Three major themes form the backbone of the GWSP. The Global Scale Initiative has three subthemes, including efforts to develop: (1) global estimates of major changes in the global water system; (2) interdisciplinary indicators of global water resource stress; and (3) global analysis and mapping of major agents of change. The Global Catchment Theme is carrying out an analysis of how water managers in large river basins use monitoring and prediction information in decision-making. Some of these large basins coincide with the GEWEX/Coordinated Energy and Water Cycle Observations Project (CEOP) Regional Hydroclimate Project areas. As a result of this meeting, this theme added its first North American basin, specifically the Lake Winnipeg Basin, which is also the GEWEX Drought Research Initiative area.

The Global Water Needs Initiative, the third major GWSP theme, is developing a global consensus on assessment of environmental flow needs, estimating the value of freshwater ecosystem goods and services and devising strategies for harmonizing the water needs of humans and nature. Progress has also been made on some of the GWSP's cross-cutting activities, including global governance and capacity building [in collaboration with the Global Change SysTem for Analysis, Research and Training (START) and NuWater].

During the breakout session, four new priority initiatives were identified: (1) water constraints on new energy developments; (2) water indicators; (3) water indicators and health; and (4) water and migration. Workshops or other activities will be developed around each of these initiatives. Efforts are underway to find funding for these new proposals and to develop a plan for the second half of the GWSP initiative. In addition, plans are under development for a GWSP Science Conference in 2011. Open questions requiring further discussion involve the GWSP legacy and plans for the next phase of the Project.

The GWSP has a number of common interests with GEWEX, particularly in the area of Hydrologic Application Working Group and some of the GEWEX data projects. It is anticipated that over the coming years several joint projects between GWSP and GEWEX will be launched to enhance the development of these bonds and to allow the GWSP activities to take full advantage of the support that can be provided by GEWEX and related WCRP projects.

31-Year (1979-2009) NLDAS-2 Forcings and Multi-Model Outputs Now Available

http://www.emc.ncep.noaa.gov/mmb/nldas

In collaboration with the Climate Prediction Program for the Americas (CPPA) Project, the NOAA/NCEP Environmental Modelling Center developed the North American Land Data Assimilation System-Phase 2 (NLDAS-2) of forcing, water fluxes, energy fluxes, and state variables from four land-surface models.

ECMWF/GLASS Workshop on Land Surface Modelling, Data Assimilation and the Implications for Predictability

9-12 November 2009
Reading, United Kingdom

Anton Beljaars[1], Gianpaolo Balsamo[1], Patricia de Rosnay[1], Bart van den Hurk[2] and Martin Best[3]
[1]ECMWF, Reading, UK; [2]Koninklijk Nederlands Meteorologisch Instituut (KNMI), De Bilt, The Netherlands; [3]Met Office, Joint Centre for Hydro-Meteorological Research, Wallingford, UK

The European Centre for Medium-Range Weather Forecasts (ECMWF) and GEWEX Global Land/Atmosphere System Study (GLASS) Workshop reviewed recent research on land-atmosphere modelling, land data assimilation, new observations and the role of soil moisture and snow in predictability in the subseasonal time range. Quality assessment of models by standardized procedures for model verification and benchmarking was also addressed. It is clear that a wide range of physical processes at the land-surface is relevant to improving predictability. Following the presentations, four working groups gave their recommendations on priorities for further research by ECMWF and the GLASS community and these are summarized below.

The **Working Group on Land-Surface Modelling and Applications** reported that representation of lakes and rivers in hydrological models is necessary for accurate land-atmosphere and land-ocean water flux predictions. The inclusion of cold processes (particularly snow accumulation and melting in heterogeneous terrain) and warm processes (e.g., evaporation and soil heat transfer) would provide the greatest potential for improvement in Numerical Weather Prediction (NWP) and climate forecasts. Land-surface models will benefit from the increasingly higher spatial resolution of remotely-sensed Earth observation data and will help to establish process-oriented schemes to replace those based on effective parameters or dominant land-use type. Finally, interactive vegetation and carbon processes should be included to bridge the gap between NWP land-surface schemes and Earth system models.

The **Working Group on Land-Surface Data Assimilation** noted that current improvements in surface data assimilation systems open a wide range of possibilities to take advantage of past, current and future satellite data. Exploiting synergies between the different types of data (soil moisture, vegetation, snow, albedo and land-surface temperature) has been identified to be of high importance for land-surface analysis activities. To achieve this, ECMWF is in a very good position to implement a multi-variate land-surface data assimilation system for NWP. A posteriori diagnostics on the land data assimilation system would be important for evaluating the self-sensitivity of different observation types.

