GEWEX WCRP

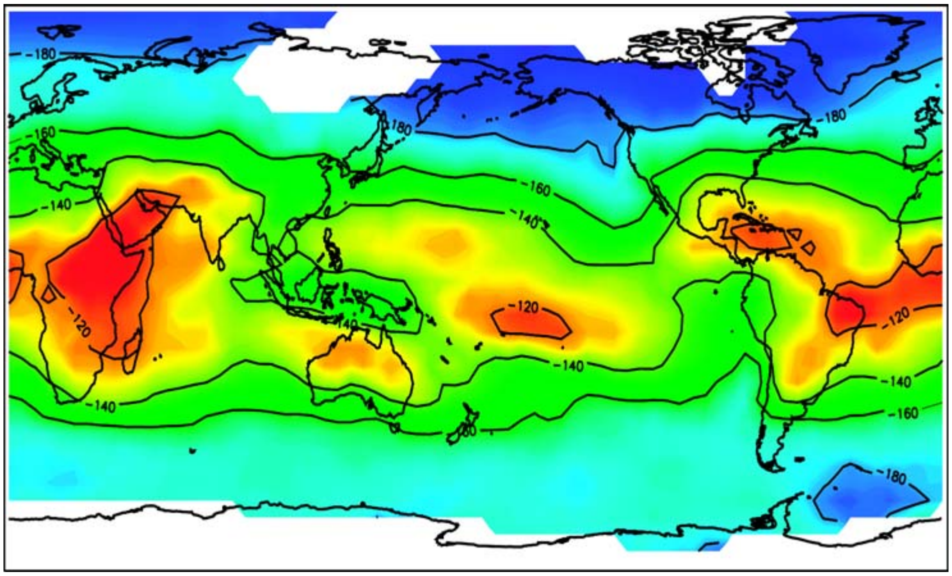
Global Energy and Water Cycle Experiment

NEWS

Vol. 17, No. 3 August 2007

GEWEX is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO.

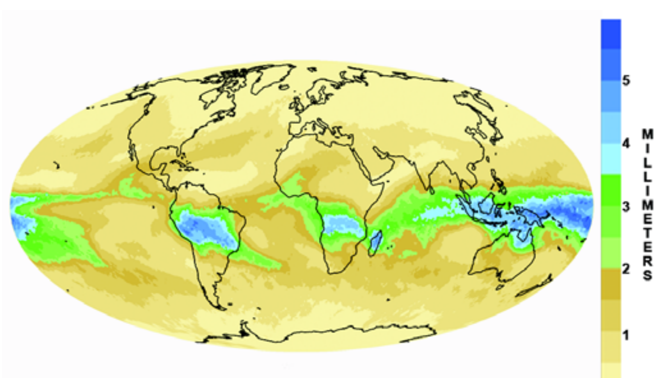
SPACE OBSERVATIONS OF WATER ISOTOPES PROVIDE A NEW TOOL FOR UNDERSTANDING THE WATER CYCLE



For the first time, global measurements of the ratio of deuterated water to H_2O are possible using observations from the Tropospheric Emission Spectrometer (TES) on board NASA's Aura spacecraft. Shown is the mean δD between 850 hPa to 500 hPa for November 2005 to December 2006.

More depleted values of δD shown at the higher latitudes indicate a long history of condensation during transit from a lower latitude source, while less depleted values in the tropics reflect ventilation of recently evaporated boundary layer vapor into the free troposphere (above 850 hPa, where TES is sensitive). Knowledge of these differences makes possible depiction of water cycling in the atmosphere. *See article by D. Noone et al. on page 9.*

HIGHLY ACCURATE AIRS DATA PROVIDE NEW OPPORTUNITIES FOR IMPROVEMENTS IN GLOBAL MODELS



Atmospheric Infrared Sounder (AIRS) retrieved water vapor integrated from the top of the atmosphere down to the 500 hPa level, averaged over the month of January 2003.

Other AIRS data show lower tropical and wetter extra-tropical atmospheres, as well as much larger moisture perturbations and extra-tropical CO_2 than current models depict. *See article by M. Chahine et al. on page 11.*

Newsletter Contents

COMMENTARY

GEWEX PLANS TO ADDRESS CRITICAL NEEDS IDENTIFIED IN THE RECENT IPCC ASSESSMENT REPORT:

A FOCUS ON IMPROVING REGIONAL-SCALE PREDICTIONS

Soroosh Sorooshian
Chair, GEWEX Scientific Steering Group

The Intergovernmental Panel on Climate Change (IPCC) recently released its much anticipated Assessment Report (AR4). As expected, the report generated a lot of media attention and continues to dominate discussions among various stakeholders. The primary conclusions of the report support the fact that there is a warming trend of the Earth's climate and, furthermore, concludes that there is a relationship between the warming and anthropogenic factors.

While direct references of World Climate Research Programme (WCRP) projects may not be explicitly described in the report, the contributions of the GEWEX global data sets and science are evident. WCRP should take pride in its Project.

It is evident that confidence in the global-scale warming trends as predicted by climate models has been increasing. However, many challenges and uncertainties at the regional scales remain, particularly where the water cycle is involved. The implications of these regional scale uncertainties are most critical to studies and assessments of various resources and environments, such as water, food and ecosystems. As a matter of fact, the IPCC Technical Paper on Climate Change and Water, which will soon be officially released, is an attempt to assess, among other things, *"…understanding of the link of both nature and anthropogenically induced climate change, its impacts, and adaptation and mitigation response options, with water issues…"*

While we await the public release of this report, one can anticipate that its conclusions will rely on published literature, much of which is based on scenarios of modelling simulations that are obtained through the coupling of catchment-scale hydrologic models with large-scale regional and global climate models. Irrespective of the specific choice between hydrologic and/or climate models, the conclusions are based on the principle of "mass balance" and, therefore, will adhere to satisfying the condition of the "closure of the water budget" over the spatial scale of interest. The reliability of values of selected model output will depend upon the accuracy of, among other factors, the values of the required inputs and parameterizations. Given that there is still much uncertainty associated with many of these factors at resolutions appropriate for regional studies, one should not be surprised that various models disagree in terms of their regional predictions and produce highly questionable results regarding water-related consequences of climate change. For instance, some well-known and popular models show disagreement over the western United States in terms of getting "wetter" or "drier" in the future. It is not surprising that the stakeholder community (e.g., water managers) have reservations about the use of climate information in their long-term planning and management strategies.

