

WCRP REPORT

World Climate Research Programme



ICSU
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GEWEX

A WCRP Core Project on Global Energy and Water Exchanges

Report of the

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GEWEX Scientific Steering Group

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1. INTRODUCTION AND OVERVIEW

This report summarizes the main developments in GEWEX during the year 2014 and includes the major items and recommendations from the 27th Session of the GEWEX Scientific Steering Group (SSG), which was hosted by Professor Germán Poveda of the Department of Geosciences and Environment at the National University of Colombia in Medellin, Colombia on 16-19 February 2015. This session of the SSG addressed both responses to advice resulting from the latest WCRP Joint Scientific Committee (JSC) meeting and developments in WCRP and the global programs. Key activities included reviewing results from recent workshops on the GEWEX Science Questions and developing an implementation strategy for advancing these topics.

1.1 Major Activities and Achievements in 2014

The major activity for GEWEX in 2014 was the 7th International Scientific Conference on the Global Water and Energy Cycle, which included GEWEX Panel meetings, Pan-GEWEX and CLIVAR meetings, and a joint GEWEX/CLIVAR SSG meeting during the same timeframe. The week before the Conference, the GEWEX Summer Sessions and an early career scientists event were held at the Delft University of Technology.

Over 560 scientists, managers, and students from 45 countries attended the 7th International Scientific Conference on the Global Water and Energy Cycle, which was held in The Hague, The Netherlands on 14-17 July 2014. The Conference, which was organized by IGPO, addressed research related to water resources, extremes in water availability, and new analyses from observations and data sets. Two hundred and eighteen students and early career scientists attended the Conference and over 150 of these participated in the competition for best presentation. Out of these there were 38 winners from 12 countries.

Over 100 CLIVAR scientists participated in both CLIVAR and GEWEX breakout sessions running parallel to the Conference. After the Conference, GEWEX and CLIVAR held joint sessions, followed by a meeting between the scientific steering groups of both projects. These meetings outlined joint activities that will make important contributions to the WCRP Grand Challenges, particularly those on regional climate information and climate extremes. Important joint efforts evolved out of these discussions. A new GEWEX/CLIVAR monsoons panel was formed, participants in a new working group on energy imbalance and ocean heat uptake were identified, and preliminary discussions on a new cross-panel working group on energy balance, linked to the Ocean Heat Content Working Group were undertaken.

Discussions at the Pan-GEWEX Meeting included plans for a new high resolution modeling initiative, the design and coordination of the 6th Generation Coupled Model Intercomparison Projects land multi-model projects (LandMIPs), new themes for GEWEX research (including land use modeling, the use of stable water isotopes in climate research, carbon-water interactions, and the closing of the global energy and water budgets), and activities to be proposed as part of the newly formed US GEWEX project office. There were preliminary discussions of a new proposal for climate process diagnostics (GEWEX Process Evaluation Study, PROES) and of a proposed initiative to integrate research on subsurface hydrology into GEWEX activities (GEWEX-Soils). Many of these activities were posed within the context of the WCRP Grand Challenges, particularly those on Water Availability and Climate Extremes.

Major activities related to the GEWEX Panels are given below.

GEWEX Data and Assessment Panel (GDAP) activities include the production of data products and conducting assessments on the quality of products and radiative transfer codes. GDAP is planning new assessments on precipitation and soil moisture data, and is exploring how to expand the GEWEX standard products to include terrestrial water storage budget terms. The aerosol optical depth (AOD) assessment is evaluating trends in AOD over the last decade and satellite data-climate model comparisons. Trend analysis was used in the water vapor assessment to compare total column water vapor (TCWV) and water vapor profiles on a global scale. The TCWV trends were shown to be significantly different, particularly in tropical land regions. This led to the recommendation to the Global Reference Upper Air Network (GRUAN) co-chairs to consider adding a tropical land-surface station during the upcoming GRUAN network expansion.

GDAP oversees and gives general guidance to the Baseline Surface Radiation Network (BSRN), which held its 13th meeting in Bologna, Italy on 9-13 September 2014. BSRN consists of volunteers operating stations that measure surface solar and infrared radiation, and has been an official surface radiation network for GCOS since 2004. A few stations began operating in 1992, and have accumulated over two decades of high-quality data. Currently, 49 stations are operational. However, there is continued concern about the ability to keep high quality reference networks like BSRN operational as they require local support for each station, which has proven tedious to maintain.

The Global Atmospheric System Studies (GASS) Panel has six new projects that span topics from process-level studies of aerosol-cloud interactions and radiative transfer to full large-scale model diagnosis of the causes for warm-biases in continental summertime surface air temperatures, and transformation of marine air masses as they advect over sea-ice. GASS is planning to co-organize its third Pan-GASS meeting with the first Pan-GLASS meeting in late 2016.

The **GEWEX Hydroclimatology Panel (GHP)** meeting was held at the California Institute of Technology in December 2014. A joint session of GHP and the Global Drought Information System (GDIS) Project was held on the first day to promote closer collaboration between the regional efforts within GHP and GDIS related to drought monitoring and forecasts through the sharing of data, modeling expertise, and local capacity building.

At the meeting, the Hydrology of the Lake Victoria Basin (HyVic) study and the Australian Energy and Water Exchange (OzEWEX) were approved as Initiating RHPs. The area of the Saskatchewan River Basin RHP was extended to include the Mackenzie River Basin, and is now called the Changing Cold Regions Network (CCRN) RHP.

Around one hundred scientists, operational staff, information users and students took part in the first national OzEWEX Workshop on 28-29 October 2014 in Canberra, Australia. The objective of the Workshop was to assess future water and climate information needs, and compare these to the current state and new developments in information services, observation sources, scientific knowledge and model technology. The program included 40 oral presentations in two plenary sessions and six discussion sessions, each involving introductory presentations followed by facilitated debate, and a poster session on the first day.

GHP has begun a scoping exercise for a regional effort located in the United States. A planning committee has been tasked with a drafting a white paper that specifies the main science issues to be addressed, the tools and possible funding sources, social issues to be considered, links with other groups and studies (both national and international), and outreach opportunities. The area around the

Colorado River Basin within the Western US climatic region is currently “considered” the preferred choice, given its importance as a major supply of fresh water.

The Global Land/Atmosphere System Study (GLASS) Panel is working with GHP on a number of research ventures and with the GEWEX Atmospheric Boundary Layer Study (GABLS) on the Diurnal Coupling Experiment (DICE). GLASS also collaborates with the WCRP Climate and Cryosphere Project (CliC) on the Earth System Model Snow Model Intercomparison Project (ESMSnowMIP) as a part of the Land Surface, Snow and Soil Moisture MIP (LS3MIP), and continues to engage with the Working Group on Numerical Experiments (WGNE) on benchmarking and data assimilation activities. A joint GABLS/CliC project to assess the thermal coupling and momentum flux in a polar climate has been proposed for the Dome-C site in Antarctica.

Two GEWEX-sponsored land-related Multimodel Intercomparison Projects (MIPs) are proposed for the sixth phase of the Coupled Model Intercomparison Project (CMIP6). The Land Surface, Snow and Soil Moisture MIP and the Land Use MIP will allow a comprehensive investigation of the impacts of land processes, forcings and feedbacks on the climate system, including land-related systematic biases in Earth System Models.

The GLASS Local Coupled Land-Atmospheric Modeling (LoCo) Working Group is collaborating with the US Department of Energy’s Atmospheric Radiation Measurement (ARM) Climate Research Facility-Southern Great Plains (SGP) campaign and has produced an ARM-supported data set for coupling studies over the SGP. In addition, a radiosonde campaign led by LoCo will commence in summer 2015 to augment the current ARM-SGP sonde launches for application to LoCo studies.

1.2 GEWEX Links to the WCRP Grand Challenges

The SSG meeting marked the advancement of changes to the structure and scientific priorities of GEWEX. These changes have been taking place incrementally under the guidance of the JSC and were motivated by a recent series of consultations with WCRP sponsors, stakeholders and affiliate network of scientists. The result has been the documenting of the WCRP Grand Science Challenges (<http://www.wcrp-climate.org/index.php/grand-challenges>), which identify high priority and relevant research and prompted GEWEX to define a complementary set Grand Science Questions (http://gewex.org/pdfs/GEWEX_Science_Questions_final.pdf). The changes have also been framed in the context of the GEWEX Imperatives: http://gewex.org/pdfs/GEWEX_IMPERATIVES_final.pdf.

WCRP has identified six 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 six science challenges, and also has connections to the four others. In the upcoming year, *GEWEX News* will provide descriptions of GEWEX involvement in the Grand Challenges and how collective research efforts within the GEWEX Panels will address them. This topic was a primary focus of the SSG meeting.

GEWEX is leading the **Grand Challenge on Understanding and Predicting Weather and Climate Extremes** and has developed an implementation plan (see February 2015 issue of *GEWEX News*). While it is expected that the implementation plan will be a “living document” that will be updated as plans and ideas progress, the current focus is on what is believed to be doable over the next few years. For that reason the main implementation strategy is focused on four core events: (1)

heatwaves, (2) droughts, (3) heavy precipitation, and (4) storms. All activities are broadly embedded within WCRP, and also within the CLIVAR and SPARC projects. They will build upon many existing activities that already have international community and coordination in place, and that are also connected to the relevant research activities of the High Impact Weather Initiative within the World Weather Research Programme.

GEWEX is also leading the **Grand Challenge on Changes in Water Availability** and the implementation plan for this is almost complete. 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 projects 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. In addition, idealized modeling frameworks are needed to study the response of convection and climate over warm land-surfaces. Within the GEWEX Hydrometeorology Panel (GHP), the Northern Eurasia Earth Science Partnership Initiative (NEESPI) Regional Hydroclimate Project (RHP) studies cyclonic activity at high latitudes. Another RHP, the Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (MAHASRI), analyzed the interannual variations of AOD, cloud effective radius, and precipitation for 2000–2012 based on El Niño-Southern Oscillation phases.

Two upcoming GASS projects could align with the **Grand Challenge on Changes in Water Availability**: (1) 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 (2) the HiRes crosscut project to evaluate water cycle processes in high-resolution models. GDAP can also contribute to this Challenge by providing past precipitation amounts and the distribution of rain rates.

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. Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity is supported by the GDAP Integrated Product.

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, flooding, and drought, and developing a hydrological model for predicting these changes. Another RHP, the HYdrological cycle in the Mediterranean EXperiment (HyMeX), has a strong focus on hydrometeorological extremes (heavy precipitation, floods, heat waves, droughts), while the NEESPI RHP studies extreme precipitation and heat waves. The MAHASRI RHP works on the attribution of extreme daily rainfall events in the Philippines and Southeast Asia: the project was able to statistically show the global warming effect for increasing extreme rainfall in wider regions in the Indochina Peninsula. 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 publication by Lockhoff et al. (2014) has already found some skill at large scales in Global Precipitation Climatology one-degree-daily products.

The **Cryosphere in a Changing Climate Grand Challenge** is addressed by two RHPs within GHP. CCRN conducts focused analysis and modeling of cryospheric process response to warming. Key areas are the biomes of the Rocky Mountains (including glacier processes), Boreal Forest, Prairies, and the sub-Arctic. The second, NEESPI, has investigated changes in snowfall and river ice.

1.3 Goals and Plans for Major Activities for 2015

An exciting new initiative is the creation of a US GEWEX project office, whose functioning is currently being negotiated. As a part of this new US project office, GEWEX is developing plans for a North American Regional Hydroclimate Project (RHP). GEWEX has also been fostering the planning of Coupled Model Intercomparison Project-Phase 6 (CMIP6)-related model experiments: the Land Surface, Snow and Soil Moisture MIP and the Land Use MIP (see the November 2014 issue of GEWEX News), as well as the HighresMIP experiment. In addition, a small number of new activities are beginning to develop under the GEWEX Process Evaluation Study (PROES). Plans for possible new regional activities in South America are also being formulated.

1.4 Interactions (Especially with WCRP Sponsors and Partners)

NASA continues to strongly support the IGPO and was a major contributor to the 7th International Scientific Conference on the Global Water and Energy Cycle, which provided an excellent venue for interactions with a number of WCRP sponsors and partners. The scientific committee for the conference was a broadly international and interdisciplinary group of noted scientists representing more than eight different countries and a dozen affiliated Agencies, Institutes, and Centers that are interested in and supportive of WCRP and GEWEX.

The major US government agencies along with the US Global Change Research Project have organized resources to establish a US GEWEX project office that will help coordinate GEWEX research on the national scale.

GEWEX and ESA are organizing the Second Conference on Earth Observations for the Water Cycle to held at ESA-ESRIN in Frascati, Italy on 20-23 October 2015. The Conference will provide a venue for a wide discussion and networking forum for the water and energy, climate, hydrology, modeling, and earth observation communities to review the latest advances in the use of earth observations for water cycle science and discuss the main scientific opportunities and research challenges for the future.

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.

1.5 Outreach and Capacity-Building Activities

Anil Mishra of the Hydrological Systems and Water Scarcity Section of the International Hydrological Programme (IHP) of UNESCO gave a presentation at the SSG on local, regional and global challenges for water security. GEWEX is leading the WCRP Grand Challenge on Changes in

Water Availability, which relates to the IHP goal to understand uncertainty and translate it back to water security. Future GEWEX activities within this Grand Challenge are planned with IHP, including co-hosting a summer school on water availability in 2017.

Another important outreach activity are the GEWEX organized conferences and summer schools. As stated in paragraph 2.1 Over 560 scientists, managers, and students from 45 countries attended the 7th International Scientific Conference on the Global Water and Energy Cycle, which was held in The Hague, The Netherlands on 14-17 July 2014. Two hundred and eighteen students and early career scientists attended the Conference and over 150 of these participated in the competition for best presentation. The week before the Conference, the GEWEX Summer Sessions were held at the Delft University of Technology.

GEWEX is benefiting greatly from strong interactions with other WMO and WCRP initiatives. The Global Data Centers for precipitation, river runoff, and lakes/reservoirs (GRDC, GPCC and Hydrolare, respectively) are affiliated activities under GEWEX and are activities that are connected through a number of outside bodies to obtain meaningful data for application to research of interest to the broader climate research community.

GEWEX has agreed to encourage the development of an international, multi-agency, field program to study multi-scale aspects of intense, organized convective systems that produce severe weather in subtropical South America. One such activity is the “Remote sensing of Electrification, Lightning, And Mesoscale /micro-scale Processes with Adaptive Ground Observations” (RELAMPAGO-working acronym) study that has already met a number of criteria for becoming an RHP, but GHP involvement will require further expansion of its science priorities and will mean working with a number of international groups outside of WCRP including several with links to applications. In addition other activities in Latin- America and the Caribbean are envisioned with strong local interest already in place.

By participating in the Latin American and Caribbean Conference on Climate and Society GEWEX is working to identify links to new regional groups that may require further support to broaden current activities into international studies that fit within the WCRP structure.

2. GEWEX PANEL STATUS REPORTS

2.1 GASS Global Atmospheric System Studies Report

Reporting Period: October 2013 – January 2015

Starting date: The GCSS and GABLS projects were combined at the end of 2010 to form GASS, which also took joint ownership of the CIRC activity along with GDAP.

URL: http://www.gewex.org/gass_panel.html

Chair(s) and term dates: Jon Petch (ended March 2014) and Steve Klein (ends March 2015)

GASS Science Steering Committee (SSC): GASS is managed by its SSC, which holds a telecon every 2-6 months and meets at Pan-GASS and Pan-GEWEX science conferences, typically, every 3-5 years. Each GASS project has a GASS SSC member as a sponsor and at least one project lead who may not be a part of the SSC. Current members of the SSC include: Chris Bretherton, Ann Fridlind, Adrian Lock, Hugh Morrison, Lazaros Oreopoulos, Robert Pincus, Pier Siebesma, Ben Shipway, Gunilla Svensson, and Steve Woolnough. There is no formal term length for the membership of SSC although it is generally agreed that 4 years is a good length to review member's contributions.

Panel Objectives: GASS provides leadership for the scientific community involved in improving the representation of atmosphere processes in weather and climate models. It addresses this goal primarily through the coordination of scientific projects that bring together experts in process modeling, observations, and the development of atmospheric model parameterizations. GASS intercomparison projects are typically based around observational field campaigns, or more idealized studies, and take from two to five years from initiation to completion with publication of the results. These intercomparisons make extensive use of initial value global forecasts with weather and climate models (so called Transpose AMIP), regional convective scale modeling, single column modeling, cloud-resolving or large-eddy simulations and a range of in situ and remote sensing observations.

Projects Status including Key GASS Achievements in 2014:

- Currently GASS has 10 active projects with four projects in the later stages. In the past year, a further four projects have finished, or finished except for the publication of project results.
- The representation of moist convection and turbulence in atmospheric models with Grey Zone resolution (1-10 km) is being studied using a cold-air outbreak case. Fifty scientists attended a Grey Zone Project workshop held in December 2014 at the Max-Planck Institute for Meteorology, where results from several models were compared.
- The representation of atmospheric boundary layer processes and their interaction with the land-surface is the focus of the joint GASS/GLASS DICE project. Over fifteen different models are involved in the project and a workshop was held at the UK Met Office in October 2013. Additionally, due to significant scientific overlap, scientists working on GABLS4 will meet with those working DICE at an upcoming workshop in May 2015 at MeteoFrance.
- The coupling of large-scale dynamics with tropical moist convection is being studied using the so-called "Weak-Temperature" Gradient methodology. Several models have contributed to this project, which aims to learn which are the most robust and valuable methodologies to

study the convection-dynamics coupling with both cloud resolving and single-column models.

- At the Pan-GEWEX meeting in July 2014, the GASS SSC met to discuss its project and status. This was the first in-person meeting of the SSC in nearly 2 years and was helpful to discuss the status of GASS projects and identify future directions.

Future and New Directions:

- Six new projects are in various early stages of project formation spanning topics from process-level studies of aerosol-cloud interactions and radiative transfer to full large-scale model diagnosis of the causes for warm-biases in continental summertime surface air temperatures and transformation of marine air-masses as they are advected over sea-ice.
- Preliminary discussions have occurred regarding a 2nd Pan-GASS science conference. An initial discussion with Joe Santanello suggests that this could be conducted jointly with a GLASS, as was done at the last Pan-GASS conference in Boulder in September 2012. It is envisioned that this would occur somewhere in Europe probably in the late summer or early fall of 2016.

Issues for attention by the GEWEX SSG:

- *GASS Co-Chair Succession:* Both co-chairs Petch and Klein are past, or at the end of, their nominal periods to serve as GASS co-chair and are keen to pass on responsibility for GASS leadership. In the past year, attempts have been made to locate new co-chairs both within and external to GASS SSC with no luck. Both Petch and Klein will spend less time carrying out GASS management in the future—whether they are replaced or not. GEWEX should address this otherwise GASS will lose the momentum that has been built over recent years. While ongoing GASS projects will continue to make progress, the spinning up of new projects and the general engagement with the broader WCRP and GEWEX communities is likely to suffer.
- *GEWEX Assistance for a possible 2016 Pan-GASS/Pan-GLASS conference in Europe:* As was the case for the 2012 joint GASS/GLASS conference in Boulder, we need meeting support through GEWEX. Given past experience, the planning for this workshop would need to begin in early summer of 2015. However, progress on a 2016 pan-GASS/GLASS conference is subject to identifying leaders for this conference; the co-chairs aren't available.

Other Issues and Recommendations:

- *Isotopes:* At the 2014 Pan-GEWEX Meeting, the subject of atmospheric isotopes came up as a potential GEWEX crosscutting activity. At it's meeting, the GASS-SSC debated whether the time was ripe to begin an isotope project. The main problem is that any study involving isotopes might tell one only about isotopes and not about the representation of atmospheric processes of convection, turbulence and microphysics, which is what GASS is concerned about. Subsequent to the GASS SSC, it was concluded that while beginning with a cloud-resolving modeling (CRM) study of isotopes would be best, that it was still premature to begin a CRM benchmark project because there are still relatively few isotope-enabled CRMs. In addition, there is not a suitable isotope case-study data set on which to base a comparison.
- *Archiving needs:* Unfortunately, no progress has been made on this subject in the past year, primarily due to the lack of individual(s) with the time and energy to pursue this topic. To recapitulate the issue, GASS continues to have a requirement for a resource to archive their project data. This will need IT equipment to deliver data over the Internet and human

resource to do the work in gathering and documenting the cases. While there have been ad-hoc archiving done to a mixed degree, there is currently no system to ensure our valuable case studies are easily available to the community.

