Twenty-Ninth Session of the GEWEX Scientific Steering Group

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Disclaimer

Contents

1. Introduction and Overview

This report summarizes the main developments in GEWEX during the year 2016 and includes the major items and recommendations from the 29th Session of the GEWEX Scientific Steering Group (SSG-29), which was hosted by Xin Li of the Chinese Academy of Sciences in Sanya, China from 6-9 February 2017. This session of the SSG addressed both responses to advice resulting from the latest World Climate Research Programme (WCRP) Joint Scientific Committee (JSC) meeting and developments in WCRP and other global programs. Key activities included assessing progress towards new data sets and goals, and the actions required to advance the GEWEX Grand Science Questions and synthesize water and energy cycle science across the Panels.

1.1. Major Activities

For GEWEX, 2016 was characterized by steady progress and maintaining its activity levels, despite a decrease in funding from the World Meteorological Organization (WMO)/WCRP for meeting support. The major activities for the GEWEX Panels are described in detail in Section 2.0. The GEWEX Data and Assessment Panel (GDAP) report is only available in presentation style in Acrobat PDF format on the SSG-29 website at: *https://www.gewexevents.org/events/ssg-29/*. The Global Atmospheric System Studies (GASS) Panel is being reformulated and that process is expected to be completed in 2018 at the Pan-GASS meeting. Both the Global Land/Atmosphere System Study (GLASS) and GEWEX Hydroclimatology Project (GHP) have consolidated their work and reformulated some projects, while closing out others, such as the Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (MAHASRI) Regional Hydroclimate Project (RHP).

The WCRP Grand Challenge on Extremes, which is being led by GEWEX, is well defined and moving forward through numerous meetings, including summer schools. The Water Grand Challenge is being refocused and the science and implementation plan will be rewritten in 2017. This Grand Challenge is being used as a framework to attract interest for several initiating regional hydroclimate projects, such as the Pannonian Basin Experiment (PannEx) in Eastern Europe and the Hydroclimate Research Program for the Andes (ANDEX) in Latin America.

1.2. GEWEX Links to the WCRP Grand Challenges

WCRP identified seven Grand Science Challenges to be addressed by the climate research community in the coming decade. These represent some of the most important and challenging scientific questions for addressing current research gaps. GEWEX is leading two of the seven science grand challenges and has connections to the others. During this reporting period, GEWEX further defined how the collective research efforts within its four Panels would address the Grand Challenges. This topic was a primary focus of this SSG meeting.

The individual and the integrated GDAP data products enable research related to three of the Grand Challenges: Clouds, Circulation and Climate Sensitivity; Changes in Water Availability; and potentially, Understanding and Predicting Weather and Climate Extremes. The

GDAP Integrated Product supports improved understanding of the interactions of clouds, aerosols, precipitation and radiation and their contributions to climate sensitivity.

GEWEX is also leading the Grand Challenge on Changes in Water Availability, now re-scoped as the **Grand Challenge on Water for Food Baskets of the World**. The implementation plan for this will be presented to the JSC at its next meeting. This Grand Challenge is one of the highest societal priorities and of great importance to governments and agencies that sponsor climate research.

A number of GASS Panel activities will contribute to the **Clouds, Circulation and Climate Sensitivity Grand Challenge**, including the Grey Zone, Weak Temperature Gradient, Low-cloud Feedbacks and Radiative Processes in Observations and Models projects. In addition, idealized modeling frameworks are needed to study the response of convection and climate over warm land surfaces. Two upcoming GASS projects could align with the **Grand Challenge on Water for Food Baskets of the World** and these are: (i) the Clouds Above the United States and Errors at the Surface (CAUSES) warm bias project, with its focus on the coupling of energy and water cycles at the land-atmosphere interface over summertime land masses; and (ii) the HiRes crosscutting project to evaluate water cycle processes in high-resolution models. GDAP could also contribute to this Grand Challenge by providing past precipitation amounts and the distribution of rain rates.

For the **Grand Challenge on Understanding and Predicting Weather and Climate Extremes**, the GHP Changing Cold Regions Network (CCRN) RHP is studying the effects of land use changes and drainage on eastern prairie hydrology and developing a hydrological model for predicting changes in flooding and drought. The HYdrological cycle in the Mediterranean EXperiment (HyMeX) has a strong focus on hydrometeorological extremes (e.g., heavy precipitation, floods, heat waves, droughts). Within GDAP, the re-engineered GDAP products (1-degree, 3-hourly time steps) may allow detection of extremes and processes related to extremes in the data.

The GHP INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes (INTENSE) Project is focused on meeting the data requirements and examining trends, variability and processes associated with heavy precipitation and drought. Data collection activities will contribute information that could underpin detection and attribution studies and model evaluation by collating and quality-controlling sub-daily precipitation data (providing data that is extensive in time and space). INTENSE is also examining how sub-daily precipitation extremes may be defined through the use of relevant indices that have to date only been established on daily timescales. Analysis of local scale thermodynamics and large-scale predictors will improve understanding and characterization of physical mechanisms leading to the occurrence of floods and droughts and the relationships between these events. By linking observations with the latest generation of climate models (and in particular the emerging high-resolution regional climate models), INTENSE will assess the deficiencies of models in the simulation of key processes and events.

The **Cryosphere in a Changing Climate Grand Challenge** is addressed by the Changing Cold Regions Network (CCRN) Project within GHP. CCRN conducts focused analysis and modeling of cryospheric process responses to warming. Key areas are the biomes of the Rocky Mountains (including glacier processes), boreal forests, prairies and the sub-Arctic.

1.3. Goals and Plans for Major Activities for 2017

One of the major goals for 2017 is the organization of the GEWEX Science Conference to be held in Canada in early 2018. In addition, GDAP is including more process-oriented research into its activities, while GASS is basically being rebuilt from the ground up, where collaboration with World Weather Research Programme (WWRP) is an important core aspect. GHP will support the development of new RHPs in various regions of the world with an initial emphasis on Eastern Europe (PannEX) and Latin America (ANDEX) to be followed by activities in Asia linked to the Third Pole Environment (TPE) Project. GLASS will push for increased coordination and effectiveness of international land model benchmarking activities with the Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project (PLUMBER). Furthermore, the model intercomparison studies, such as the Land Surface, Snow and Soil Moisture Model Intercomparison Project (LS3MIP) continue to be strong and are cemented formally as the Coupled Model Intercomparison Project (CMIP6). The Local Land-Atmosphere Coupling (LoCo) Project Working Group is still going strong after being established nearly a decade ago to focus on the goal of accurately understanding and modeling coupled land-atmosphere processes.

1.4. Interactions (Especially with WCRP Sponsors and Partners)

The National Aeronautics and Space Administration (NASA) continues to strongly support the International GEWEX Project Office. The major U.S. government agencies have been supportive for the development of a U.S. RHP located in the Western U.S. and Canada.

Other space agencies, such as the European Space Agency (ESA), continue to be a strong supporter of GEWEX activities and we expect an increased collaboration with the Japan Aerospace Exploration Agency (JAXA).

GDAP shares responsibility with the Global Climate Observing System (GCOS) for the Baseline Surface Radiation Network (BSRN), which is essential for setting standards and providing high quality radiation measurements for the evaluation of satellite data sets and climate models. The Alfred Wegener Institute (AWI) hosts the World Radiation Monitoring Center (WRMC), which is the central archive of BSRN data. The archive contains approximately 700 years of BSRN station data, which have been heavily used and cited in over 1200 peer-reviewed articles. BSRN is directly participating in the WWRP Polar Prediction Project and several stations are a part of the International Arctic Systems for Observing the Atmosphere (IASOA) Radiation Working Group.

The Subseasonal to Seasonal Prediction Project (S2S), a WWRP initiative, is of interest to the GLASS Panel and a GLASS representative attends the S2S meetings on a regular basis.

The WMO Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) Initiative continues to host International Satellite Cloud Climatology Project (ISCCP) data processing at the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI), which is supported by several data centers (mostly space agencies) delivering the needed input data for ISCCP.

The International Soil Moisture Network (ISMN), which serves a large international scientific community through improvement of weather and climate models and remote sensing

products, and support to agriculture applications, is coordinated by GDAP in cooperation with the Group of Earth Observation (GEO) and the Committee on Earth Observation Satellites (CEOS). The database is hosted by the Department of Geodesy and Geoinformation at the Vienna University of Technology (TU Wien). ISMN integrates 49 networks containing almost 2050 stations that have added over 8000 soil moisture data sets into the archive. It also contains historical soil moisture data sets dating back to 1952. Operational data sets are updated in near-real time. ISMN is rapidly growing and several new networks and data sets will be integrated in the near future, including China (Wuhan University), Korea and Romania. Further growth potential, such as the hundreds of soil moisture stations operated by the Chinese meteorological service, was discussed at the GDAP annual meeting with Chinese representatives giving positive signals on a potential integration.

1.5. Outreach and Capacity-Building Activities

GEWEX is leading the WCRP Grand Challenge on Changes in Water Availability, which relates to the UNESCO International Hydrological Programme (IHP) goal to understand uncertainty and translate it back to water security. Future GEWEX activities within this Grand Challenge are planned with IHP.

GEWEX is also exploring potential collaboration with the WMO Hydrology Climate Land Water Department and Regional Panels and the Climate and Cryosphere (CliC) Project. A connection to CliC has been proposed through the GABLS Stable Planetary Boundary Layer Project (GABLS4) over the arctic region. In addition, the Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP), is a collaborative effort between CliC and GLASS. The Land Surface, Snow and Soil Moisture Model Intercomparison Project (LS3MIP), a CliC and GEWEX project, is addressing core research questions of WCRP and is relevant to a large number of WCRP activities.

GDAP shares responsibility with the Global Climate Observing System (GCOS) for the Baseline Surface Radiation Network (BSRN), which is essential to setting standards and providing high quality radiation measurements for the evaluation of satellite data sets and climate models.

GEWEX benefits greatly from its strong interactions with other WMO and WCRP initiatives. The Global Data Centers for precipitation, river runoff, and lakes/reservoirs [Global Runoff Data Centre (GRDC), the Global Precipitation Climatology Centre (GPCC) and the International Data Centre on Lakes and Reservoirs (HYDROLARE), respectively] are affiliated activities under GEWEX and are connected through a number of outside bodies to obtain meaningful data for application to research of interest to the broader climate research community.

Under GDAP, the Surface Radiation Budget Project (SRB) is participating in the WCRP Data Advisory Council (WDAC) Surface Fluxes Task. In addition, GDAP has presented a paper to WDAC on “Data Set Quality Assessments: Needs, Benefits, Best Practices and Governance,” which provides guidance for a more homogeneous approach towards assessments of data set quality. The GDAP chairman continues to be active in the WDAC Observations for Model Intercomparisons Project (Obs4MIPs) Task Team and supports the open data call.

GEWEX is working to identify links to new regional groups in Latin America that may require further support to broaden current activities into international studies that fit within the

WCRP structure. The 2015 GEWEX SSG meeting was held in Medellin, Colombia and the SSG has a new member from Colombia. A regional initiating RHP meeting is planned for late in 2017.

Cross collaboration opportunities between GEWEX and the integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) are being identified within the different GEWEX Panels. Under GHP, MAHASRI had collaborative activities with the Japanese iLEAPS and International Geosphere Biosphere Programme (IGBP) communities, as well as the Asian Stratosphere-troposphere Processes And their Role in Climate (SPARC) Project community. A new GHP-GLASS-iLEAPS project for the Saskatchewan River Basin is being investigated.

HyMeX and the Australian Water and Energy Exchanges research initiative (OzEWEX) are collaborating with the Global Earth Observation for Integrated Water Resource Assessment (Earth2Observe) Project and the Hydrological Ensemble Prediction Experiment (HEPEX) in hydrological forecasting. As Earth2Observe is finalizing in 2017, new avenues need to be pursued.

GEWEX and CLIVAR joint activities include the new JSC task group on extreme weather and climate, and the WCRP Monsoon Panel. In addition the Earth energy Imbalance issue may become a strong collaborative project with a meeting planned in conjunction with the annual GDAP meeting in October of 2017.

Continued collaboration with the Group on Earth Observations (GEO) is provided through the Director of IGPO, who has been active in the Integrated Global Water Cycle Observations (IGWCO) Project. In addition, the Director of IGPO serves on the Board of the FP7 Earth2Observe Project and the Board of the Helmholz Alliance as a user group representative.

There are many cross collaboration activities between the GEWEX Panels and other programs. GEWEX and iLEAPS collaboration is underway through the GLASS Global Soil Wetness Project, Phase 3 (GSWP-3) Project. In addition, the Land-Use and Climate, IDentification of robust impacts (LUCID) activity is an iLEAPS-GLASS supported project. GLASS is also recruiting member(s) from iLEAPS to be actively involved in both the planning and analysis of its new carbon activity.

To encourage the involvement of young scientists in GEWEX/WCRP activities, IGPO has invited the Young Hydrologic Society (YHS) and the Young Earth System Scientists (YESS) communities to contribute one-half page in each issue of the GEWEX Newsletter to advertise their activities.

As part of the organization of the GEWEX Conference in 2018, the inclusion of research from both early career scientists and those from lesser-developed countries is important. Funding will be a critical aspect in making in particular the latter aspect a success.

2. GEWEX Panel Status Reports

2.1. GEWEX Data and Assessment Panel (GDAP)

Reporting Period:	January 2016–December 2016
URL:	http://gewex.org/GDAP.html
Chair(s) and term dates:	Jörg Schulz (July 2014–March 2017); Vice Chair: Matthew McCabe (January 2015– March 2017); Remy Roca (April 2017-); Tristan LEcuyer (April 2017-)

The formal report of this Panel is not available. Please see the GDAP summary presentation at: *http://www.gewexevents.org/wp-content/uploads/GDAP_SSG-29.pdf*

2.2. GEWEX Hydroclimatology Panel (GHP)

Reporting Period: January 2016 – December 2016
Chair(s) and term dates: Jason Evans (2012-2019), Jan Polcher (2011-2016), Joan Cuxart Rodamilans (2017-2020)

2.2.1. Major Panel Accomplishments

- Active GHP very productive: GEWEX achieving maturity generating spin-off activities; CCRN enlarging and ensuring continuation of activities.
- New GHPs OzEWEX and HyVic report significant steps forward leading to organized research activities in their respective areas, each following a different approach. Baltic Earth, already in motion, has very recently become an RHP.
- Increasing interest to organize new activities, such as developing crosscutting projects and the prospective PannEx GHP in the Pannonian basin. Foreseen new activities in America and Asia.

2.2.2. Panel Activities

The GEWEX Hydroclimatology Panel (GHP), has been organized around several Regional Hydroclimate Projects (RHPs) and a number of crosscutting (CC) science topics. The aim of GHP is especially focused on improving the knowledge about global climate change and its impacts at regional scales and to propagate that knowledge from one region to the other, then, synthesizing the results at the global scale.