What does the above discussion have to do with GEWEX? In my view, this is exactly the area where GEWEX science will likely have its greatest impact in the years to come. In this regard, the roles of all three GEWEX panels—the GEWEX Radiation Panel (GRP), the GEWEX Modelling and Prediction Panel (GMPP), and the newly organized hydroclimate panel, the Coordinated Energy and Water-Cycle Observations Project (CEOP), which is the merger of the GEWEX Hydrometeorology Panel (GHP) and the "old" CEOP (Coordinated Enhanced Observing Period—are critical. **In particular the productive cooperation between GMPP and the jointly sponsored WCRP/World Meteorological Organization (WMO) Commission for Atmospheric Sciences (CAS) Working Group on Numerical Experimentation (WGNE) on improving parameterizations and reducing regional-scale prediction uncertainties should not only be the priority for GEWEX (strongly reaffirmed during the Pan-GEWEX Meeting held in October 2007), but should be one of the highest for WCRP and its Joint Steering Committee.**

PLANNING UNDERWAY FOR THE

6TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE

Melbourne, Australia
September 2009

RECENT NEWS OF RELEVANCE TO GEWEX

FORMER CHAIR OF GEWEX SSG RECEIVES PRESTIGIOUS NASA AWARD

Dr. Moustafa (Mous) T. Chahine, Jet Propulsion Laboratory, California Institute of Technology, received the National Aeronautics and Space Administration's (NASA) Exceptional Scientific Achievement Medal in recognition of outstanding science leadership and scientific contributions to the Atmospheric Infrared Sounder (AIRS) on the NASA Aqua mission (see article on page 11). AIRS data have significantly improved the accuracy of operational weather prediction in the United States and other weather prediction centers around the world. Dr. Chahine was responsible for establishing the scientific basis for the instrument.

CHAIR OF GEWEX SSG APPOINTED MEMBER OF THE NRC SPACE STUDIES BOARD AND OF THE INTERNATIONAL ACADEMY OF ASTRONAUTICS

Prof. Soroosh Sorooshian, Distinguished Professor of Civil and Environmental Engineering and Earth Systems Science, and Director of the Center for Hydrometeorology and Remote Sensing, University of California, Irvine was appointed as a member of the National Research Council's Space Studies Board (SSB). The SSB provides an independent, authoritative forum for all aspects of space science and applications and it serves as the focal point within the National Academies for activities on space research.

Prof. Sorooshian was also elected as a member to the International Academy of Astronautics, which brings together on a regular basis, the world's foremost experts in the disciplines of astronautics to recognize the accomplishments of their peers, to explore and discuss cutting-edge issues in space research and technology, and to provide direction and guidance in the non-military uses of space and the ongoing exploration of the solar system.

RECONSTRUCTION OF RIVER RUNOFF TO THE BALTIC SEA FOR THE PERIOD 1500–1995

Christin Eriksson, Daniel Hansson, Anders Omstedt, and Deliang Chen

Earth Sciences Centre, Oceanography, Göteborg University, Sweden

This article presents results by the GEWEX Baltic Sea Experiment (BALTEX) in the reconstruction of river runoff in the Baltic Sea for the past 500 years. The Baltic Sea in northern Europe is one of the largest brackish water bodies in the world and its catchment area is home to nearly 85 million people. Freshwater budget modelling efforts require reasonable estimates of annual and seasonal river runoff. Variability of the atmospheric circulation results in an annual river runoff of about 15,000 m^3s^{-1} into the Baltic Sea, while net precipitation adds about 1,000 m^3s^{-1} (Omstedt et al., 2004). River runoff estimates on a monthly basis from the Baltic Sea catchment area are available for the 20th century through earlier studies. Data from 1950 and onwards are available at the BALTEX Hydrological Data Centre (*http://baltex@gkss.de*).

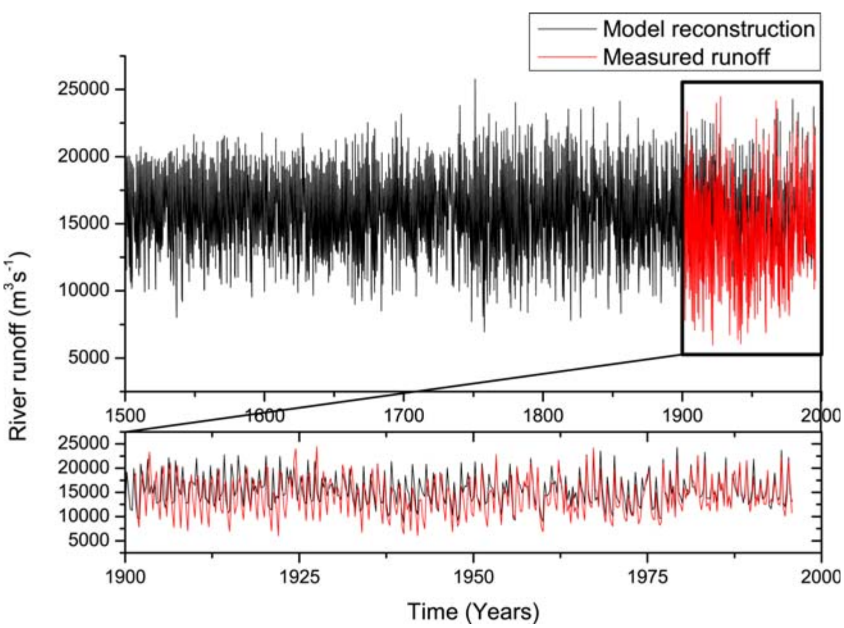
The Baltic Sea river runoff catchment area is quite diverse zonally and meridionally. A large temperature and humidity gradient stretches across the region due to cyclonic activity that brings mild and humid air from the North Atlantic into the region, or anti-cyclones that bring cold and dry air from continental Russia. In order to establish a statistical relationship for these different regimes, the Baltic Sea catchment area was divided into three sub-areas: (1) northern area, including the Bothnian Bay and the Bothnian Sea; (2) eastern area, including the Gulf of Finland; and (3) southern area consisting of the remaining part of the Baltic Sea. The southern area is influenced most by North Atlantic cyclonic activity, with milder temperatures and more humid air, while the northern area is usually dominated by colder and drier air masses governed by the strenghtening or weakening of the Russian high. The Gulf of Finland is also more often influenced by cold and humid air; however, the river runoff to this basin is modulated by two large lakes: Lake Ladoga and Lake Onega.

