects of land surface model representation might lead to performance improvements relative to the out-of-sample empirical models used in that work.

Streamflow Forecasting: From Uncertainty to Decision

This session, organized by the Hydrological Prediction WG, hosted five invited presentations in two parts: (1) understanding uncertainties in streamflow forecasting and (2) BOM's operational seasonal streamflow forecasting systems. Prof. Tony Jakeman and Dr. Barry Croke (ANU) succinctly summarized challenges and issues of parameter identifiability and suggested eclectic approaches in model selection, parameterization and calibration. A simple deconvolution to examine data errors was introduced. Dr. Francis Chiew (Commonwealth Scientific and Industrial Research Organization, CSIRO) presented two main issues in predicting water futures: non-linear climate-runoff relationships and large uncertainties in rainfall projections. Dr. Murray Peel (University of Melbourne) discussed the potential sources of uncertainties in model-based runoff projection as interpreted from extensive calibration experiments and historical streamflow data analyses. He concluded that the conceptual rainfall runoff models currently used are not capable of reproducing non-unique rainfall-runoff relationship to varying wetness regimes, due to the combination of imperfect model structure and calibration/verification.

In the second part of the session, Dr. Q. J. Wang (CSIRO) and Dr. Narendra Tuteja (BOM) presented the operational seasonal flow forecasting system these organizations developed. Dr. Wang discussed opportunities for increasing seasonal forecast skill by merging statistical and dynamical forecasts, and by integrating climate model outputs for longer-term forecasts. Dr. Tuteja described the evolving streamflow forecasting performance of the operational system and a roadmap for numerical weather prediction models for the near future.

Feedback from Participants

The participants confirmed there wish for further continuation of discussion and activities in the WGs. We look forward to a productive year for OzEWEX in 2016.

GEWEX/WCRP Calendar

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

2–4 March 2016—International Scientific Conference on MAHASRI—Tokyo, Japan.

29 March–1 April 2016—Austin International Conference on Soil Modeling—Austin, Texas, USA.

5–15 April 2016—WWRP/WCRP/Bolin Centre School on Polar Prediction—Abisko Scientific Research Station, Sweden.

7–11 April 2016—WCRP Data Advisory Council (WDAC) Meeting—Asheville, North Carolina, USA.

13–15 April 2016—Aerosols, Clouds, Precipitation and Climate (ACPC) Meeting—Oxford, United Kingdom.

17–22 April 2016—EGU General Assembly—Vienna, Austria.

25–27 April 2016—37th Session of the WCRP Joint Scientific Committee—Geneva, Switzerland.

25–30 April 2016—31st Meeting of the Working Group on Numerical Experimentation (WGNE)—CSIR, South Africa.

26–29 April 2016—14th BSRN Scientific Review and Workshop—Canberra, Australia.

3–5 May 2016—Workshop on the North American Regional Climate Effort—Columbia, Maryland, USA.

9–13 May 2016—ESA Living Planet Symposium—Prague, Czech Republic.

10–13 May 2016—Conference on Earth Observation and Cryosphere Science—Frascati, Italy.

16–18 May 2016—6th Third Pole Environment Meeting—Columbus, Ohio, USA.

17–20 May 2016—CORDEX 2016: International Conference on Regional Climate Change—Stockholm, Sweden.

2–3 June 2016—Eric Wood Symposium—Princeton, New Jersey, USA.

13–17 June 2016—1st Baltic Earth Conference—Nida Curonian Spit, Lithuania.

16–23 September 2016—CLIVAR OSC—Qingdao, China.

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