The objectives of GHP are to contribute effectively to the leading role that GEWEX plays in the hydrological sciences and related modeling activities. The GEWEX Science Questions http://www.gewex.org/pdfs/GEWEX_Science_Questions_final.pdf and the related WCRP Grand Challenges http://www.wcrp-climate.org/grandcha.shtml, are key to the strategy for implementation of the Panel activities. Discussions on a number of important issues that range from monsoons, to extremes and how to help coordinate the number of national/regional initiatives in those areas, have been fostered by the Co-Chairs. These include collaborations with groups including GDIS, GDAP, GLASS, CLIVAR, CliC and WGRC that have common interests in land-surface processes.

In addition, in keeping with the need to be responsive to the WCRP/GEWEX main challenges and scientific questions GHP has organized itself to address the GEWEX science questions from a regional and integrated perspective. The driving premise for this approach is that only at the regional scale can the water cycle be addressed from its physical to human and socioeconomic aspects.

The RHPs (Figure 1) are an essential tool in this endeavor as they bring together various disciplines on the water issues of greatest importance to the advancement of the GSQs. The crosscutting projects allow GHP to propagate knowledge from one region to the other and synthesize results at the global scale. They also allow development and testing of applications developed with the new understanding that they deliver both science advances and applicable outcomes for stakeholders and services.

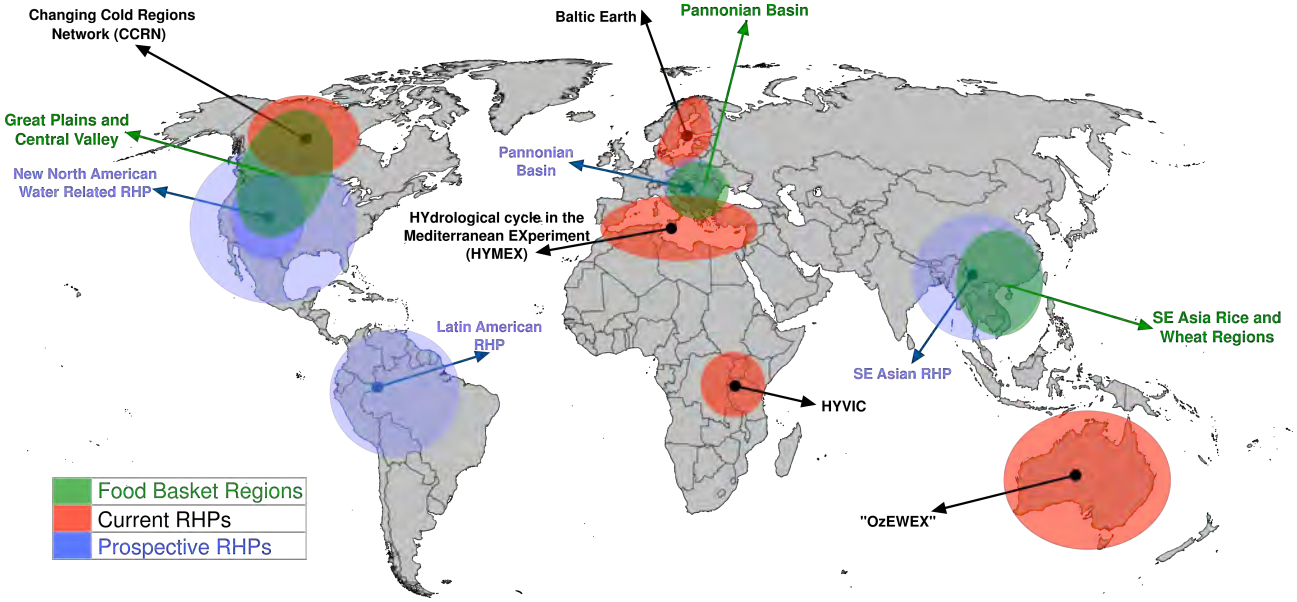

Figure 1: GHP Regional Hydroclimate Projects (RHPs) and Water for the Food Baskets of the World focus Regions

GHP Regional Hydroclimate Projects List

Recently closed

- MAHASRI (Jun Matsumoto)

Currently active

- CCRN (Howard Wheater)
- HyMex (Philippe Drobinski)

Initiating Status

- OzEWEX (Albert VanDijk/Seth Westra)
- HyVic (Fred Semanzzi)
- BalticEarth (Markus Meier)

Proposed

- Pannex (Monika Lakatos/Ivan Güttler)

GHP Crosscutting Projects List

Currently active

- INTENSE (Sub-daily precipitation) (H. Fowler)
- Cold/Shoulder Season Precipitation Near 0°C, (R. Stewart/P. Groisman)
- INARCH (Mountain Hydrology) (J. Pomeroy)

Proposed

- MOUNTerrain (Mountainous Terrain rainfall) (J. Renwick)
- Including water management in large scale models (R. Harding/J. Polcher)

2.2.3. New Projects in Place

Baltic Earth applied for, and was granted, initiating RHP status. It becomes the newest RHP and builds upon the legacy left by the previous BALTEX projects.

2.2.4. New Projects and Planned Activities

New Projects

Baltic Earth (new RHP since Fall 2016)
This programme intends to achieve an improved Earth System understanding of the Baltic Sea region, inheriting the Baltex network of scientists and infrastructures. This will be made through an interdisciplinary and international collaboration by an holistic view of processes on land, sea, atmosphere and the anthrophosphere. Knowledge gaps will be identified and addressed, for instance by funded projects. Service to society and education will be key points. The community in charge is very mature and a lot of activity is present. Six Grand Challenges have been defined in the Science Plan: i) salinity dynamics; ii) land-sea biogeochemical linkages; iii) natural hazards and extreme events; iv) sea level and coastal dynamics of the Baltic Sea; v) regional variability of water and energy exchanges; and vi) multiple drivers of regional Earth system changes.

The Pannonian Basin RHP (Pannex) held its second workshop in order to get feedback from local scientists on the draft white paper and garner further participation from the regions scientists. Five Flagship Questions have been defined dealing with Agronomy, Air Quality, Sustainable Development, Water management and Education. A third workshop is planned for March 2017 in Cluj-Napoca, Romania, where reflection on the Science and the Implementation plans will start. This should progress Pannex towards initiating RHP status in 2017 or 2018.

A workshop to investigate the potential for a **Regional Hydroclimate Project in Latin America** is being planned for May 2017.

The potential crosscut **"Water management in large scale models"** held a successful workshop in September 2016. Subsequent activities are being planned including submission of a formal crosscut proposal to GHP.

Planned Activities
RHPs

HyMex
This RHP explores the water cycle in the Mediterranean basin, with focus on high-impact weather events and social vulnerability and adaptation capability. The long term observation plan will extend until 2020, whereas two special observation periods were held in the NW mediterranean in 2012 (flash-floods) and 2013 (dense water formation). This has allowed to advance toward a very efficient observing and model chain such as convection permiting simulations, coupling between models of the different parts of the Earth system, including data assimilation.

Planned activities following a 5 year review:
During the second half of HyMeX, there is a need to continue collecting long-term observations and exploiting the numerous data accumulated during the various field campaigns and the dissemination of the on-going research. Second, some of the HyMeX research lines need now to be tackled in a more continuum-scale (also called seamless) object-oriented approach. Some others will benefit or are enough mature to be addressed within more integrated transdisciplinary perspectives in relation with societal and environmental challenges. Transverse and transdisciplinary approaches have been already developed during the first phase of HyMeX and should be enhanced in the future, on the one hand, for flash-floods (WG3)

and social vulnerabilities (WG5) and, on the other hand, for water resources, droughts and impacts (WG2/WG5). Progresses made in knowledge as well as in development and validation of individual models for atmosphere, ocean, continental surfaces, hydrology and impacts during the first phase also allow envisaging the design of more integrated modelling systems and interdisciplinary approaches driven by social, economic or environmental demands and applications. The two fields identified are: i) the design of more integrated forecasting systems for heavy precipitation, flash-floods and impacts over coastal areas and ii) the water cycle and renewable energy related challenges in the Mediterranean meteorological and climate context. As regard the object-oriented studies, the objects (or phenomena) for which more synergy between process and climate studies is sought are the heavy precipitation (WG3), the Mediterranean cyclones (WG4/WG3) and the ocean circulation and dense water formation (WG1/WG4).

CCRN
It is a project nationally funded (2013-2018) including the Saskatchewan and the Mackenzie river basins. The Network aims to understand, diagnose and predict interactions amongst the cryospheric, ecological, hydrological, and climatic components of the changing Earth system at multiple scales, with a geographic focus on Western Canada's rapidly changing cold interior. It is structured in 5 themes: A: Observed Earth System Change in Cold Regions - Inventory and Statistical evaluation; B: Improved Understanding and Diagnosis of Local Scale Change; C: Upscaling for improved Atmospheric Modelling and River Basin Scale Prediction; D: Analysis and Prediction of Regional and Large Scale Variability and Change; E: User Community Outreach and Engagement.

In Theme A, and as a contribution to other Themes, we will continue our efforts towards the development of scenarios of change for our observatories and for our main ecoregions, based on conceptual and process understanding. Theme B efforts will focus on CRHM historical diagnostic modelling at the observatories, with reporting at our upcoming AGM, and then on synthesizing results and developing individual and synthesis papers, representing the completion of Theme B. Future CRHM analyses will be based on the WRF pseudo-warming simulations (used as driving data) to diagnose future hydrological change and sensitivity, with reporting at our 2017 AGM, and papers to follow. This will represent completion of our last of the four work packages in Theme D. In Theme C we expect to have working models for both major basins ready for subsequent use in Theme D analyses by the fall. We plan to build on the discussions at the AGM regarding scenarios of change and will pull together all the large-scale modelling work and progress on the Theme B CRHM project at the upcoming fall modelling workshop. From here, we will decide on driving products and best approaches moving forward for the large-scale modelling analyses to be done in Theme D. Several focal topics have been added as areas of study in Theme D for the coming year, including a synthesis and examination of the three back-to-back extreme wildfire seasons in western Canada (2014–16), an examination of changes in the timing of the zero degree Celsius isotherm and associated impacts, a review of future projected changes (following review of past change, and linking with scenarios of change), and an examination of the chain-of-events around recent major disasters in our region.

HyVic: Its primary purpose is to provide understanding of the climate over the Lake Victoria Basin (LVB) and improve its predictability and projections to support decision-making in the region. The science plan outlines five research themes (Translational Research to Interface with Applications, Severe Weather and Water Currents, Lake Victoria Basin Water and Energy Budgets, Modeling of the LVB Hydroclimatological System, and Monitoring of the LVB

Hydroclimatological System) and three mechanisms to coordinate the research themes (HyVic Implementation Sites, HyVic International Panel, and HyVic International Project Office).

The planned activities are:

- HyCristal project: Continuation of HyCristal project funded by DFID, on climate change over East Africa.

- ICPAC-HyVic CMIP project: ICPAC is the Climate Prediction and Applications Centre serving users to optimize the use of climate information. HyVic aims to provide underpinning knowledge in the development of capacity for using WCRP CMIP climate model simulations. This will in particular entail engaging the international WCRP community to contribute to the proposed new GHACOF-Climate Change component by building on the present form focusing only on seasonal prediction. Anticipated funding Source: DFID WISER Program.

- ICPAC-HyVic data rescue project: Major progress has been made with the DARE pilot project focussing on Tanzania, through the Tanzania Meteorology Agency (TMA), in rescuing rainfall data for 257 stations. The natural next step of this very important project is to upscale the initiative to all the 11 ICPAC member countries. HyVic will contribute by applying its research work and experience on missing data (Angus, 2016; personal communication) by ensuring objective selection of the rain gauge stations for the expanded DARE project region. Anticipated funding Source: DFID WISER Program.

- HyVic workshop: HyVic workshop is planned to, (a) bolster ICPAC's capacity to use WCRP CMIP climate model simulations, and (b) plan the development of the co-designed curriculum with ICPAC and partner universities. Proposed funding Source: Anticipated funding Source: DFID WISER Program.

OzEWEX

The OzEWEX leadership panel, presently consisting of the two co-chairs and WG chairs, decided to change its structure. There are some drivers for this restructure: challenges in some of the WGs to plan or progress activities; varying interpretations of the purpose of WGs; and challenges in finding the resources needed to support WG activities. In the revised panel structure, current WG chairs will instead become Theme Leads and continue to play a liaising and coordinating role. In addition, a small number of active, limited-period projects will be developed and resourced subject to annual review, with Project Leads also becoming part of the leadership group. The changed structure will also more closely resemble other GEWEX leadership structures.

An exciting new OzEWEX activity is the organization of the first Australian Climate and Water Summer Institute, a prestigious event that will offer ca. 15 of the best students in Australia and New Zealand a unique opportunity, with expenses covered, to work closely with peers and experts from academia and government agencies, to enhance climate and water information and its practical applications. The Institute will take place in Canberra from 5 December 2016 – 21 January 2017, breaking for Christmas and New Year. The selected students will collaborate intensively in small teams for six weeks to work on projects developing an application or improvement to data services and analysis tools from the Summer Institute consortium partners (CSIRO, Bureau of Meteorology, Geoscience Australia, Murray-Darling Basin Authority, National Computational Infrastructure, Bushfire and Natural Hazards CRC, ARC Centre of Excellence for Climate System Science, several universities and some private donors). The formation of the consortium has included the establishment of an overseeing board, and it is

anticipated that this board may be approached for advice and assistance in pursuing other OzEWEX project.

Crosscutting Projects

INTENSE (sub-daily precipitation)

Continued data acquisition and initiatives to update and expand the existing database. Thought was given to where to host data collection and calculation of new indices for sub-daily precipitation. Talks are developing with ECA&D among others. Data will be held at an approved data center (TBD) where freely distributable, and sub-daily seasonal/monthly indices will be developed for all stations. Other station metrics will also be calculated such as diurnal cycle or precipitation-temperature scaling relation. The indices will be made available to the public through a dedicated web site, which will also indicate data availability and links to data providers and licensing arrangements etc. Publications are planned on analyzing the indices.

Global scale analysis of trends in sub-daily extreme precipitation. Analysis of the UK data is underway in this regard, developing methods that may be applied more widely in the project including tests of homogeneity. The UK analysis includes assessment of consistency with climate change projections derived from the UK Met Office convection permitting climate model.

Working collaboratively with Andy Prein at NCAR on CPM and observations over the US, trying to understand the role of thermodynamics and dynamics in driving sub-daily precipitation extremes.

A global scale analysis of the extreme precipitation-temperature relationship will be undertaken using sub-daily datasets gathered by INTENSE during a trip by Renaud Barbero to Seth Westra's group at Adelaide University.

INARCH

- Participate in snow model comparisons at sites where inputs can measured/defined through links with GLASS.
- Reduce measurement uncertainty by implementing WMO SPICE recommendations for solid precipitation measurements at all sites and making contact with Global Cryosphere Watch for how to further improve measurement quality.
- Develop a downscaling toolbox by examining various techniques for statistical, dynamical and medium complexity downscaling.
- Continue climate sensitivity comparative analysis of various alpine basins using "standard virtual basin" modelling to compare the response of snow cover, snowpack, glaciers and hydrology to variations in temperature and precipitation in various climate regimes.