To reconstruct the past 500 years of river runoff from the Baltic Sea catchment area, three data series were used: (1) Basin-specific river runoff estimates for the southern, eastern and northern areas with a monthly resolution from 1950 and onwards. (2) Total runoff estimate for the Baltic Sea extending back to 1901 (used for validation of the reconstruction). (3) A gridded data set consisting of a sea level pressure reconstruction with a resolution of 1° over the area from 30°N to 70°N and 30°W to 40°E over the period 1500–1995. This is an updated version of the 5° data set prepared by Luterbacher et al. (2002) for the period 1500–1995. From the gridded data set, indices were calculated describing the geostrophic velocity field and the rotational components of the wind field. A decomposition of the Sea Level Pressure (SLP) field provides information about the entire pressure field and is therefore better than single circulation indices such as the North Atlantic Oscillation.

Taking these series, assuming stationarity and relating the river runoff to the atmospheric circulation over the area by using the gridded SLP reconstruction (Luterbacher et al., 2002), it was possible to reconstruct the river runoff series on a seasonal time scale back to the year 1500 using statistical modelling. The statistical model developed was based on a stepwise regression routine, choosing only predictors determined by an F-test to be statistically significant at the 0.08 level. Therefore, it is ensured that only predictors with a statistically significant contribution are used in the Baltic Sea River Runoff Model. Calibration and validation carried out over the 1902–1995 period showed the model produced realistic results.

Each submodel describes the runoff to the three sub-areas. Assuming that the statistical relationships found by the stepwise regression method remain stationary over time, the river runoff from the year 1500 to the year 1995 can be reconstructed. The full reconstruction, based on gridded circulation, is shown in the figure below. To validate the results, the models were combined and verified against a time series for the total Baltic Sea runoff going back to 1901. This analysis showed that the model has a tendency to overestimate river runoff during the validation period. It should be noted that the later parts of the series had more data than the earlier parts. This may have affected the relationship and could account for some of the earlier differences. Reconstructed river runoff shows less variability over the first two centuries, a consequence of the predictor data being less dense in information during this time period.

The statistical analysis revealed that there is large interannual and interdecadal variability in the annual river runoff to the Baltic Sea. However, no statistically significant trend was observed over the last half millennium, which implies no significant change in precipitation in the Baltic Sea catchment area. Changes may have occurred on an interseasonal time scale but have not been investigated in detail at this point. However, the Baltic Sea possesses a period of oscillation on a time scale of 33 years (Omstedt and Hansson, 2006) and therefore the interannual variability is more important for the Baltic Sea salinity than interseasonal changes. The research reported here shows how regression techniques can be used to tune paleo data to instrumental data in a satisfying way. This allows for multi-century hydroclimatic records to be developed, thereby providing insights about the global and regional water cycles over much longer time scales than allowed for by the instrumental record.



Model results for the period 1500–1995, together with real river runoff estimates used for validation.

Acknowledgements: This work was funded by Göteborg University and the Swedish Research Council under the G600-335/2001 contract.

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POTENTIAL OF RAINFALL PRODUCTS FOR USE IN LANDSLIDE HAZARD ASSESSMENT IN THE CARIBBEAN REGION

Dalia Bach[1,2], Robert Adler[2], and Yang Hong[2,3]

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Precipitation is one of most significant drivers of hydrological and geomorphic hazards in the Caribbean Region. Rainfall-triggered landslides occur frequently within mountainous areas and pose a substantial economic and social threat to local populations. Studies generally characterize the potential for a rainfall-triggered landslide event according to a rainfall intensity-duration threshold from past landslide and rainfall occurrences. These thresholds have been produced on the global, regional, and local scales and rely on landslide mapping and rainfall gauge information.

The development of a threshold relationship requires information on the intensity (km/hour) and duration (hours) of the rainstorm event that corresponds to the location of the landslide and time it occurred. This information is often challenging if not impossible to retrieve due to the relatively sparse network of rain gauges in most parts of the world and the inability to determine exactly when landslides were initiated. This article provides a brief discussion of the current issues in precipitation estimation within the context of effective landslide hazard assessment as well as a potential future path for this type of analysis.

Past landslide hazard research has relied on spatially and temporally heterogeneous rainfall gauge data. To improve upon these studies and to broaden their applicability, landslide hazard assessment requires more comprehensive and widespread rainfall data. Rain gauges provide accurate measurements of precipitation in small areas, but they can be highly affected by wind and gauge placement, causing significant underestimations of rainfall. Some developed countries use measurements from operational surface radars to provide near-complete coverage at high spatial and temporal resolution, although results in mountainous areas—where landslides occur—are questionable due to beam shielding errors.

Rainfall estimates from remote sensors on orbiting satellites can provide frequent and consistent coverage over large areas. In the mid-latitudes and tropics, low-orbiting satellites such as the National Aeronautics and Space Administration (NASA's) Tropical Rainfall Measuring Mission (TRMM), image the rainfall structure using active and passive microwave sensors. Other passive microwave instruments on polar-orbiting satellites also provide precipitation information over land. While TRMM and other individual orbiting platforms can provide relatively accurate instantaneous rainfall rates, the return period of individual satellites limits the ability to estimate storm intensity and duration on small temporal scales.