Links with the WCRP Grand Challenges:

- *“Clouds, Circulation and Climate Sensitivity” Grand Challenge:* GASS is an active participant in this challenge in several ways: GASS co-chairs Klein and Petch and GASS SSC members Robert Pincus and Pier Siebesma have helped to formulate the challenge through white papers, project meetings, arranging for breakout sessions at the 2014 GEWEX conference, and co-authoring of the summary publication describing the “four questions” of the Grand Challenge. Although this will require more thought, a number of GASS projects are expected to contribute to this Grand challenge including the Grey Zone, Weak Temperature Gradient, Low-cloud feedbacks, and radiative processes projects. One important need identified from breakout at the GEWEX conference was for idealized modeling frameworks to study the response of convection and climate over warm land-surfaces.
- *“Water Availability” Grand Challenge:* Two upcoming projects discussed at the GEWEX conference could align with this challenge, specifically the 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 a potential GEWEX cross-cut project that will evaluate water cycle processes in high-resolution models (the HiRes project described in the GEWEX Newsletter for the conference). A third potential area of interaction for the “Water Availability” Grand Challenge is in the area of isotope modeling; however, as described above, it is premature to organize a model intercomparison project in this area.
- *“Cryosphere” Grand Challenge:* GASS SSC member Gunilla Svensson is a contributor to the WCRP Polar Climate Prediction Initiative, which is a part of this grand challenge.

Additional Cooperation with Other WCRP Projects:

- GASS is not only under GEWEX but is also a major project supervised by WGNE, and as such contributes to WGNE’s plans and presents reports to the annual WGNE meetings
- A number of GASS projects have been conducted jointly with other organization including the just finished MJO project which was a joint project of GASS and the WCRP-WWRP MJO task force, and the on-going Low-Cloud Feedbacks project which is a joint project of GASS and the CFMIP project of WGCM. Also, CAUSES links closely with the Department of Energy ASR program.
- A GASS SSC member, Gunilla Svensson, is a steering committee member of both new Polar project initiatives of WWRP and WCRP and has been a significant contributor to the science and implementation plans being developed by these projects.
- GASS is represented by Steve Woolnough on the joint WWRP/WCRP seasonal prediction project and is helping to be a modeling liaison with the plans toward developing for future tropical convection field campaigns including the Year of Maritime Continent project and a more distant potential monsoon field campaign.
- GASS has always struggled with forging a strong relationship with the iLEAPS Aerosol-Cloud-Precipitation-and-Climate initiative (ACPC). This is in part because ACPC has been something of a stop-start initiative with little of substance to engage with. However, we have done our best and currently, SSC member Ann Fridlind has been actively in contact with them as they formulate plans for an Observational System Simulation Experiment aiming to observationally investigate aerosol effects on shallow or deep convection from microscale to mesoscale with a closure approach. A planned workshop in April 2015 in New York City

will aim to identify potential conditions, regions, approaches, and issues. GASS has repeatedly come up as a potential source of helpful input and will participate in the next stage if that is reached as envisioned.

Meetings: In the reporting period, the main meeting with GASS attendance was the July 2014 GEWEX conference on the water cycle and the associated pan-GEWEX meeting in The Hague. GASS attendance was quite good with a number of poster and oral sessions being sponsored by GASS, or joint with GLASS. Additionally, there were several breakout sessions for specific GASS projects (GABLS3/4, DICE, and CAUSES) as well as the Clouds Grand Challenge. Finally the GASS SSC held a ½ day meeting during the pan-GEWEX meeting. Apart from the Hague conference, GASS had smaller workshops associated with DICE (at the MetOffice in October 2013) and the Grey Zone projects (at the MPI in December 2014). GASS is interested in organizing, perhaps joint with GLASS, another pan-GASS/GLASS conference in late summer/early fall of 2016 on the same scale as the very successful 1st Pan-GASS science conference 10-14 September 2012 in Boulder, Colorado, which had around 200 attendees.

Key Publications: Please see the list of publications provided in the progress reports of the individual projects below.

SUPPLEMENTAL MATERIAL: Progress reports of GASS projects

The following pages present progress reports for individual GASS projects according to their stage of development. Projects that are in formation or early phase include:

- Clouds Above the United States and Errors at the Surface (CAUSES)
- GABLS4: Stable Boundary Layer on the Antarctic Plateau
- Kinematic Driver model - Aerosol intercomparison project (KiD-A)
- Mid-latitude Cirrus
- Polar Air mass Transition
- Radiative Processes in Observations and Models

Projects that are mature include:

- Grey-Zone
- Land-Atmosphere Interactions (DICE)
- Low Cloud Feedbacks (CGILS)
- Weak Temperature Gradient

Projects where the intercomparison is complete and written up (or close to being written up) include:

- GABLS3: Stable Boundary Layer at Cabauw
- Polar Clouds
- Stratocumulus-to-Cumulus Transition
- Vertical Structure and Diabatic Processes of the MJO

As with most GASS projects there is likely to be significant work carried out in the future based around the output of these projects. It is complete in the sense this is no longer managed by GASS formally. Often the project leads will remain involved in related activities.

CLOUD RADIATION ERRORS AND SURFACE TEMPERATURE BIASES (CAUSES)

SSC sponsors: Jon Petch and Stephen Klein

Project leads: Cyril Morcrette, Hsi-Yen Ma, Jon Petch, Stephen Klein, and Shaocheng Xie

Project status: Early

a. Accomplishments

This proposed project is new with an observationally-based focus, which evaluates the role of cloud, radiation, and precipitation processes in contributing to the surface temperature biases in the region of the central United States and which are seen in several weather and climate models.

The warm bias over the US in summer is common to many GCMs and it is seen in the long-term climate mean and it shows up as a bias within a few days when running the climate models from analyses in NWP mode. While there are many potential causes, we are proposing study of two areas of investigation:

1. What is the contribution of radiation errors to the temperature errors? How much of the errors in radiation result from errors in clouds and their properties? Which cloud regimes contribute most the radiation errors? The analysis will be led by Cyril Morcrette (UK Met Office) and based largely upon Morcrette et al. (2012).

2. What is the relative contribution of precipitation errors to the temperature errors? Does this atmosphere provide the correct amount of precipitation for the soil? Which type of precipitating convection systems dominates the errors in the surface precipitation? Does the surface energy balance reveal signs that evaporation is underestimated due to the lack of soil moisture? The analysis will be led by Hsi-Yen Ma (LLNL) and based largely on Klein et al. (2006).

In October 2014, an experimental specification document was distributed via the GASS mailing list. It details the set up and diagnostics required from both NWP-type and climate type simulations as well as simulations that allow one to diagnose the drift towards the climate state. The document detailed the data format and file-naming convention aimed at simplifying the use of data from multiple models. Additionally, an informal survey of the community suggests that there will be participation from 7 modeling groups, including some regional as well as global climate models.

b. Activities for next 1-2 years

The intercomparison has officially begun and first simulation output has been requested. A tentative timeline is:

- June 2015: Deadline for participants' data to be submitted to LLNL or Met Office.
- Oct 2015: Participants' Data processed and analyzed.
- Nov 2015: Discuss plots and plans for papers at "ASR Fall Meeting"
- Jan 2016: Circulate outline for planned papers
- March 2016: First draft of the inter-comparison papers led by Cyril and Hsi-Yen
- June 2016: Submit manuscripts

c. List of key publications

A paper summarizing applying some of the methodologies to 2 models was submitted:

Van Weverberg, K., C. J. Morcrette, H.-Y. Ma, S. A. Klein, and J. C. Petch, 2015: Cloud regime analysis to find the causes of surface temperature errors in weather and climate models. *Quart. J. Roy. Met. Soc.*, submitted.

d. List of meetings, workshops held

A breakout session occurred at the pan-GEWEX meeting in The Hague, July 2014, and before that at the ASR/ARM meeting near Washington, D. C., March 2014.

e. Planned meetings and workshops

A breakout session to discuss this project will occur at the ASR/ARM meeting near Washington, D. C., March 2015 as well as the subsequent ASR/ARM meeting in Fall 2015.

GABLS4: STABLE BOUNDARY LAYER ON THE ANTARCTIC PLATEAU

SSC sponsor: Gunilla Svensson

Project leads: Eric Bazile, Bert Holtslag and Gunilla Svensson and Timo Vihma

Project status: Early

a. Accomplishments

As a follow-up on the recommendations from the ECMWF/GABLS workshop in Reading November 2011, a case to test boundary-layer schemes in conditions with stronger stability than previous cases is launched. The aim of the GABLS4 case is to study the interaction of a boundary layer with strong stability ($Ri \gg 1$) with a snow surface. This will provide a case with low conductivity and a high cooling potential. The case is based on observations taken at the Antarctic Plateau at Dome-C. The case is a “typical diurnal cycle for summer” with an amplitude of about 18K, and a very shallow boundary layer during night; the first one with a full coupling with the surface (snow) scheme and the second one with a prescribed surface temperature. Possibilities for a LES inter-comparison are discussed.

b. Activities for next 1-2 years

The case was announced to the community at several conferences during 2014 and the model results were handed in December 2014. Results for the second part of the experiment are due in May 2015 and they will be discussed at a workshop in May. It is likely that these first submissions will lead to follow-up experiments for the community to tackle. So far, SCM and Land models are involved, we expect LES to take part in a more idealized case setup as well.

c. List of key publications

Bazile E., O. Traullé, H. Barral, T. Vihma, A.A.M. Holtslag, and G. Svensson, 2013: GABLS4: An intercomparison case for 1D models to study the stable boundary layer at Dome-C on the Antarctic plateau. EMS Annual Meeting Abstracts Vol. 10, EMS2013-578, 2013

d. List of Meetings

- AMS BLT meeting Leeds, June 2014
- WWOSC2014, Montreal, August 2014
- Pan-GEWEX meeting, Hague, July 2014

e. Planned meetings, workshops

This case will be discussed at the upcoming GABLS4/DICE workshop on 20-22 May 2015 at MeteoFrance in Toulouse, France.

KINEMATIC DRIVER MODEL AEROSOL INTERCOMPARISON PROJECT

SSC sponsor: Ben Shipway

Project leads: Adrian Hill, Zach Lebo

Project status: Early

a. Accomplishments

The purpose of this Kinematic Driver model Aerosol (KiD-A) intercomparison project is to compare aerosol-aware cloud microphysics models in a consistent framework without the added complexity of dynamically coupled simulations. There are two key objectives to this intercomparison:

- Comparison of detailed cloud microphysical models and their response to aerosol (with no aerosol processing)
- Comparison of detailed cloud microphysical models that include aerosol processing with bulk models with aerosol processing capability

The goal of this project is to have individuals contribute by coupling his/her microphysics parameterization to the Kinetic Driver model (KiD). The coupling is straightforward with examples provided. A suite of simulations is requested with specific model output. Important details and additional information regarding the motivation for this intercomparison project, how to obtain the model and couple it with a microphysics scheme, and the requested output can be found at the following address:

http://appconv.metoffice.com/kid_a_intercomparison/kid_a/home.html

Results of this work will help further our understanding of aerosol-cloud-precipitation interactions.

To date, results have been submitted from groups using 7 different microphysics schemes including those using bulk, bin and super droplet parameterizations. Where the capability exists, groups have also submitted results from simulations, which include the physical processing of aerosol, allowing us for the first time to estimate the importance as well as the uncertainty in this aspect of cloud-aerosol interactions.

b. Activities for next 1-2 years

- Following an assessment of the initial results, the case set up will be reviewed and adjusted.
- The project will be finished and discussed at the 2016 Cloud Modeling Workshop
- A paper reporting the analysis and consequences thereof will be written.
- A follow on project considering a dynamical case will be considered.

c. List of key publications

- Hill, A, B.J. Shipway and I. Boutle, ‘How sensitive are aerosol-precipitation interactions to the warm rain representation?’ submitted to Journal of Advances in Modeling Earth Systems.
- Shipway, B.J. and Hill, A.A, 2012, Diagnosis of systematic differences between multiple parametrizations of warm rain microphysics using a kinematic framework. Q.J.R. Meteorol. Soc.. doi: 10.1002/qj.1913.

- Bretherton, C., A. Fridlind, H. Morrison, and B. Shipway, 2010: GCSS workshop on microphysics and polar/precipitating clouds. GEWEX News, 20, no. 4, 17-19.
- Shipway, B.J. and Hill, A.A., 2011, The Kinematic Driver model (KiD), Met Office Technical Report No. 549.

d. List of Meetings

A session on this project was held at the Pan-GASS meeting in Boulder, CO, 2012.

e. Planned meetings, workshops

The case will be presented at the cloud workshop on Eulerian vs Lagrangian microphysics at Warsaw in 2015 and will be discussed at the Cloud Modeling Workshop at Exeter UK in 2016.

MID-LATITUDE CIRRUS

SSC sponsors: Hugh Morrison

Project leads: Andreas Muhlbauer and Thomas Ackerman

Project status: Early

a. Accomplishments

Initiation of the cirrus model intercomparison project based on a case study from the U. S. DOE Small Particles in Cirrus (SPartICus) field campaign. The objective of this case study is to investigate the microphysical and macrophysical evolution and life cycle of a deep-wave cirrus observed over the ARM Southern Great Plains (SGP) site in Oklahoma and to compare simulated cirrus cloud properties and radiative effects among models and with observations. Special emphasis is on the contribution of small ice crystals in cirrus and the role of homogeneous and heterogeneous ice nucleation. Simulations are compared and evaluated with in situ aircraft observations and with various ground-based and space-borne remote sensors. This project specifically targets cloud-system resolving (CSRMs) models, cloud-resolving (CRM) models, large eddy simulation (LES) models and single column models (SCM) with advanced cloud microphysics schemes such as multi-moment bulk microphysics parameterizations or bin microphysics schemes. A detailed description of the project can be found at http://www.atmos.washington.edu/~andream/case3_midlatitude_cirrus/case3_midlatitude_cirrus.html.

b. Activities for next 1-2 years

The following activities are envisioned:

- Finalize case setup and logistics for participating models
- Analyse model results, focusing on cirrus macrophysical and microphysical properties through detailed intercomparison of models and comparison of models with in-situ and remotely sensed observations
- Draft a paper detailing results from the model intercomparison

c. List of key publications

Muhlbauer, A., W. W. Grabowski, S. P. Malinowski, T. P. Ackerman, G. H. Bryan, Z. J. Lebo, J. A. Milbrandt, H. Morrison, M. Ovchinnikov, S. Tessendorf, J. M. Thériault, G. Thompson, 2013: Reexamination of the State of the Art of Cloud Modeling Shows Real Improvements, *Bulletin of the Amer. Meteor. Soc.*, 94, 45-48, doi: <http://dx.doi.org/10.1175/BAMS-D-12-00188.1>

Muhlbauer, A., T. P. Ackerman, J. M. Comstock, M. Deng, G. Diskin, and P. Lawson, 2015: Evaluation of cloud resolving model simulations of midlatitude cirrus with ARM and A-Train observations, submitted to *J. Geophys. Res.*

d. List of Meetings

The following meetings have been held for this project:

- January 2012, Introduction of the project during the MACPEX/SPartICus Science Team Meeting (Salt Lake City, UT, USA)

- March 2012, Discussion of the project during the U. S. DOE ASR Science Team Meeting (Arlington, VA, USA) at a breakout meeting on cirrus, where the case was introduced
- July 2012, International Cloud Modeling Workshop (Warsaw, Poland); a breakout session devoted to the cirrus intercomparison project
- September 2012, 1st Pan-GASS conference (Boulder, CO, USA); a breakout session on cirrus clouds that was centered around the intercomparison project including detailed presentations of the case and preliminary results

e. Planned meetings, workshops

No Meetings are currently planned.

POLAR AIRMASS TRANSITION

SSC sponsor: Gunilla Svensson

Project lead: Felix Pithan

Project status: Early

a. Accomplishments

This is an idealized case to examine the models ability to capture the correct processes that changes the marine air mass when it is advected over the sea ice. This process involves cooling and stabilization of the air mass, condensation and cloud formation, radiative properties and glaciation to form snow and eventually the typical Arctic inversion should be present. The setup is based on conceptual understanding and there are currently no observations to compare with. Nevertheless, this is an important case to study to help motivate the observational efforts promoted by WWRP Polar Prediction Project and WCRP Polar Climate Predictability Initiative.

b. Activities for next 1-2 years

About ten model centers have run the case and the results are currently being analyzed and will be summarized in a paper. The results and possible extensions might be discussed at the GABLS4/DICE workshop.

c. List of key publications

The case is based on the experiments presented in:

Pithan, F., G. Medeiros and T. Mauritsen, 2014: Mixed-phase clouds cause climate model biases in Arctic wintertime temperature inversions. *Climate Dynamics*, 43, 289-303.

d. List of Meetings

Poster presentation at the Pan-GEWEX meeting, Hague, July 2014

e. Planned meetings, workshops

Possible discussions at the GABLS4/DICE workshop, May 2015 and at the YOPP (Year of Polar Prediction) meeting, Geneva, July 2015

RADIATIVE PROCESSES IN OBSERVATIONS AND MODELS

SSC sponsors: Robert Pincus and Lazaros Oreopoulos

Project leads: Robert Pincus and Eli Mlawer

Project status: Early

a. Accomplishments

This relatively new GASS project is envisioned as an extension and expansion of the Continual Intercomparison of Radiation Codes (CIRC) project. CIRC is the latest of a series of intercomparisons of radiation codes made in the GASS spirit, testing approximate against reference models and observations for a small set of well-characterized cases. During the reporting period, CIRC was highlighted as a major ARM accomplishment in a monograph about the first 20 years of ARM (see publication list below). The CIRC project presented a Working Group progress report at the International Radiation Committee (IRC) business meeting at COSPAR 2014 in Moscow.

In addition to CIRC, this GASS activity supports the component of the Radiative Forcing Model Intercomparison Project (RFMIP), which assesses the accuracy of clear-sky radiative forcing by greenhouse gases at the global scale (i.e. as relevant to climate sensitivity and feedback analyses). RFMIP was formally awarded association with the sixth phase of the Coupled Model Intercomparison Project (CMIP6). Preliminary planning for this activity was performed, including a trial study of 4xCO₂ radiative forcing experiments based on four CIRC cases that was presented at the 2014 AMS Radiation Conference in Boston, MA. This trial run suggested there is much room for assessment and improvement of GCM radiation parameterizations of gas absorption.

b. Activities for next 1-2 years

The gaseous forcing component of RFMIP is expected to come to the forefront of this project's activities in the next 1-2 years. This includes the final determination of the forcing experiments that will be included in this effort, running reference line-by-line calculations for these experiments for a large and diverse set of base atmospheres, supporting members of the global modeling community as they participate in this RFMIP component, and, finally, leading the analysis of the results.

CIRC intends to use RFMIP experience and outcomes to identify and design new observationally based cases that will help resolve questions about model performance that may arise. Examples of such potential issues are the impact of ignoring or poorly resolving the spectral dependence of surface albedo and of choosing different water vapor continuum parameterizations.

c. List of key publications

Oreopoulos, L., and E. Mlawer (2010). The Continual Intercomparison of Radiation Codes (CIRC): Assessing anew the quality of GCM radiation algorithms Bull. Am. Met. Soc., 91, 305-310doi:10.1175/2009BAMS2732.1

Oreopoulos, L., et al. (2012), The Continual Intercomparison of Radiation Codes: Results from Phase I, J. Geophys. Res., 117, D06118, doi:10.1029/2011JD016821.

Mlawer, E.J., M.J. Iacono, R. Pincus, H.W. Barker, L. Oreopoulos and D.L. Mitchell (2015), Contributions of the ARM program to radiative transfer modeling for climate and weather applications, *The Atmospheric Radiation Measurement Program: The First 20 Years*, Meteor. Monograph, Amer. Meteor. Soc., in press.

d. List of meetings, workshops held

RFMIP Planning Workshop, Hamburg, 3-5 September 2014

e. Planned meetings and workshops

None at this time

GREY ZONE

SSC sponsor: Pier Siebesma

Project Committee: Pier Siebesma, Andy Brown, Christian Jakob, Jeanette Onvlee.