Near 0°C Precipitation

New scientific activities include:

- As more data sets from different regions become available, we will move towards greater standardization and making this information as readily available as possible.
- We have established collaboration with a research group in China that will use our joint analyses of daily and sub-daily data for North America and Russia in order to overcome the deficiency of Chinese sub-daily data about the freezing events occurrence.
- Given the diversity of issues underway and there progress, a synthesis article will be scoped out. This will help to bring together the numerous participants.

2.2.5.Science Highlights

- A major CCRN effort was centered on a comprehensive focal examination of the extreme weather and flooding in southern Alberta in June 2013, focusing on meteorological, hydrological, and water management aspects of the flood. This has led to a collection papers being published in a special issue of Hydrological Processes. (See http://www.ccrnetwork.ca/news-events/news/2016/ccrn-special-issue-papers-on-the-2013-alberta-flood-coming-online.php for further details and links to all published papers.)
- HyMex continues the analysis of the information gathered during the last five years. It has substantially progressed in the quantification of the Mediterranean water cycle at different scales by modelling and observation, and has a better understanding of the uncertainty propagation in the studies of future climate. Hydrological studies show large improvement, especially in the quantification of freshwater inputs in the Mediterranean and a better understanding of the underground water processes.
- The OzEWEX Trends and Extremes WG published a Special Issue on historical and future changes in Australian natural hazards, including coastal extremes, floods, drought, land and marine heatwaves, fire, frost, storms, wind and hail. The articles review evidence of changes based on observational and modelling lines of evidence, and propose research directions for the next decade to better understand, quantify and predict changes to each of the natural hazards. Seven articles are available online (McKinnes et al., 2016; Johnson et al., 2016; Crimp et al., 2016; Perkins-Kirkpatrick et al., 2016; Kiem et al., 2016; Walsh et al., 2016; Sharples et al., 2016). A major common challenge identified across hazards was the attribution of changes in natural hazards to climate and non-climate causes. The WG also organized a session at OzEWEX '15 on this topic.
- Assessment of hourly rainfall scaling with temperature in high-resolution climate model runs – results show same downturn at high temperatures as seen in observations – paper published in Nature Geoscience in January 2016.
- Using synoptic data across the northern extra-tropics, we compiled a data set of more than 1,500 long-term time series (40 years of data) of synoptic observations with freezing precipitation information
- INARCH developed specialized science on downscaling atmospheric models in mountain regions through the activities of a working group on the subject. The working group implemented and tested the new ICAR intermediate complexity atmospheric research model at high resolution at various mountain locations and also raised the need for "snow drift resolving" atmospheric models in mountains that made a series of presentations to CORDEX 2016 base.

2.2.6. Science Issues

2.2.7. Contributions to Developing GEWEX Science

Observations and Predictions of Precipitation

- Assessments of various precipitation products and remotely sensed observations, including GPM, and characterization and regionalization of precipitation and drought characteristics over western Canada, with several papers in draft. Relevant publications include: Asong et al. (2015), Khaliq et al. (2015), Masud et al. (2015)
- Analysis of large-scale hydrological model performance for the Saskatchewan and Mackenzie basins. Identification of key challenges – input uncertainty, permafrost, cold region lakes and wetlands, mountain hydrology, prairie hydrology, anthropogenic water management. Work initiated to address these with a number of draft papers underway

and some recent publications. Much of this work (at various stages of development) had been reviewed and synthesized at a workshop last year (see www.ccrnetwork.ca/science/workshops/2015-modelling-workshop). Relevant publications include: Hassanzadeh et al. (2014, 2015), Mekonnen et al. (2014), Nazemi and Wheater (2014a, 2014b, 2015a, 2015b).

- INTENSE - Collation of global sub-daily precipitation data (see section 1 above for a summary of progress).
- INTENSE - Development of procedures for the quality control of sub-daily precipitation data has been undertaken for the UK. Future work will examine how the methods developed can be applied more widely in the context of global data acquisition
- HymEx is progressing in the analysis of the Special and Long observation periods, which include many cases of floods.

Global Water Resource Systems

The ERA-Interim precipitation, incoming solar radiation (ISR), air temperature, air humidity, and wind speed, are compared with their SAFRAN counterparts. Also, interpolated in situ ISR observations are used in order to consolidate the evaluation of this variable. The daily precipitation estimates produced by ERA-Interim over France correlate very well with SAFRAN. However, the values are underestimated by 27%. A GPCP-corrected version of ERA-Interim is less biased (13%).

2.2.8. Contributions to GEWEX Science Questions

Changes in Extremes

A major CCRN effort was centered on a comprehensive focal examination of the extreme weather and flooding in southern Alberta in June 2013, focusing on meteorological, hydrological, and water management aspects of the flood. This has led to a collection papers being published in a special issue of Hydrological Processes. (See http://www.ccrnetwork.ca/news-events/news/2016/ccrn-special-issue-papers-on-the-2013-alberta-flood-coming-online.php for further details and links to all published papers.) Relevant publications include: Fang et al. (2016), Harder et al. (2015), Kochtubajda et al. (2016), Liu et al. (2016), Pomeroy et al. (2016a, 2016b), Shook et al. (2015), Whitfield and Pomeroy (2016). See outreach brochure summarizing our findings at www.ccrnetwork.ca/outputs/outreach/docs/CCRN_2013Flood_Poster.pdf

Water and Energy Cycles

- Using an oceanic regional reanalysis for the Mediterranean, a first result concerned the clear warming and saltening trend visible in the deep water masses since the beginning of dense observations in the Gulf of Lions in 2007 (Houpert et al., submitted, Somot et al., submitted)
- Use of soil moisture monitoring networks for improving observation of soil freeze-thaw processes and evaluation of soil moisture scaling properties at resolutions applicable to the NASA Soil Moisture – Active Passive (SMAP) mission, upscaling of energy and water balance components from point- to field-scales, and evaluation of wetlands and soil moisture using RADARSAT-2 in prairie and taiga–tundra eco-regions. Relevant publications: Adams et al. (2015), Burns et al. (2016), Champagne et al. (2016), Djamai et al. (2015), Manns et al. (2015), Rowlandson and Berg (2015), Rowlandson et al. (2015), Roy et al. (2016).
- INARCH - Water and energy cycles in mountain catchments are dominated by snow mass and energy exchange processes such as blowing snow, snow interception, sublimation, and melt. The following example provided by Kabir Rasouli shows how

annual fluxes of these processes vary by eco-zone in the Reynolds Creek Research Watershed, Reynolds Mountain East sub-basin operated by Dr. Danny Marks of USDA and how sensitive they are to perturbed climate. The four climate scenarios are a) control period of current climate, b) P=100%, T= +5 C, c) P=120%, T=+5C. d) P=80%, T=+5C

- HymEx is quantifying the water cycle with special effort on the continental hydrological aspects.

2.2.9. Other Key Science Questions

Regional Sea-Level Rise

- ***Cryosphere response to climate change (including ice sheets, water resources, permafrost and carbon)***
- CCRN will determine whether future changes cross 'tipping points' in Earth system behaviour, leading to further extremes and dramatic system changes, such as deglaciation, permafrost disappearance and terrestrial ecosystem transition. Local scale assessments have begun in Theme B with several publications (Pomeroy et al. (2015b), Rasouli et al. (2014, 2015)), and planned CRHM historical and future diagnostic modelling (see: http://www.ccrnetwork.ca/science/workshops/crhm-workshop-2016/index.php)

- Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity

- Past and future changes in water availability (with connections to water security and hydrological cycle)

2.2.10. Contributions to WCRP Grand Challenges

Science underpinning the prediction and attribution of extreme events

- INTENSE - Data collection activities will contribute information (overarching theme: document) that could underpin detection and attribution studies and model evaluation by collating and quality controlling sub-daily precipitation data (providing data that is extensive in time and space). INTENSE is also examining how sub-daily precipitation extremes may be defined through the use of relevant indices that have to date only been established on daily timescales.
- INTENSE - Analysis of local scale thermodynamics and large-scale predictors will improve understanding and characterization of physical mechanisms leading to the occurrence of floods and droughts (overarching theme: understand), and the relationships between these events.
- By linking observations with the latest generation of climate models (and in particular the emerging high-resolution regional climate models) INTENSE will assess the deficiencies of models in the simulation of key processes and events. It will contribute valuable information as to the types of events that current models can provide credible and robust simulations for, and where high-resolution models offer added value on the projected change signal compared with coarse resolution models (overarching theme: simulate).

Near Term Climate Prediction (New)

Carbon Feedbacks in the Climate System (New)

2.2.11. Cooperation with WCRP Projects and Other International Programs

CCRN

- The International Network for Alpine Research Catchment Hydrology (INARCH; http://www.usask.ca/inarch/index.php) is a GEWEX Hydroclimate Panel project that is an international spin-off from CCRN, led by Professor John Pomeroy. CCRN and INARCH are closely linked and share many common research priorities and objectives. A workshop will be held in mid-October, that members of CCRN will attend.
- The Cold/Shoulder Season Precipitation Near 0oC project is a GHP crosscut project that addresses multiple aspects of precipitation phase transitions, and is led by CCRN investigators. There are many areas of overlap between these projects; in particular, CCRN is conducting a detailed assessment of changes in the 0°C isotherm, with objectives that are directly linked to this project.
- Another GHP crosscutting project is focused on water management in large-scale models, and is led by several CCRN investigators, including the Principal Investigator. Considerable progress on this issue has been achieved through CCRN studies, and both initiatives have goals to include newly developed reservoir schemes into models, such as MESH. A workshop will be held in late September, that members of CCRN will attend.

INARCH
Collaboration with UNESCO IHP and information collaboration with SPICE and Global Cryosphere Watch (CliC).

OzEWEX - the first Australian Climate and Water Summer Institute, a prestigious event that will offer ca. 15 of the best students in Australia and New Zealand a unique opportunity, with expenses covered, to work closely with peers and experts from academia and government agencies, to enhance climate and water information and its practical applications. The Institute will take place in Canberra from 5 December 2016 – 21 January 2017, breaking for Christmas and New Year. The selected students will collaborate intensively in small teams for six weeks to work on projects developing an application or improvement to data services and analysis tools from the Summer Institute consortium partners (CSIRO, Bureau of Meteorology, Geoscience Australia, Murray-Darling Basin Authority, National Computational Infrastructure, Bushfire and Natural Hazards CRC, ARC Centre of Excellence for Climate System Science, several universities and some private donors).

2.2.12 Workshops/Meetings Held

- CCRN modelling workshop, Saskatoon, SK, November 28-29, 2016
- CCRN 4th Annual General Meeting - OAC Centennial Arboretum Centre, University of Guelph, Guelph, ON, November 2-4, 2016
- CCRN Special Observation and Analysis Period (SOAP) workshop, Saskatoon, SK, October 3-4, 2016
- Cold Regions Hydrological Model (CRHM) Expert Workshop, Saskatoon, SK, June 6–7, 2016
- CCRN Theme D synthesis workshop, University of Manitoba, Winnipeg, MB, May 10-11, 2016

- The INTENSE project held a community-building workshop in Newcastle, UK from 13th-15th September 2016 “Sub-daily rainfall extremes: data, processes and modelling” This aimed to: (a) Explore best practice for using sub-daily rainfall data, including quality control; (b) Examine current research theories around processes affecting sub-daily rainfall extremes (mainly observations); (c) Identify a set of sub-daily extreme rainfall indices useful to a wide variety of users; (d) Discuss progress on convection-permitting models and the current gaps in our understanding, and how to best combine observational and modelling studies; (e) Plan the next steps in this area, including a publication from the workshop.
- Near 0C precipitation - June 22-23 2016 (Toronto) - main issue was near 0°C data quality over Canada

2.2.13. Workshops/Meetings Planned

- **GHP annual meeting** (This meeting is planned late each October.)
- **OzEWEX annual meeting** (planned November/December)
- **HyMex annual meeting** (planned each September). 10th Annual workshop in Barcelona (4-7 july 2017)
- **CCRN annual meeting** (planned each November) CCRN 5th Annual General Meeting - Delta Bessborough Hotel, Saskatoon, SK, November 1-3, 2017
- CCRC - Scenarios of future change follow up workshop, National Hydrology Research Centre, Saskatoon, SK, March 20-21, 2017
- CCRN - Spring modelling workshop on land and water futures, location TBD, Saskatoon, SK, June 19-20, 2017
- HyVic workshop: HyVic workshop is planned to, (a) bolster ICPAC’s capacity to use WCRP CMIP climate model simulations, and (b) plan the development of the co-designed curriculum with ICPAC and partner universities. Proposed funding Source: Anticipated funding Source: DFID WISER Program.
- Baltic Earth: i) workshop on "Coupled atmosphere-ocean modeling for the Baltic Sea and the North Sea" (7-8 Feb 2017; Warnemünde (IOW), Germany); ii) Joint ESA-Baltic Earth workshop on remote sensing applications (29-31 March 2017, Helsinki, Finland)
- PannEx 3rd workshop, Cluj-Napoca (Romaina), 20-22 March 2017

2.2.14. Other Meetings Attended on Behalf of GEWEX

- AGU
- EGU

2.2.15. Issues for the SSG

None

2.2.16. List of Key Publications

Chan, S.C., Kendon, E.J., Roberts, N.M., Fowler. H.J., Blenkinsop, S. The characteristics of summer sub-hourly rainfall in a high-resolution convective permitting model. Environmental Research Letters, in press.

Kendon, E.J., Ban, N., Roberts, N.M., Roberts, M.J., Chan, S. Fowler, H.J., Fosser, G., Evans, J. and Wilkinson, J. Using new high resolution models to assess the reliability of regional climate projections. Bulletin of the American Meteorological Society, in press.

Blenkinsop, S., Lewis, E., Chan, S., Fowler, H.J. 2016. Quality control of an hourly rainfall dataset and climatology of extremes for the UK. International Journal of Climatology, DOI: 10.1002/joc.4735.

Chan, S.C., Kendon, E.J., Roberts, N.M., Fowler, H.J., Blenkinsop, S. 2016: Downturn in scaling of UK extreme rainfall with temperature for future hottest days. Nature Geoscience, 9, 24–28, DOI: 10.1038/NGEO2596.

Pomeroy, J.W., Essery, R.L.H. and W.D. Helgason. 2016. Aerodynamic and radiative controls on thesnow surface temperature. Journal of Hydrometeorology, DOI:10.1175/JHM-D-15-0226.1 Weber, M., Bernhardt, M., Pomeroy, JW., Fang, X., Harer, S., and K. Shulz. 2016. Description ofcurrent and future snow processes in a small basin in the Bavarian Alps. Environmental Earth Sciences, 75(17), 1223. doi:10.1007/s12665-016-6027-1

Pomeroy J.W., Fang, X. and Marks D. 2016. The Cold Rain-on-Snow Event of June 2013 in the Canadian Rockies – Characteristics and Diagnosis. Hydrological Processes. DOI:10.1002/hyp.10905.

Fang X. and Pomeroy J. 2016. Impact of antecedent conditions on simulations of a flood in a mountain headwater basin. Hydrological Processes. DOI: 10.1002/hyp.10910.