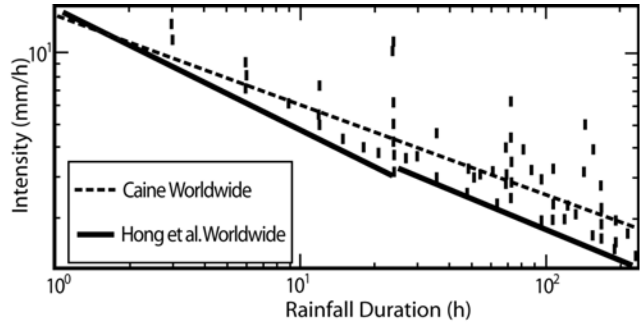
Infrared cloud-top brightness temperature sensing from geostationary infrared data provide 4 km, 15-minute resolution rain rates of cloud-top temperature and other information. The generally poor correlation between the coldest cloud areas and rainfall intensity suggests that these rain rates may be difficult to use independently, although they can be used to enhance other precipitation products.

To improve upon single-instrument precipitation estimates, many studies have made use of more sophisticated methodologies or have merged satellite information to produce enhanced products. The TRMM Multi-Satellite Precipitation Analysis (TMPA; Huffman et al., 2007) integrates data from multiple microwave satellites to provide a 3-hourly 0.25º product. More than 9 years of the TMPA product is available for research including a real-time version available for use in hydrological applications. Another example, the PERSIANN-CCS algorithm (Hong et al., 2005) uses geosynchronous infrared data that provide quasi-global rainfall estimates at 4 km hourly resolution by incorporating information on cloud temperature, texture and geometry. The table on page 6 summarizes some of the rainfall products.

Orography limits the accuracy and availability of the majority of many rainfall products and has sizeable consequences for landslide hazard assessment. In mountainous areas, precipitation generally increases with elevation as moist air is forced upwards, causing significant rainfall on the windward side of a mountain. For all types of *in situ* and remote sensing instruments, mountains can bias the areas in which gauges are installed, cause large signal interference of radar beams, and alter atmospheric flows in ways that can distort the typical cloud-top temperature-rain rate relationship. Studies have attempted to correct for orographic precipitation effects by introducing additional surface data such as terrain, elevation and surface wind direction. While these studies assist rainfall estimation in mountainous settings, they still do not provide the spatial and temporal resolution required for landslide hazards assessment.

Landslide hazard assessment is performed on a wide array of scales. For studies at the slope or watershed level, gauge or radar data remain the most reliable sources available. However, for large scale studies and for evaluating areas without an *in situ* network, satellite data can provide crucial information for general landslide hazard analysis and susceptibility mapping. The lead author examined rainfall events over Puerto Rico using the highest resolution satellite database available, PERSIANN-CCS, by comparing the data with rain gauge information over the same area. Preliminary results indicate that at a 4 km resolution, the satellite data were able to resolve the timing of large rainfall events over the island but had limited ability to accurately provide intensity values for those events or total seasonal accumulation measurements. The figure at the top of page 16 illustrates satellite data resolution differences over Puerto Rico and compares them to landslide inventories.

Given the improved resolution capabilities of merged satellite information, new studies are using these data on the global scale to assess susceptibility to landslide events. By using precipitation information from the TMPA, Hong et al. (2007) developed a satellite-based rainfall intensity/duration threshold from landslide cases in various climate and geological locations and mapped out a global landslide susceptibility index by combing land surface characteristics such as topography, soil type, and land cover (see figure in next column). Knowledge of landslide susceptibility and the ability to detect heavy rain events that meet threshold conditions provide the basis for exploring the potential and limitations of such approaches for analyzing and studying the occurrences of landslides on a global basis, and even possibly forecasting them.



Rainfall intensity duration thresholds derived from a global study by Caine (1980) from rainfall gauge data, and from Hong et al. (2006) from TMPA. Figure from Hong et al. (2006).

Although important advances are being made to integrate satellite precipitation data into landslide hazard assessment, it is important to recognize the relative scale at which this type of analysis can be executed. Because of the current limitations in providing accurate rainfall information on small spatial and temporal scales, satellite-based landslide hazard analyses cannot resolve rainfall events that trigger a landslide in less than 3 hours in a relatively small area. While this may serve to limit the application of the satellite-based rainfall information to larger-scale events, the current products and steps already taken demonstrate that satellite information will be increasingly important in enhancing our knowledge of landslide hazard assessment.

Rainfall Product	Coverage (Geographic)	Spatial Resolution	Temporal Resolution	Limitations
Rainfall Gauges (NCDC, USGS)	Variable, 10,000 stations globally monitored by NCDC	Point Source (~30 cm radius)	Hourly, 1970s to present	Wind errors, reporting issues, gauge placement
Surface Radar	US, Canada, Europe, China, and Japan. 400 km max. radius	4 km gridding	4-10 minutes, hourly products, 1988 to present	Beam shielding and errors in mountain areas
IR calibrated with merged-MW (PERSIANN-CCS)	Global	~4 km	Hourly, 2001 to present	Large uncertainty at small spatial and temporal scales
Low-Orbit Satellites, e.g., TRMM (TMI, PR)	50° N-S	0.25º	Instantaneous, 12+ h, 1997 to present	Limited temporal sampling, algorithm inconsistencies
TMPA	50º N-S	0.25º	3h, 1998 to present	Not available at small spatial scales (<25km)

Overview of different precipitation data sets, their coverage, resolution, time of operation and general limitations.