Case Leaders: Paul Field, Adrian Hill, Stephan de Roode, Pier Siebesma, Lorenzo Tomassini

Project Status: Mature

a. Accomplishments

WGNE has recently expressed the need to organize a systematic evaluation project of atmospheric models that operate in the so-called Grey Zone Resolution range of 1~10km. As a response a Grey Zone Project has been established and the project committee has performed a survey and came with the conclusion that especially from the mesoscale model community there was a strong preference to select a cold air outbreak as a first intercomparison study for the Grey Zone Project.

The Case leaders have worked over the last 12 months to set up a cases for a full hierarchy of models (global, LAM and LES) based on observations from the CONSTRAIN experiment during which a classic cold air outbreak over the North Sea north of Great Britain was observed. Realistic high-resolution simulations with the correct classic spatial mesoscale features with 2 independent LES models have been produced.

The case has been released in 2013 and many modelers have submitted model results. In total we received results from 6 LES codes, 7 mesoscale models and 7 global models. December 1-3 2014, around fifty scientists visited the first Workshop on the Grey Zone Project organized by Lorenzo Tomassini at the Max Planck Institute for Meteorology in Hamburg, Germany. They came together to present and discuss: (i) the model results of the intercomparison study based on the CONSTRAIN cold air outbreak; (ii) novel ways of representing physical processes (clouds, convection and turbulence) in models that operate in the Grey Zone with respect to these processes; and (iii) to discuss any further coordinated actions.

b. Activities for next 1-2 years

The following activities are planned for this project:

- April 2015: Submission deadline of the 2nd round of the cold air outbreak
- May-Sept 2015: Analysis Results
- Late 2015: Drafts ready for submission of four papers (two on the mesoscale/global model results, 1 on the LES results and 1 general BAMS-like paper)
- 2016: There is interest to have a follow-up case on deep convection along the same lines (i.e. exploring the resolution-dependency of convection-representation)

c. List of key publications

- GEWEX Newsletter article on the Grey Zone Project and the first Grey Zone Workshop.

d. List of Meetings

- December 1 - 3, 2014 at the Max Planck Institute for Meteorology in Hamburg, Germany.

LAND-ATMOSPHERE INTERACTIONS (DICE) (JOINT WITH GLASS)

SSC sponsor: Adrian Lock

Project leads: Martin Best and Adrian Lock

Project status: Mature

a. Accomplishments

This project grew out of the GABLS/ECMWF workshop in Nov 2011 where there was a consensus that the atmospheric boundary layer and land surface communities needed to work more closely together. At the pan-GASS meeting in Sept 2012, it was proposed to initiate a project, joint between GASS and GLASS, on a clear-sky diurnal cycle case study, from the same observational campaign as was used for GABLS2. The period chosen consists of 3 full diurnal cycles covering a range of different stable boundary layer regimes. The intercomparison, initially, has three components. In stage 1, land surface and single column (atmosphere only) models are run separately (uncoupled) for the 3-day period forced entirely by observed quantities (noting that the soils in the LSM must be spun up by running, forced by observations, for several years of data previous to the campaign to ensure these are in balance for each model). In stage 2 the two models are run coupled. These two stages allow the impact of coupling to be evaluated. In stage 3 the submitted results from the models in stage 1 are used to derive multiple forcings (i.e., the surface fluxes are extracted from the LSM and the near-surface atmospheric variables from the SCM) so that each participant can run an ensemble of LSM and SCM simulations. This will allow the sensitivity of each model to differences in forcing to be quantified. Overall this project should both promote greater understanding of each model's strengths and weaknesses, help quantify the importance of coupling the two systems together and give insight into what aspects are important for surface coupling sensitivity.

The case was released in Spring 2013 and so far 10 LSM and 12 SCM are participating so far. Detailed analysis and final checking of data sets received is underway with draft papers to be completed by summer 2015.

The project website is <http://appconv.metoffice.com/dice/dice.html>

b. Activities for next 1-2 years

The following activities are envisioned for this project:

- Complete overview analysis of intercomparison data received and submit papers describing the key results
- Discuss draft papers and plan additional analysis at the upcoming synthesis workshop
- Discussions underway for potential special issue to collate DICE-related studies from the participants

c. List of key publications

Best, M., A. Lock, J. Santanello, G. Svensson, and B. Holtslag (2013) A New Community Experiment to Understand Land-Atmosphere Coupling Processes. *GEWEX News*, May 2013.

d. List of Meetings

Past meetings include:

- Workshop at the Met Office, Exeter from 14-16 October 2013
- Break-out meeting held at the GEWEX conference in The Hague on 15th July 2014

A synthesis workshop in May 2015 will be held at MeteoFrance (Toulouse) joint with GABLS4.

LOW CLOUD FEEDBACKS: CFMIP-GASS INTERCOMPARISON OF LES AND SCMS (CGILS)

SSC sponsor: Chris Bretherton and Adrian Lock

Project leads: Peter Blossey, Chris Bretherton, Minghua Zhang

Project status: Mature

a. Accomplishments

CGILS was formulated in 2008 to help understand physical mechanisms of low cloud feedback in climate models, and why these feedbacks differ substantially across models. The strategy has been to use a column modeling framework to intercompare subtropical marine boundary layer cloud response to idealized climate changes between different LES and SCMs, using cases grounded at least loosely in observations. Three locations along the GPCI were selected corresponding to different summer cloud regimes: S12 (well-mixed Sc), S11 (Cu under Sc) and S6 (trade cumulus).

Summary of Phase 1 results (finished)

The climate perturbation ('P2S') studied in Phase 1 of CGILS, completed in 2012, was a 2 K SST increase, a corresponding moist-adiabatic increase of free tropospheric temperature, and an 11% decrease in mean subsidence. Zhang et al. (2012) document the detailed case specification. After some iterations of the case specification, 15 SCMs (representing single-column versions of many of the world's leading climate models) and 6 LESs submitted final results, described in a set of four papers published in 2013-2014. For the S12 case, the LES models also considered a variation 'P2' on the climate perturbation with no subsidence change, and one LES also considered other climate perturbations that CMIP models suggest will accompany global warming in the subtropics, such as CO₂ increase, wind speed and free-tropospheric relative humidity changes, and increased inversion strength.

The cloud response of the SCMs scattered widely between each other and away from their parent GCMs. Because of the smallness of the climate perturbation and the use of steady forcings, the SCMs responses were distorted by locking of cloud features to discrete grid levels. In general, models and cases with active shallow cumulus parameterizations tended to show positive cloud feedbacks (Zhang et al 2013). After harmonization of the radiation and surface flux schemes, the LES models produced more similar responses. Without subsidence, all LESs showed cloud thinning in the warmer climate, but reduced subsidence counteracted this to varying degrees in the different models (Blossey et al. 2013). Thus LES suggested that there are multiple compensating cloud responses whose net result dictates the overall cloud feedback (Bretherton et al. 2013). In the S6 (shallow cumulus) case the equilibrium cloud-layer depth in each LES was also sensitive to its microphysical parameterizations (Blossey et al. 2013; Bretherton et al. 2013).

CGILS Phase 2 (ongoing)

At the Sept. 2012 Pan-GASS meeting, CGILS Phase 2 of was formulated. Based on sensitivity studies with a single LES (Bretherton et al. 2013) and recent results on the fast adjustment of clouds in GCMs, two further forcing perturbations were added to the original case, for all three locations. The first (4CO₂) was a quadrupling of CO₂ with no change in surface or free-tropospheric temperature. The second (dCMIP3) uses composite forcing perturbations taken from the CMIP3 multimodel mean for a CO₂-doubled climate (Bretherton et al. 2013). So far, six LES have

successfully run the perturbed cases, and all show reductions in cloud cover and albedo with both forcing perturbations, consistent with the single-LES results.

The other prong of CGILS Phase 2 was to test whether more consistency between SCMs and GCMs, as well as between LES and observed climatology, could be obtained using transient (synoptically-varying) forcing at each location, derived from a summer of ECMWF analyses provided to us by Martin Koehler, and adding the climate perturbations as a uniform-in-time increment to these transient forcings. It was decided that one LES group (Blossey and Bretherton at UW) would test out the feasibility of this approach. The approach worked for the S6 (trade cumulus case), but problems arose for the S11 (decoupled stratocumulus case) in a 4xCO₂ case with observed SSTs because the simulated inversion sank too low to be consistent with the ECMWF forcings, which have strong vertical and temporal gradients near the ECMWF-analyzed inversion height. It was agreed to try a simpler approach with composite periodic forcings that might be better controlled for such effects. The goal is to obtain a transient-forcing setup with a connection to real observations that is tractable for LES, can be logically extended to a future climate, and which involve inversion fluctuations of 500-1000 m that are larger than the grid spacing of a SCM, minimizing grid-locking artifacts.

b. Activities for next year

The steady-forcing results from CGILS Phase 2 have been finalized and are being written up for JAMES (tentative citation below). Brian Medeiros of NCAR has volunteered to coordinate an SCM intercomparison based on these steady-forcing cases, but this is not yet organized.

Blossey and Bretherton have worked extensively on realistic periodic-forcing setups. They have developed an approach, which works well for one case (S6), but still leads after a while to abrupt cloud breakup for another case (S11) that may make it a challenging comparison for SCMs. A satisfying resolution has not yet been found. So far, the LES cloud response in the transient forcing case is rather similar to in the steady forcing case, with 4xCO₂ and overall warming of the atmosphere and ocean column both independently producing cloudiness reductions. We will discuss next steps at the June 2015 CFMIP meeting, if not before.

c. List of key publications

M. Zhang and 39 co-authors, 2013: CGILS: First Results from an International Project to Understand the Physical Mechanisms of Low Cloud Feedbacks in General Circulation Models. *J. Adv. Model. Earth Syst.*, **5**, DOI: 10.1002/2013MS000246. – Overview of CGILS SCM and LES results.

M. Zhang, C. S. Bretherton, P. N. Blossey, Sandrine Bony, Florent Briant and Jean-Christophe Golaz, 2012: The CGILS experimental design to investigate low cloud feedbacks in general circulation models by using single-column and large-eddy simulation models. *J. Adv. Model. Earth Syst.*, **4**, doi:10.1029/2012MS000182. – CGILS Phase 1 case specifications

P. N. Blossey, C. S. Bretherton, M. Zhang, A. Cheng, S. Endo, T. Heus, Y. Liu, A. Lock, S. R. de Roode and K.-M. Xu, 2013: Marine low cloud sensitivity to an idealized climate change: The CGILS LES Intercomparison. *J. Adv. Model. Earth Syst.*, **5**, doi:10.1002/jame.20025 --Phase 1 LES results

C. S. Bretherton, P. N. Blossey and C. R. Jones, Mechanisms of marine low cloud sensitivity to idealized climate perturbations, 2013: A single-LES exploration extending the CGILS cases. *J. Adv. Model. Earth Syst.*, **5**, doi:10.1002/jame.20019 – Phase 1 Single-LES sensitivity study

Blossey, P. N, C. S. Bretherton, A. Cheng, J. J. van der Dussen, S. Endo, T. Heus and A. Lock, 2015. Marine low cloud sensitivity to increased CO₂ and a CMIP3 composite climate perturbation: Phase 2 of the CGILS LES intercomparison. *J. Adv. Model. Earth Syst.*, in preparation.

d. Meetings in 2014

July 2014: Session at CFMIP workshop, Egmont aan Zee, NL– detailed presentations of results

July 2014: GASS session at pan-GEWEX meeting, den Haag, NL – review of overall findings and plans

e. Planned meetings, workshops in 2015

June 2015: CFMIP workshop, Monterey, CA.

WEAK TEMPERATURE GRADIENT

SSC sponsor: Steve Woolnough

Project leads: Steve Woolnough, Adam Sobel, Sharon Sessions, Gilles Bellon, Shuguang Wang, Chimene Daleu

Project status: Mature

a. Accomplishments

This project arose out discussions proceeding and at the Pan-GASS meeting in Boulder, with the objective of comparing two methods of parameterizing the feedbacks from the large-scale tropical circulation in process models of convection. A comprehensive project specification was released in December 2013 and results from 5 CRM and 8 SCM models were submitted during the Spring/Summer of 2014 with analysis conducted over the summer

http://www.met.reading.ac.uk/~fj019034/WTG_project/.

A paper on the behavior of the Weak Temperature Gradient and Damped Gravity Wave methods for experiments with uniform SSTs is near submission, the main findings of this study are that: (i) there is a wider diversity of behavior in WTG than DGW methods; (ii) there is a wider diversity of behavior in SCMs than CRMs; and (iii) that the behavior in WTG method is sensitivity to the treatment of the large-scale in the boundary layer.

b. Activities for next 1-2 years

Following the initial analysis of the non-uniform SST case and the division of the results into two papers a further set of experiments has been requested, and the modeling centers have agreed to submit results during February 2015. Additional analysis and paper preparation will occur during spring 2015. Early discussion has begun on a set of additional experiments with interactive radiation but the specification and timeline for this has not been finalized.

c. List of key publications

d. List of Meetings

Results have been presented at the 7th International Scientific Conference on the Global Energy and Water Cycle, The Hague, 14-17 July 2014 and the AGU Fall Meeting, San Francisco, 15-19 December 2014.

e. Planned meetings, workshops

None

GABLS3: STABLE BOUNDARY LAYER AT CABAUW

SSC sponsor: Gunilla Svensson

Project leads: Gunilla Svensson and Bert Holtslag

Case leads: Fred Bosveld and Sukanta Basu

Project status: Finished, subject to final publication of papers

a. Accomplishments

The third GABLS intercomparison, based on a case selected Cabauw, the Netherlands, with the aim to study the model's performance for the LLJ development, morning and evening transitions and surface-atmosphere coupling. The intercomparison consists of a SCM and a LES case coordinated by Fred Bosveld and Sukanta Basu, respectively. The latter is focusing on a shorter time span than the SCM. Two papers on the SCM case are in the final publication state in *Boundary-Layer Meteorology*. The LES case focused on the nighttime conditions and the morning transition. Main findings from these studies are that the LES is able to capture the transition fairly well after considerable effort was put on the case setup. The SCM results show large variability and strong sensitivity to the forcing provided and the results are analyzed using a method which allows the interpretation of differences among models in terms of the dominating physical processes in the stable boundary layer, i.e. coupling to the soil, turbulent mixing and long wave radiation. Substantial differences among models are found in the representation of these three processes.

c. List of key publications

Basu, S., et al., 2014, GABLS Intercomparison of Large-Eddy Simulation models with Cabauw observations. In preparation for *Boundary Layer Meteorology*.

Bosveld F.C., P. Baas, E. van Meijgaard, E.I.F. De Bruijn, G.-J. Steeneveld and A.A.M. Holtslag, 2014. The third GABLS intercomparison case for model evaluation, part A: Case Selection and Set-up. *Boundary Layer Meteorology*, 152, 133-156, DOI: 10.1007/s10546-014-9917-3.

Bosveld F., P. Baas, G.J. Steeneveld, A.A.M. Holtslag, F. C. Bosveld, W. M. Angevine, E. Bazile, E. I.F. de Bruijn, D. Deacu, J. M. Edwards, M. Ek, V. E. Larson, J. E. Pleim, M. Raschendorfer, and G. Svensson, 2014: The third GABLS intercomparison case for model evaluation, Part B: Single Column Model results and process understanding. *Boundary-Layer Meteorology*, 152, 157-187. DOI: 10.1007/s10546-014-9919-1.

Holtslag, A.A.M., G. Svensson, P. Baas, S. Basu, B. Beare, A.C.M. Beljaars, F.C. Bosveld, J. Cuxart, J. Lindvall, G.J. Steeneveld, M. Tjernström, and B.J.H. Van De Wiel, 2013: Diurnal cycles of temperature and wind – A challenge for weather and climate models. *Bulletin of the American Meteorological Society*. 94, pp. 1691-1706, doi:10.1175/BAMS-D-11-00187.1

POLAR CLOUD

SSC sponsors: Ann Fridlind

Project leads: Mikhail Ovtchinnikov

Project status: Finished

a. Accomplishments

This case was a follow up to previous MPACE and SHEBA intercomparisons, but under different conditions and using a more constrained model setup with respect to ice particle properties, model's spatial resolution, and parameterization of radiative effects. The case received quite wide participation, and follow-up sensitivity studies were performed by the groups running both size-resolved bin microphysics and bulk microphysics schemes. It was found that the two independent bin microphysics models agreed quite well, and differences between bin and bulk schemes could be closely attributed to the parameterization of ice particle size distribution. When bulk scheme ice size distribution parameters were set to the mean fit to bin scheme results, bin and bulk scheme results were brought into agreement, as well, emphasizing the importance of representation of ice particle size distribution.

c. List of key publications

Ovtchinnikov, M., A.S. Ackerman, A. Avramov, A. Cheng, J. Fan, A.M. Fridlind, S. Ghan, J. Harrington, C. Hoose, A. Korolev, G.M. McFarquhar, H. Morrison, M. Paukert, J. Savre, B.J. Shipway, M.D. Shupe, A. Solomon, and K. Sulia, 2014: Intercomparison of large-eddy simulations of Arctic mixed-phase clouds: Importance of ice size distribution assumptions. *J. Adv. Model. Earth Syst.*, 6, no. 1, 223-248, doi:10.1002/2013MS000282.

STRATOCUMULUS-TO-CUMULUS TRANSITION

SSC sponsor: Adrian Lock

Project leads: Stephan de Roode, Irina Sandu, Roel Neggers

Project status: Finished, subject to final publication of papers

a. Accomplishments

This project studies the stratocumulus to trade cumulus transition, one that is of climatological importance for understanding low cloud cover variations in the marine subtropics. There are two parallel LES intercomparisons as well as SCM intercomparisons. These intercomparisons are being run in collaboration with a European project, EUCLIPSE. In combination these cases challenge models to produce both a realistic transition compared to detailed in situ data and also a realistic sensitivity of the speed of transition to changes in environmental forcing. Results suggest the LES do a good job of capturing these details, although requiring very high (5m) vertical resolution. One of the motivations for this intercomparison was that these transitions would present a particular challenge for SCMs, many of which would need to make the transition between different parameterizations of vertical mixing. Over 20 SCMs have participated and, although many do indeed struggle to generate realistic transitions, it is encouraging that those organizations that have worked hard to develop these aspects of physical parameterizations (invariably using previous GCSS intercomparison cases) can do a much better job.

b. Activities for next 1-2 years

The final activity to complete this project will be submission of a SCM paper describing these studies in much more detail; a draft paper was circulated in September 2014. Separate spin-off work is continuing to investigate the difference between forcing the SCM with mean forcing as compared to running an ensemble of SCM and taking the mean. While of general interest to GASS this is not considered part of this intercomparison.

c. List of key publications

Neggers et al: Single-column model simulations of subtropical marine boundary layer cloud transitions under weakening inversions. In preparation

van der Dussen, J. J., S. R. de Roode, A. S. Ackerman, P. N. Blossey, C. S. Bretherton, M. J. Kurowski, A. P. Lock, R. A. J. Neggers, I. Sandu, and A. P. Siebesma (2013), The GASS/EUCLIPSE model intercomparison of the stratocumulus transition as observed during ASTEX: LES results, *J. Adv. Model. Earth Syst.*, 5, doi:10.1002/jame.20033.

De Roode, S.R. et al (2012) LES Results of the GASS-EUCLIPSE Lagrangian Stratocumulus to Shallow Cumulus Transition Cases, *AMS-BLT Conference*, https://ams.confex.com/ams/20BLT18AirSea/webprogram/Manuscript/Paper208663/intercomparison_lags.pdf

Lock, A.P. (2011) GCSS/CFMIP/EUCLIPSE Meeting on Cloud Processes and Climate Feedbacks. *GEWEX News*, August 2011

d. List of Meetings

The following meetings have been held for this project:

- September 2010, Joint workshop with EUCLIPSE on the Transition and CGILS cases held at KNMI (deBilt, Netherlands)
- June 2011, joint meeting with CFMIP and EUCLIPSE including further discussions on the Transition and CGILS cases held at the Met Office (Exeter, Devon, UK)
- April 2012, some discussion of progress alongside an otherwise EUCLIPSE-only meeting at MeteoFrance (Toulouse, France)
- September 2012, Discussion of project at the 1st pan-GASS meeting (Boulder, CO, USA)

e. Planned meetings, workshops

No more meetings are currently planned, although work will continue.