Liu A., Mooney C., Szeto K., Thériault J.M., Kochtubajda B., Stewart R.E., Boodoo S., Goodson R., Li Y., and Pomeroy J. 2016. The June 2013 Alberta Catastrophic Flooding Event: Part 1 – Climatological aspects and hydrometeorological features. Hydrological Processes. DOI: 10.1002/hyp.10906.

Rothwell R., Hillman G., and Pomeroy J.W. 2016. Marmot Creek Experimental Watershed Study. The Forestry Chronicle, 92 (1): p. 32-36. DOI: 10.5558/tfc2016-010.

Somot, S., Houpert, L., Sevault, F., Testor, P., Bosse, A., Taupier-Letage, I., Bouin, M.-N., Waldman, R., Cassou, C., Sanchez-Gomez, E., Durrieu de Madron, X., Adloff, F., Nabat, P. and Herrmann, M., 2016: Characterizing, modelling and understanding the climate variability of the deep water formation in the North-Western Mediterranean Sea. Climate Dynamics.

Waldman, R., Somot, S., Herrmann, M., Testor, P., Estournel, C., Sevault, F., Prieur, L., Mortier, L., Coppola, L., Taillandier, V., Conan, P. and Dausse, D., 2016: Estimating dense water volume and its evolution for the year 2012-2013 in the Northwestern Mediterranean Sea: an observing system simulation experiment approach. Journal of Geophysical Research: Oceans, **121**, 6696–6716.

Estournel, C., Testor, P., Taupier-Letage, I., Bouin, M.-N., Coppola, L., Durand, P., Conan, P., Bosse, A., Brilouet, P.-E., Beguery, L., Belamari, S., Béranger, K., Beuvier, J., Bourras, D.and Canut G., Doerenbecher, A., Durrieu de Madron, X., D'Ortenzio, F.and Drobinski P., Ducrocq, V., Fourrié, N., Giordani, H., Houpert, L., Labatut, L., Lebeaupin Brossier, C., Nuret, M., Prieur, L., Roussot, O., Seyfried, L. and Somot, S., 2016: HyMeX-SOP2: the field campaign dedicated to dense water formation in the northwestern Mediterranean. Oceanography, **29**, 196-206.

2.2.17. List of Members and Term Dates

- Prof. Jason Evans – co-chair - 2013-2020
- Dr. Joan Cuxart Rodamilans – co-chair - 2017-2020*
- Dr. Nicole van Lipzig - 2014-2017*
- Dr. Silvina Solman - 2014-2017*
- Prof. Christel Prudhomme - 2015-2018*
- Dr Ben Zaitchik - 2015-2018*
- Dr Craig Ferguson - 2015-2018* (GLASS rep)
- Prof. Sylvester Danour - 2016-2019*
- Prof. Xin Li - 2016-2019*

2.3. Global Land/Atmosphere System Study (GLASS)

Reporting period: 1 January 2016–31 December 2016
URL: http://www.gewex.org/panels/global-landatmosphere-system-study-panel
Chair(s) and term dates: Aaron Boone (2013–2016); Michael Ek (2015–2018); Gab Abramowitz (2017-2020)

Overview
GLASS focuses on land surface model development and evaluation, concentrating on improving the representation of land states, fluxes and interaction with the overlying atmosphere. Ultimately, it aims to understand the predictability of land surface variables and their role in the predictability of weather and climate. To achieve these aims, GLASS is organized into three 'themes': Land-Model Benchmarking, Model Data Fusion (MDF), and Land-Atmosphere Coupling (LAC), described in the panel activities below.

2.3.1 Major Panel Accomplishment or Significant Contributions

1. *Increased coordination and effectiveness of international land model benchmarking activities.* The PLUMBER benchmarking MIP from 2015 continued into 2016 with new publications and activities, PALS is nearing release of a new generation online benchmarking system, ILAMB had considerable uptake and buy-in within the land community in 2016, and work is ongoing to bring PALS and ILAMB (and potentially LVT) together.
2. *LS3MIP cemented formally as a CMIP6 MIP with detailed protocol and motivation paper published.*
3. *Local Land-Atmosphere Coupling (LoCo).* The LoCo working group (WG) is going strong after being established nearly a decade ago to focus on the goal of accurately understanding and modeling coupled land-atmosphere processes. There was a dedicated session at the October 2016 GLASS panel meeting devoted to status and future plans, with highlights from many studies and publications on various metrics, models, and applications, including involvement in LoCo-WG targeted field programs. Many young scientists continue to be involved.

2.3.2. Panel Activities (and Science Highlights and Science issues):

Land model benchmarking and evaluation

PALS (Gab Abramowitz)
The Protocol for analysis of Land Surface models (PALS) is a web application designed for automated evaluation and benchmarking of LSMs. PALS hosts experiments, which each include: the data sets required to force or constrain a model for a particular experiment; model outputs uploaded by users (who run their models locally), including ancillary files; and 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 60+ institutions, and was used both for MIPs (e.g. PLUMBER, SavannaMIP) and model development. The system is currently offline, with the second-generation system in testing and development. The PALS system had very strong initial uptake, with users at: UKMO, NASA, NOAA, NCAR, ECMWF, ORNL, CSIRO, BureauMet, USGS, COLA, Yale, Imperial, UExter, Ureading, BostonU, UColorado,

UWashington, ColumbiaU, UArizona, UMaryland, Stony Brook, UOklahoma, ANU, MonashU, UNSW, and 40+ others, from 20+ countries.

Development on the second-generation system, however, has been slow, largely due to limited resources and a lack of external collaborators. The second-generation PALS system (modelevaluation.org) is not specific to LSMs, and is much more flexible, partly to attract new funding possibilities from other institutions engaged in natural system modelling. Key features of the second-generation system include analysis not being specific to any particular computing language or analysis package. It is structured to allow the original PALS analysis suite, as well as integrate other existing packages, such as ILAMB (Python) or LVT (Fortran), with use of a relatively simple wrapper.

The new system also allows flexible user-defined benchmarks. When submitting a model output to an experiment, users can nominate any other model outputs already submitted as benchmarks, so that the analysis engine can utilise this information when generating plots.

Finally, the new system is being build with a distributed architecture, designed to allow multiple compute nodes to run analyses. 'Worker' nodes (e.g. R / Python analysis servers) can be installed on virtual machines across multiple locations, co-located with large data sets. In practice, this means that 'upload' of model outputs to the system can simply store the path. If local worker node is present, files are not copied, otherwise files are uploaded.

A workflow system dedicated to benchmarking and evaluation allows increasingly strict enforcement of provenance and ancillary data collection. This ultimately aids reproducibility; the ability to tie a model's performance history to changes in structure, and the potential to data mine simulation meta-data as part of automated analyses.

With all source code public on GitHub, and coding structures built for team development, the future aim for PALS is simply get the second generation system functioning and adopted by the community as a community owned project. A visit to ORNL in December 2016 has laid the groundwork for integration of ILAMB as an analysis engine within the PALS system.

PLUMBER (Martin Best, Gab Abramowitz)
The PALS Land surface Model Benchmarking Evaluation project (PLUMBER) is a LSM MIP using the PALS system, designed to highlight the importance of benchmarking over traditional evaluation. That is, defining performance expectations *a priori*. Defining benchmarks before model simulations are performed, if done well, can help answer the question of whether a group 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 9 IGBP vegetation types, using 8 different performance metrics. While LSMs performed markedly better than 1st generation LSMs, they performed poorly against empirical models, especially for sensible heat flux.

Fifteen different LSM variants participated, including from the UKMO, ECMWF, CNRM, LSCE, NOAA, NASA, COLA, and CSIRO. Two papers were published by PLUMBER participants in the *Journal of Hydrometeorology* (2015, 2016, each with 20+ co-authors), lead by Martin Best (UKMO) and Ned Haughton (UNSW). The first currently has 37 citations on Google Scholar – it is clearly having an impact on the broader community. Other bodies of work using PLUMBER data are continuing (e.g., Ukkola et al, 2016, ERL; Clark et al, in prep).

The key result from the original PLUMBER paper was that despite clearly performing better than older LSMs, current generation LSMs as a whole were not utilising the information available in their input data about latent and sensible heat fluxes. That is, simple empirical models, tested out of sample (i.e. training site data was not used to test the empirical models), clearly outperformed LSMs for common metrics (such as correlation, normalised mean error, standard deviation and mean).

The second paper by PLUMBER participants (published mid 2016, led by Ned Haughton, UNSW) investigated whether this result was because of methodological flaws in the original PLUMBER experiment, and was essentially a collection of negative results. It investigated whether lack of energy conservation in flux tower data, time scale of analysis, diurnal biases, poor LSM initialisation, metric value aggregation, or site choices might have been responsible for the original result. It concluded that the most plausible explanation for the result was a shared weakness amongst LSMs, noting that the mean of all participating LSMs did not show a radical improvement in performance (suggesting that LSM error correlation is high).

Recent work by Ukkola et al (2016, ERL) used the PLUMBER data to show that in dry-down periods LSMs tended to systematically under-estimate evapotranspiration, and commonly over estimated evapotranspiration early in the growing season.
Ned Haughton is currently building broader hierarchy of empirical models, extending those used in PLUMBER. Another 3 tiers of more capable empirical models are again tested out-of-sample, as per original PLUMBER work. This will provide a lower bound estimate of how much information about latent /sensible heat flux is available in met forcing data (i.e. the predictability of sensible, latent heat flux). This will further the goals of PLUMBER in highlighting the importance of this definition of benchmarking, so that LSM performance can then be assessed by utilisation of information.

International Land Model Benchmarking (ILAMB) project (Dave Lawrence)
Building upon past model evaluation studies, the goals of the International Land Model Benchmarking (ILAMB) project are to:

- Develop internationally accepted land model evaluation experiments by drawing upon international expertise and collaboration
- Promote the use of these benchmark experiments by the international community for model intercomparison
- Strengthen linkages between experimental, remote sensing, and climate modeling communities in the design of new model tests and new measurement programs
- Support the design and development of open source benchmarking tools.

ILAMB is mainly lead/funded through US DOE Regional Climate Modeling Program. Project leadership team includes Forrest Hoffman (ORNL), Jim Randerson (UCI), Bill Riley (LBNL), David Lawrence (NCAR), and Gretchen Keppel-Aleks (U. Michigan). 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. ILAMB is being utilized by the international land modeling research community, and hosted a workshop in May 2016 at DOE with approximately 50 participants from around the world. The workshop report, which will be released in spring 2017, provides a roadmap for land model benchmarking/assessment activities going forward. Future Work: ILAMB will continue to be augmented with new metrics introduced by our international collaborators, and will be utilized in CMIP6 assessments, including assessments of LS3MIP land-only simulations. Collaboration with PALS is under discussion.

ALMIP2 (Aaron Boone)

AMMA (African Monsoon Multidisciplinary Analysis) Land Surface Intercomparison Project Phase 2 (ALMIP2) focused on the local to mesoscale, where the main goal was to improve understanding and modeling of key surface, vegetation and hydrological processes over West Africa, e.g. the subtle hydrology and vegetation processes in the region (large rooting depths, near-surface aquifers, soil crusting, lateral transfer processes, strong runoff variability). This project is spinning down with a number of papers submitted in 2016. As follow on, in addition to GHP links to AMMA, it was suggested that sensitivity to surface forcing could be further investigated by expanding LoCo or DICE for the AMMA region.

GSWP3 (Hyungjun Kim)

The Global Soil Wetness Project Phase 3 is a global offline LSM MIP. Meteorological forcing at 0.5 degree has been developed specifically for this MIP, and will additionally be used for LS3MIP and SoilWat (both described below). The "Fast-track" phase of initial simulations using preliminary a version of the forcing data is complete, with submissions from seven institutes (NCAR, ETH, U-Tokyo, Meteo-France, ECMWF, KNMI, and JMA). Analysis with the ILAMB package is complete, and manuscript preparation from the first round analysis and validation is under way. The goal was to test the forcing within a sub-set of the land surface models in order to identify any issues (which in turn, could result in changes/updates to the input forcings). This is 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 (frozen at the end of 2016) and global simulations in some instances (with CLM), have been shown to better using the GSWP3 forcing as opposed to CRU-NCEP or WFDEI forcing.

GSWP3 is also tied in with LS3MIP (Land Surface, Snow, Soil moisture Model Intercomparison Project) under its offline component, LMIP (which is endorsed as part of CMIP6). While GSWP3 simulations will run of 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 keep the consistency with CMIP6, a long-term retrospective GSWP3 experiment (EXP1) starts in 1850, with prescribed land-use/land-cover changes derived from the Land Use Harmonization (LUH) data set

The standard forcing data of EXP1 is generated combining spectral nudging dynamic downscaling and bias correction techniques. 20Th Century Reanalysis is spatio-temporally disaggregated to 3-hourly T248 resolution using a global spectral model. Multiple in-situ measured surface variables (i.e., precipitation, short-/long-wave downward radiation, and air temperature) are used to reduce intrinsic biases of the downscaled reanalysis fields.

EXP1 results submissions are due mid 2017. GSWP3 land reanalysis fields, compiled from submissions, are expected to be released in late 2017.

LS3MIP (Bart van den Hurk, Sonia Seneviratne, Hyungjun Kim et al)

The Land surface, soil moisture and snow model intercomparison project (LS3MIP), part of the CMIP6 experiment suite, aims to assess land surface, snow and soil moisture feedbacks on climate variability and climate change, including:

- land-atmosphere coupling and its impacts (for climate trends, water resources, predictability);
- linking patterns and trends of ECVs to land model properties and biases;
- mapping (uncertainty of) water resources over the 20th century (and beyond);
- explore model-dependent land-atmospheric coupling;

- investigate the ability of climate models to capture observed rates of spring snow cover
- understand the linkage between snow-albedo feedback and 21st century warming

LS3MIP therefore focuses primarily on the physical system, with carbon cycle and vegetation dynamics covered in more depth by CMIP complements C4MIP and LUMIP respectively (more on LUMIP below). It is divided into two phases: LMIP (offline) and LFMIP (online, with Feedbacks), and aims both to compare CMIP6 historical and DECK simulations with observations, as well as examine changes to energy and water cycles through the historical period through to projected futures. These also include coordinated SnowMIP model intercomparisons.

The LFMIP experiments include land-atmosphere as well as land-atmosphere-ocean coupled simulations, with different combinations of prescribed land conditions, sea surface temperatures and smoothed boundary conditions used to asses the roles of land-climate and land-climate-ocean feedbacks on ECVs and seasonal predictability.

A detailed description of the protocol was published this year by van den Hurk et al (2016).

The LS3MIP timetable is essentially determined by the CMIP6 timetable. Participants include: ACCESS, BCC-CSM2-MR, CanESM, CESM, CMCC, CNRM-CM, EC-Earth, FGOALS, GFDL, GISS, IPSL-CM6, MIROC6-CGCM, MPI-ESM, MRI-ESM1.x, NorESM, UKESM.