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COMPARISON OF MONTHLY MEAN PRECIPITATION RATES FROM GPCP OBSERVATIONS AND ECHAM5 SIMULATIONS

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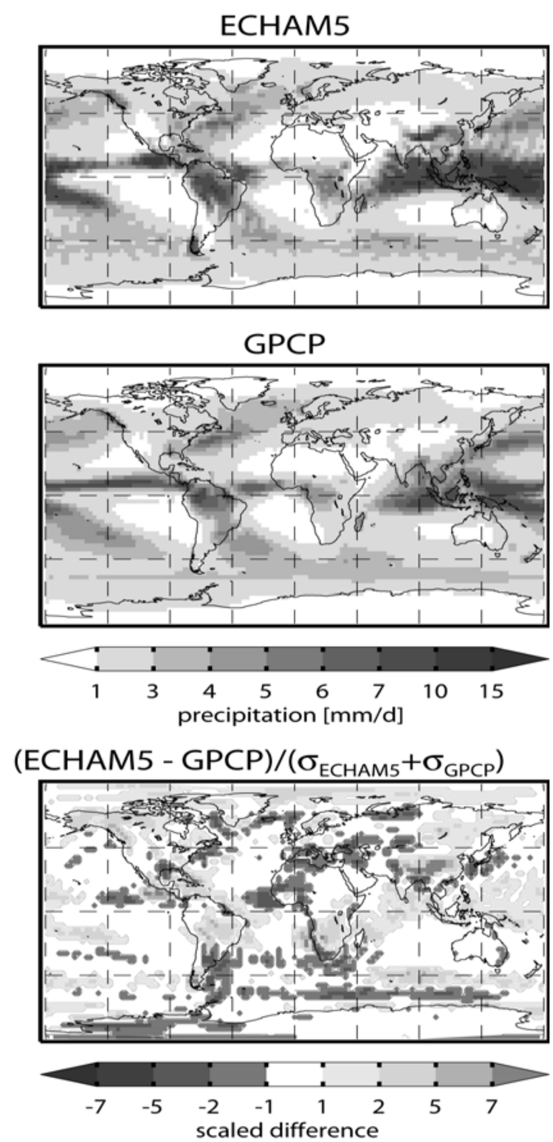
Clouds and precipitation play an important role in the Earth's hydrological cycle. Changing precipitation patterns (e.g., due to climate change) may result in shifted vegetation zones and affect water quality, soil structure/erosion and runoff into rivers and oceans (Hatfield and Prueger, 2004). Through feedback processes, these changed precipitation rates have an impact on cloud formation and microphysical processes which, in turn influence precipitation rates. The prediction of precipitation is therefore an important issue for the climate modelling community. In order to obtain reliable results and to evaluate model behavior, it is essential to compare precipitation rates from model simulations with direct observations. This study was conducted using observational data from the Global Precipitation Climatology Project (GPCP) to evaluate model simulations of the ECHAM5 General Circulation Model (GCM).

The GPCP data set provides monthly averaged precipitation fields on a 2.5° x 2.5° grid for the period of 1979 to the present. GPCP combines satellite data with surface rain gauge measurements to retrieve precipitation data sets. The satellite measurements include microwave precipitation estimates from the Special Sensor Microwave/Imager (SSM/I) and infrared precipitation estimates from geostationary and polar-orbiting satellites, as well as low-earth-orbit estimates from the TIROS Operational Vertical Sounder (TOVS) and Outgoing Longwave Radiation (OLR) Precipitation Index (OPI) (Huffman et al., 1997; Adler et al., 2003).

The ECHAM5 GCM is based on the European Centre for Medium-Range Weather Forecasts' model and is being further developed at the Max Planck Institute for Meteorology. Within ECHAM5, the prognostic equations for temperature, surface pressure, divergence and vorticity are solved on a spectral grid with a triangular truncation (Roeckner et al., 2003). Prognostic equations for cloud water and cloud drop number concentrations, cloud ice and ice crystal number concentration, and detailed cloud microphysics are used according to Lohmann et al. (2007). In this study, the autoconversion parameterization of Khairoutdinov and Kogan (2000) is used to form precipitation. All rain water is removed from the model column after one time step as surface precipitation or by evaporation/sublimation in the subsaturated air below the cloud.

The precipitation rates of a 10-year ECHAM5 simulation in T42 resolution (2.8125° x 2.8125°) are compared to 28 years (1979–2006) of GPCP data. Monthly mean values of the precipitation rates were used for the statistical analysis. The global distributions of the yearly averaged precipitation rate simulated by ECHAM5 and retrieved by GPCP are shown in the figure below (upper and middle panels). The difference between model simulation and observa-

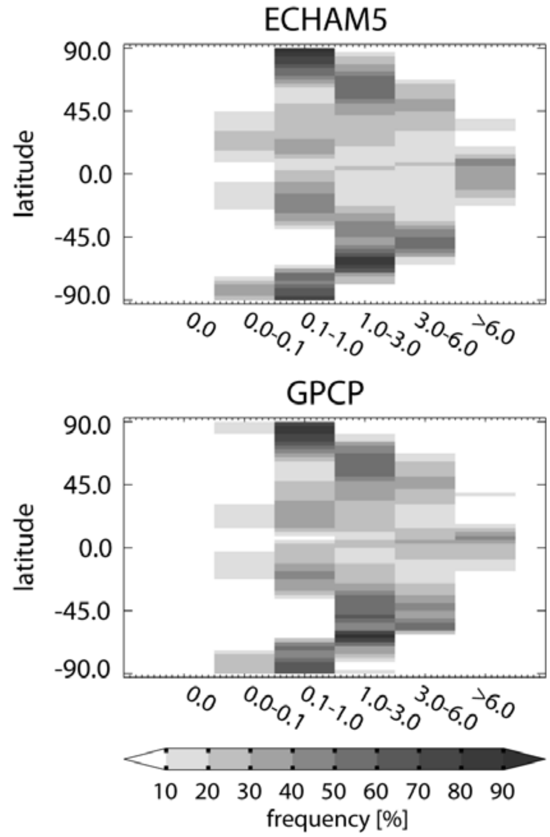


Global mean precipitation (mm/d) for ECHAM5 (10 years, upper panel) and GPCP (28 years, middle panel) as well as the difference between the global mean precipitation of ECHAM5 and GPCP scaled by the standard deviation (interannual) of the ECHAM5 simulation.