VERTICAL STRUCTURE AND DIABATIC PROCESSES OF THE MJO

SSC sponsors: Jon Petch and Steve Woolnough

Project leads: Jon Petch, Duane Waliser, Prince Xavier, Nick Klingaman, Xianan Jiang & Steve Woolnough

Project status: Finished, subject to final publication of papers

a. Accomplishments

This project, conducted jointly between GASS and the WCRP-WWRP MJO task force, studied the vertical structure of diabatic process in the MJO in global models and its relationship to MJO simulation fidelity using 3 sets of model integrations: 20 year climate simulations, 2-day hindcasts from 2 YOTC MJO cases (E&F), and 20-day hindcasts of the same events. Over the spring/summer of 2012 data submissions for one or more components of the project were received from 23 modeling centers. The initial analysis of the 3 components has been carried out and papers on each component have been submitted and are under revisions following the review process. In response to the reviewers and editor's comments, a further short synthesis paper is being developed.

A database of the output from these simulations is available at <https://earthsystemcog.org/projects/gass-yotc-mip/>

b. Activities for next 1-2 years

See papers through review process. This includes the planned synthesis paper.

c. List of key publications

- Petch, Jon, Duane Waliser, Xianan Jiang, Prince Xavier, and Steve Woolnough: A Global Model Intercomparison of the Physical Processes Associated with the Madden-Julian Oscillation, 2011, *GEWEX News*, 21, 3-5.
- Jiang, X., D. E. Waliser, P. K. Xavier, J. Petch, N. P. Klingaman, S. J. Woolnough, Bin Guan, G. Bellon, T. Crueger, Charlotte DeMott, C. Hannay, H. Lin, W. Hu, D. Kim, C.-L. Lappen, M.-M. Lu, H.-Y. Ma, T. Miyakawa, J. A. Ridout, S. D. Schubert, J. Scinocca, K.-H. Seo, E. Shindo, X. Song, C. Stan, W.-L. Tseng, W. Wang, T. Wu, K. Wyser, X. Wu, G. J. Zhang, and H. Zhu, 2014: Vertical structure and physical processes of the Madden-Julian Oscillation: Exploring key model physics in climate simulations. (*under revision for JGR*)
- Klingaman, N. P., S. J. Woolnough, X. Jiang, D. Waliser, P. K. Xavier, J. Petch, M. Caian, C. Hannay, D. Kim, H.-Y. Ma, W. J. Merryfield, T. Miyakawa, M. Pritchard, J. A. Ridout, R. Roehrig, E. Shindo, F. Vitart, H. Wang, N. R. Cavanaugh, B. E. Mapes, A. Shelly, and G. Zhang, 2014: Vertical structure and physical processes of the Madden-Julian Oscillation: Linking hindcast fidelity to simulated diabatic heating and moistening. (*under revision for JGR*)
- Xavier, P. K., J. C. Petch, N. P. Klingaman, S. J. Woolnough, X. Jiang, D. E. Waliser, M. Caian, S. M. Hagos, C. Hannay, D. Kim, J. Cole, T. Miyakawa, M. Pritchard, R. Roehrig, E. Shindo, F. Vitart, and H. Wang, 2014: Vertical structure and physical processes of the Madden-Julian Oscillation: Biases and uncertainties at short range. (*under revision for JGR*)
- Klingaman, Xianan Jiang, Prince K. Xavier, Jon Petch, Duane Waliser, Steven J. Woolnough: Vertical structure and physical processes of the Madden-Julian oscillation: Synthesis and summary. (*submitted to JGR*)

d. List of Meetings

The following meetings have been held for this project:

- 1st pan-GASS meeting in Boulder September 2012 where preliminary results were discussed
- GASS/MJO-TF meeting on Diabatic Processes in the MJO, Singapore Met Office, 3-5 June 2013 – discussion of model analysis and plans for future work on CINDY/DYNAMO case

2.2 GDAP GEWEX Data And Assessments Panel Report

Reporting Period: October 2013 – January 2015

Starting date: GDAP is the new brand of the Panel following the GEWEX Radiation Panel (GRP) since 2011. GDAP and GASS took joint ownership of the CIRC activity along with GDAP.

URL: <http://gewex.org/GDAP.html>; <http://rain.atmos.colostate.edu/GDAP/index.html>

Chair(s) and term dates: Christian Kummerow (ended July 2014), Jörg Schulz (ends March 2017)

Vice-Chair: Jörg Schulz (ended July 2014), Matthew McCabe (ends March 2017)

Panel Objectives

GDAP activities can be divided into Data Products, Product Quality Assessments, and Radiative Transfer Code Assessments. The product quality assessments commonly bring together a variety of in-situ measurements. Some of these are well coordinated and quality controlled while others exist largely in their own regional domains. The panel, therefore, sees a role as identifying such networks of in-situ observations and fostering the development of integrated global datasets that can be used to both construct and/or validate the global climate products.

The individual and the integrated GEWEX data products enable research related to Grand Challenges on changes in water availability, clouds, circulation and climate sensitivity and potentially for climate extremes. Within GEWEX a specific objective is to provide a better understanding of variability and change of the water and energy cycles and individual state variables mainly derived from satellite observations. To fulfill this objective global moderate space (~50 km) and high time (~3 hourly) resolution data sets with quantified and validated uncertainty are needed. Quantification and validation of uncertainty estimates becomes a major thrust of research performed in GDAP.

Major objectives of the product quality assessments are to provide independent and transparent quality assurance for existing data records, to endorse the use and the credibility of data records to a broader community not necessarily familiar with the data sources and methods used to generate the data records, to identify key limitations in data records to stimulate improvements, and to allow objective selections of appropriate data records, e.g., for evaluating climate models in Climate Model Intercomparison Projects (CMIP).

Radiative transfer code assessments performed as GEWEX projects had the objectives to provide a new standard for assessing the performance and potentially certifying GCM-style SW and LW RT codes, to compare performance of 3D radiative transfer codes and comparison of canopy radiative transfer models under controlled experimental conditions.

Status and Results

a) GEWEX Products

The production of GEWEX individual products for Clouds (ISCCP), Aerosols (GACP, MAC), Radiation Fluxes (SRB), Turbulent Fluxes (SeaFlux and LandFlux) as well as Precipitation (GPCP) continues with reasonable support from agencies except for GACP, which remains unfunded. The

Max Planck Institute für Meteorologie continues production of an Aerosol Climatology that is being adopted by GDAP instead. Some of the GEWEX reference products, e.g., ISCCP and GPCP have been transferred to NOAA for routine processing (keeping a timeliness of about 1 month). Others may follow depending on funding. Other sustained activities such as in Europe continue to produce data records on the energy and water cycle comparable in nature and quality to the standard GEWEX products but no real attempts on an integrated product have been made.

The Integrated GEWEX product is designed to ensure that geophysical signals and their covariance are tied to the data and products themselves rather than inconsistencies in their assumptions. Reviewing the progress in the production of the integrated product using common assumptions was the primary goal of the GDAP team meeting in The Hague, The Netherlands, on 16 and 18 July 2014. Some of the data products for the Integrated GEWEX Product, including radiative energy, turbulent fluxes, and condensation heating, were finalized over the past year. Other data to be included were initially hampered by delays in individual components but are now nearing completion. However, the panel has encountered significant issues, of the scientific rather programmatic nature, as it has forged ahead to create this product. In particular, basic building blocks such as surface temperature, temperature and humidity profiles are not as good as hoped for. Large differences between products were found and little in terms of absolute validation is available. In addition, the profile data in the lower levels are significantly different from inputs used for individual products of turbulent heat and radiation fluxes, e.g., derived from passive microwave imager data over ocean or coming from reanalysis. In that sense the integrated product is an important step forward in that the very interdependence of the products makes it difficult to produce, but is also a very strict QC procedure. Due to these issues it is currently difficult to announce a delivery date other than as soon as possible.

GDAP has begun to explore the expansion of GEWEX standard products to include terrestrial water budget terms. With Wouter Dorigo (Soil Moisture) and Felix Landerer (GRACE Observations of water storage) two experts on these topics joined the Panel advising on best ways to incorporate potential data sets. The very short GDAP meeting in The Hague in summer 2014 decided to start a formal data set quality assessment on soil moisture and expects an outline paper for the 2015 GDAP meeting. Ground water storage related activities were postponed until 2015, as Felix Landerer could not participate in the GDAP meeting 2014.

b) Data Set Quality Assessments

Currently, GDAP has two running data set quality assessments on water vapor and aerosol optical depth. Both are crucial elements of the integrated product and were originally designed to provide information on different existing data sets derived from satellite data.

The aerosol assessment was concentrating on a level 3-type comparison (retrievals mapped to geographical grid) but was not able to finalize it in 2014, mostly because of too little time available and lacking motivation by the leaders of the assessment. The assessment is considering new interesting aspects, e.g., trends in aerosol optical depth over the last decade and satellite data – climate model comparisons but struggles with delivering a report to GDAP. It is a major concern of GDAP for 2015 to find a way forward for this assessment.

The water vapor assessment (www.gewex-vap.org) has continued to make progress and here it clearly helped to have a written agreed assessment plan at the beginning of the workshop. The 4th G-VAP workshop was hosted by the Institute of Space Sciences at FU Berlin, Berlin, Germany on 09+10 October 2014. More than 30 scientists from all over the world participated and nearly

everybody contributed with a presentation. The willingness of the participants to take over responsibility in WCRP report drafting is noteworthy and highly acknowledged.

Trend analysis was used as a tool to compare total column water vapor (TCWV) and water vapor profiles on global scale. The TCWV trends were found to be significantly different, in particular in tropical land regions, which led to the recommendation to the Global Reference Upper Air Network (GRUAN) co-chairs to consider a tropical land surface station during GRUAN network expansion (www.gruan.org). Using homogeneity tests these differences in TCWV were found to be caused by break points in the time series which temporally coincide in almost all cases with changes in the observing system. Results are also available from the comparison of short-term data records using PDF analysis. The analysis included the nnHIRS temperature and water vapor profile product, which is input to the GEWEX Integrated Product. Largest differences were found for the satellite-based data sets, especially over high-pressure areas over the ocean. The assessment has managed to agree on the structure of the final report and distributed responsibilities for the chapters.

Some new directions such as an enhancement of the evaluation of water vapor and temperature at the surface and in the boundary layer to strengthen the evaluation of energy fluxes (land and ocean) and of the planetary boundary layer and enhanced quality analysis of profile data records over open ocean, in particular over subsidence areas was discussed. In addition, at a later stage water vapor transport products could be used to analyze atmospheric dynamics and to evaluate the assumption of constant relative humidity in the upper troposphere.

At present the assessment expects to finalize its report in 2016 and not in 2015 as originally planned. The reason for the delay lies in the fact that comparisons of temperature and humidity profile data cannot be finished in time. A transfer of resources from Europe to the US to support activities at NOAA was finally failing due to too high administrative hurdles.

GDAP provided a draft of Data Set Quality Assessments: Needs, Benefits, Best Practices and Governance to the WCRP Data Advisory Council. The document was endorsed but needs further update to include the perspective concerning the link of data product quality assessments and obs4mips. The update is planned to be finished prior to the WCRP JSC in April 2015.

c) Radiative transfer model assessments

Radiative transfer code and satellite simulator assessments have not been considered in detail during recent GDAP meetings mostly because lack of time and funding of the individual projects. The Continual Intercomparison of Radiation Codes (CIRC) project that formerly reported to GDAP is now jointly owned with the GASS project Radiative Processes in Observations and Models. The needs for activities concerning 3D radiative transfer models and the still active RADIATION transfer Model Intercomparison (RAMI) initiative that proposes a mechanism to benchmark models designed to simulate the transfer of radiation at or near the Earth's terrestrial surface, i.e., in plant canopies and over soil surfaces need to be discussed at the next GDAP meeting.

d) In situ networks

The BSRN network reported improved data submissions for several sites. In total about 50 station years are currently in the BSRN archive. In addition a significant uptake of BSRN data in scientific publication has been found with a 12% growth from 2011 to 2012 and a further 32% growth from 2012 to 2013. BSRN performed a network workshop in Bologna, Italy from 9-12 September 2014 that had about 70 registered participants showing ongoing strong interest in BSRN (see GEWEX

News November 2014 for the full report). However, despite this success BSRN is suffering also from station closures (see below under Issues and Recommendations) and may need renewed support.

The International Soil Moisture Network (ISMN) (<https://ismn.geo.tuwien.ac.at/>) includes soil moisture in situ measurements from 42 networks (active and historical) with ~1600 stations. The ISMN has become successful and indispensable for validation of satellite estimates. Improvements on the quality control procedures taking into account co-varying variables such as air/soil temperature, precipitation, snow depth, etc. It was reported at the last GDAP meeting in The Hague that issues exist with funding after 2016 with the danger that the ISMN would deteriorate in the following years.

The water vapor assessment has created a link to the GRUAN network and is providing recommendations to the network related to usability for validating satellite-derived products.

New directions:

a) Products

With regard to the usage of GEWEX and other data sets in particular the integrated product further, analysis, application and development activities will be needed. As first analysis of the integrated product is pointing at issues in particular with atmospheric temperature and humidity we certainly need to assess the potential role of global reanalysis for the integrated product, which should be done on the basis of the water vapor assessment results that include reanalysis data. Considering the inherent uncertainties in individual products one way forward might be to create data product ensembles out of products that have taken part in GEWEX assessments. Further, we need to foster the analysis of parameter covariance statistics in order to evaluate flux and budget statistics as close as possible to the native processes.

In terms of applications, GDAP will make an attempt to bring the integrated product and also a more complete set of GEWEX products to the CMIP-6 activities by interrogating with the obs4mips activity. It is expected that such a usage will create valuable feedback for further developments of the integrated product. For individual products we need to further study items that are currently not included such as interception loss for evapotranspiration. This requires looking into new data sources such as the recently launched SMAP mission as well.

Another more long-term issue is to better characterize the uncertainty of products that includes the provision of uncertainty estimates with the products and their evaluation. Currently, SeaFlux products contain estimates from systematic and random effects in the measurements and retrievals that are propagated to mapped air-sea turbulent flux products. In addition some initial activities exist to assess the uncertainty budget for some precipitation data sets in the Tropics. However, GDAP needs to follow up the uncertainty characterization more systematically for all products to resolve random, systematic, and so-called structural (situation and magnitude dependent) uncertainty. The provision of uncertainty measures with the products will certainly trigger needs for new reprocessing activities.

In addition, terrestrial water and energy budget closure at scales important to climate processes is a key area that GDAP will focus its energy on in the next 5-10 years. This includes questions about precipitation cycling and feedbacks between soil moisture and precipitation.

b) Assessments

Provision of information about existing data sets related to the energy and water cycle in form of scientific quality assessment will remain an important activity of GDAP. It has been very challenging to perform assessments basically with only marginal or no funding. The still running water vapor assessment benefitted very much from space agency funding, which established a core activity that keeps momentum for several years. It has been recognized that because of the funding situation assessments take far too long to deliver results. Thus, one objective will be to organize upcoming assessments in a different way.

It is important that assessments activities and their results become better known to those who should benefit from the results, e.g., climate modelers, etc. It is indicative to not only produce a very big report at the end of an assessment as it was done for clouds and radiation fluxes but to keep the audience interested with regularly updated information, e.g., every two years. Assessment plans/white papers should structure the activities in near, medium and long-term goals and then publish results and receive feedback early in the process. It may also help to be responsive to specific applications such as process studies or climate model evaluation, which may necessitate very different perspectives for an assessment.

The GDAP meeting in The Hague in July 2014 decided to embark on two new product quality assessments that will cover precipitation and soil moisture data sets. For precipitation already a white paper has been drafted (see Annex). For soil moisture a similar draft is expected for discussion at the next GDAP meeting late September 2015. The latter assessment may also consider consistency between soil moisture, precipitation and evaporation at the surface. A third topic for an assessment might be groundwater related products, but this should be explored and suitable people found.

Future: Next year foreseen activities:

- Assess the status of all GDAP related projects and activities – revive those which are needed;
- Carefully consider GDAP membership to secure long term future of the Panel;
- Finalize the production of the integrated product and start evaluating its quality by using it for energy and water budget studies. It needs to be understood that during such studies it is expected that several shortcomings in the integrated product will be detected. Depending on the quality of the integrated product GDAP may even start to plan a next production cycle for the integrated product and try to embed this in ongoing product generation activities such as SCOPE-CM. Without appropriate funding progress will be very limited;
- Foster relation with obs4mips and start to bring the integrated product to the ESG. This topic was discussed at the last GDAP and availability of funding to provide needed meta data structure and format can become a major issue;
- Consider link with GEWEX PROES and define what GDAPs contribution could be;
- Assess and may reinforce relation with SCOPE-CM by clearly address mutual benefits of collaboration;
- Define routes to close out the aerosol and water vapor assessments that lasts since a couple of years;
- Discuss and start two new data set quality assessments on precipitation and soil moisture
- Evaluate the feasibility of formalizing the Satellite Simulator Assessment started in 2012 and decide at next GDAP meeting in the autumn of 2015;
- Discuss if GDAP may engage into support of the WMO Rolling Review Requirements process. GEWEX has provided requirements to this process in back in 1998. The WCRP Data Advisory Panel considered this in 2013 but was not launching any activity. Key is to be clear about how requirements should be constructed along the applications relevant for GEWEX. Maybe

providing some quite broad ranges (relevant to various applications) would be most practical, rather than focusing on single numbers. It might be useful if rather data product users engage in the requirement process than producers;

- Support WDAC task team on turbulent heat fluxes by contributing to the GEWEX WG on fluxes;

Issues and Recommendations:

In situ data sets:

- In-situ datasets of radiation, precipitation, clouds properties, water vapor soil moisture and turbulent fluxes are important reference data for satellite Climate Data Records. Almost all are under funding pressure with little international visibility or status. As anchors to many of the global products, it would be good to see WCRP and possibly WMO elevate these measurements to a level where we can get national commitments to their maintenance as well as capacity building that is desperately needed in underdeveloped regions of the world. WCRP might consider a concerted effort to foster small but highly characterized networks (similar to BSRN) that can be used to assess stability of satellite data records over very long periods.
- Recent examples for specific networks:
 - GDAP received a report from Norman Loeb that the BSRN site at the Chesapeake Lighthouse, 25 km off the coast of Virginia Beach will disappear. The CERES team has been maintaining and operating BSRN and AERONET instruments there since 2000. The Department of Energy took over the lighthouse from the Coast Guard in October 2012 with plans to construct a 100 m tower with an array of instruments for wind research. Unfortunately, DOE recently concluded that the cost of repairs to the platform and 100-m tower exceeds their cap so they've decided to scrap their plans and return the platform to the U.S. General Services Administration (GSA), who will put the lighthouse up for auction. Because of safety concerns, DOE has asked to remove all instruments from the platform ASAP. NASA has no interest in acquiring the platform (we explored this possibility a few years ago). It's really unfortunate as there is no other BSRN site that far away from a coast. Although the BSRN site in Darwin continues operations funded by the Australian Government we are seeing the effects of decaying support for BSRN and we need to renew the support for both sites and analysts to make these data available to support the whole range of things that GEWEX (and the rest of WCRP) is working on.
 - It was reported at the last GDAP meeting in The Hague that issues exist with funding after 2016 with the danger that the ISMN would deteriorate in the following years. It is suggested to bring this item to the attention of the WDAC and maybe also the JSC to ask for continued support of the ISMN network;

Support to sustain assessment activities:

- The EUMETSAT CM SAF may offer the opportunity to provide long-term services for updating water vapor assessment results due to the sustained funding scheme via EUMETSAT. A support letter for their next proposal to EUMETSAT by the GEWEX chairs is appreciated.

Issues for attention by the SSG:

- The BSRN project manager, Joseph Michalsky, retired at the end of 2014. He provided the GDAP with two applications to succeed him. GDAP considered the applications and asks the SSG to formally appoint Charles N. Long, Senior Research Scientist at Pacific Northwest National Laboratory Richland, Washington, USA as new BSRN chair;

- The current chair and vice chair of GDAP plan to pass on the responsibility after the SSG 2017. SSG is asked to support the search for new leaders of GDAP during the next two years;
- Changes to the membership of GDAP are needed and the GDAP meeting 2014 indicated that additional expertise in the field of reanalysis and climate modeling is needed to fully exploit the integrated product and potentially to improve it. In addition, expertise on top of the atmosphere radiation budget and integrated analysis with sea level rise needs to be reinforced. SSG is asked to support the GDAP chair and vice-chair in finding appropriate candidates;
- GDAP members have been hampered to participate in GDAP meetings in the last two years due to travel restrictions in the US, which is of concern as this often means that they also cannot contribute to the work.