Model data fusion

Project for the Intercomparison of Land Data Assimilation Systems (PILDAS) (Rolf Reichle, Sujay Kumar) is a community effort organized through the GEWEX/GLASS panel that provides a framework for comparing and assessing land surface data assimilation systems. The objective is to:

- enable better communication among LDAS developers,
- develop and test a framework for LDAS comparison and evaluation,
- compare land assimilation methods,
- conduct sensitivity studies of assimilation input parameters (such as model and observation errors),
- provide guidance and priorities for future land assimilation research and applications, and
- ultimately, produce enhanced global data sets of land surface fields.

Participants include (Institution, POC): ECMWF (P. de Rosnay, G. Balsamo), Environment Canada (S. Belair, M. Carrera, B. Bilodeau), Ghent University (V. Pauwels, N. Verhoest), Meteo-France (J.-F. Mahfouf), Monash University (J. Walker), NASA/GMAO (R. Reichle, Q. Liu), NASA/Hydrological Sciences Lab (S. Kumar, M. Navari), NOAA/NCEP (J. Dong, M. Ek), Norwegian Institute for Air Research (NILU) (W. Lahoz, T. Svendby), USDA/ARS Hydrology and Remote Sensing Lab (W. Crow), CAREERI/Chinese Academy of Sciences (X. Han).

The PILDAS experiment protocol has been developed and has been tested with two different land DA environments – the GEOS5 land data assimilation system (LDAS) and the NASA Land Information System (LIS). The initial assimilation experiments employ soil moisture retrieval assimilation and demonstrated improvements in the near surface and root zone soil moisture states from assimilation.

Outline of Future Work: the PILDAS configuration requires the specification of several components, more complicated than prior GLASS community experiment projects. The next step in the process would be to solicit the participation of the larger land DA community.

The PILDAS experiment is expected to help in the development of best practices in land DA systems for the optimal exploitation of the information content of remote sensing data. The improvements in land DA systems are key to improving land surface model predictions for a variety of science research and applications ranging from the study of water and energy cycles, weather/climate initialization, agricultural and water resources management.

Land-atmosphere coupling

LoCo (Joe Santanello)

The motivation for Local Land-Atmosphere Coupling (LoCo) has been clear for some time, in that the results of offline projects such as the Project for the Intercomparison on Land-surface Parameterization Schemes (PILPS) and the Global Soil Wetness Project (GSWP) are limited by the lack of atmospheric feedback. Although the results of Global Land-Atmosphere Coupling Experiment (GLACE) provide an assessment of global circulation model (GCM) coupling coherence, they cannot isolate and evaluate the processes implied in the coupling that lead to model development. In terms of accurately representing the relationship between soil moisture (SM) and precipitation (P) and coupling strength in models, and to have the proper understanding and related improvement, it is necessary to carefully examine and quantify the full series of interactions and feedbacks (i.e., links in the chain) at the process-level, including the planetary boundary layer (PBL) feedback. To this end, the LoCo working group (WG) was established nearly a decade ago to focus on development of quantitative process-based metrics/diagnostics of land-atmosphere (L-A) coupling that could be applied equally to observations and models across scales.

The LoCo WG is comprised of ~15 GLASS panel and non-panel members. It is not meant to be exclusive, and has a high proportion of young scientists who have been motivated by L-A interactions studies. LoCo has closest links with GEWEX GASS/GABLS (Global Atmosphere System Studies/GEWEX Atmospheric Boundary Layer Study) and Diurnal Coupling Experiment (DICE), due to the inherent importance of the Planetary Boundary Layer (PBL) and model development in each. For example, Joe Santanello and Mike Ek are working on a paper bringing the LoCo metrics to bear on the DICE results. LoCo is attempting a request to CMIP6 (via GSWP and Land Surface, Snow and Soil Moisture Model Intercomparison Project, LS3MIP) for an increased set of L-A variables to be included in the standard output of participants.

The LoCo effort just reached the 10-year mark, and held a dedicated session at the GLASS panel meeting (early October, CNRS, Gif-sur-Yvette, France) devoted to the status and future plans of LoCo and the LoCo WG. There are many studies and publications from the WG in recent years focused on various metrics, models, and applications. See the GEWEX-LoCo website: www.gewex.org/loco/, also a nice synthesis by Paul Dirmeyer: http://cola.gmu.edu/dirmeyer/Coupling_metrics.html, and LoCo coupling metrics toolkit from Ahmed Tawfik: www.coupling-metrics.com.

Observations of L-A processes and the need for assessment/improvement has been a recent point of emphasis of the LoCo WG, including PBL (Joe), soil moisture (Paul), and fluxes (Pierre)). As a result, field campaigns have been a point of emphasis such as the enhanced sonde at the DOE Southern Great Plains site (SGP) (Craig, Joe, Pierre) in Summer 2015,

improved soil moisture and co-located L-A measurements from DOE-ARM (Joe), NY State Mesonet (Craig), and the Land-Atmosphere Feedback Experiment (LAFE : Volker Wulfmeyer, NASA, NOAA) @ SGP in Summer 2017. In addition, Joe Santanello has received funding for a Science Task Group at NASA focused on PBL retrieval from space.

The future of LoCo and a three-pronged approach was developed :
a) Continue to follow and broaden the science of LoCo and WG participation. Suggestions: snow, geology, carbon, LULCC, momentum, radiation, fluorescence, monsoon – each are evolving naturally via independent research.

b) Synthesize what we have now in terms of metrics and message. Leverage off existing MIPs: LoCo-Plumber, LoCo-DICE, LoCo-CMIP.

c) Engage and entrain the operational/model development community, i.e. Ahmed Tawfik and Craig Ferguson – convective schemes + observing networks, CMIP6 variable request (in process).

GABLS/GLASS/DICE Experiments
Please refer to the GABLS summary provided by Gunilla Swensson and Bert Holtslag. Focus on GABLS4, "DICE-over-ice", lead by Eric Bazile, Fleur Couvreux, Patrick Le Moigne (Météo-France).

LS3MIP (Bart van den Hurk, Sonia Seneviratne, Hyungjun Kim et al)
Note that LS3MIP, as described above in the benchmarking and evaluation section, also has a strong coupling focus.

2.3.3. New Projects in Place

GEWEX-SoilWat (Dani Or, et al)
Following discussions between GEWEX and the soil and critical zone communities regarding how to improve interactions and integration of soil and subsurface processes in present climate models and other activities of *GEWEX*, a planning workshop aimed at designing and prioritizing interactions took place in June 28-30, 2016 in Leipzig. The *GEWEX-SoilWat* first planning workshop attracted 25-30 participants for 2 days of presentations and discussions. The key issues discussed revolved around how soil processes (infiltration, evaporation, soil properties, etc.) are represented in land-surface models; issues related to the role of plants in climate models; how to bridge scales between traditional soil models and representation relevant to climate modeling; effective incorporation of groundwater models; and how to best move forward with integration of the communities. Some of the main outcomes of the planning workshop are: (1) to survey how basic soil processes are represented in climate models with emphasis on revisiting the pedotrasnfer functions used to convert soil information to parameters for modeling (Harry Vereecken and Anne Verhoef – leads); (2) to assess the utility of more resolved soil maps, a sensitivity analysis (*SoilParameterMIP*) to evaluate several climate models using old and new soil maps and parameters (Lukas Gudmundsson, Matthias Cuntz and the ISMC [Dani Or and Harry Vereecken] leads); (3) survey of groundwater database and strategies for incorporating groundwater in climate models (Stefan Kollet, Anne van Loon and Peter van Oevelen – leads). We also agreed to write a perspective paper to clarify the needs, objectives, and future directions of the *GEWEX-SoilWat* initiative (Sonia Seneviratne, Peter van Oevelen, Gerrit de Rooij, and Dani Or – leads). The workshop was successful in galvanizing the interactions between the two communities and highlighted the commitment and interest in finding ways to cooperate for improving soil and subsurface in

climate models and informing the soil communities of climate models capabilities and opportunities. It was agreed to follow up with a second GEWEX-SoilWat workshop within the coming year (2017) to report progress and discuss processes not addressed in this workshop (soil and plant processes, human interactions).

LUMIP (Dave Lawrence)

The Land Use Model Intercomparison Project (LUMIP) aims to further advance understanding of the impacts of land-use and land-cover change (LULCC) on climate, specifically addressing the questions: (1) What are the effects of LULCC on climate and biogeochemical cycling (past-future)? (2) What are the impacts of land management on surface fluxes of carbon, water, and energy and are there regional land-management strategies with promise to help mitigate against climate change? In addressing these questions, LUMIP will also address a range of more detailed science questions to get at process-level attribution, uncertainty, data requirements, and other related issues in more depth and sophistication than possible in a multi-model context to date. There will be particular focus on the separation and quantification of the effects on climate from LULCC relative to all forcings, separation of biogeochemical from biogeophysical effects of land-use, the unique impacts of land-cover change versus land management change, modulation of land-use impact on climate by land-atmosphere coupling strength, and the extent that impacts of enhanced CO2 concentrations on plant photosynthesis are modulated by past and future land use.

LUMIP involves three major sets of science activities: (1) development of an updated and expanded historical and future land-use dataset, (2) an experimental protocol for specific LUMIP experiments for CMIP6, and (3) definition of metrics and diagnostic protocols that quantify model performance, and related sensitivities, with respect to LULCC. In this manuscript, we describe the LUMIP activity (2), i.e., the LUMIP simulations that will formally be part of CMIP6. These experiments are explicitly designed to be complementary to simulations requested in the CMIP6 DECK and historical simulations and other CMIP6 MIPs including ScenarioMIP, C4MIP, LS3MIP, and DAMIP. LUMIP includes a two-phase experimental design. 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 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. This paper documents these simulations in detail, explains their rationale, outlines plans for analysis, and describes a new subgrid land-use tile data request for selected variables (reporting model output data separately for primary and secondary land, crops, pasture, and urban land-use types). It is essential that modeling groups participating in LUMIP adhere to the experimental design as closely as possible and clearly report how the model experiments were executed.

LUMIP is one of the CMIP6 satellite MIPs and therefore is integrated with all CMIP6 activities. In particular, LUMIP was designed in collaboration with LS3MIP, C4MIP, and DAMIP. LUMIP is crosscutting across GEWEX and iLEAPS activities. LUMIP is lead by David Lawrence (NCAR) and George Hurtt (U. Maryland). The LUMIP SSG includes: Almut Arneth (KIT), Victor Brovkin (Max Planck), Kate Calvin (PNNL), Andrew Jones (LBNL), Chris Jones (Hadley Centre), Peter Lawrence (NCAR), Julia Pongratz (Max Planck), Sonia Seneviratne (ETH-Zurich), and Elena Shevliakova (GFDL). LUMIP is kicking off in 2017 so there are no science highlights at this point. LUMIP has been presented at many meetings, including AGU, CESM Workshop, ILAMB, and CRESCENDO meetings. A LUMIP kickoff webinar was held in October 2016. The LUMIP experimental protocol has been documented in Lawrence et al (2016) (See: 18. Publications below)

2.3.4. New Projects and Planned Activities

PALS Phase 2 release. As described above, the second phase of the PALS system is undergoing testing, and despite limited resources, will likely launch in 2017. This aims to facilitate a range of model development and comparison activities.

PLUMBER 2. As noted above, PLUMBER related work is continuing, in the form of a more comprehensive suite of empirical models (used as a hierarchy of utilization of information by LSMs). This, together with the recent Fluxnet release, and the considerable impact of the initial PLUMBER work suggests that a second phase of PLUMBER, with more sophisticated and ideally process-based metrics, would likely benefit the community. This relies on the release of PALS phase 2, but the PALS system will be ready for this style of experiment immediately after release. Likely timeline: experiment planning late 2017 / early 2018; simulations and analysis 2018; paper submission 2019.

Potential new project: Improved representation and testing of anthropogenic water management within LSMs. At the Joint GHP-GLASS workshop on this topic (more below), strategies for incorporation of relevant processes (without compromising conservation principles) were discussed. This would clearly rely upon identification of large-scale basins were enough observational data of these processes might exist (and be accessible) to sufficiently constrain LSMs, to point of diagnostic model evaluation. The Ebro and Murray-Darling basins were identified as possible candidates, but investigations around data availability are ongoing, so that despite momentum in the area no specific project details have yet emerged. Likely in the medium term though – no specific timeline.

Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE; Martin Best et al). Semi-arid environments are sensitive regions for land-atmosphere coupling with stressed vegetation at times, and often a high degree of heterogeneity. There is a need to better evaluate the simulation of the surface energy budget in order to improve models and properly represent the seasonal dry-down period in these regions. Data sets to be used for comparisons with models will include a comprehensive collection of surface/near-surface measurements over the diurnal cycle for a full annual cycle, augmented by atmospheric profile and aircraft measurements. The ground site is not yet definitively chosen, but the current likely timing for the measurement program is May 2019 to May 2020, with linkage between GLASS, GHP and other projects.

Science highlights (described with 2.3.2 Panel Activities)
Science issues (described in 2.3.2 Panel Activities)

2.3.5. Contributions to Developing GEWEX Science

GEWEX Imperatives: Data Sets, Analysis, Processes, Modeling, Applications, Technology Transfer, and Capacity Building.

GLASS contributes *most directly* to the following GEWEX Imperatives:

Process: Develop approaches to improve process-level understanding of energy and water cycles in support of improved land and atmosphere models.

- Identify feedbacks and the interactions among different processes, and build confidence in their replication in models (LoCo).

- Develop metrics to aid benchmarking activities for both un-coupled and coupled modeling activities (PALS/PLUMBER, DICE)
- With the current and expected increasing complexity of land models in terms of various hydrologic and vegetation treatments, model optimization (i.e., parameter estimation approaches) will continue to be relevant to GLASS efforts (through Model Data Fusion).
- Investigate alternative representations of sub-grid processes in land surface schemes (heterogeneity).
- Develop improved understanding of climate variability and change on land surface properties, including soils, vegetation and hydrological processes, and an associated modeling capability (GSWP3, ALMIP2, GEWEX soils initiative).
- Investigate the scope for development of next generation land surface models with improved representation of subsurface hydrology, including groundwater processes; identify suitable areas for their evaluation.
- Improved representation of cold season land surface, Carbon and hydrological processes (potential CCRN project)

Modeling: Improve global and regional simulations and predictions of precipitation, clouds, and land hydrology, and thus the entire climate system, through accelerated development of models of the land and atmosphere.

- Coordinate the construction of a global land reanalysis system, building on ongoing and preparatory activities in Landflux, GSWP3, GLDAS and operational weather centers.
- Develop a framework and infrastructure for evaluation of land-atmosphere feedbacks. This should include the development of more quantitative estimates of uncertainty in the land condition and how this uncertainty propagates through to the atmosphere (e.g., PBL, convection, water and energy, carbon). This objective will be advanced in conjunction with the Processes Imperative in developing diagnostics.
- Organize coordinated intercomparison experiments for a range of model components in state-of-the-art land models, especially with regard to: treatment of soils, groundwater hydrology; surface water treatment (snow, river routing, lakes, irrigation, and dynamic wetlands); vegetation phonology and links between carbon and water; treatment of soils (GEWEX Soils Initiative); and Land Data Assimilation systems (follow-up to the PILDAS initiative).
- Evaluation of these land model components will also have to be considered in their interactive (coupled) context with the PBL, while taking into account and developing more quantitative measures of uncertainty in the land parameters and states will enable more robust evaluation of data assimilation systems.