tion is scaled with the sum of the standard deviations for each grid point of both the model simulation and GPCP on an interannual basis (lower panel). ECHAM5 represents the global distribution of the precipitation quite well. The main differences appear in the tropics where the model predicts more precipitation along the Inter Tropical Convergence Zone (ITCZ) than shown by GPCP. This points to deficiencies in the parameterization of the convection in the model. Moisture convergence, which triggers convection in ECHAM5, is concentrated over Indonesia (warm pool); thus, the eastern Pacific has less moisture and, therefore, less convection. This results in lower precipitation rates for the simulations than for GPCP, as the difference plot reveals. A similar feature is visible for the Amazon basin with enhanced convection and precipitation and weakened convective precipitation in the adjacent Atlantic region. Another large feature is apparent over the Mediterranean with large negative values. This area experiences low amounts of precipitation. The model simulations show very weak variability and therefore a small standard deviation so that the very small differences are amplified and exaggerated in this area. In the southern midlatitudes a shift of precipitation between simulation and observation is apparent. The ECHAM5 forms precipitation further north than where GPCP indicates it occurs. There seems to be some deficiency in placing the frontal systems in ECHAM5 but the amount of precipitation along the storm track is captured rather well. This feature is not visible in the northern Atlantic and Pacific storm tracks.

The frequency distributions were also analyzed giving the results shown in the figure in the next column. In this analysis each grid point value of the monthly mean precipitation rate is categorized in one of the six precipitation rate classes (0 mm/d, 0–0.1 mm/d, 0.1–1 mm/d, 1–3 mm/d, 3–6 mm/d, >6 mm/d). Afterwards, the resultant frequency distributions are zonally averaged.

In general, the distributions of the GPCP observations and the ECHAM5 simulations show a very similar form. Differences appear in the tropics, where ECHAM5 overestimates the frequency of heavy precipitation events (>6 mm/d) and underestimates the frequency of the medium precipitation events in the tropics. The precipitation in the storm track regions (north and south of 45° and –45°, respectively) is captured very well. Very weak precipitation events such as drizzle are slightly overestimated by ECHAM5. In summary, the model is able to represent the zonal and global precipitation patterns rather well and seems to treat the precipitation formation sufficiently well.



Frequency distributions (zonally averaged) of global precipitation.

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SPACE OBSERVATIONS OF WATER ISOTOPES GIVE A NEW TAKE ON WATER CYCLING

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To understand the processes controlling atmospheric water, not only must the state of the water cycle be established, but the strength of key fluxes such as evaporation and precipitation must be characterized. Measurements of the stable isotope composition of water [e.g., ratio of deuterated water (HDO) to H_2O] are valuable in this regard because of isotopic fractionation in which the heavier HDO molecules are removed preferentially during condensation and lighter H_2O nuclides evaporate more readily. Since the location and condition of the water source (either evaporation from the ocean or soil or as transpiration from vegetation) differ from those of the condensation sink, global measurements of the HDO/H_2O ratio in atmospheric water vapor provide an integrated account of the history of moist processes.

Infrared emission spectra measured from the Tropospheric Emission Spectrometer (TES) on NASA's Aura spacecraft have been used to estimate the HDO to H_2O ratio for the first time on a global scale in the troposphere (Worden et al., 2006). The figure at the top of page 1 shows the annual mean distribution of HDO from TES for the layer 850 hPa to 500 hPa as δD (the deviation of the observed isotope ratio from the Vienna Standard Mean Ocean Water standard, in units of parts per thousand or permil). The horizontal footprint of each observation is 8 km by 5 km, and the error on any individual measurement is around 10 permil. More depleted values at higher latitudes indicate a long history of condensation during transit from a lower latitude source. Less depleted values in the tropics reflect ventilation of recently evaporated boundary layer vapor into the free troposphere (above 850 hPa, where TES is sensitive).

Knowledge of these differences makes possible depiction of water cycling in the atmosphere (Worden et al., 2007). The figure at the bottom of page 16 shows the TES δD observations between late October 2004 and March 2005 plotted as a function of H_2O volume mixing ratio. Evaporation is described as turbulent mixing of vapor saturated at the ocean surface into a drier air parcel aloft. The isotopic composition of this saturated layer is estimated from equilibrium theory and represents the ultimate water source (shown as the black curve in the figure to span sea surface temperatures from 5ºC to 25ºC). The orange curves in the figure show the evolution of δD under continual evaporation toward the isotopic composition of ocean sources at different temperatures. Condensation and precipitation can be described as the continual preferential removal of the heavier HDO as vapor is lost (i.e., the so-called Rayleigh process) and are represented by the cyan-colored curves assuming a condensation temperature 15ºK colder than the ocean surface (clouds at about 2.5 km). A simple description of the global atmospheric water cycle is that any given observation of an air parcel will reflect a history of evaporation and Rayleigh condensation and therefore, as shown in the figure on page 16, lie between the theoretical extremes of the curve for condensation from moisture originating over a warm oceanic source and evaporation toward equilibrium with a cold oceanic source. As such, the hydrologic cycle can be seen, as indicated by the arrows, as movement upward along the evaporation curves and downward along the condensation curves, with the isotopic composition of the vapor not changing during advective transport.

This isotopic description of the hydrological cycle is clearly seen by separating the TES data into groupings of "moist" (relative humidity is larger than 80 percent and the cloud optical depth is larger than 0.3) and "dry" (relative humidity less than 50 percent and cloud optical depth less than 0.1) as seen in the figure on page 16 as red and blue points. Since clouds and high relative humidity are consistent with condensation conditions, the moist TES observations are displaced to the right and are better aligned with the condensation curves. Similarly the dry observations are more likely to be affected by evaporation and are displaced to the left, and consequently are more aligned with the evaporation curves.