Contributions to WCRP Strategic Themes/Grand Challenges (preferably with indication towards GEWEX Science Questions):

The individual and the integrated GEWEX data products enable research related to Grand Challenges on changes in water availability, clouds, circulation and climate sensitivity and potentially for climate extremes.

Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation, and their contributions to climate sensitivity is supported by the GDAP Integrated Product. Science articles GDAP plans to publish go directly to answering questions about the interactions of clouds precipitation and the radiation balance. The data sets are made specifically to test co-variance and climate sensitivity

On changes to water availability GDAP can certainly help with past precipitation amounts and the distribution of rain rates that might be viewed as important for water availability, the panel has no particular information on water availability or changes therein.

The re-engineered GDAP products (1 degree, 3 hourly time steps) may allow detecting extremes and processes related to extremes in the data. The publication by Lockhoff et al. (2014) has already found some skill at large scales in GPCP 1DD products.

In addition the products can be used to perform process studies at regional scales that would be essential to verify that the regional climate models are indeed capturing the key elements of each region's unique physics.

Summary for GEWEX report:

Will be provided after the SSG meeting.

List of key publications:

Individual data products continue publications that continue to have high citation rates. The given list of publications is only a small excerpt of what has been published since 2013. We would benefit from having a central publication screening at the GEWEX office.

L'Ecuyer, T. S., H. Beaudoin, M. Rodell, W. Olson, B. Lin, S. Kato, C. A. Clayson, E. Wood, J. Sheffield, R. Adler, G. Huffman, M. Bosilovich, G. Gu, F. R. Robertson, P. R. Houser, D. Chambers, J. S. Famiglietti, E. Fetzer, W. T. Liu, X. Gao, C. A. Schlosser, E. Clark, D. P.

Lettenmaier, and K. Hilburn, 2015: The Observed State of the Energy Budget in the Early 21st Century, *J. Climate*, Submitted

Rodell, M., H. K. Beaudoin, T. S. L'Ecuyer, W. S. Olson, J. S. Famiglietti, P. R. Houser, R. Adler, M. Bosilovich, C. A. Clayson, D. Chambers, E. Clark, E. Fetzer, X. Gao, G. Gu, K. Hilburn, G. Huffman, D. P. Lettenmaier, W. T. Liu, F. R. Robertson, C. A. Schlosser, J. Sheffield, and E. F. Wood, 2015: The Observed State of the Global Water Cycle in the Early 21st Century, *J. Climate*, Submitted

Brown, P. J. and Christian D. Kummerow, 2014: An Assessment of Atmospheric Water Budget Components over Tropical Oceans. *J. Climate*, 27, 2054–2071.

Lockhoff M., O. Zolina, C. Simmer, and J. Schulz, 2014: Evaluation of Satellite-Retrieved Extreme Precipitation over Europe using Gauge Observations. *J. Climate*, 27, 607–623. doi:<http://dx.doi.org/10.1175/JCLI-D-13-00194.1>

Mueller, B., M. Hirschi, C. Jimenez, P. Ciais, P. A. Dirmeyer, A. J. Dolman, J. B. Fisher, M. Jung, F. Ludwig, F. Maignan, D. G. Miralles, M. F. McCabe, M. Reichstein, J. Sheffield, K. Wang, E. F. Wood, Y. Zhang, and S. I. Seneviratne, 2013, *Hydrol. Earth Syst. Sci.*, 17, 3707–3720, 2013.

Stone, T.C., W.B. Rossow, J. Ferrier, and L.M. Finkelman, 2013: Evaluation of ISCCP multisatellite radiance calibration for geostationary imager visible channels using the Moon. *IEEE Trans. Geosci. Remote Sens.*, 51, 1255-1266, doi:10.1109/TGRS.2012.2237520.

Tselioudis, G., W. Rossow, Y.-C. Zhang, and D. Konsta, 2013: Global weather states and their properties from passive and active satellite cloud retrievals. *J. Climate*, 26, 7734-7746, doi:10.1175/JCLI-D-13-00024.1.

List of meetings, workshops:

- Third Meeting of the GEWEX Data and Assessments Panel (GDAP), The Hague, The Netherlands, 16 and 18 July 2014.
- 13th Baseline Surface Radiation Network Scientific Review and Workshop, Bologna, Italy 9–12 September 2014.
- GEWEX Water Vapor Assessment workshop, Berlin, Germany, 9-10 October 2014.

Planned meetings, workshops:

- GDAP chair will present GDAP work to a GCOS and GEO joint Session on "Global Environmental Research and Policy" at the International Symposium on Remote Sensing of Environment (ISRSE), Berlin, Germany, 12 May 2015.
- GDAP chair will present GDAP science to a special IAMAS session on IRC Working Groups in an IUGG/IAMAS session on Radiation in the Climate System, Prague, Czech Republic, 22 June – 2 July 2015.
- 4th Meeting of the GEWEX Data and Assessments Panel (GDAP), Xiamen, China, 29 September – 2 October 2015.
- GEWEX Water Vapor Assessment Workshop, Madison, Wisconsin, USA, 4-5 November 2015.

List of members and their term dates where appropriate (including changes)

Christian Kummerow	2008 – present (chair since July 2015)
Joerg Schulz	2010 – present (chair from July 2015 – present)
Wouter Dorigo	2013 – Present
Carlos Jimenez	2010 – present
Felix Landerer	2013 – present
Norman G. Loeb	2005 – present
Hirohiko Masunaga	2010 – present
Matthew McCabe	2008 – present (vice-chair from January 2015 – present)
Axel Schweiger	2008 – present
Sonia Seneviratne	2008 – present
B.J. Sohn	2007 – present
Claudia Stubenrauch	2007 – present
Susan Van den Heever	2008 – present
Tianjun Zhou	2011 – present
Andrew Heidinger	2012 – present

GDAP Precipitation Assessment: Proposal Outline (draft)

Hiro Masunaga (Nagoya University)
Christian Kummerow (Colorado State University)

Introduction

The GEWEX Data and Assessments panel, meeting in The Hague in July 2014, decided that the increased availability of climate precipitation products, coupled with uncertainties in the global Water and Energy budget terms available from these products, merited a new assessment of the precipitation products. The GDAP assessment reports recently published include the cloud assessment and radiative flux assessment, which are both remarkably thorough and detailed. The cloud assessment report is a 176-page document and the radiative flux assessment report consists of two volumes each containing more than 200 pages and took nearly a decade to complete. It is a demanding task to complete such a comprehensive report in a practical timeframe. While it remains important to publish a full assessment report, it would be beneficial to quickly deliver a concise interim report (or a series of interim reports) in order to address the urgent needs of broad science community in a timely manner. This document is an attempt to sharpen the assessment strategies so that such an interim report is kept useful and informative despite its conciseness. The envisioned timeframe for this report is approximately 2 years from the charter to completion.

Strategies for timely delivery of the assessment reports

First, the foci of assessment should be clearly identified in advance. A tentative list of the proposed foci is presented below. Second, the identified foci must be prioritized to select the ones that can be addressed within a reasonable period of time. The foci that are important but require a substantial effort to address may be excluded from interim reports and left for a full report. Finally, unessential sections may be omitted from interim reports. For instance, a detailed description of individual data products, retrieval algorithms, and satellite instruments should be available elsewhere and does not need to be entirely repeated. Such information would be useful and even indispensable for a full report, but may be substantially shortened and only provided as needed in an interim report.

Data Sets

This section briefly summarizes global precipitation products broadly that are in broad use. The first step of a new assessment would be to review and edit this list to focus on all available products being used or designed for Climate Research Purposes.

1) *Combined products from multiple satellites w or w/o ground data*

- GPCP: 2.5°x2.5°, monthly/pentad/daily, 1979-present
- CMAP: 2.5°x2.5°, monthly/pentad, 1979-2014
- CMORPH: (8 km, 30 min)/(0.25 °x0.25 °, 3-hourly/daily), late 2002-present
- GSMaP: 0.1 °x0.1°, hourly, data periods vary among product types (MWR/MVK/NRT)
- TRMM 3B42 or TMPA: 0.25 °x0.25°, 3-hourly/daily/monthly, 1998-present

2) *Individual satellite products*

*The list below is sorted by satellite missions. Each mission may have multiple products constructed with different algorithms.

- Aqua (AMSR-E): 2002-2011
- CloudSat (CPR): 2006-present
- GCOM-W (AMSR2): 2012-present
- GPM (DPR, GMI, combined, and the whole constellation): 2014-present
- DMSP series (SSM/I and SSMIS): 1987-present
- TRMM (PR, TMI, and combined): 1998-present

3) Rain gauge analysis datasets

- GPCC: $0.5^\circ \times 0.5^\circ / 1^\circ \times 1^\circ / 2.5^\circ \times 2.5^\circ$, monthly, 1901-2010

Basic guidelines

Precipitation estimates disagree among different products for different reasons. Best satellite measurements are not guaranteed to compare well with rain gauge data even if the spatial and temporal matching was perfect, owing to the non-uniform beam filling effect. Precipitation estimates are sensitive to spatial resolution and temporal sampling because of the highly sporadic nature of precipitation. While satellite data have retrieval uncertainties in addition to sampling and sensor noises, rain gauge networks are limited in spatial representativeness. In-situ data are not literally a ground "truth" but an estimate with its own sources of uncertainties. The goal of precipitation assessment therefore should not be a validation against an absolute reference but inter-comparison of data products (regardless of satellite-based or ground-based) that have different error characteristics in nature from one another. It is particularly important to separate sampling noise from structural errors. The latter arises from assumptions in the inversion models as discussed later.

Sampling noise would be mitigated by spatial and temporal averaging to a common resolution to the extent that the errors are random. Sampling errors are however *not* entirely random in that the frequency of precipitation occurrence has a negative correlation with precipitation intensity (i.e., the heavier the rarer). Averaging operation would smear out extreme events preferentially compared to modest rainfall. This effect will not seriously affect the climatological assessment of precipitation, but could be problematic for some hydrological applications (river runoff etc.) and high-impact weather monitoring. The probability distribution function (PDF) rather than the mean would be instrumental when extremes are the target.

Assessment Foci

(a) Global and Regional Climatology (long-term mean and trend)

Reliable estimates of precipitation climatology are crucial for quantifying its long-term trend associated with climate change. It is critical that the data are as unbiased as possible so that subtle changes over decades are precisely captured. The main focus for this assessment is to carefully identify the relative biases among the products in precipitation climatology including the multi-decadal changes as well as the long-term mean.

Precipitation products often contain systematic regional biases. The largest among all is the contrast between land and oceans, since most retrieval algorithms take essentially different strategies between oceanic and continental rains. Other sources of regional biases arise when algorithm assumptions (DSD, freezing level height, etc.) are not properly tuned to accommodate the regional variability in the climatological characteristics of precipitation. Regional biases potentially contain

useful information for tracking down the algorithmic issues that are responsible for the biases specific to each product.

The datasets with a sufficiently long temporal record are qualified for this assessment focus. For example, GPCP and CMAP are well qualified, and the 17-year long data of TRMM are marginally useful from climatological perspectives, while GPM is obviously not ready yet under this criterion. This main focus of this section would be to assess the agreement of global precipitation trends, regional differences, and connection between these two among these products.

(b) Time series analysis in the context of different modes of climate variability

The natural variability of precipitation over time exists over a wide spectral range. The most notable are the diurnal and annual cycles, intra-seasonal oscillations (MJO etc.), and inter-annual variations (ENSO, Arctic Oscillation, etc.). Some products may be found to have a greater temporal variability than others, and understanding such biases would be beneficial for identifying algorithmic issues.

(c) Extremes

A standard measure to quantify the detectability of extreme events is precipitation rate at, say, the 99 % percentile of PDF. Such estimates would be sensitive to the spatial and temporal scales, so the resolutions should be carefully matched before different products are compared.

In contrast to the climatological assessment, the capability to detect localized heavy rainfall is more important than the length of record. Spaceborne radars (TRMM, CloudSat, and GPM) are most useful to this end among satellite instruments.

(d) Frozen precipitation

The reliability of snowfall estimates is confronted by a number of technical challenges. Snow retrieval requires additional assumptions with significantly larger uncertainties than rain retrieval. Some datasets may store the liquid and solid phases of precipitation separately, while others do not. Despite its practical importance for some hydrological applications, it would be unrealistic to include in-depth discussions on frozen precipitation in the assessment report within a short timeframe.

(e) Structural Errors

As mentioned above, uncertainties in algorithm assumptions yield spatially and temporally inhomogeneous biases in precipitation estimates. Such systematic errors, or structural errors, do not readily average out and can be confused with real climate signals when analyzed without care. They are also very difficult to quantify based upon observations alone. We envision instead, a qualitative examination of these errors based upon result of (a) - (d) along input from the algorithm developers who are in the best possible position to anticipate such errors.

Summary

For a timely release of precipitation assessment reports, it is feasible to deliver interim reports targeted on a limited number of prioritized foci while a full assessment report is being prepared on a mid- or long-term basis. The prioritized assessment foci include:

- Global and regional climatology including the long-term trend.
- Time series analyzed in light of different modes of climate variability
- Extreme weather events focusing on PDFs of precipitation
- Frozen precipitation assessment
- Qualitative structural error analysis

2.3 Global Land/Atmosphere System Study (GLASS) Report

Reporting period: 16 October 2013– 31 December 2014

URL: <http://www.gewex.org/glass.html>

Chair(s) and term dates:

Joseph Santanello 2011-2014 (ended 31 Dec.)

Aaron Boone 2013 – 2016

Michael Ek 2015 – 2018 (began 1 Jan)

Overview and Summary:

“Support improved estimate and representation of (land) states and fluxes in models, the interaction with the overlying atmosphere, and maximize the utilized fraction of inherent predictability.”

The aim of GLASS is to promote community activities that improve our best estimates and the model representation of state variables (e.g., soil moisture) and fluxes (e.g., evaporation), or to improve our understanding of land/atmosphere feedbacks and the role of land surface in predictability. To achieve these aims, GLASS is organized into three ‘themes’: Benchmarking, Model Data Fusion (MDF) and Land-Atmosphere Coupling (LAC). The concept of model benchmarking (rather than validation) enables the modeling community to identify the current strengths and weaknesses of our models in relation to their required applications. This is a big shift of focus for the modeling community and considerable work and discussions have been held on the definitions of the a priori metrics that a model needs to achieve. The GLASS PLUMBER project directly addresses this theme with the goals of demonstrating this approach to benchmarking for the community. As of the writing of this report, a paper is under review on the results of this project. This paper will serve as a community-wide reference on the subject and an example, which is applicable to land surface models. Many of the GLASS panel members participated and have co-authored this international effort.

The second theme of MDF brings data assimilation and parameter estimation techniques to both the initial value problem and to constrain the bounds of unknown parameters by using historical datasets. In the past, land data assimilation has been limited due to restrictions in observational data of the land components (e.g. soil moisture), but new satellite data enables an opportunity to explore more advanced data assimilation techniques. The PILDAS project will directly address this theme of GLASS, and connections look to be made between GHP/GDAP and GLASS with regards to the GSWP3 and ALMIP2 projects, and a new potential GHP-GLASS-iLEAPS project.

The final theme of LAC aims at understanding the physical interactions between the land and the atmosphere and how feedbacks can change the subsequent evolution. While the GLACE1 and GLACE2 projects demonstrated regions of the globe and situations where the land can have a significant impact on atmospheric evolution, they also highlighted large differences between modeling systems. The goal of the LS3MIP experiment is to provide a comprehensive assessment of land surface-, snow-, and soil moisture-climate feedbacks, and diagnosing systematic biases in the land modules of current ESMs using constrained land-module only experiments. The solid and liquid

water stored at the land surface has a large influence on the regional climate, its variability and its predictability, including effects on the energy and carbon cycles. Hence GLASS will help to facilitate two aspects of land/atmosphere coupling, the first being to understand the physical processes whilst the second will strive to understand how both land and atmospheric parameterizations interact. The focus is at both the process/local level (LoCo) and the global behavior of the coupling (GLACE). This understanding will help to maximize the inherent predictability of the coupled land/atmosphere system.

In summary, GLASS currently has a good mix of established and new projects getting off the ground and in the planning stages, each of which maps well to the themes (MDF, Benchmarking, LAC). GLASS has reached out to GHP on a number of projects, is launching projects with GABLS (e.g. DICE), CliC (ESMsnowMIP as a part of LS3MIP) and continues to engage WGNE on benchmarking and data assimilation activities.

1. Panel Activities and 4. Science Highlights

GSWP3 (Hyungjun Kim)

The pilot stage of the Global Soil Wetness Project Phase 3 was initiated in autumn 2014 and is ongoing, and the results of ‘fast-track’ simulations were reported at a GLASS side-meeting of AGU Fall Meeting, San Francisco in December 2014. Since it has been proposed to be a part of LS3MIP (Land Surface, Snow, Soil moisture Model Intercomparison Project) under LMIP (which is endorsed as part of CMIP6), there are new or updated components being considered for this project:

- In order to keep the consistency with CMIP6, a long-term retrospective experiment (EXP1) extends the proposed simulation back to 1850 (as opposed to the original proposition of 1870), and future simulations (EXP2) span the period 2015-2100 using multiple projected future climate from CMIP6 ScenarioMIP. This includes some interesting global trends in hydrology, but is also long enough for carbon processes considering land use/cover changes (LULCC).
- Include carbon models in order to explore/attribute a possible carbon-related effect or changes in eco-system functioning on these trends. This could provide a bridge to the terrestrial carbon cycle modeling community. GLASS will recruit member(s) of iLeaps to be actively involved in both the planning and analysis of the carbon component of GLASS.
- Explore uncertainties in model physics, forcings, and parameters by assessing the large set of ensemble combinations, and propose an optimal set as a land reanalysis. Extensive sets of observations including both in-situ (e.g., discharge and soil moisture) and satellite remote sensing products (i.e., terrestrial water storage) will be aggressively exploited.

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 3hourly 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. A “white paper” (experimental protocol) and the list of variables is being updated with a inter-community contribution component. It will be distributed to the participating modeling groups before launching the actual phase (planned in February 2015). The second phase of ISI-MIP (Inter-Sectoral Impact Model Intercomparison Project) adopted GSWP3 EXP1 forcing data as one of standard model input data sets, and it will be circulated among key contacts within the carbon community to get their buy-in before the project

begins. This will enable both carbon and water and energy cycle land surface models to be included, and simultaneously evaluated in them (e.g. the hydrology of carbon models and vice-versa).

GLASS/GABLS DICE Experiment (Martin Best, John Edwards)

The GLASS/GABLS Diurnal Coupling Experiment (DICE) experiment began in 2013. The first DICE workshop was held during Oct 14-16 at the UKMO in Exeter and a second workshop was held at the GEWEX science conference from 14-18 July 2014 at The Hague. This project involves the GABLS and GLASS members running fully coupled SCMs at the CASES 99 experiment (which was the GABLS2 project) and controlling for surface fluxes vs. atmospheric forcing in each component to isolate the impact of land-atmosphere coupling in the models over the full diurnal cycle (stable and unstable PBLs). Stages 1 (offline land surface), 2 (fully coupled) and 3 (column models forced by surface fluxes) are complete and analyses are currently being undertaken with a view to having 3 draft scientific papers ready for a further workshop in Toulouse during 20-22 May 2015. In addition, the hope is that a number of studies will be undertaken with these data by other DICE participants on the various coupling diagnostics that have been developed, with the subsequent scientific papers forming a special collection of a journal. These further studies will also be discussed during the workshop in Toulouse.

LoCo and the SGP Testbed (Joe Santanello)

The LoCo Working Group has continued to grow over the last year and is actively continuing work on diagnostics of L-A interactions and coupling across an array of scales and models. Over 25 recent papers have been produced by members of the WG focusing on aspects of LoCo such as diagnostic development, soil moisture-precipitation coupling, cold process coupling, mesoscale processes, and GCM/RA/CMIP applications. A wide net has been cast in developing coupling metrics and producing maps, but it is recognized that now is the time to reel in these efforts, and synthesize them to get at more science-driven questions of coupling. To this end, the LoCo WG has been collaborating with the U.S. Department of Energy's ARM-SGP campaign and has produced an ARM-supported dataset for coupling studies over the U. S. SGP. In addition, a radiosonde campaign led by the LoCo WG will commence in Summer 2015 to augment the current ARM-SGP sonde launches for application to LoCo studies. These new dataset will allow the array of LoCo diagnostics to be applied consistently to the same location in order to understand their hierarchy and to develop a classification system based on the metrics.