Additionally, GLASS contributes to: **Technology Transfer** (develop new observations, models, diagnostic tools and methods, data management, and other research products for multiple uses and transition to operational applications in partnership with climate and hydrometeorological service providers), and **Capacity Building** (Promote and foster capacity building through training of scientists and outreach to the user community).

2.3.6 Contributions to the GEWEX Science Questions

- **Observations and Predictions of Precipitation:** How can we better understand and predict precipitation variability and changes?
  - *The GLASS activities below address the linkages of precipitation (and its accuracy) to land surface processes and LSM predictability. Related current GLASS activities:
    - LS3MIP to begin within CMIP6 framework.
    - LoCo – Regional/Local Process-Level Quantification of land-PBL interactions and impact of land surface on precipitation (POC: Joe)

- ALMIP2 – Specific precipitation event studies and heterogeneity issues in soil moisture-precipitation feedbacks (POC: Aaron, project ending)
- PILDAS – Land DA of soil moisture; multi-variate coupled DA (precip and soil moisture) in a future phase (POC: Rolf)
- GSWP3 – Precipitation as a key forcing for 20th Century simulations – this effort should quantify the error bounds on the 'land reanalysis' generated due to precipitation uncertainty (POC: Hyungjun)
- Land Model Benchmarking – How does Precip uncertainty impact offline and coupled model evaluation – spread of LSM physics vs. spread due to precipitation errors (POC: Martin, Gab)

  Future activities:
- Incorporation of new satellite products (GPM, SMOS, SMAP) into these efforts more explicitly.

- **Global Water Resource Systems**: How do changes in land surface and hydrology influence past and future changes in water availability and security?

– *Water Use, Resources, and Sustainability issues are at the heart of this challenge. How can GEWEX be positioned to meet this challenge given the current structure and makeup, currently focused on modeling groups and model intercomparisons with loose ties only (at best) with water resource and planning communities? Current activities are trying to answer various aspects of the science issues here (e.g. soil moisture and drought in a changing climate), but not yet at the stage of integrating the entire terrestrial water budget. GRACE is the only current tool we have in this regard, but is very limited in space and time scales such that regional and diurnal studies and models cannot be improved or assessed using this dataset. Carbon, ecosystem, cryosphere, ground water, and distributed hydrology models are not traditionally GEWEX activities – but fully integrated Earth System and Land models are the future so we need to be forward thinking. It seems this challenge is really the overarching challenge of all land hydrology for climate studies.

– As a result, this challenge also intersects directly with other entities (ILEAPS, iLAMB, CLiC, DMIP, LULCC/LUMIP). This challenge might boil down to coordinating model development from previously disparate disciplines and applications, and based on CMIP5 results in terms of the limitations and sensitivities to the land hydrology (e.g. previously reported LUCID results).

  Related concluded GLASS activities:
  - LUCID1 and 2 (POC: Andy)
  - ALMIP1 and 2 (POC: Aaron)
  - PILDAS/SMAP (DA of surface and root zone soil moisture will be critical to link with GRACE)

- **Changes in Extremes:** How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?

– *This continues to be a 'hot topic', e.g. how will the frequency and location of extremes change due to 'x' amount of warming in the future? The NASA Energy and Water Cycle Study (NEWS) chose 'Extremes' as one of it's core integration projects, and could be looked at as a model both of what and what not do, and what can be learned by a limited

subset of the community (material available online). Model evaluation and benchmarking becomes critical here as well. Most models are tested offline and only for average conditions, and once into extreme realms of forcing or states tend to behave much differently. Recent LSM calibration/parameter estimation studies suggest that a vastly different set of parameters (lookup tables) is required for extremes vs. average conditions. As observational data improves (e.g. challenge #1), this is no guarantee the models will behave better as a result. DA and Calibration studies should be a focus here. Calibration is a weak component of GLASS currently and should be expanded under 'Model Data Fusion'. You can learn a lot about model behavior and limitations that way, especially in concert with DA.

Related current GLASS efforts:

- PILDAS - DA w/ Calibration for improved soil moisture representation during extreme conditions.
- LoCo - quantification during extremes to get at model behavior & how LSMs impact the persistence of droughts/floods and feedbacks. Seasonal drought prediction needs a lot of improvement with the emphasis on the land impact (http://www.climatecentral.org/news/lack-of-warning-on-2012-us-drought-reflects-flaws-in-forecasting-14823/)
- ALMIP2 - inherently encompasses dry extremes/feedbacks over AMMA with monsoon precipitation.
- LS3MIP is examining impact of soil moisture on extremes in CMIP5 (IPCC report just out on the subject).
- Benchmarking - should look at model performance stratified by regime (e.g. PLUMBER)
    - *Future activities:*
- CORDEX-GLASS collaboration possibly needs to a) exist and b) accelerate to answer these questions in the context of climate model predictions.

- **Water and Energy Cycles and Processes**: How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?
    -
    - *This seems to be the most traditional GEWEX-type challenge in that it promotes a lot of activities in the current panels and relies on the strengths of the current makeup. What this challenge also shows is how much more work needs to be done in quantifying and improving water and energy cycle prediction in models of all scales and types. Results and improvements as a result are felt throughout the remaining three challenges, WCRP, and other communities as well. In order to close the land surface energy balance, we need to address all the issues and model evaluation and development listed in this challenge, and it will require SMOS/SMAP, GPM, GRACE, etc. to get right.
    - Related current GLASS efforts:
    - GSWP3 – Land reanalysis and sensitivity of surface fluxes to forcing uncertainties including radiation.
    - LoCo – Determining Processes; How are land and PBL fluxes quantified and interact with each other?
    - PILDAS – Constraining LSMs with observations for improved land surface energy balance.
    - Benchmarking – Asses land surface energy balance in models vs. empirical models, and evaluating the 'goodness' of a model prediction.
    - Future activities:

- GLASS-GDAP – Improve connection between SRB, Landflux and GLASS modeling and prediction and consistency between data products and models.
- Anthropogenic Influences on the Global Water Cycle initiative: better characterize and prediction the impact of the human imprint on the water cycle

2.3.7 Other Key Science Questions

As in previous years, the following remain on our list:

1. The impact of the land surface, soil moisture and vegetation (interactive phenology), and L-A coupling on Seasonal/Drought Prediction.

2. A common modular interface for LSMs (new ALMA), such that different models and components can be more easily transferred to other's platforms, intercompared, and swapped. This would also include a common land-atmosphere coupling modularity such that different atmospheric and land models can be intercompared in order to evaluate the impact of each on the coupling results. Continuing to mproving Benchmarking methods/tools/datasets for the community as a whole.

3. Pressing Model developments/improvements: Improved cold season processes (interactions between permafrost and greenhouse gas emissions), ground water interactions, anthropogenic processes/water management (irrigation, aquifer uptake, crop harvest, improved LULCC), and the LSM "grey zone" (in anticipation of ever-higher resolution research and NWP applications: lateral fluxes of mass and energy), improved representation of soils and their highly heterogeneous nature.

A new item:

4. Follow-on DICE activities in partnership with GABLS to better understand and assess land-atmosphere interaction at the process level, for a much larger number of sites across the globe for different seasons, ecosystems, etc. This would most likely utilize data sets from a number of field programs (with co-located surface flux measurements) through an extensive "data mining" effort. This could expand the PALS/PLUMBER concept into (local) coupled observational and modelling assessments.

2.3.8. Contributions to WCRP Grand Challenges

Cryosphere response to climate change (including ice sheets, water resources, permafrost and carbon)

- Links to GABLS4 experiment and stable PBL coupling.
- ESMsnowMIP component of LS3MIP will address coupling between the atmosphere and the cryosphere (namely snow covered areas).
- Possible new project based on CCRN interactions.

Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity

- None direct, but L-A Coupling theme addressing the soil moisture-precipitation feedbacks.
- Improved aerosol emissions in regional to large-scale models could possibly be assisted within the context of GEWEX Soils Initiative (better soils data and processes).

- **Past and future changes in water availability (with connections to water security and hydrological cycle)**
  - GSWP3, LS3MIP, and GPM/GRACE/SMOS/SMAP synergy.
  - LAC (process-level improvement in water and energy cycle feedbacks).
  - Improved understanding of land-surface and hydrological processes in semi-arid zones where water resources are already limited (ALMIP2).
  - The human imprint on the hydrological cycle within the new Anthropogenic Influences ("Water Management") on the water cycle initiative (GHP+GLASS).

- **Science underpinning the prediction and attribution of extreme events**
  - See above w.r.t. GEWEX Challenge #3 (Changes in Extremes; strongest contribution from GLASS is possibly here).
  - Benchmarking (model goodness during extreme conditions), MDF (data assimilation and model calibration during extremes), and LAC (improvements in coupling leading to improved predictability of extreme events from local to global scales)

- **Near Term Climate Prediction (New)**
  - None

- **Carbon Feedbacks in the Climate System (New)**
  - GSWP3, ILAMB, LS3MIP (land, snow/ice/permafrost, soil moisture), ILEAPS

2.3.9. Cooperation with WCRP Projects and Other International Programs

Subseaonal-to-Seasonal (S2S) Project (Paul Dirmeyer is GEWEX/GLASS Liaison)

S2S hindcast and real-time forecast data set documentation from 11 operational centers was lacking information on land surface model characteristics and initialization. GLASS drafted a questionnaire on recommendation of F. Vitart that was circulated to modeling centers. As of mid-December 2016, 9 of 11 centers have responded (no NCEP or HMCR yet) and that information has been incorporated into the models' documentation on the S2S Project web site: https://software.ecmwf.int/wiki/display/S2S/Models

Many S2S models not reporting soil moisture ("required" variable); ECMWF, CMA, HMCR and NCEP have 20cm and 1m-soil moisture reported, BoM only 20cm, all others not reporting. ECCC did not know to interpolate, will begin reporting in 2017. UKMO, Météo-France says they will begin reporting after land model upgrades in 2017. The Met Office is lacking a lot of surface variables.

S2S Prediction project http://s2sprediction.net/ entering 4th year of 5-year lifetime, contemplating renewal for an additional 5 years. This is a time to recommend changes to make forecasts/hindcasts/data sets more useful and relevant to the GEWEX community.

S2S includes 6 subprojects with different research foci – all are open to additional membership by interested parties http://s2sprediction.net/static/subproject:

- Extreme weather (F. Vitart)
- Monsoons (A. Marshall, H. Hendon)
- MJO (S. Woolnough and D. Waliser)
- Africa (R. Graham, A. Robertson)
- Teleconnections (H. Lin, C. Stan)
- Verification (C. Coelho, Y. Takaya)

New US effort supported by NOAA/CPO called "SubX" is also a sub-seasonal forecast/hindcast experiment http://cola.gmu.edu/subx/, and differs from S2S in the following ways:

- Evolved from seasonal prediction predecessor: NMME (North American Multi-Model Ensemble) – focus remains on multi–model ensemble techniques
- Only North American models involved, includes research models (NCEP/CFSv2, NCEP/GEFS, NASA/GMAO, NCAR-CCSM4, ECCC, USNavy)
- All models synchronize IC dates, output data grid, land/sea mask, period of hindcasts
- No time embargo on real-time forecasts

Also, more GEWEX-relevant output variables than S2S; another resource for GLASS studies. Hindcasts should be completed by the end of 2017.

NOAA/Climate Program Office/Model Analysis, Prediction and Projection also supporting now a research effort on S2S predictability and prediction: http://cpo.noaa.gov/ClimatePrograms/ModelingAnalysisPredictionsandProjections/MAPPTaskForces/S2SPredictionTaskForce.aspx. Task force (made of funded PIs) leadership includes Dirmeyer.

Joint GEWEX/CLIVAR Monsoon Panel (MP; Dirmeyer is co-chair with Andy Turner)

Regional working groups have been constituted – these are the primary bodies through which research and outreach occur, and including Working Groups from Asia-Australia, Africa, and the Americas. MP membership updates put before the GEWEX SSG, include nomination of Françoise Guichard to replace Paul Dirmeyer as co-chair from GEWEX, Francina Dominguez as second member from the Americas working group. The CMIP6 Global Monsoons Modeling Intercomparison Project (GMMIP) constituting an SSC, ToR, soliciting input from regional monsoon WGs for performing analyses as well as global analyses from the MP. There is interest in promoting a workshop on the role of the land surface and land-atmosphere feedbacks in monsoons, possibly as an ICTP workshop / targeted training activity, and/or as a theme/topic for the next GEWEX Open Science Conference. ICMPO-Pune functionality issues are an ongoing problem; qualified project office personnel and leadership are still lacking.

WCRP Modelling Advisory Council (WMAC): The Mission of WMAC is to coordinate high-level aspects of modelling across WCRP, ensuring cooperation with main WCRP partners such as World Weather Research Programme (WWRP), and acting as a single entry point for all WCRP modelling activities. Joe Santanello has represented GLASS and land modeling interests in his capacity as a WMAC panel member.

Working Group on Numerical Experimentation (WGNE): [WCRP/WGNE Updates (Mike)] The Working Group on Numerical Experimentation (WGNE), jointly established by the WCRP Joint Scientific Committee (JSC) and the WMO Commission for Atmospheric Sciences (CAS), which is responsible for WWRP and GAW, has the responsibility of fostering the development of atmospheric circulation models for use in weather, climate, water and environmental prediction on all time scales and diagnosing and resolving shortcomings.

HyMEX (Pere/Philippe)

HyMeX (Hydrological Cycle in the Mediterranean Experiment) studies the Mediterranean coupled system using a multi-disciplinary and multi-scale approach with a focus on extremes.

Within HyMeX, the Drought and Water Resources Science Team is focusing on Mediterranean drought processes, drought observation and description, drought prediction at seasonal and climate scales, understanding the role of humans as part of the system and also the social impacts of drought and water management practices. HyMEX links with GEWEX GLASS and GHP, and other groups.

ILEAPS collaborations (Eleanor Blyth)

While GEWEX/GLASS focuses on observations and modeling of the land-atmosphere exchanges of heat and water, ILEAPS has as its focus biogeochemical cycles and the interaction of land with atmospheric chemistry and role of humans. The potential for joint GLASS-ILEAPS activities includes land model benchmarking, observations for process-level understanding, freezing and arctic processes, and extremes.

Applications and/or Links to the Global Framework of Climate Services

None.

Outreach and Capacity-Building Activities

In an effort to promote process-level understanding (land-hydrology, land-atmosphere interaction), encourage young scientist to join GLASS to participate in GLASS-led and cross-cut projects (within and external to GEWEX), eventually taking on project leadership and GLASS panel leadership roles. The GLASS LoCo WG is a good example.

2.3.10. Workshops/Meetings Held

- 28-30 June 2016: The GEWEX-SoilWat initiative: first planning workshop for scope and interactions in Advancing Integration of Soil and Subsurface Processes in Climate Models, held in Leipzig, Germany.