Building on this simple description, some notable exceptions arise. First, although the Rayleigh condensation model depicts an end member case, there are a number of observations more depleted than the most depleted Rayleigh curve. This can only occur if other processes act to enhance the fractionation. An example is when rain drops evaporate as they fall from clouds since there is a second opportunity for the isotopic separation—once during formation of the raindrop, and again as the drop evaporates. Given this mechanism, the percentage of rain evaporation can be estimated from the isotope measurements, as shown in the figure at the bottom of page 16 as purple curves. Mass balance indicates that rain evaporation in the tropics is about 20 percent in the mean.

Since the ultimate source of water in the atmosphere is the ocean, simple evaporation and condensation cannot produce isotope ratios less depleted than the ocean itself. A second exception to the simple cycling is found where there are observations with δD values between -100 and -50 permil in the figure at the bottom of page 16. Most of these differences are over the continents rather than the oceans. These are evidence of transpiration because unlike evaporation, transpiration is not accompanied by net isotopic fractionation. **As such, the isotopes give insight to the role of the terrestrial biosphere and provide a powerful tool for monitoring the effects of land use change on regional scale hydrology.**

A promising new development is the possibility of using TES estimates of $H_2^{18}O$, which compliments the HDO by being able to separate evaporation from transpiration and capturing rapid cycling processes such as the evaporation of rain and the formation of ice clouds. The TES observations are most reliable in the tropics and are limited to sensitivity above the boundary layer. Examining these same relationships at higher latitudes and better constraining the exchange processes at lower altitudes will require a new instrument with spectral wavelengths that are optimized for estimating the isotopic composition of troposphere water vapor, and represents an exciting opportunity for future space missions. In the meantime, should the intensity of the hydrologic cycle change, isotopic assessments can provide a framework for interpreting which processes and water sources are responsible and the TES observations have provided a baseline against which hydrologic changes can be measured.

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MODELLING OF DEEP CONVECTION AND CHEMISTRY IN THE TROPICAL TROPOPAUSE LAYER: OUTCOMES FROM THE SPARC-GEWEX-IGAC WORKSHOP

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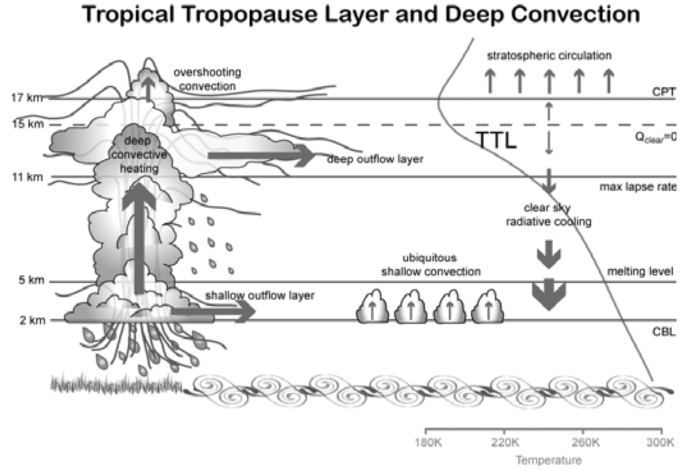
The Tropical Tropopause Layer (TTL) is an example of coupling between dynamics, radiation (including cloud and ozone feedbacks) and cloud microphysics. Convection in the tropics plays a key role in redistributing trace gases and aerosols in the Upper Troposphere Lower Stratosphere region, and the interaction between cloud dynamics, radiation and microphysics is of fundamental importance in these processes. The global scale models used to study climate typically have spatial and temporal resolutions that limit their ability to properly represent many of these processes, yet a solid understanding of their role is necessary. Cloud Resolving Models (CRMs), particularly when supported by observations, can be used to better understand the different processes and their interactions.

The TTL is a transition region where the combination of large-scale and convective processes (see figure below) result in mixed stratospheric and tropospheric properties. Observations suggest regions of deep convective outflow in the upper troposphere, typically between 10 km and 18 km with a local maximum near 12–14 km. The level at which clear-sky net radiative heating vanishes (Q_{clear}=0) is located near the top of the convective outflow layer; however, a significant amount of convection penetrates above this level. Other defining features of the TTL

Tropical Tropopause Layer and Deep Convection



region include a maximum in the temperature lapse rate in the upper troposphere, often found near the level of maximum convective outflow, a less pronounced minimum in ozone near this level with a rapid increase above, and a more uniform vertical structure of the wind and temperature fields.

The magnitude and variation of water vapor in the tropical lower stratosphere is regulated within the TTL. The minimum in water vapor that is typically found in the stratosphere near the tropopause is indicative of the dehydration of air ascending into the lower stratosphere. Dehydration associated with large-scale transport is a mechanism that has been explored extensively in the context of Lagrangian trajectory studies, wherein possible trajectories of air parcels passing from the troposphere to the stratosphere through the TTL are determined using wind fields derived from large-scale reanalyses.

At a joint workshop (*see report at http://www.atmosp.physics.utoronto.ca/SPARC/Newsletter%2028_web/Newsletter%2028.pdf*) held in 2006 with the GEWEX Cloud Systems Study (GCSS) Precipitating Convective Cloud Systems (PCCS) Working Group, the Stratospheric Processes And their Role in Climate (SPARC) Project, and the International Global Atmospheric Chemistry (IGAC) Project, discussions on ways to improve understanding of the role of convection in determining the thermal structure and composition of the TTL led to a number of collaborative activities. Some of the case studies that have been used by the PCCS Working Group (e.g., the Tropical Ocean Global Atmosphere Coupled Ocean Atmosphere Response Experiment–TOGA COARE) in previous CRM comparisons are being revisited with the objective of developing a better understanding of modelling issues in convective scale processes that are of importance in the TTL. As an initial step, the 2006 GCSS Deep Convection Intercomparison case of TOGA COARE will be exploited with the inclusion of 1-2 tracers. Modelling intercomparison case studies are planned to facilitate the examination of TTL processes and will include observations from recent field campaigns (e.g., Tropical Warm Pool International Cloud Experiment, the Tropical Convection, Cirrus and Nitrogen Oxides Experiment, the Stratospheric-Climate Links with Emphasis on the UTLS-O3, Aerosol and Chemical Transport In Tropical Convection and the African Monsoon Multidisciplinary Analysis Project).