PALS and Benchmarking (Gab Abramowitz)

The Protocol for the Analysis of Land Surface models (<http://pals.unsw.edu.au>) has progressed to a more advanced version that includes gap filling, empirical benchmarks, and automated metrics along with a large suite of Fluxnet data. PALS been designed to analyze in a standard way uploaded single site model simulations with site observations. Extensions to other data sets and the development of benchmarking tests are under development. For example, implementation of the Manabe bucket model and the Priestly-Taylor approach to flux estimation has been performed in order to use as standard benchmarks of the 'goodness' of current LSMs. The joint GHP-GLASS project PLUMBER has been conceived to demonstrate benchmarking through PALS and a review paper is currently under review (see next item). Discussions are now under way for including two-dimensional (ideally for specific well-instrumented and documented basins which implies developing links with GHP and GDAP) case studies within PALS potentially under the auspices of a future follow-on intercomparison project.

PLUMBER (Martin Best, Gab Abramowitz)

PLUMBER is a benchmarking project using the PALS system. Data was acquired in conjunction with GHP for 20 FLUXNET sites was used to evaluate an array of land surface models and comparing metrics vs. that of simple formulations (bucket model, P-M, and simple regressions).

Many GLASS member groups participated in this initial stage of PLUMBER, and results have been presented at conferences (e.g. AMS, January 2014) and an overview paper (co-authored by many GLASS panel members) is currently under review for the Journal of Hydrometeorology.

LUCID (Andy Pitman & Nathalie de Noblet-Ducoudré)

Seven papers have been published during 2012-2014 summarizing the LUCID and LUCID-CMIP5 results. This includes evaluation of the impact of land cover change in seven GCMs using the LUH data set. The effects of land cover change on temperature and rainfall extremes in multi-model ensemble simulations have been studied, along with the effect of anthropogenic land-use and land-cover changes on climate and land carbon storage. Some of the main findings are that LULCC matters at the regional scale even though it may not be visible at the global scale, the differences in the land surface model parameterizations explain 1/2 to 2/3 of the inter-model dispersion, and that differential amounts of forests removed explain approximately 1/3 of the inter-model dispersion.

Thus:

- a key result supports the need to engage LSM and LCC dataset providers both, to see how to intelligently implement LCC in models. This is what will be achieved within the framework of a new EU project (<http://luc4c.eu/>) that has begun in November 2013. N. De Noblet-Ducoudré (LUCID) is contributing to the development of a new methodology to include LUC within DGVMs, and coordinating the Work Package entitled 'Net climate effects of past and future LULCC' of this project.
- LUCID would also like to gauge interest of C20C / D&A community as regional impacts of LUC may be as strong as changes GHG-induced climate changes, and may also be of opposite sign of the LCC community in CO2C/CMIP5, but it has been tough to get their attention. More may be needed to ensure that the impact of LUC on 20C climate is properly discussed in future papers.

In terms of future actions:

1. Some plans linking LUCID and GLACE are emerging building on Lorenz et al. (2014). The issue of how land coupling affects climate sensitivity to land cover change will require coordinated experiments in AMIP-style and could be combined with C20C simulations.
2. LUCID would like to gauge interest of the CORDEX community as downscaling of future scenarios of global climate change need to be combined with scenarios of regional LUC, specially if those regional climates are meant to be used for impact studies. Some CORDEX leaders have been approached but more needs to be done.
3. There may be linkages between GSWP3 and the land cover treatment in the 20c simulations and LUCID efforts that will be investigated.

GLACE-CMIP5 (Sonia Seneviratne and Bart vd Hurk)

Experiments 1-A and 1-B of GLACE-CMIP5 have been completed. This involved AR5 reruns of climate change projections using a 1971-2000 soil moisture climatology versus using a seasonal transient cycle of soil moisture and evaluated during the 2070-2100 period. Six groups are participating in the simulations (GFDL, IPSL, ECHAM, CESM and EC Earth, as well as ACCESS since 2014). The analysis and the experimental design are coordinated by ETH and KNMI. An

overview article has been published (Seneviratne et al. 2013). Additional papers have also been submitted. Future phases of experiments are considered, including some investigating the joint effects of changes in soil moisture versus changes in CO₂ concentration for plant transpiration. Highlights show a large impact of projected soil moisture changes on changes in daily mean and max temperature, including hot extremes. Effects on precipitation changes are less clear, and additional analyses will be conducted to investigate the underlying feedbacks and associated effects on the water balance (E-P). These analyses should be completed over the next 18 months. The currently planned CMIP6 experiment LS3MIP (“Land Surface, Snow and Soil Moisture MIP”) builds in part on the GLACE-CMIP5 framework (e.g. Seneviratne et al. 2014).

PILDAS (Rolf Reichle)

The launch of PILDAS has been delayed to 2015. The experimental design is essentially complete, and a pilot study by the project lead to use 2 LSMs with 1 DA algorithm in NASA’s LIS has been developed, however, this portion of the project was delayed by new modifications to the ALMA convention made by the GLASS panel (requiring a considerable effort to update software). Phase-1 is focused on operational centers (rather than niche research projects), synthetic observations, and different DA algorithms w/different LSMs for a 1/8-degree domain over the SGP. Later phases will focus on coupled DA systems and actual satellite observations from SMOS and SMAP. GLASS will take the experimental plan and pilot results to WGNE to put pressure on centers that are not currently listed.

ALMIP2 (Aaron Boone)

The 2nd AMMA phase 2 Land MIP was launched in Spring 2012. In all, 22 LSMs, 5 hydrological models, and 1 ET model are all included in this phase. In this experiment, the focus is on a much higher spatial resolution (mesoscale: 5km) than in ALMIP1 (regional scale: 0.5 deg), to focus on the subtle hydrology and vegetation processes that dominate there (occasionally very large rooting depths which access water in near surface aquifers, soil crusting, lateral transfer processes, strong variability in surface runoff), and to enable use of high resolution satellite data. The period covers 4 years, where the forcing is coming from a blend of in-situ and NWP/radar/Landsat/other satellite data. ALMIP2 takes advantage of observational data along a meridional transect from the AMMA-CATCH network, which cuts across a zone with a large gradient in surface characteristics and rainfall. The project will give recommendations on the parameterization of runoff scaling and potentially missing or poorly parameterized processes, which are key to the functioning of the West African land surface. This project is now in publication phase and the Journal of Hydrometeorology has accepted a proposal for a special collection of papers. Eight to 10 papers will be submitted during a time window (yet to be defined by JHM) during 2015. Some parts of this project will likely be folded in the proposed LOCO-AMMA project.

2. Projects being launched

1) PILDAS was delayed to this year, but should finally be able to get started. The PI of this project has been very busy as he plays a major role in the SMAP science team. Launch of the satellite is slated for January 2015, thus it is anticipated that the PI will likely have time to re-initiate this effort during 2015. In the meantime, there is a pilot experiment underway internally at NASA-GSFC with the PI and Sujay Kumar that should lead to the larger community experiments. There is a very big interest in this project (especially from WGNE), thus the panel has continued to strongly encourage the PI to launch this project, despite the delays.

2) The LoCo-SGP Testbed project (Ferguson, Santanello, Gentine, Findell, and Shaocheng Xie) was proposed to the DOE Atmospheric Research Program. Three GLASS panel members (Ferguson, Santanello, and Gentine) were successful in securing radiosondes from DOE for an IOP for summer, 2015. The ARM Climate Research Facility will support a LoCo working group-led enhanced frequency radiosonde campaign this summer at the ARM Southern Great Plains Central Facility (CF). For twelve days the operational launch schedule at the CF will be augmented by daytime hourly radiosondes with 3-hourly trailer (10-minute lagged) radiosondes—a total of (14) additional radiosondes/day. The data will be useful for: forcing single column model experiments such as DICE; evaluation and refinement of the PBL daytime transition in models; and directing the instrument reconfiguration at ARM-SGP to better support high-resolution modeling.

3) CMIP6-Endorsed MIPs: Land Surface, Snow and Soil Moisture (LS3MIP). The goal of the LS3MIP experiment is to provide a comprehensive assessment of land surface, snow, and soil moisture-climate feedbacks, and diagnosing systematic biases in the land modules of current ESMs using constrained land-module only experiments. Snow cover is an essential component of the Earth System that interacts with the atmosphere and the surfaces it covers (land, ice, sea ice). It is also an important source of (positive) feedbacks within the climate system. A WCRP/CLiC Initiative was proposed in 2013 for an ESM-SnowMIP intercomparison programme as a contribution to the WCRP Grand Challenge Cryosphere in a Changing Climate. The experimental design of the GLACE-CMIP5 study, carried out with a limited CMIP5 ensemble with prescribed SSTs (AGCMs) and vegetation, is used as blueprint for the second set of proposed LS3MIP experiments. The new LS3MIP experiments will allow a full quantification of soil moisture-climate feedbacks in the CMIP6 models and provide reference diagnostics for the evaluation of the CMIP6 ESMs, which will be of key relevance for the application of constraints to reduce uncertainties in projections.

4) GSWP3: The official launch for the Global Soil Wetness Project phase 3 is planned for early 2015. See **GSWP3** in the section **1. Panel activities and 4. Science Highlights** for further details.

3. New Projects and Activities Planned

1) Proposals related to the LoCo/SGP Testbed Project have been submitted by LoCo PI's (Ferguson, Santanello, Gentine) to implement new ARMBE-Land project to establish a benchmark of L-A coupling based on LoCo-derived diagnostics compiled by the working group. This includes a proposal for an extended field campaign to better monitor the PBL through augmented radiosonde launches, an integrative proposal to bring together the LoCo metrics and the ARMBE data, and investigation of additional site suitability for LoCo studies (e.g. India (monsoon), AMMA, and Cabauw) as suggested by the GEWEX SSG (2012).

2) GABLS Stable Boundary Layer project. Eric Bazile presented a proposal for a GABLS project for the Dome-C site in Antarctica. A science plan is forthcoming. GLASS will be involved in terms of assessing the thermal coupling and momentum flux in a polar climate (to date has been lacking in terms of GLASS activities and focus). Since GLASS does not currently have members with experience cold region processes in an Antarctic climate, it has been proposed that a link to CLiC needs to be established. An approach to CLiC will be made to find someone who could join the GLASS panel and form a link between GLASS, GABLS and CLiC for this project. It was also agreed at the Pan-GASS GABLS breakout session that the first step of a joint project should have both communities concentrating on their components of the system to fully understand these. A second step could then investigate the impact of land/atmosphere coupling in this environment.

3) Discussions have been initiated with Howard Wheeler (University of Saskatchewan) on a potential GHP-iLeaps-GLASS-CLiC Cold Season Processes Project. This project would use observational data from the Changing Cold Regions Network (CCRN) (<http://www.ccrnetwork.ca/>). CCRN will integrate existing and new experimental data with modeling and remote sensing products to understand, diagnose and predict changing land, water and climate, and their interactions and feedbacks, for this important region. CCRN will use a network of world-class observatories to study the detailed connections among changing climate, ecosystems and water in the permafrost regions of the Sub-arctic, the Boreal Forest, the Western Cordillera, and the Prairies. CCRN will integrate these and other data to understand the changing regional climate and its effects on large-scale Earth system change and the region's major rivers - the Saskatchewan, Mackenzie and Peace-Athabasca. So, this project could potentially help improve land surface, Carbon and hydrological processes in a region, which is very sensitive to climate change. Discussions on preparing a white paper for a potential multi-model project have begun.

5. Science Issues

1. The LS3MIP science details are being finalized: A document was circulated among a number of the GLASS panel members in December 2014. The objectives of LS3MIP respond to each of the three CMIP6 overarching questions: what are regional feedbacks and responses to climate change, what are the systematic biases in the current climate models, and what are the perspectives concerning the generation of predictions and scenarios.
2. The definition of 'local' vs. 'non-local' coupling and representation of each by the array of LoCo diagnostics is a non-trivial issue. This will be addressed directly by the SGP Testbed dataset and diagnostic intercomparison, and will include the effect on coupling metrics of spatial and temporal scales.
3. Forcing height used to force the PILDAS experiments needs to be resolved (either 2/10m or lowest model level). There is not an optimal best solution here at the moment, as some models have only one or the other available.

6. Contributions to GEWEX Science and Fit to Imperatives

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

1) Develop diagnostic 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 (GLACE, LoCo).
- Spin-up activities in *advanced diagnostics* through a joint pan-GEWEX effort/workshop (GRP, GLASS, GHP, and others).
- Develop metrics to aid benchmarking activities for both un-coupled and coupled modeling activities (PLUMBER)
- 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).

- 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)

2) 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). 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: groundwater hydrology; surface water treatment (snow, river routing, lakes, irrigation, and dynamic wetlands); vegetation phenology and links between carbon and water; and Land Data Assimilation systems (follow-up 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.

7. Contributions to the GEWEX Grand Science Questions

#1: 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:

GLACE – Land/SM impact on precipitation and predictability (POC: Sonia/Bart; 1 and 2 complete; CMIP in progress), 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, nearly complete)

PILDAS – Land DA of soil moisture; multivariate-coupled DA (precipitation and SM) in a future phase (POC: Rolf)

GSWP3 – Precip 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)

Benchmarking – How does precipitation 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.

#2: How do changes in the 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). 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. LUCID recent results).

Related current GLASS activities:

LUCID1/2 (POC: Andy)

ALMIP1/2 (POC: Aaron)

PILDAS/SMAP (DA of surface>root zone will be critical to link with GRACE)

#3: How does a warming world affect climate extremes, and especially droughts, floods and heat waves, and how do land area processes, in particular, contribute?

*This seems to be the ‘hot topic of the year’, 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 its 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 and 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.

GLACE2-CMIP is examining impact of SM 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.

#4: 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 how do they 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.

8. Other key science questions that you anticipate your community would want to tackle in the next 5-10 years within the context of a land-atmosphere project (1-3 suggestions)

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.
3. Pressing Model developments/improvements: Improved cold season processes (interactions between permafrost and greenhouse gas emissions), ground water interactions, anthropogenic processes (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, energy...)

9. Briefly list any specific areas of your panel's activities that you think would contribute to the WCRP Grand Challenges as identified by the JSC

Provision of skillful future climate information on regional scales (includes decadal and polar predictability)

- o GSWP3, ALMIP2
- o Benchmarking (defining skillful), MDF (improved prediction and skill), and LAC (process-level improvement in L-A coupling)

Regional Sea-Level Rise

- o None

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

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

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

- o None direct, but L-A Coupling theme addressing the soil moisture-precipitation feedbacks.

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

- o GSWP3, GLACE(CMIP), and GPM/GRACE/SMOS/SMAP synergy
- o LAC (process-level improvement in water and energy cycle feedbacks)
- o improved understanding of land-surface and hydrological processes in semi-arid zones where water resources are already limited (ALMIP2)

Science underpinning the prediction and attribution of extreme events

- o See above WRT GEWEX Challenge #3 (strongest contribution from GLASS is here?)
- o 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)

10. Cooperation with other WCRP projects (CLIVAR, CliC, SPARC), outside bodies (e.g., IGBP) and links to applications

1) A connection to CliC has been proposed through the GABLS Stable PBL Project over the arctic region. In addition, ESMSnowMIP (of LS3MIP) is a collaborative effort between CliC and GLASS. A suitable GLASS representative for both cold processes and stable PBLs has yet to be identified, however.

2) Better integration between GEWEX and iLEAPS is tentatively underway through collaboration on the GSWP3 project. There is a potential for further interactions within a new project based on the CCRN (as mentioned, still in the planning phase). Discussions on experiment design, protocols (such as variables of interest to study/report, appropriate units, etc.), and input data sets (time length covered) are underway.

3) LS3MIP is addressing core research questions of the WCRP and is relevant for a large fraction of the WCRP activities. It is initiated by two out of four WCRP core projects (CliC and GEWEX) and directly related to three WCRP Grand Challenges (Cryosphere in a changing climate, Changes in Water Availability, and Climate Extremes).

11. Workshops/Meetings Held

- GSWP3 Kick-off meeting: Tokyo, Feb. 2014
- WGNE Annual Meeting (GLASS presentation)
- AMS Annual Meeting (Benchmarking session hosted by GLASS): Atlanta, February 2014
- 2014 GLASS Panel Meeting, Pan-GEWEX 2014, Hague, NL

12. Workshops/Meetings Planned

- Joint GLASS/GABLS - DICE Workshop, 20-22 May 2015, at Météo-France, Toulouse, France
- 2015 GLASS Panel Meeting, 18-19 May 2015, at Météo France, Toulouse, France (Same venue and week as the GLASS/GABLS and DICE Workshops).
- LandMIP Meeting (LS3MIP/GSWP3/GLACE and LUMIP/LUCID), Oct., 2015, Zurich, Switzerland
- Pan-GLASS Conference is proposed for Fall 2016 to be combined with the next Pan-GASS meeting. Likely to be held/hosted in Europe.

13. Other meetings that were attended on behalf of GEWEX or your Panel

14. Issues for the SSG (*need to update these issues or raise new ones)

The LUCID and LUMIP (now evolving into LSMIP) projects both deal with Land Use Land Cover Change (LULCC) in fully coupled models. There have been some communication issues, but now we are trying to actively distinguish/differentiate the two projects (goals, etc.) and foster communication.

15. List of key publications (*where appropriate*)

GEWEX

Santanello, J. and **A. Boone**, 2014: Global Land/Atmosphere System Study Panel Meeting. *GEWEX News*, November 2013, **23**(4), 13-16.

Seneviratne, S. I., B. van den Hurk, **D. Lawrence**, G. Krinner, G. Hurtt, **H. Kim**, C. Derksen, **T. Oki**, **A. Boone**, **M. Ek**, V. Brovkin, **P. Dirmeyer**, H. Douville, P. Friedlingstein, S. Hagemann, R. Koster, N. de Noblet-Ducoudré and **A. Pitman**, 2014: Land processes, forcings, and feedbacks in climate change simulations: The CMIP6 LandMIPs. *GEWEX News*, **24**(4), Nov., 2014.

LAC

Gentine, P., A. A. M. Holtslag, F. D'Andrea, and **M. Ek**, 2013 : Surface and atmospheric controls on the onset of moist convection over land, *J Hydrometeorol*, 130211131121003, doi:10.1175/JHM-D-12-0137.1.

Seneviratne, S.I., M. Wilhelm, T. Stanelle, B.J.J.M. van den Hurk, S. Hagemann, A. Berg, F. Cheruy, M.E. Higgins, A. Meier, V. Brovkin, M. Claussen, A. Ducharne, J.-L. Dufresne, K.L. Findell, J. Ghattas, **D.M. Lawrence**, S. Malyshev, M. Rummukainen, and B. Smith, 2013: Impact of soil moisture-climate feedbacks on CMIP5 projections: First results from the GLACE-CMIP5 experiment. *Geophys. Res. Lett.*, 40 (19), 5212-5217

Boysen L R, V Brovkin, V K Arora, P Cadule, N de Noblet-Ducoudré, E Kato, J Pongratz and V Gayler, 2014: Global and regional effects of land-use change on climate in 21st century simulations with interactive carbon cycle. *Earth Syst. Dynam.*, 5, 309–319.

Lorenz, R. and **A. J. Pitman**, 2014: Effect of land-atmosphere coupling strength on impacts from land cover change experiments in Amazonia, *Geophysical Research Letters*, 41, 5987–5995, doi: 10.1002/2014GL061017.

Benchmarking

Best, M.J., **G. Abramowitz**, H. Johnson, **A.J. Pitman**, **A. Boone**, M. Cuntz, B. Decharme, **P.A. Dirmeyer**, J. Dong, **M. Ek**, V. Haverd, B.J.J.M van den Hurk, G.S. Nearing, B. Pak, **C. Peters-Lidard**, **J.A. Santanello Jr.**, L. Stevens, N. Vuichard, 2014: The plumbing of land surface models. *J. Hydrometeor.*, (under review)

Model Data Fusion (MDF)

Santanello, J. A., S. V. Kumar, **C. D. Peters-Lidard**, K. Harrison, and S. Zhou, 2013: Impact of Land Model Calibration on Coupled Land-Atmosphere Prediction. *J. Hydromet.*, 14, 1373-1400.