- 8-10 August 2016: International Workshop on Land Surface Multi-spheres Processes of Tibetan Plateau and their Environmental and Climate Effects Assessment, held in Xining, China. Peter van Oevelen provided a short slide presentation on GLASS land model benchmarking and land-atmosphere interaction activities, with possible application to the Third Pole Environment (TPE).

- 28-30 September 2016: Joint GHP-GLASS “Water Management” workshop on anthropogenic influences on the global water cycle, held at CNRS in Gif-sur-Yvette, France, with focus on representing the human dimension in land-surface models (LSMs). This is a crosscutting initiative that promotes the inclusion of human processes in LSMs and broadens GEWEX’s current consideration of anthropogenic influences.

- 3-5 October 2016: GLASS panel meeting, held at CNRS in Gif-sur-Yvette, France, the week following the Water Management workshop

- Also informal side meetings were held at e.g. AMS (January), EGU (April), Washington DC (May, following ILAMB), AGU (December).

2.3.11. Workshops/Meetings Planned

- 15-19 May 2017: GLASS panel meeting (15-16 May) and GSWP3-ISIMIP workshop (17-19 May) to be held in Tokyo.

- 19-23 June 2017: 5th Working Group on Numerical Experimentation (WGNE) workshop on systematic errors in weather and climate models to be held in Montréal, Canada.

- 9-13 October 2017: 32th session of the Working Group on Numerical Experimentation (WGNE-32) to be held in Exeter, UK as part of a WCRP Joint WGCM-WGSIP-WGNE-OMDP meeting.

2.3.12. Other Meetings Attended on Behalf of GEWEX

- WGNE: 31th session of the Working Group on Numerical Experimentation (WGNE-31), CSIR, Pretoria, South Africa, 26-29 April 2016 (Mike Ek).
- WMAC: 5th Session of the WCRP Modelling Advisory Council (WMAC-5), Geneva, Switzerland, 25-27 April 2016 (Joe Santanello)
- ILAMB: hosted a workshop 16-18 May 2016 at the Department of Energy in Washington, D.C. with approximately 50 participants from around the world. The workshop report, which will be released in spring 2017, will provide a roadmap for land model benchmarking/assessment activities going forward (Dave Lawrence, Gab Abramowitz, Martin Best).

2.3.13 Issues for the SSG

Interaction with other GEWEX panels and other external groups. Fortunately GABLS remains strong via leadership from Gunilla Swensson, Bert Holtslag and e.g. those in GABLS leading DICE efforts connected to GLASS, plus John Edwards (as a our radiation expert and liaison to GASS). But how can other GASS activities with relevance to GLASS (and vice versa) be strengthened? GHP has been strengthened via the recent (October) joint GHP-GLASS workshop on water management. Additionally we have previously reported on a potential Cold Season Processes Project where GLASS could play a role with GHP, ILEAPS, and CliC focused on e.g. Saskatchewan and Mackenzie river basins (in cooperation with Howard Wheater et al at University of Saskatchewan), involving the CliC Permafrost Modeling Forum, with links to the Permafrost Carbon Network (PCN). Similarly there is the potential for GLASS involvement in a new RHP initiative in the US (workshop last spring in Columbia, MD). Finally, use of satellite data via collaboration with GDAP could be of benefit to GLASS projects, e.g. for land model benchmarking exercises.

There have been tentative plans for a Pan-GLASS meeting sometime in the future, but with the upcoming GEWEX conference planned for 2018, it makes sense to delay such a meeting until some time after this, e.g. 2020, which is approximately mid-point between GEWEX conferences. It is anticipated that such a Pan-GLASS workshop would include joint sessions with relevance to GASS, GHP and GDAP.

2.3.14 List of Key Publications

Land Model Benchmarking

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. Hydrometeor., 17, 1705-1723, doi: 10.1175/JHM-D-15-0171.1.

2. Ukkola, A. M., De Kauwe, M. G., Pitman, A. J., Best, M. J., Abramowitz, G., Haverd, V., Decker, M., Haughton, N. (2016) Land surface models systematically overestimate the intensity, duration and magnitude of seasonal-scale evaporative droughts, *Environmental Research Letters*, vol. 11, http://dx.doi.org/10.1088/1748-9326/11/10/104012
3. Whitley R;Beringer J;Hutley LB;Abramowitz G;De Kauwe MG;Duursma R;Evans B;Haverd V;Li L;Ryu Y;Smith B;Wang YP;Williams M;Yu Q, 2016, 'A model inter-comparison study to examine limiting factors in modelling Australian tropical savannas', *Biogeosciences*, vol. 13, pp. 3245 - 3265, http://dx.doi.org/10.5194/bg-13-3245-2016
4. Getirana, A., A. Boone, C. Peugeot, and the ALMIP-2 Working Group, 2017: Streamflows over a West African basin from the ALMIP-2 model ensemble. *J. Hydrometeor.*. (accepted)
5. Grippa, M., L. Kergoat, A. Boone, C. Peugeot, J. Demarty, B. Cappelaere, L. Gal, P. Hiernaux, E. Mougin, M. Anderson, C. Hain, and the ALMIP2 Working Group, 2017: Modelling surface runoff and water fluxes over contrasted soils in pastoral Sahel: evaluation of the ALMIP2 land surface models over the Gourma region in Mali. *J. Hydrometeor.*. (accepted)

Land/Atmosphere Coupling

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

Model Data Fusion

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. *GMD*, **9**, doi:10.5194/gmd-9-2973-2016.
2. 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, 2016 www.geosci-model-dev.net/9/2809/2016/ doi:10.5194/gmd-9-2809-2016.

2.3.15. List of Members and Term Dates

The following is the list of members and their affiliations currently on the GEWEX web site. At the time of this report this list is out of date but is being actively reviewed for those who wish to stay on the panel and be an integral part in panel activities, including establishing term dates. Some have cycled off the panel but remain involved in GLASS activities (e.g. Martin Best), and others that have assumed different roles in GEWEX (e.g. Gianpaolo Balsamo). YS denotes Young Scientist.

Gab Abramowitz, UNSW
Michael Ek, NCEP
Gianpaolo Balsamo, ECMWF
Aaron Boone, CNRM-Météo France
Martin Best, UK Met Office
Nathan Brunsell, Univ. Kansas
Fei Chen, NCAR
Wade Crow, USDA
Paul Dirmeyer, George Mason Univ.
John Edwards, UK Met Office
Craig Ferguson, SUNY

Pierre Gentine, Columbia Univ.
Chiel van Heerwaarden, Wageningen Univ. (YS)
Hyungjun Kim, Univ. Tokyo
Sujay Kumar, NASA
Lifeng Luo, Michigan State Univ.
Taikan Oki, Univ. Tokyo
Christa Peters-Lidard, NASA
Andrew Pitman, UNSW
Rolf Reichle, NASA
Matt Rodell, NASA
Patricia De Rosnay, ECMWF
Joshua Roundy, Univ. Kansas (YS)
Joseph Santanello, NASA
Sonia Seneviratne, ETH
Tomo Yamada, Hokkaido Univ.

Recent invitations:
Martyn Clark, NCAR
Aude Lemonsu, CNRM-Météo France

Also, LoCo working group members likely to be or have been given invitations to be on the GLASS panel:
Benoit Guillod, ETH
Patricia Lawston, NASA
Benjamin Lintner, Rutgers Univ.
Ahmed Tawfik, NCAR

Annex 1: List of Participants

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Annex 2: Agenda

Monday, 25 January 2016

8:30	8:50	Registration	
9:00	9:10	Opening and Welcome	S. Seneviratne, G. Stephens, P. van Oevelen
9:10	9:20	Logistics	S. Seneviratne, P. van Oevelen
9:20	10:30	Chairs Report	S. Seneviratne, G. Stephens
10:30	11:00	Break	
11:00	12:30	WCRP and JSC, Outreach/CB	G. Brasseur, D. Carlson, B. Lee
12:30	14:00	Lunch	
14:00	14:25	CLIVAR	D. Stammer
14:25	14:50	WMO-CCI, CHy and GFCS	R.K. Kolli
14:50	15:15	ESA	M. Rast
15:15	15:40	iLEAPS	H.C. Hansson
15:40	16:15	Break	
16:15	16:40	WWRP	S. Jones
16:40	17:15	JSC Action Items	G. Stephens, S. Seneviratne, P. van Oevelen
17:30		Adjourn	
18:30	**21:00**	**Reception**	

Tuesday, 26 January 2016

8:30	10:00	GHP Panel - Science	J. Polcher/J. Evans
10:00	10:30	Break	
10:30	12:00	GLASS Panel – Science	A. Boone
12:00	12:25	CliC	G. Krinner, L. Hislop (TBC)
12:25	12:40	New Member Presentation	N. De Noblet
12:40	13:50	Lunch	
13:50	15:20	GDAP Panel - Science	J. Schulz/M. McCabe
15:20	15:50	Break	
15:50	16:15	WGNE	A. Zadra (TBC WEBEX)
16:15	16:35	NASA	J. Entin (TBC WEBEX)
16:35	16:55	LandMIP Workshop	S. Seneviratne
16:55	17:30	UNESCO	A. Mishra
17:30		Adjourn	

Wednesday, 27 January 2016

8:30	9:00	Extremes Grand Challenge	S. Seneviratne, L. Alexander
9:00	9:15	ETCCDI	L. Alexander
9:15	10:00	Water Grand Challenge	G. Stephens, P. van Oevelen
10:00	10:30	Discussion WCRP GCs	G. Stephens, S. Seneviratne
10:30	11:00	Break	
11:00	11:45	GEWEX PROES	G. Stephens
11:45	12:30	GEWEX Soil and Water	D. Or, P. van Oevelen
12:30	14:00	Lunch	
14:00	14:30	GDAP Panel – Action Items/GCs	J. Schulz, M. McCabe
14:30	15:00	GHP Panel – Action Items/GCs	J. Polcher, J. Evans
15:00	15:30	GLASS Panel – Action Items/GCs	A. Boone
15:40	16:10	Break	
16:10	16:30	SPARC	F. Tummon
16:30	17:15	Other WCRP Activities (WDAC/WMAC/Regional/Monsoon)	D. Carlson, B. Lee, others (TBC)
17:15		Adjourn	

Thursday, 28 January 2016

8:30	9:00	Rapporteur Report GHP	P. Webster, X. Li
9:00	9:30	Rapporteur Report GDAP	L. Alexander, R. Uijlenhoet, M. Zhang
9:30	10:00	Rapporteur Report GLASS	R. Anyah, N. de Noblet
10:00	10:30	GASS Report and Discussion	G. Stephens, P. van Oevelen, B. Holtslag (TBC)
10:30	11:00	Break	
11:00	11:45	IGPO Report and SSG-27	P. van Oevelen
11:45	12:30	GEWEX Regional Activities – Africa/Latin America/US	R. Anyah, P. van Oevelen, G. Stephens
12:30	14:00	Lunch	
14:00	14:30	ETH Presentation	P. Greve
14:30	15:00	GEWEX Regional Activities – Asia Discussion	P. Webster, B. Lee, G. Stephens
15:00	15:30	Meetings, Travel Support, ECS	P. van Oevelen
15:30	16:00	Break	
16:00	16:30	Draft Actions and Recommendations SSG-28	P. van Oevelen
16:30	17:00	Next Meeting, AOB	P. van Oevelen, S. Seneviratne, G. Stephens
17:00		Adjourn	

Annex 3: Rapporteurs Reports on GEWEX Panels

1. GEWEX Data and Assessments Panel (GDAP)

Rapporteurs: Gianpaolo Balsamo (GB) and Remko Uijlenhoet (RU)

1: Overview is fine and covered well the content of GDAP Objectives, Data Products, Data Quality Assessments, Ground-Based Observations, New Activities, Contributions to GEWEX Science Questions and GEWEX links to other WCRP or ex-WCRP activities.

2: The objectives of the GDAP panel are focused actions on the following activities:

1) Data records
    a. Guide production and analysis of global data sets with respect to GEWEX questions, e.g., energy and water budget closure;
    b. Use new data sources in the data sets, e.g. GPM;
    c. Tailor data sets to needs of GCs, e.g., water availability, extremes and PROES activities and directly participate/interact with GCs and PROESs;
    d. Evaluation of climate models – obs4mips connection.
2) In situ networks
    a. Guidance of surface networks such as BSRN and GPCC needed for assessments;
    b. Evaluation of satellite products;
    c. Evaluation and tuning of models.
3) Data quality assessments
    a. To assure quality and knowledge about data sets. including suitability for applications;
    b. To improve uncertainty estimation for data records;
    c. Assess adequacy of observing system - Interaction with CEOS/CGMS WG Climate

3: Status: The current status is reported for GDAP dataset, membership and actions.
The datasets produced and/or evaluated within GEWEX/GDAP are

- ISCCP (Bill Rossow and NOAA NCEI)
- Aerocom MAC (Stefan Kinne)
- SRB (Paul Stackhouse)
- GPCP (Bob Adler et al.)
- SEAFLUX (Carol Anne Clayson)
- LandFlux (Matt Mc Cabe, Carlos Jimenez)
- Soil Moisture (Wouter Dorigo)
- GEWEX Merged and Integrated Product (Paula Brown and Chris Kummerow)

The GDAP Membership Status

- Rémy Roca (Chair), LEGOS 2017
- Tristan LÈcuyer (Vice-Chair), University of Wisconsin 2017
- Wouter Dorigo, Technical University Vienna 2016
- Andrew Heidinger, NOAA/NESDIS 2016
- Carlos Jimenez, Estellus, S.A.S., Paris 2017
- Christian D. Kummerow, Colorado State University 2017
- Hirohiko Masunaga, Nagoya University 2017

- Claudia Stubenrauch, Lab. de Meteorol. Dynamique 2016
- Tianjun Zhou, LASG/IAP/CAS, Beijing, China 2017

The GDAP actions from SSG-28 in red and older in green

- Dave to warm up Karin Lochte asking her what would be needed to fulfil our wish. Send Dave a brief containing the details what we want.
- ISCCP processing: Graeme to talk to Tom Carl, I can strengthen while I am there.
- Restrict radar to certain areas needed for the GCs, talk to Andreas Becker and Brian Nelson in April.
- Update membership list and circulate with Sonia and Graeme – Found new chairs and leave selection of members to them.
- Send G-VAP report to SSG after GDAP review – ongoing.
- DOI registration for GEWEX data sets – what is the situation with the individual data set producer. Publication in data journal. – all strive for that, some have issues to find a publication agent.
- Several data prices exist – awareness is small. WDAC data price announcement has been distributed to GDAP.
- Connect with GLASS – has not happened, missed their annual meeting.
- Consider doing a global fluorescence data set in GDAP – not discussed at last GDAP.
- Proposal for mobile ARM on GLASS Pannex activity / has been confirmed to be useful on last day.
- Link to SPARC – SPARC WAVACS has participated in G-VAP workshops, both agree to do complementary work (SPARC concentrating on water vapour above 200 hPa).