Stand-alone (without atmospheric analysis) and offline (forced by atmospheric fields) surface analyses are under development at ECMWF and these procedures will be of great interest for

seasonal forecast and reanalysis activities, as well as for research and development. In this context, the first Project of Intercomparison of Land Data Assimilation Systems (PILDAS) was suggested as a new GLASS activity.

The **Working Group on Observations for Terrestrial Surfaces** noted the importance of investigating the benefit of assimilating albedo, vegetation parameters, land-surface temperature and snow cover extent using satellite data. Physiographic information (e.g., land-use and elevation maps) is also important to take into account in land-surface modelling and data assimilation systems.

Validation and benchmarking activities should consider both ground-based and satellite data. Comparing established observation networks [e.g., the Flux Tower Network (FluxNET), the GEWEX Coordinated Energy and Water Cycle Observations Project (CEOP), and Snopack Telemetry observations (SNOTEL)] with model and data assimilation results could be very useful. ECMWF was encouraged to create a structured set of ground data to verify land-surface modelling and analysis results on a systematic basis. Satellite data provides two-dimensional information that is relevant for verification of radiative and evaporative fluxes as well as land-surface temperature.

Global meteorological forcing data sets are crucial to support coordinated activities such as land-surface model intercomparison projects. Modern reanalyses [e.g., ECMWF ReAnalysis-Interim (ERA-Interim)] with appropriate bias corrections for precipitation are suitable for this purpose and should be extended to cover multi-decadal periods.

The **Working Group on the Contribution of Land-Surface to Predictability** reported that research efforts to improve long-term prediction across several NWP and climate research centers have indicated the crucial role of the land-surface. This is associated with the slow surface processes for which initial anomalies persist through the forecast (due to memory effects) for days and weeks. Large multi-model projects such as the GEWEX Global Land-Atmosphere Coupling Experiment (GLACE) provided evidence of strong coupling between soil moisture and precipitation in mid-latitude and tropical areas. Results from GLACE-2 helped to quantify the predictability gain coming from accurate land-surface initial conditions up to two months in the future.

More accurate snow cover and snow depth are also considered to be a high priority for model initialization. Snow processes have an impact on temperature profiles in northern latitudes and teleconnections with large-scale circulation patterns, such as the Indian monsoon. It would be highly beneficial to investigate both local and remote impacts of snow through GLACE-type exploratory experiments.

Reports on the working group discussions will be published in the forthcoming proceedings together with short papers on the individual contributions. Workshop presentations are available at: *http://www.ecmwf.int/newsevents/meetings/workshops/2009/Land_surface_modelling/presentations.html*.

Conference on Earth Observation and Water Cycle Science: Towards a Water Cycle Multi-Mission Observation Strategy

ESA-ESRIN, Frascati, Italy
18-20 November 2009

Peter van Oevelen
International GEWEX Project Office

Nearly 200 scientists from 30 countries assembled at this Conference to assess state-of-the-art observations and scientific research for characterizing global water cycle variability and identifying the main needs in modelling and data assimilation to improve our knowledge and ability to quantify future changes in water cycle variables. Organized by the European Space Agency (ESA), GEWEX, the European Geosciences Union (EGU), and International Society for Photogrammetry and Remote Sensing, this was the first in a series of EGU topical conferences on the hydrological cycle.

The plenary discussions focused on current gaps in water cycle research and provided valuable input to the strategy and future directions of global climate research programs, such as GEWEX. Presentations were given on current and planned space missions, precipitation, clouds and water vapor, turbulent energy fluxes, evapotranspiration, floods and droughts, modelling the water cycle, and soil moisture. In addition, Dr. Yann Kerr, the lead investigator for the recently launched Soil Moisture and Ocean Salinity Mission, unveiled the first data sets from the satellite.

Round table discussions focused on the main gaps and scientific challenges ahead to better observe, monitor and characterize the different components of the water cycle in view of improving our ability to cope with water management and governance in a world where water is more and more at the center of international law, policy and conflicts. Also discussed were the challenges and opportunities in water cycle science in reducing uncertainties in water-related climate change impacts and adaptation strategies in water resources. The Conference recommendations represent a major step for a scientific roadmap that outlines the main priorities for the development of new global geo-information data products, improved models and effective data assimilation systems.

Earlier this year, ESA initiated, as a part of its new Support To Science Element Program and in collaboration with GEWEX, the Water Cycle Multi-Mission Observation Strategy (WACMOS). This project supports the development of novel techniques to study the water cycle using satelite derived Earth observations. WACMOS is carried out by an international team of experts led by the International Institute for Geo-Information Science and Earth Observation (ITC) located in The Netherlands. The WACMOS team presented preliminary results of its activities addressing key elements of the water cycle, including global evapotranspiration, soil moisutre, clouds and water vapor. This project, among others, as well as the Conference results, represents ESA's contribution the international coordination effort carried out by GEWEX to better understand, describe and predict the global water cycle.