16. List of members and their term dates (including changes) where appropriate:

The GLASS Terms of Reference have been presented at the panel meetings in 2011 and 2012, and were ratified by the GEWEX SSG. These TORs include term limits on chairs of 4 years, staggered in 2-year intervals for continuity of leadership. Two main categories of panel members have been established and without term limits: Experienced Scientists (including project leads) and Young

Scientists, as well as a protocol for new members of each category that they attend the next panel meeting and establish their interest and relevance to the panel activities. Template letters signed by GEWEX/Sonia Seneviratne and Graeme Stephens have also been developed to welcome new panel members and to thank departing members for their service.

Joe Santanello (Co-chair through 31 Dec 2014)

Aaron Boone

Michael Ek (Co-chair beginning 1 Jan 2015)

Hyungjun Kim

Rolf Reichle

Martin Best

Paul Dirmeyer

Andy Pitman

Gianpaolo Balsamo

Matt Rodell

Christa Peters-Lidard

Patricia de Rosnay

Sonia Seneviratne

Gab Abramowitz

Craig Ferguson

Nathan Brunsell

Lifeng Luo

Fei Chen

Pierre Gentine

Tomo Yamada

John Edwards

Wade Crow

Taikan Oki

Ahmed Tawfik

Sujay Kumar

Chiel van Heerwaarden

Obbe Tuinenburg

Benoit Guillod

Josh Roundy

2.4 GEWEX Hydroclimatology Project (GHP) Report

Reporting Period: October 2013 – January 2015

URL: <http://gewex.org/projects-ghp.html>

Co-Chairs and term dates:

Dr. Jan Polcher (appointed 1 November 2011)

Dr. Jason Evans (appointed 1 November 2012)

4-year terms (renewable one time, upon mutual agreement)

1. Overview

GEWEX integrates scientific research, production and collection of information in the form of observational data, as well as products derived from applied algorithms and analysis of numerical model solutions, all distributed among different panels. The GEWEX Hydroclimatology Panel (GHP), has been organized around several Regional Hydroclimate Projects (RHPs) and a number of crosscutting 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

2. Objective(s):

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, to keep 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.

3. Status: Past year

The leadership role of GHP in the hydrologic sciences and modeling activities within WCRP has been established, as has the progress of the GEWEX Regional Hydroclimate Projects (RHPs). GHP continues to be organized around two core activities; namely, all of the Regional Hydroclimate Projects (RHPs), (See Figure 1) and Cross-cutting Sub-projects (see list below).

The RHPs 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 GEWEX Science Questions.

GEWEX REGIONAL HYDROCLIMATE PROJECTS

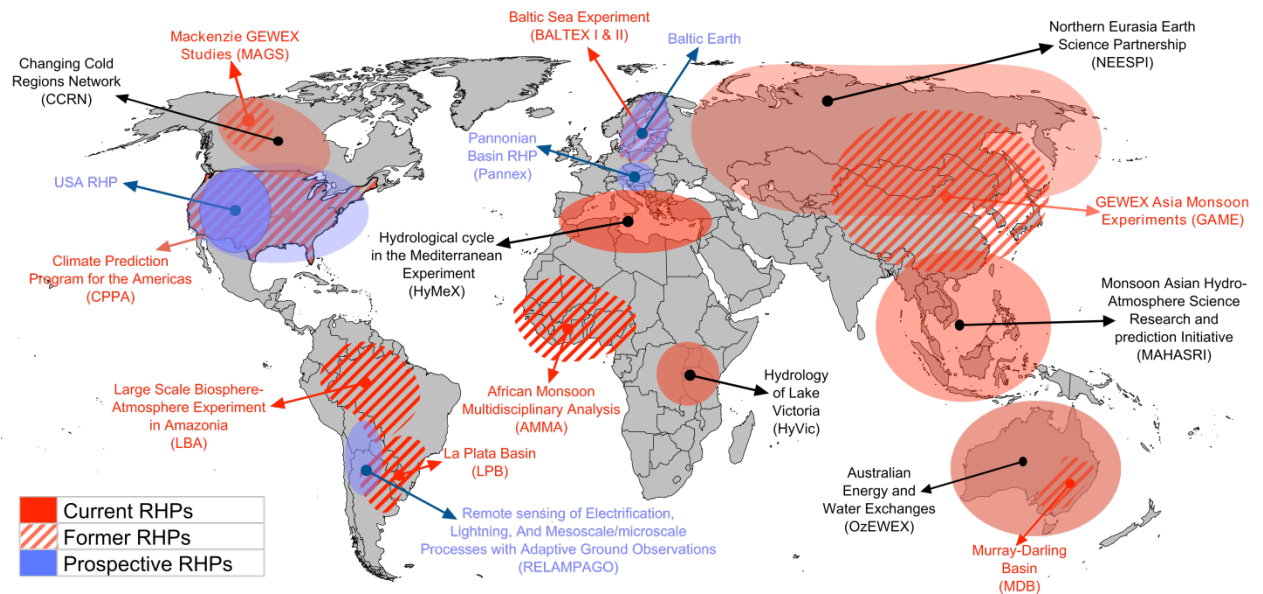


Figure 1: Summary of GHP Regional Hydroclimate Projects (RHP) and related Features

The Crosscut 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.

GHP Crosscut 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)
- LSM validation & Benchmarking (M. Ek) – has become a more general attempt to encourage GLASS-GHP collaboration

Proposed

- MOUNTerrain (Mountainous Terrain rainfall) (J. Renwick)
- Water management in large scale models (R. Harding/A. Nazemi)

Potential

- Seasonal hydrologic prediction (A. Wood/HEPEX)
- GDAP integrated product regional evaluation

Two regional studies (one in Australia–OzEWEX and the other in Africa–HyVic) that had been developing as prospective RHPs were elevated to Initiating RHP status by the Panel. Another important action by the Panel was to consider that the Changing Cold Regions Network (CCRN), 2013-2018, Project, which they were informed of at the GHP September 2013 meeting and which enlarged the scope of SaskRB, become a new GHP RHP that would have as its domain both the Saskatchewan River Basin (SaskRB) and the Mackenzie River Basin. The Panel made the recommendation, to be carried forward to the SSG for endorsement that CCRN be approved as a RHP replacing SaskRB.

BALTIC-Earth was presented as a prospective RHP that would build on the legacy of a previous RHP in the Baltic Sea region (BALTEX), but the Panel reserved action on this new effort pending more action to clarify issues where the new effort did not meet Initiating RHP Status in accordance with the current criteria for that level of development.

Two other potential RHPs that are developing in South America (RELAMPAGO - Remote sensing of Electrification, Lightning, And Meso-scale/micro-scale Processes with Adaptive Ground Observations) and the other in the Pannonian basin (PannEx) made exceptional progress over the past year. The Panel complimented this work and specified actions that, if followed through upon by the leaders of these studies, would most certainly lead to them becoming Initiating RHPs in due course. The Panel heard a similarly positive presentation/discussion concerning the possibility of developing a proposal that meets the criteria of a GEWEX–style regional effort dealing with water and energy exchanges positioned in USA. The Panel agreed to assist with the scoping of this initiative.

Two existing RHPs, one covering Eurasia (Northern Eurasia Earth Science Partnership Initiative - NEESPI) and the other in Asia (Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative-MAHASRI) were confirmed to be ending in 2015 and 2016 respectively. NEESPI is promoting a follow-on effort designated “Northern Eurasia’s Future” Initiative (NEFI) that will be presented to the Panel in 2015. MAHASRI also expects to present a follow-on initiative within the next 2-year period.

For the crosscutting Sub-projects:

(i) “INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes” (INTENSE), led by Dr Hayley Fowler has evolved into a funded European Research Council project. This provides the funded core of a community effort looking into the collection and analysis of sub-daily precipitation data and model outputs with a number of international project partners as a contribution to GHP.

(ii) The Panel recommended that the Cold/Shoulder Season Precipitation Near 0°C effort led by Dr R. Stewart and P. Groisman, and the International Network for Alpine Research Catchment Hydrology (INARCH) (Crosscut) Study led by Dr. J. Pomeroy be accepted as a formal GHP CCs.

(iii) The Panel recommended that each of the MOUNTerrain (Mountainous Terrain rainfall) crosscut science proposal presented be by Dr J. Renwick, through a Skype connection, the “Including water management in large scale models” concept presented by Drs R. Harding/H. Wheeler (with A.

Nazemi) be encouraged to develop further and that their progress toward formal acceptance as a GHP CCs be reviewed again at the 2015 meeting.

(iv) The Panel agreed that seasonal stream flow forecasting could be an important research focus at which GHP and the Hydrological Ensemble Prediction Experiment (HEPEX) could have a mutually beneficial connection. They, therefore, asked Dr A. Wood to write a proposal using the GHP CC Template that reflects the elements of a Seasonal hydrologic prediction CC that could link the HEPEX and GHP communities.

(v) The GDAP integrated product regional evaluation initiative was undertaken by GHP to interact with GDAP on higher priority science issues such as validation of the precipitation product over mountainous areas. In this context the Panel asked the Co-Chairs to contact the new Chair of GDAP, Dr Joerg Schulz to gauge further interest in the two Panels working together on science research topics that can advance progress on the GSQs by applying GHP CCs and RHP resources that can benefit from linking with GDAP datasets and related assets.

(vi) The Panel noted that the LSM validation & Benchmarking effort had evolved into a more general attempt to encourage Inter-Panel linkages, the collaboration has been undertaken by Dr Ek, on behalf of GHP, through the GEWEX Global Land/Atmosphere System Study (GLASS) Panel. Having identified this effort as an inter-Panel coordination function the Panel decided that it will not be carried forward as a GHP CC but will remain an important part of GHP.

4. New directions

Part of what is driving the GHP vision of its future directions was expressed at the meeting to be the realization that water, had become perhaps the most pressing concern of governments around the world and that these authorities were turning to the science community to assist in the extreme challenges for the sustainable management of water resources at all levels from the local to the global scale. The World Climate Research Programme's (WCRP) Water Availability Grand Challenge, which GEWEX is leading and to which GHP is contributing with support from other WCRP core projects, including CliC and CLIVAR has been launched to help the broader climate science community in its attempt to understand and predict changes to the planet's water cycle.

GHP is trying to orient its efforts to focus on issues that had come up at the recent climate symposium in Darmstadt, Germany, that specified that modeling the important aspects of the water cycle will require ever higher resolution schemes. GHP notes that this matter can be integrated into its longer term vision. This decision was reinforced in the recent GEWEX newsletter article by the GEWEX SSG Co-Chair, Dr Graeme Stephens. GHP is planning to be at the center of the GEWEX effort to continue and expand on its real coordinated initiative that focuses on the terrestrial water cycle. In a practical sense the Panel recognized that throughout the International community and recently in the USA new resources are being applied to the planning and implementation of high resolution experiments motivated in part by the issues raised within the Panel and across the entire WCRP/GEWEX framework.

As also noted recently by the GEWEX SSG Co-Chairs, by contributing to this work, GHP will align plans with these efforts that are being designed to be responsive to the needs of the population to know and understand the answers to the most basic questions surrounding climate change including for example: what levels of climate change could be dangerous, where and for whom? What climate variations and changes may be expected to occur, where, and with what implications? Can society be made more resilient and better prepared for hazardous weather and climate extremes arising from climate variability and change? and What if anything can be done to mitigate and adapt to climate change to avoid its worst impacts? These questions are regional in nature and thus are addressed within the RHPs.

GHP's deliberations and future plans, are being designed to shed light on our strategy to make progress on the two main themes of the Water Availability Grand Challenge namely, (1) Predicting Changes to Precipitation as Climate Changes e.g. what sets the spatial pattern of precipitation change? (wet/wetter, dry/drier?) and what determines the regional changes to precipitation intensity (e.g. land surface feedbacks?) and (2) Human Influences on Water Availability and Water Security (e.g. land use changes, land management change, climate change,...).

5. Future

In the next year GHP will confirm the location and timing of the next full GHP Business meeting. Arusha, Tanzania and Taiwan are under consideration.

For the RHPs, the Panel will take the following actions in 2015:

- (i) Ensure progress is made in the implementation of two regional studies (one in Australia – OzEWEX and the other in Africa-HyVic) that were raised to Initiating RHP status by the Panel this year.
- (ii) Evaluate the effectiveness of the decision to enlarge the scope of SaskRB to include both the Saskatchewan River Basin (SaskRB) and the Mackenzie River Basin and to re-designate the entire effort to be the Changing Cold Regions Network (CCRN), 2013-2018, Project.
- (iii) Communicate directly with the Baltic Earth Science Steering Group (BESSG) that had been installed as of June 2014, in an attempt to ensure that the Baltic Earth Science Plan that is being finalized by March 2015 includes the components that would allow it to be more consistent with meeting the criteria to be designated as a new/Initiating RHP.
- (iv) Request progress reports on the three potential RHPs that are developing in different parts of the globe, namely, South America (RELAMPAGO), the Pannonian basin (PannEx), and the USA (UWEX-working acronym).
- (v) Confirm that the plans for NEESPI and MAHASRI to conclude in 2015 and 2016 respectively include synthesis reports showing the contribution these studies have made to the GSQs.

The Panel will take the following actions in the coming year for the crosscutting Sub-projects:

- (i) Ask Dr Hayley Fowler to summarize progress on INTENSE CC.
- (ii) Assess progress on the newly designated Cold/Shoulder Season Precipitation Near 0°C effort and the International Network for Alpine Research Catchment Hydrology (INARCH).
- (iii) Ensure that the MOUNTerrain (Mountainous Terrain rainfall) crosscut, the “Including water management in large scale models” concept, make progress toward formal acceptance as a GHP CCs.
- (iv) Re-evaluate the possibility of GHP and the Hydrological Ensemble Prediction Experiment (HEPEX) coordinating on a Seasonal hydrologic prediction CC that could benefit the HEPEX and GHP communities.
- (v) Meet with the new Chair of GDAP, Dr Joerg Schulz to gauge further interest in the two Panels working together on science research topics that can advance progress on the GSQs by applying GHP CCs and RHP resources that can benefit from linking with GDAP datasets and related assets.

6. Key results

- (i) In matters related specifically to GEWEX, INTENSE is contributing to the GSQ1, 3 & 4 with main inputs to GSQ1 and 3. INTENSE is already contributing to an improved understanding of sub-daily rainfall extremes and their changes globally and how these are simulated by high and very high-resolution climate models and projected to change. Additionally,
- (ii) for GSQ4, energy and water cycle process studies are dependent on good quality datasets and INTENSE is beginning to provide the required datasets for sub-daily precipitation.
- (iii) INTENSE has also provided information on improvements gained from running very high-resolution climate models in different regions.
- (iv) The Cold/Shoulder Season Precipitation CC has begun to contribute to improved understanding of future changes in hazardous cold/shoulder season precipitation and storms, especially occurring near 0°C that have been shown to be devastating to a number of societal activities and, which are sensitive to changing climate uncertainties. A review article for BAMS is in work that will articulate other accomplishments within the framework of this GHP CC.
- (v) The International Network for Alpine Research Catchment Hydrology (INARCH) (Crosscut) Study has shown that some alpine catchments are contributing to higher frequency of floods and/or droughts. Work has also been accomplished in the evaluation of different downscaling schemes from meteorological to hydrological models in mountains.

(vi) Work was started on a crosscut proposal to improve seasonal climate and hydrologic predictability by exploiting the state-of-the-art datasets and models in the GEWEX RHPs and the improved understanding of how well methods across the statistical-dynamical spectrum harness local-to-regional scale hydrometeorological predictability for a basin collection determined from water resources considerations as HEPEX has promoted.

A large number of specific key results have come out of the work being carried out at the regional scales in each of the RHPs and these can be found in the presentations that have been staged at: <http://www.gewexevents.org/ghp-agenda/>.

7. Issues for attention by the SSG:

The Panel made several recommendations that they felt would be of interest to the SSG and where endorsement of the SSG would lend weight to the action of the Panel. These included:

(i) The Panel was advised that the Changing Cold Regions Network (CCRN), 2013-2018, Project which they were informed of at the GHP September 2013 meeting and which enlarged the scope of SaskRB, was being formally proposed as a new RHP that would have as its domain both the Saskatchewan River Basin (SaskRB) and the Mackenzie River Basin. The Panel made the following Recommendation (R-1) to be carried forward to the SSG for endorsement, namely, that CCRN be accepted as a RHP replacing SaskRB.

(ii) Since the meeting at The Hague, Drs Polcher and Evans had worked with Dr Semazzi to upgrade the documentation and provide guidance necessary for HyVic to meet the RHP criteria for Initiating status. The outcome was that the Panel made the following Recommendation (R-2) to be carried forward to the SSG for endorsement, namely that HyVic be accepted as a new/Initiating RHP with the stipulation that IGPO assist HyVic to establish a Web Page and that Semazzi advance the case for a local drought monitoring system and additional capacity building within the HyVic Framework.

(iii) The Panel heard that the outcome of the OzEWEX 1st Annual OzEWEX Workshop 28–29 October 2014 Canberra, Australia (Reference Summary in GEWEX Newsletter, Vol. 24 No. 4, November 2014), as reported by Dr Albert van Dijk, included agreements on a set of amalgamating themes that were oriented toward meeting the criteria of an Initiating RHP.

The Panel concluded that these outcomes had strengthened the OzEWEX concept and that there is a sufficient number of investigations into a broad range of issues that need to be worked on and that relate directly to the WCRP Grand Challenges and GEWEX Science Questions to warrant the Recommendation (R-3), to be carried forward to the SSG for endorsement, that OzEWEX be accepted as an Initiating GHP RHP.

(iv) The SSG should be aware that the Panel was asked by the GEWEX SSG Co-Chairs (Stephens/Seneviratne) to help with a scoping exercise for a GEWEX–style regional effort positioned in USA, by developing a proposal that meets the GHP criteria for such studies. To begin this exercise the Panel appointed a planning committee made up of the following members: F.

Dominguez (U. Arizona), R. Rasmussen (NCAR), A. Barros (Duke Uni.), Tom Painter (JPL) and Levi Brekke (Bureau of Reclamation) to immediately begin the task of preparing a draft whitepaper that specifies the main science issues to be addressed by such a study along with the region(s) of interest, the tools and funding sources/opportunities, the main stakeholders/applications, social issues to be considered, links with other groups/studies (both national and International), outreach opportunities, etc. The SSG may want to comment on the suggestions the Panel made to help start the work of the planning Committee on a USA RHP, namely that:

- Time scales should go from weather to climate
- The project should be centered on application driven researchers
- The region of choice could be the Colorado basin within the Western US Climatic region.
- The whitepaper, once completed, should be publicized in an article in the GEWEX Newsletter.

(v) The Panel acknowledged that the proposal for a Cold/Shoulder Season Precipitation crosscut project by Drs Groisman/Stewart had merit in that this phenomenon is of interest/importance to the GHP/GEWEX climate research agenda. Drs Stewart and Groisman were asked to follow through on the plan to prepare a review article for BAMS that would articulate more clearly what is needed and what will be accomplished within the framework of a GHP CC, especially what the results (deliverables) will be in the next 2-3 year period and how they will advance progress on addressing the GSQs. The Panel recommendation (R-4), to be carried forward to the GEWEX SSG for endorsement, was that the Cold/Shoulder Season Precipitation Near 0°C effort be accepted as a formal GHP CC.

(vi) The Panel acknowledges the extent of the maturity of the International Network for Alpine Research Catchment Hydrology (INARCH) (Crosscut) Study specifically the level of International involvement in the list of Co-proposers, and the significance of issues surrounding mountain hydrology. On this basis and the fact that funding has been sought and is being committed to some aspects of the work the Panel agreed to: The Panel recommendation (R-7), to be carried forward to the GEWEX SSG for endorsement, is to accept INARCH as a formal GHP CC.

(vii) Three new panel members are needed due to current member terms ending. One of these is the GLASS representative to be nominated by GLASS (replacing Mike Ek). The other two leaving members are from the USA and the UK. Options for suitable replacements are being sought.