4: Vision: GDAP has foreseen to consolidate and extend the GDAP Membership and invest in the quality assurance of the GEWEX dataset. An expert judgement of the dataset qualities (effective resolution, accuracy, geographical limitations, etc.) will be an extremely valuable addition (e.g. GPCP solid precipitation accuracy).

4a: Membership

- Remy Roca enters as new chair; Joerg Schultz has stepped down as chair; Tristan l'Ecuyer currently moving, hence not involved in GDAP report
- Membership has been shrinking; Remy and Tristan will increase membership within 6 months
- LandFlux (evaporation) people (Miralles et al.) want to leave from the GDAP panel, may leave gap

4b: Science

- Clouds
  - ISCCP (cloud product) from lab to NOAA
  - GDAP: How to deal with new GEO data in research environment?
- Aerosols
  - Aerocom (aerosols): active and growing community
  - MPI aerosol climatology (MAC)
  - Difficulties in terms of assessment
- Surface radiation budget
  - All products developed independently --> consistency?
  - Slow but continuous process of improvement
- Precipitation
  - GPCP, GPM
  - Change in processing SSM/I --> SSM/I-S caused declining trend in global average precip; corrected, now in line (see GEWEX newsletter)

- GPCP > GPM at high latitudes
- Precipitation assessment largely done without considering solid precipitation, other products available (e.g. EXTREMES)

- Water vapor
  - No problems
  - Trends from datasets show large differences between products --> accounting for uncertainties is crucial
  - Trends (1998-2008) from various products do not match Clausius-Clapeyron
  - Similar trend analyses for precip?
- SeaFlux
  - No problems, good progress
  - Link on GEWEX website broken
- LandFlux
  - Interesting and relevant work, however, data not shared with GDAP panel members
- Data quality assessments
  - Clouds
  - Water vapour: not available after 10 years --> worrying, what to do?
  - Precipitation: more than 2 products, broadening the scope, including e.g. PERSIANN
  - BSRN: high standards set by new chair; difficult to meet for individual groups
  - Soil moisture: good progress; suggestion from SSG: comparison of soil moisture retrieved from satellite (+ models) with re-analyses (GDAP also to include re-analysis people); soil moisture (Wouter Dorigo) needs an assessment, but needs financial support
- New activities
  - World-wide surface radar rainfall for extremes grand challenge; issues: data formats not yet up to standards with satellite community, merging of individual radars is challenging (also from political perspective)
- Funding
  - Proposal to Copernicus call in Europe may provide significant funding for new assessments

5: Future: The very important role that GDAP plays in the GEWEX community is to ensure a GEWEX-label for data-quality, which can be ensured by strong leadership and coordination and by reporting on the main GDAP output and their added value (e.g. GPCP v.2.3 w.r.t. previous).

6: Key results: Demonstrated the active role of the GDAP Panel in coordinating and synthesising the results of global water and energy cycle datasets to the community.

7: Issues: The consolidation of GDAP panel and activities may benefit from SSG support.

Questions for SSG

- Suggestions for new members from SSG appreciated, in particular from evaporation (LandFlux) community
- Connection with CLIVAR?
- Connection with PROES?

2. GEWEX Hydroclimatology Panel (GHP)

Rapporteurs: Michael Bosilovich and Germán Proveda

1. Accomplishments and Activities. GHP reports strong accomplishments and continued activities, advancing toward GEWEX objectives, noting progress in RHPS (OzyWEX and HyVic) and new efforts (PannEx). InARCH fieldwork and model comparisons are well developed and making progress. The agenda of meetings and workshops is strong and productive.

2. Contributions. GHP have made relevant contributions to the WCRP Grand Challenges in topics such as:

- (a) Provision of skillful future climate information on regional scales.
- (b) Regional sea-level rise.
- (c) Cryosphere response to climate change.
- (d) Interactions of clouds, aerosols, precipitation, & radiation and their role in climate sensitivity.
- (e) Past and future changes in water availability.
- (f) Science behind the prediction and attribution of extreme events.

3. Going Forward. Areas to address in the next year

a) There seems to be an imbalance of effort toward precipitation, while GLASS handles SM (soil moisture) and evaportranspiration. River flow, in particular floods, and connections to P, E, soil moisture and snowmelt do not appear well connected (though this is not across GHP as HyMEX does emphasize full budget research and data).

b) Similarly groundwater appears marginalized, a fundamental component of resource management and long term drought.

c) A potential topic for GHP to consider inclusion is water quality and its connection with water quantity at different time scales.

d) GHP is focused on the “offer” part of water, the “demand” part is not considered extensively. For instance, the proposed scientific meeting in Banff next year is aiming at Extremes and Water for the Food Basket. The latter one brings about the demand side of the issue. If so, water for all types of consumptions is important (human, agriculture, industry, etc). A decision from GEWEX needs to be made in this regard.

e) Development of the US RHP appears to be leaning toward applications. As this effort progresses, points 3a-d may be worth revisiting in the context of new RHPs for the US and Andes.

f) There seems very little interaction (or crosscut) with GLASS. Aside from the fluxes, the RHPs will have local understanding of the meteorology data (for forcing land models) and the geography (soil and veg characteristics, topography). The offline land modeling in GLASS is very much local and GHP (or the RHPs) have a lot of local knowledge to offer.

g) GHP proposes a GDAP crosscut that seems to have little maturity at this point. In the context of the GDAP integration effort, RHPs (then CSEs) played a significant role in regional energy and water cycles comparison to global data sets (e.g. the work of J. Roads in early 2000s). This cross cut could be more than a validation exercise by building on the previous work.

h) The Cold Shoulder work seems to be a useful and interesting topic. However, how does this fit with the overall GEWEX questions/plan? Is it just extremes? The relationship needs improved articulation.

i) INTENSE shows promise of a good effort, but can it incorporate a model component (e.g., model inability to reproduce diurnal cycle of precipitation)?

j) MOUNTterrain needs leadership to carry on.

Summary

There is tremendous work going on with GHP, and many of the regional projects are performing successfully. The leadership has done a tremendous job with the variety and number of efforts within the GHP. It is hoped that these suggestions prove useful.

3. Global Land/Atmosphere Study (GLASS)

Rapporteurs: Branka Ivančan-Picek and Nathalie de Noblet-Ducoudré

The GLASS report is available at:
https://www.gewexevents.org/wp-content/uploads/SSG29_GLASS_Panels_Rapporteurs.pdf

Annex 4: Acronyms and Other Abbreviations

AGU	American Geophysical Union
ALMIP2	Land Surface Model Intercomparison Project (CMIP)
AMMA	Multidisciplinary Analysis of the African Monsoon
ARM	Atmospheric Radiation Measurement (U.S. Department of Energy)
ARMBE	ARM Best Estimate
AWI	Alfred Wegener Institute
BSRN	Baseline Surface Radiation Network
CAUSES	Clouds Above the United States and Errors at the Surface
CCI SM	Climate Change Initiative-Soil Moisture (ESA)
CCMP	Cross-Calibrated Multi-Platform
CCRN	Changing Cold Regions Network
CDR	Climate Data Record
CEH-GEAR	Centre for Ecology and Hydrology Gridded Estimates of Areal Rainfall
CEOS	Committee on Earth Observation Satellites
CERES	Clouds and the Earth's Radiant Energy System
CFMIP	Cloud Feedback Model Intercomparison Project
CGMS	Coordination Group for Meteorological Satellites
CLASS	Canadian Land Surface Scheme
CLiC	Climate and Cryosphere Project
CLIVAR	Climate and Ocean – Variability, Predictability, and Change (WCRP Core-Project)
CMAP	CPC Merged Analysis of Precipitation (NOAA)
CMIP	Coupled Model Intercomparison Project (WCRP)
CMORPH	CPC MORPHing technique (NOAA)
CONVEX	Research Project on Observational Evidence and Process Understanding to Improve Predictions of Extreme Rainfall Change
CORDEX	Coordinated Regional Climate Downscaling Experiment (WCRP)
CPC	Climate Prediction Center (NOAA)
DIAL	Differential Absorption Lidar
DICE	Diurnal Land/Atmosphere Coupling Experiment
DOE	Department of Energy
DOIs	Digital Object Identifiers
DWD	German Weather Service
ECMWF	European Centre for Medium-range Weather Forecasts
ECVs	Essential Climate Variables
EEI	Earth's energy imbalance
EGU	European Geophysical Union
ESA	European Space Agency
ESGF	Earth System Grid Federation
ESMs	Earth science models
ET	Evapotranspiration
ETH	Swiss Federal Institute of Technology in Zürich
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EXP1	Long-term retrospective experiment

FE	Future Earth
FIDUCEO	Fidelity and uncertainty in climate data records from Earth Observations
FMI	Finnish Meteorological Institute
FOCI	Frontiers of Climate Information (WCRP)
FPS	Flagship Pilot Study (FPS)
GABLS	GEWEX Atmospheric Boundary Layer Study
GAIA-CLIM	Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring
GC	Grand Challenge (WCRP)
GCOS	Global Climate Observing System
GDAP	GEWEX Data and Assessment Panel
GDIS	Global Drought Information System
GEO	Group of Earth Observation
GERICS	Climate Service Center Germany
GEWEX	Global Energy and Water Cycle Exchanges (WCRP Core-Project)
GFCS	Global Framework for Climate Services
GHP	GEWEX Hydroclimatology Panel
GHRSST	Global High Resolution Sea Surface Temperature
GNSS	Global Navigation Satellite Systems
GLACE	The Global Land–Atmosphere Coupling Experiment
GLASS	Global Land/Atmosphere System Study
GPCC	Global Precipitation Climatology Centre
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Mission
GRACE	Gravity Recovery and Climate Experiment
GSFC	Goddard Space Flight Center (NASA)
GSMaP	Global Satellite Mapping of Precipitation (JMA)
GSOP	CLIVAR Global Synthesis and Observations Panel
GSQs	GEWEX Science Questions
GSW	GEWEX Soils and Water
GSWP3	Global Soil Wetness Project 3
G-VAP	GEWEX Water Vapour Assessment
HEPEX	Hydrologic Ensemble Prediction EXperiment
HIRS	High Resolution Infra Red Radiation Sounder
HOAPS	Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data
HyMeX	Hydrological Cycle in the Mediterranean Experiment
HyVic	Hydrology of Lake Victoria Basin
IASOA	International Arctic Systems for Observing the Atmosphere
ICDR	GPCP Monthly Interim Climate Data Record
ICSU	International Council for Science
IDF	Intensity-Duration-Frequency
IGBP	International Geosphere Biosphere Programme
IGPO	International GEWEX Project Office
IGWCO	Integrated Global Water Cycle Observations
iLAMB	International Land Model Benchmarking
iLEAPS	integrated Land Ecosystem-Atmosphere Processes Study
INARCH	Alpine Research Catchment Hydrology
INTENSE	INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes

IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOCCG	International Ocean Color Coordination Group
IPCC	Intergovernmental Panel on Climate Change (WMO, UNEP)
IQuOD	International Quality Controlled Ocean Database
IR	Raman lidar and infrared
ISCCP	International Satellite Cloud Climatology Project
ISI-MIP	Intersectoral Impact Model Intercomparison Project (CMIP)
ISMN	International Soil Moisture Network
ISSI	International Space Science Institute
IUGG	International Union of Geodesy and Geophysics
JMA	Japanese Meteorological Association
JSC	Joint Scientific Committee (WCRP)
KMI	Belgium Meteorological Institute
KNMI	Royal Netherlands Meteorological Institute
LAC	Land-Atmosphere Coupling
LAFE	Land-Atmosphere Feedback Experiment
LAI	Leaf Area Index
LE	Latent heat
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LIS	Land Information System (NASA)
LoCo WG	Local Land-Atmosphere Coupling Working Group
LSM	Land Surface Model
LS3MIP	Land Surface, and Snow, Soil moisture Model Intercomparison Project
LUCID	Land-Use and Climate, IDentification of robust impacts
LULCC	Land Use Cover Changes
LUMIP	Land Use Model Intercomparison Project (CMIP)
MAC v1	Max Planck Aerosol Climatology version 1
MAHASRI	Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction
MDF	Model Data Fusion
MERRA	Modern-Era Retrospective Analysis for Research and Applications
MESH	MEC – Surface and Hydrology
MOUNTerrain	GEWEX Mountainous Terrain Precipitation Project
NASA	National Aeronautics and Space Administration
NEESPI	Northern Eurasia Earth Science Partnership Initiative
NCAR	National Centers for Atmospheric Research
NCEI	National Center for Environmental Information
NDVI	Normalized Difference Vegetation Index
nnHIRS	neural network High Resolution Infra Red Radiation Sounder
NOAA	National Oceanic and Atmospheric Administration (USA)
NRCan	Natural Resources Canada
NWP	Numerical Weather Prediction
OAFlux	Objectively Analyzed Air-sea Fluxes
Obs4MIPS	Observations for Model Intercomparisons
ORA-IP	Ocean Reanalysis Intercomparison project
OzEWEX	Australian Energy and Water Exchanges

PALS	Protocol for the Analysis of Land Surface models
PannEx	Pannonian Basin Experiment
PI	Principal Investigator
PILDAS	Project for the Intercomparison of Land Data Assimilation Schemes
PLUMBER	Land Surface Model Benchmarking Evaluation Project (PALS)
POC	Point Of Contact
Qa	Atmospheric humidity
RAOBS	Paposo Lower Site Radiosondes
RHPs	Regional Hydroclimate Projects
PROES	Process Evaluation Study
S2S	Subseasonal to Seasonal Prediction Project
SACRA	global data sets of satellite-derived crop calendars for agricultural simulations
SCOPE-CM	Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring
SCOR	Scientific Committee on Oceanic Research
SGP	Southern Great Plains (USA)
SMAP	Soil Moisture Active Passive (NASA)
SMOS	Soil Moisture and Ocean Salinity (ESA)
SPARC	Stratospheric Processes and their Role in Climate
SRB	Surface Radiation Budget Project
SSCZP	Soil Systems and Critical Zone Processes
SSG	Scientific Steering Group (GEWEX)
SSMIS	Special Sensor Microwave Imager/Sounder
SST	Sea Surface Temperature
THORPEX	The Observing system Research and Predictability Experiment
TOA	Top Of Atmosphere
TU Wien	Vienna University of Technology
UCAR	University Corporation for Atmospheric Research
UKMO	UK Met Office
UKWIR	UK Water Industry Research
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
URC	International Radiation Commission
USDA	United States Department of Agriculture
UTLS	Upper Troposphere Lower Stratosphere
UTTC	Tropospheric Clouds and Convection (PROES)
WACMOS-ET	Water Cycle Observation Multi-mission Strategy-EvapoTranspiration
WCRP	World Climate Research Programme (WMO, IOC and ICSU)
WDAC	WCRP Data Advisory Council
WECC	Water, Ecosystem, Cryosphere and Climate (CCRN)
WGIR	Working Group on Information for Regions (WCRP, to be approved)
WGNE	Working Group of Numerical Experimentation
WGRC	Working Group on Regional Climate (WCRP)
WMO	World Meteorological Organization

WRMC	World Radiation Monitoring Center
WWRP	World Weather Research Program
YESS	Young Earth System Scientists Community
YHS	Young Hydrologic Society