Commentary

Challenges in GEWEX

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The past few months have been exceedingly busy for many of us in the World Climate Research Programme (WCRP) community, largely due to preparations related to the WCRP Open Science Conference (OSC) held in Denver from 24-29 October 2011. Also, many working group and panel meetings were held immediately before and after the Conference. Over 1900 attendees from 86 countries attended this highly successful Conference, including 523 students and early career scientists, and 332 scientists from developing countries. The format of the Conference worked well, with the plenary lectures session followed by poster sessions on the theme of the day, and two oral parallel sessions in the afternoon. I thank and applaud the many GEWEX scientists who helped with the planning, especially those who convened a session. There were four oral parallel sessions and 15 poster sessions directly related to GEWEX activities and they were all well attended.

The Working Group on Numerical Experimentation (WGNE) met the week before the OSC, and GEWEX was represented there by the Chairs of the GEWEX Global Atmospheric System Study (GASS) and Global Land/Atmosphere System Study (GLASS) Panels. In addition, the GEWEX Hydroclimatology Panel (GHP) had a 3-day panel meeting and GLASS had an intense one-day meeting prior to the OSC. The Joint Scientific Committee that provides oversight of WCRP met for two days after the OSC. In August, the GEWEX Radiation Panel (GRP), which has been renamed "the GEWEX Data and Assessment Panel (GDAP)" to better reflect its objectives, met in Tokyo. All of this provided ample information and substance for the GEWEX Scientific Steering Group (SSG) Meeting that was held in Rome on 14-18 November 2011.

The "living" document, "GEWEX Imperatives: Plans for 2013 and Beyond," which outlines the strategic future directions of GEWEX, has been reviewed and is available on the GEWEX website. The document is being used extensively by the GEWEX Panels in planning. However, it has become clear that we now need to include more specific plans and a strategy for their implementation for the immediate future (the next 5–7 years). Accordingly, the SSG spent a substantial amount of time on the planning and drafting of Grand Science Challenges for GEWEX.

The Grand Challenges must be specific and focused, while identifying ways to advance the science, and they must resonate among agencies, program managers, and the public. These Challenges must provide vehicles to encourage the different GEWEX Panels to interact in pursuing a common goal and provide a way forward that is tractable, (e.g., via new observations and computer and model advancements). They must also address possible benefits and impacts and links to issues related to food, water, health, energy, and biodiversity.

The GEWEX SSG has identified four such Grand Challenges that will be further developed in the next few months. The questions are evolving but shape up as follows:

1. **How can we better understand and predict variations and changes in precipitation?** This question focuses on the use and further development of expected improved data sets on precipitation and soil moisture from ongoing and planned satellite missions and in situ observations; evaluation and analysis of these data sets into various products that are used to document mean, variability, patterns, extremes and full probability density functions, and confront models in new ways; improved understanding of atmospheric and land-surface processes and their modeling that in turn feeds into improved simulations of precipitation; and new techniques of data assimilation and forecasts that can lead to better predictions of the

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hydrological cycle. These results should lead to improved climate services.

2. **How do changes in land surface and hydrology influence past and future changes in water availability and security?** There is a need to address terrestrial water storage changes and close the water budget over land through exploitation of new data sets, data assimilation, and improved physical understanding and modeling skill across scales, from catchments to regional to global with links to the entire hydrological cycle, including hydrogeological aspects of ground water recharge. Attention is needed in the use of realistic land-surface complexity with all anthropogenic effects taken into account, instead of a fictitious natural environment. This encompasses all aspects of global change, including water management, land use change, and urbanization. Water quality and especially water temperature, both of which are greatly affected by industrial and power plant use, are of immediate concern, to be followed by nutrients. The ecosystem response to climate variability and responsive vegetation must be included, as must cryospheric changes such as permafrost thawing and changes in mountain glaciers. Feedbacks, tipping points, and extremes are of particular concern. The results should enhance the evaluation of the vulnerability of water systems, especially to extremes, which are vital for considerations of water security and can be used to increase resilience through good management and governance.

3. **How does a warming world affect climate extremes, especially droughts, floods, and heat waves, and how do land area processes, in particular, contribute?** A warming world is expected to alter the occurrence and magnitude of extremes from droughts to rainfall intensity, as well as the geographic distribution of rain and snow. Such changes are related to an acceleration of the hydrologic cycle and circulation changes, and include the direct impact of warmer conditions on atmospheric water vapor amounts, rainfall intensity, and snow-to-rain occurrence. How well are models able to handle extremes and how can we improve their capability? Data sets at high frequency (e.g., hourly) are needed to properly characterize many of these facets of our climate and to allow for assessment against comparable model data sets. Activities are needed to promote analyses of which changes are consistent with our expectations and how we can best contribute to improving their prediction in a future climate. Confronting models with new observationally based products will lead to new metrics of performance and highlight shortcomings and developmental needs that will focus field programs, process studies, numerical experimentation, and model development. Applications will be developed for improved tracking and warning systems, and assessing changes in risk of drought, floods, river flow, storms, coastal sea-level surges, and ocean waves. In most cases, such applications will be done in conjunction with the Climate Variability and Predictability (CLIVAR) and the Climate and Cryosphere (CliC) projects.

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 question includes goals of improved consistency between net solar and infrared radiation and sensible and latent heat fluxes at the surface to reveal processes that in turn must be replicated in climate models. This question relates also to uncertainties introduced by incomplete understanding of cloud-aerosol-precipitation interactions and their feedbacks on the climate system. Only through a better understanding of the uncertainties in observations and models will it be possible to discriminate natural variability from longer-term trends of key variables such as temperature and precipitation. Possibilities of new satellite-based measurements, combined with observations at the surface and in the ocean, should enable improved reconciliation between observed changes in the radiative imbalance at the top-of-atmosphere and the inventory of changes in energy throughout the Earth system. Upgraded GEWEX data sets, global reanalyses of atmosphere and ocean, and improved modeling together with advanced diagnostics being planned throughout the GEWEX Panels play key roles in advancing this topic. The result is improved tools and products for climate services.

These science questions will have elements associated with the GEWEX Imperatives: observations and data sets, their analysis, process studies, model development and exploitation, applications, technology transfer to operationalize results, and capacity building and training of the next generation of scientists. They involve all of the GEWEX Panels, and frequently strong interactions with other parts of WCRP and even the International Geosphere-Biosphere Programme. They also contribute to the larger science questions posed by WCRP as a whole.

We welcome your comments, suggestions, and involvement in developing and furthering these topics. Workshops are anticipated to encourage participation and ideas. Please provide expressions of interest or thoughts and reactions to *gewex@gewex.org*.

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