8. Contributions to WCRP Strategic Themes/Grand Challenges (preferably with indication towards GEWEX Science Questions):

The Co-Chairs have developed an outline of plans for further study and implementation over the next 2-3 year period. Decisions have been made concerning the priority of each element in the context of the contribution GHP must make to the GEWEX Science Questions that have been derived from the WCRP Grand Challenges. These decisions are at the center of the GHP strategy for implementation of its 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. This process has allowed the Co-Chairs to make

recommendations to the SSG about consolidating GHP work and redirecting priorities to be more in line with the current phase of GEWEX. Each RHP and crosscutting science element in GHP will continue to focus on issues that contribute to the Grand Challenges and the GSQs. In specific it is felt that several of the GHP RHPs and crosscuts include elements of each GC/GSQ and, therefore, that they represent a good approach for GHP to show progress on work related to the GSQs. This framework is exhibited in Figure 2.

GHP activities in relation to GSQs

GEWEX Science Questions		Regional Hydroclimate Projects						Cross-cut activities
		MAHASRI	NEESPI	HyMeX	CCRN	HyVic	OzEWEX	
Observations and Predictions of Precipitation	How well can precipitation be described?	y	y	y	y	y	y	Precipitation near 0°C
	How do changes in climate affect the characteristics?	y	y	y	y	y	y	Mountain precipitation
	How much confidence do we have in predictions?	y		y			y	Sub-daily precipitation INTENSE
Global Water Resource Systems	How do changes in the land surface and hydrology influence water resources?	y	y	y	y	y	y	Mountain hydrology INARCH
	How does climate change impact water resource systems?	y	y	y	y		y	Water management in land-surface models
	How can new observations lead to improved management?	y			y		y	Drought
Changes in extremes	Observing system requirements	y	y	y	y		y	Seasonal Hydrologic prediction
	Modelling capabilities			y	y	y	y	GDAP integrated product evaluation
	Modelling processes involved in extremes			y	y	y	y	
	Improved early warning systems	y			y	y		
Water and energy cycles	Can we balance the budget at TOA?							
	Can we balance the budgets at the surface?			y			y	
	Can we track the changes over time?			y			y	
	Can we relate changes and processes?							
	Cloud-aerosol-precipitation feedbacks							

Figure 2: Cross-cut Science/RHP Contribution to GEWEX Science Questions Summary Matrix

9. Summary: 10-15 lines (should be directly usable for GEWEX report)

GHP efforts have recently been aligned with the deliberate planning process in WCRP and GEWEX that has evolved around determining the highest priority issues in climate research and articulating those in the form of a number of WCRP Grand Challenges and the GEWEX Science Questions. As a consequence GHP has become an essential element in the GEWEX strategy to answer key questions on the energy and water cycle. The strategy GHP is employing to address first GEWEX scientific questions and consequently to contribute to the WCRP Grand Challenges is through regional hydroclimatology projects (RHPs) and crosscut science activities. The regional focus of GHP has the added value of enabling the GHP community to include and reach out to application driven

efforts and groups and to transform our knowledge into action oriented information. The vision of the future for GHP is to maintain the momentum it has built up through its current organizational structure and to link with the other GEWEX Panels and core projects and working groups including GDAP, GLASS, CLIVAR, CliC, SPARC, GDIS, WGRC and other related global environmental change (GEC) research programs, such as the Future Earth initiative, to find opportunities for building new RHPs and Crosscutting science initiatives that will allow the Panel to meet its commitments not just to better understand the regional issues but to contribute to the goals of WCRP and GEWEX at all scales.

10. List of key publications

There has been a large number of publications that have resulted from work in studies that are part of GHP, especially the RHPs. As a way of indicating the scope of these publications a sample list is shown below from three of the active RHPs, including HyMeX, MAHASRI, and NEESPI. For further details a link is provided to the reports <http://www.gewexevents.org/ghp-agenda/> where more extensive publication lists are available.

HyMeX: *Publications*: www.hymex.org/?page=publications/
191 peer reviewed articles

Publications describing HyMeX and its components:
Programme :

Drobinski, et al, 2014:HyMeX, a 10-year multidisciplinary program on the Mediterranean water cycle. *Bulletin of the American Meteorological Society*, 95, 1063-1082.

SOP1 :

Ducrocq, et al, 2014: HyMeX-SOP1, the field campaign dedicated to heavy precipitation and flash flooding in the northwestern Mediterranean, *Bulletin of the American Meteorological Society*, 95, 1083-1100.

Bousquet, et al., 2014: Multiple-frequency radar observations collected in southern France during the field phase of the hydrometeorological cycle in the Mediterranean experiment (HyMeX), *Bulletin of the American Meteorological Society*, sous presse.

Defer et al, 2014 : An overview of the lightning and atmospheric electricity observations collected in Southern France during the HYdrological cycle in Mediterranean EXperiment (HyMeX), Special Observation Period 1, *Atmospheric Measurement Techniques* (en révision)

Davolio, et al, 2014: The role of the Italian scientific community in the first HyMeX SOP: an outstanding multidisciplinary experience. *Met. Zeit.*, sous presse

Ferretti, et al, 2014:Overview of the first HyMeX Special Observation Period over Italy: observations and model results. *Hydrology and Earth System Sciences*, 18, 1953-1977.

Jansà, et al, 2014: Heavy rain and strong wind events over Spain during HyMeX SOP1. *Thetys, Revista de meteorologia i climatologia mediterrània*, 11, 25-38.

SOP2 :

Estournel, C., et al, 2014: HyMeX-SOP2, the field campaign dedicated to dense water formation in the north-western Mediterranean, *Oceanography*. (en révision)

EOP :

Braud, et al, 2014: Multi-scale hydrometeorological observation and modeling for flash-flood understanding. *Hydrology and Earth System Sciences*, 18, 3733–3761.

MEDCORDEX :

Ruti, et al, 2014: MED-CORDEX initiative for Mediterranean climate studie. *Bulletin of the American Meteorological Society* (en révision)

Coordination of four special journal issues:

Results from SOP1 at the Quarterly Journal of the Royal Meteorological Society (*submission deadline: 17 April 2015, ~ 50 expected articles, 2 articles published, contact : V. Ducrocq*)

« Flash floods, hydro-geomorphic response and risk management » at the Journal of Hydrology, (*submission deadline: 30 April 2015, contact : I. Braud*) – EGU2015 session

Regional climate modeling at Climate Dynamics (*submission deadline: June 2015, 25 expected articles, contact : S. Somot*)

Results from SOP2 at Ocean Sciences (*still in discussion*)

PhD theses: 57

(28 defended, 29 on-going)

MAHASRI: <http://gewex.org/ghp-gdap/docs/MAHASRI.pdf>

Nguyen-Thi, H.A., J. Matsumoto, T. Ngo-Duc, and N. Endo, 2012. A Climatological Study of Tropical Cyclone Rainfall in Vietnam. SOLA, 8, 041–044.

Nguyen-Thi, H.A., J. Matsumoto, T. Ngo-Duc, and N. Endo, 2013. Long-term Trends in Tropical Cyclone Rainfall in Vietnam. Jour. Agrofor. Env. Bangladesh (in press).

NEESPI: <http://gewex.org/ghp-gdap/docs/NEESPI.pdf>

Publications related to NEESPI activities in 2014 are still being collected. Meanwhile in 2013, 179 peer-reviewed papers, books, and book chapters were published and in 2014, *according to an incomplete account*, 57 were published another 22 are in press or submitted. Their list is presented at http://neespi.org/science/NEESPI_publications.pdf. Below we list additionally a brief EOS overview report about the Initiative and a representative subset of publications that characterize research made within the NEESPI community in 2014.

Groisman, P., S. Gulev, and Sh. Maksyutov, 2014: Earth System Studies in Northern Eurasia, *EOS*, **95**, No. 16, 133-135, 22 April 2014.

Kicklighter, D. W., Y. Cai, Q. Zhuang, E. I. Parfenova, S. Paltsev, A. P. Sokolov, J. M. Melillo, J. M. Reilly, N. M. Tchebakova and X. Lu . 2014. Potential influence of climate-induced vegetation shifts on future land use and associated land carbon fluxes in Northern Eurasia. *Environ. Res. Lett*, **9**, 035004,

Kukavskaya E.A., Ivanova G.A., Conard S.G., McRae D.J., Ivanov V.A. 2014: Biomass dynamics of central Siberian Scots pine forests following surface fires of varying severity. *International Journal of Wildland Fire*. **23** (6). 872-886. DOI: 10.1071/WF13043.

Kuemmerle, T., L. Baskin, P. Leitao, A. Prishchepov, K. Thonicke, and V. C. Radeloff. 2014: Potential impact of oil and gas development and climate change on migratory reindeer calving grounds across the Russian Arctic. *Diversity and Distributions*, **20**(4): 416-429

Liu Y., Q. Zhuang, Z. Pan, N. Tchebakova, D. Kicklighter, D. Miralles, J. Chen, A. Sirin, Y. He, J. Melillo. 2014: Responses of evapotranspiration and water availability to the changing climate in Northern Eurasia 2014. *Climatic Change* DOI 10.1007/s10584-014-1234-9

Majorowicz J., Safanda J., Przybylak R., 2014, The Little Ice Age signature and subsequent warming seen in borehole temperature logs versus solar forcing model, *International Journal of Earth Sciences* (Geol Rundsch), 1163-1173, DOI 10.1007/s00531-014-1008-7.

Muskett, R. 2014: MODIS-Derived Nighttime Arctic Land-Surface Temperature Nascent Trends and Non-Stationary Changes. *American Journal of Climate Change*, **3**, 169-177, 2014. doi: 10.4236/ajcc.2014.32016.

11. List of Meetings

7-10 Oct 2013 7th HyMeX Workshop Cassis, France.

15-18 Oct 2013 The Africa Climate Conference 2013 (ACC-2013) Arusha, Tanzania.

28-31 Oct 2013 26th Session of the GEWEX SSG Boulder, Colorado, USA.

Held a side meeting at the 9-12 Dec 2013 Fall American Geophysical Union Meeting San Francisco, CA.

17-21 March 2014 WCRP Conference for Latin America and the Caribbean: Developing, linking and applying climate knowledge, Montevideo, Uruguay.

14-17 July 2014 7th International Scientific Conference on the Global Energy and Water Cycle and the 17-18 July 2014 3rd Pan-GEWEX Meeting both at The Hague, The Netherlands.

Held a GHP side meeting at the 14-17 July 2014 7th International Scientific Conference on the Global Energy and Water Cycle and the 17-18 July 2014 3rd Pan-GEWEX Meeting both at The Hague, The Netherlands.

December 2014 Annual GHP Business meeting in Pasadena, CA., USA.

12. Planned meetings, workshops

There have been a large number of meetings planned that are part of GHP, especially the RHPs. As a way of indicating the scope of these meetings/events a sample list is shown below from three of the active RHPs, including HyMeX, MAHASRI, and NEESPI. For further details a link is provided to the reports <http://www.gewex.org/ghp-agenda/> where more extensive publication lists are available.

General:

The GHP Business meeting is currently being considered to be held in Arusha, Tanzania or Taiwan during the 4th Quarter of 2015.

MAHASRI: <http://gewex.org/ghp-gdap/docs/MAHASRI.pdf>

March 10-12, 2015: The fourth International Workshop of Climatic Changes and Their Effects on Agriculture in Asian Monsoon Region (GRENE-CAAM Workshop) at Hanoi, Vietnam;

May 24-28, 2015: JpGU International session “Asian monsoon Hydroclimate” at Chiba, Japan;

August 2-7, 2015: AOGS AS session “AMY” at Singapore;

August 2-7, 2015: APHW HS session “Asian monsoon hydroclimate” at Singapore

NEESPI: <http://gewex.org/ghp-gdap/docs/NEESPI.pdf>

December 15-19, 2014, San Francisco, USA. Open NEESPI Session at the Annual Fall AGU Meeting (deadline passed; 41 abstracts submitted)

April 9-12, 2015, Charles University in Prague, Czech Republic, Workshop “Ten years of Northern Eurasia Earth Science Partnership Initiative (NEESPI): Synthesis and Future Plans”

April 13- 19, 2014, Vienna, Austria. Open NEESPI Session at the Annual EGU Assembly

July dates TBD, 2014, Novosibirsk, Russia. CITES Educational Scientific Event and Science Conference

December, 2015, San Francisco, USA. Open NEESPI/NIFI Session at the Annual Fall AGU Meeting.

HyMeX: <http://www.hymex.org/?page=workshops>

9th HyMeX Workshop in Mykonos (Greece) 21 – 25 Sept 2015

Summer schools:

Support and/or participation to: « Water & Society Summer School », May 2015, France

13. List of members and their term dates where appropriate (including changes)

Co-chair - Dr Jan Polcher (4 year appointment 2011-2015 with option for 1 4-year reappointment)

Co-Chair - Dr Jason Evans (4 year appointment 2012-2016 with option for 1 4-year reappointment)

Dr Hugo Berbery, (charter member appointment Self-terminated (18 July 2014); nominal end date February 2015) - Not eligible for reappointment

Dr Mike Ek, (charter member appointment extended up to February 2015) – not eligible for reappointment

Dr Richard Harding, (charter member appointment extended up to February 2015) - not eligible for reappointment

Dr. Li Yaohui, (3 year appointment February 2013/16 with option for one 3 yr. reappointment)

Prof. Kei Yoshimura (3 year appointment February 2013/16 with option for one 3 yr reappointment)

Prof. Joan Cuxart Rodamilans (3 year appointment February 2014/17 with option for one 3 yr reappointment)

Dr. Silvina Solman (3 year appointment February 2014/17 with option for one 3 yr reappointment)

Dr. Nicole Van Lipzig (3 year appointment February 2014/17 with option for one 3 yr reappointment)

Prof. Hama Yacouba (3 year appointment February 2014/17 with option for one 3 yr reappointment)

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3. AGENDA

27th Session of the GEWEX Scientific Steering Group (SSG-27)

University of Colombia, Medellin, Columbia, 16-19 February 2015

Monday, 16 February 2015

08.00	Shuttle pick up at the Inntu Hotel to University of Colombia
08.30 – 09.00	Registration
09.00 – 09.05	Opening (P. van Oevelen)
09.05 – 09.15	Welcome from Local Host (G. Poveda)
09.15 – 09.45	Co-Chairs' Report (G. Stephens/S. Seneviratne)
09.45 – 10.00	Introductions, new panel co-chairs and SSG members
10.00 – 10.30	Update on WCRP Activities and JPS (G. Brasseur)
10.30 – 10.45	BREAK
10.45 – 11.15	IGPO Report/SSG-26 Actions and Recommendations (P. van Oevelen)
11.15 – 11.30	JSC-35 Outcome (G. Stephens/S. Seneviratne)
11.30 – 11.45	Water availability Grand Challenge overview + embedding within GEWEX (G. Stephens)
11.45 – 12.00	Extremes Grand Challenge overview + embedding within GEWEX (S. Seneviratne)
12.00 – 12.15	Post-AR5 WCRP/IPCC workshop report (S. Seneviratne /G. Stephens)
12.15 – 12.30	GEWEX Science Questions: Planned Workshops and meetings (G. Stephens/ S. Seneviratne)
12.30 – 14.15	LUNCH
14.15 – 14.45	WDAC (J. Schultz)
14.45 – 15.15	UNESCO (A. Mishra)
15.15 – 15.45	Interactions with CliC and SPARC (S. Seneviratne /G. Stephens)
15.45 – 16.15	BREAK
16.15 – 16.45	US and Latin American RHPs Exploration (F. Dominguez)

17.15 – 17.45	7 th International GEWEX Science Conference: Summary of Conference and Pan-GEWEX and Pan-CLIVAR meetings (P. van Oevelen)
18.00 – 20.00	Reception
20.00	Shuttle pick up at University of Colombia to Inntu Hotel

Tuesday, 16 February 2015

08.30	Shuttle pick up at the Inntu Hotel to University of Colombia
09:00 – 09:15	CLIVAR (S. Schubert via skype)
09.15 – 09:30	Clouds, Circulation and Climate Sensitivity Grand Challenge (G. Stephens)
09:30 – 10.00	GEWEX contributions to CMIP6: LandMIPs, HighResMIP (S. Seneviratne, G. Stephens)
10.00 – 10.15	WCRP Grand Challenge: Climate Sensitivity (G. Stephens)
10.15 – 10.45	BREAK
10.45 – 12.00	GASS (G. Stephens for GASS co-chairs)
12.00 – 12.15	GASS contribution to Grand Challenges, esp. water availability (G. Stephens)
12:15 – 12.30	Discussion
12.30 – 14.00	LUNCH
14:00 – 15.15	GLASS (M. Ek)
15.15 – 15.30	GLASS contribution to Grand Challenges; esp. water availability and extremes (M. Ek)
15.30 – 15.45	BREAK
15.45 – 17.00	GHP (J. Evans)
17.00 – 17.15	GHP contribution to Grand Challenges; esp. water availability and extremes (M. Ek)
17.15 – 18.15	WCRP Grand Challenge on Water availability + discussion (G. Stephens, P, van Oevelen)
18.15	Shuttle pick up at University of Colombia to Inntu Hotel

Wednesday, 17 February 2015

08.30	Shuttle pick up at the Inntu Hotel to University of Colombia
09.00 – 10.15	GDAP Part 1 (J. Schulz)
10.15 – 10.45	BREAK
10.45 – 11.30	GDAP Part II (J. Schulz)
11:30 – 11.45	Contributions of GDAP to WCRP Grand Challenges, esp. Water Availability/Extremes (J. Schulz)
11.45 – 12.30	Opportunities for Latin America (G. Proveda)
12.30 – 14.00	LUNCH
14,00 – 14.30	ETCCDI (L. Alexander)
1430	New SSG Member Presentation (L. Alexander)
15:00 – 15:15	BREAK
15:15 – 15.40	GDIS (S. Schubert via skype)
15:40 – 16:00	GEWEX/CLIVAR Monsoon Panel (P. Dirmeyer via skype)
16.00 – 16.20	WCRP Grand Challenge on Extremes + discussion (L. Alexander/S. Seneviratne)
16.20 – 16.50	Water Availability GC (G. Stephens)
16:50 – 17:20	GEWEX PROES (G. Stephens)
17.20 – 18.00	African Activities (R. Anyah)
18.00	Shuttle pick up at University of Colombia to Inntu Hotel

Thursday, 18 February 2015

08.00	Shuttle pick up at the Inntu Hotel to University of Colombia
08.30 – 08.50	GDAP Rapporteur Report and Discussion (See agenda below)
08.50 – 09.10	GHP Rapporteur Report and Discussion (See agenda below)
09.10 – 09.30	GASS Rapporteur Report and Discussion (See agenda below)
09.30 – 09.50	GLASS Rapporteur Report and Discussion (See agenda below)

09.50 – 10.15	Extremes Rapporteur Report and Discussion (See agenda below)
10.15 – 10.45	BREAK
10:45 – 11:15	Extremes and hazard prediction (and mitigation) in the less developed world (and the Third Pole) (P. Webster)
11:15 – 11:40	New Member Presentation (P. Poli)
11:40 – 12.00	GEWEX Soil Initiative (P. van Oevelen/G. Stephens)
12.00 –12.15	US GEWEX (G. Stephens/P. van Oevelen)
12.15 – 12.30	Procedures Travel Requests, Funding and other support (P. van Oevelen)
12.30 – 14.00	LUNCH
14.00 – 14.45	Actions and Recommendations/Summary and Conclusions (P. van Oevelen)
14.45 – 15.00	Next Meeting and Any Other Business
15.05	Adjourn
15.05 – 15.30	BREAK
15.40	Shuttle pick up at University of Colombia to Inntu Hotel

Reviewers and Rapporteurs

GASS

Peter Webster GASS Rapporteur
 Graeme Stephens
 Minghua Zhang (absent)

GDAP

Lisa Alexander GDAP Rapporteur
 Paul Poli
 Remko Uijlenhoet (absent)

GLASS

Siegfried Schubert GLASS Rapporteur
 Richard Anyah
 Rene Garreaud (absent)

GHP

Sonia I. Seneviratne GHP Rapporteur
 Xin Li (absent)
 Eleanor Blythe (absent)
 Peter van Oevelen

27th GEWEX Scientific Steering Group (SSG) Meeting
National University of Colombia, Medellin, Colombia
16-19 February 2015

List of Participants

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