Future intercomparison studies may include mass flux analyses. Also under consideration is a field study conducted in concert with cloud-scale and large-scale model simulations to quantify the mass flux of key compounds by convection into the TTL.

AIRS—A FACILITY INSTRUMENT FOR CLIMATE RESEARCH

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The Atmospheric Infrared Sounder (AIRS) is one of six instruments on board the National Aeronautics and Space Administration's (NASA's) Aqua satellite launched in a sun-synchronous near-polar orbit on May 4, 2002. AIRS and its partner microwave instrument, the Advanced Microwave Sounding Unit (AMSU-A), provide high quality data facilitating studies of the global water and energy cycles, climate variation and trends, and the response of the climate system to increased greenhouse gases.

The exceptional stability of the AIRS instrument provides climate record quality thermal infrared radiances spanning the 3.74–15.4 mm spectral band with 2378 channels at a nominal resolution of l/Dl = 1200 (Chahine et al., 2006). Currently, assimilation of AIRS radiances by the National Centers for Environmental Prediction (NCEP) has extended the operational National Oceanic and Atmospheric Administration (NOAA) 6-day weather forecasts by 6 hours (Le Marshall et al., 2006).

Water vapor in the atmosphere is critically important to the determination of the warming of the Earth as a result of anthropogenic forcing. Comparison of the AIRS specific humidity product to state-of-the-art climate models has shown most models exhibit a pattern of drier than observed (by 10–25%) in the tropics below 800 hPa and moister than observed (by 25–100%) between 300 and 600 hPa in the extra tropics (Pierce et al., 2006). The figure on the bottom of page 1 showing the AIRS retrieved water vapor integrated from the top of the atmosphere down to the 500 hPa level averaged over the month of January 2003 is an example of a product that can be used in model evaluations.

AIRS water vapor measurements also reveal tropospheric moisture perturbations that are much larger than those depicted in previous NCEP reanalysis and European Centre for Medium-Range Weather Forecasts (ECMWF) analysis data sets, both of which have been widely used to validate models. This suggests that the impact of convection-induced downdrafts on the atmospheric boundary layer is significantly underestimated in both ECMWF and NCEP reanalyses (Fu et al., 2006).

AIRS data have led to the discovery of significant differences in the lower troposphere moisture and temperature fields during the evolution of the Madden Julian Oscillation (MJO). The anomalous lower troposphere temperature structure is observed in detail by AIRS for the western Pacific, while it remains much less well defined in the NCEP temperature fields (Tian et al., 2006).

Increased attention has been given to atmospheric composition due to its critical impact on the climate system. In addition to temperature and water vapor, AIRS data products include ozone (O_3), carbon monoxide (CO), research carbon dioxide (CO_2), and methane (CH_4), as well as flags for sulfur dioxide (SO_2) and dust. The SO_2 flag is transmitted by NOAA within 3 hours of observation to the Washington Volcanic Ash Advisory Center (WVAAC) to alert airline pilots to the presence of volcanic eruption plumes.

AIRS data have provided detailed, daily global observations of the transport of mid-tropospheric CO from biomass burning emissions (McMillan et al., 2005). The transport of this product of slash and burn agriculture practiced in South America, Africa and Indonesia can be tracked daily as it repeatedly rises into the free troposphere and then is transported over the South Atlantic, Indian and Western Pacific Oceans. Transport of CO from China and large fires in Siberia is also traced across the Northern Pacific Ocean to North America.

Maps of CO_2 in the tropical cloud-free upper troposphere also have been produced from AIRS data. Current research by the AIRS Project has shown that direct retrievals are capable of providing detailed daily global maps of the mid-tropospheric (300–500 hPa) CO_2 distributions with a demonstrated accuracy of ±1.2 ppmv (Chahine et al, 2005). Significant differences have been found between numerical models derived and AIRS derived CO_2 abundances outside of the tropics, raising questions about the lower to upper troposphere transport pathways in current numerical models.

Information about the AIRS mission, products and research may be found at: *http://airs.jpl.nasa.gov*. AIRS data products are freely accessible at the Goddard Earth Sciences Data and Information Services Center at: *http://disc.gsfc.nasa.gov/AIRS/*.

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GEWEX SCIENTISTS AMONG 2007 ELECTED AGU FELLOWS

GEWEX congratulates the following scientists elected as 2007 American Geophysical Union Fellows: Dr. Dennis D. Baldocchi, University of California, Berkeley; Dr. William K. M. Lau, NASA Goddard Space Flight Center; Dr. John C. Schaake, NOAA National Weather Service; Dr. Kevin E. Trenberth, National Center for Atmospheric Research.

GEWEX NEWS

Published by the International GEWEX Project Office

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WORKSHOP/MEETING SUMMARIES

FIRST NEESPI SUMMIT

3–4 May 2007
Helsinki, Finland

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The Northern Eurasian Earth System Partnership Initiative (NEESPI), a multinational, interdisciplinary environmental research project that addresses global change issues in northern Asia, held its first Summit at the University of Helsinki. The meeting was hosted by the Integrated Land Ecosystem-Atmospheric Processes Study (iLEAPS) Project office. The approximately 35 participants included NEESPI theme leaders, and representatives from national agencies and organizations and from international programs.

Since the NEESPI Science meeting held in Vienna, Austria in February 2006, the Initiative has grown in scope and level of activity. Through projects funded by the National Aeronautics and Space Administration (NASA), the U.S. National Science Foundation, the Russian Academy of Sciences (RAS), and the International Association for the Promotion of Co-operation with Scientists from the New Independent States of the Former Soviet Union (INTAS) Program supported by the European Union, NEESPI has launched at least 40 new projects, mainly in the physical sciences, and is developing a number of new data sets. In January 2007, GEWEX accepted NEESPI as a Regional Hydrology Project (RHP) within the framework of its Coordinated Energy and Water Cycle Observations Project (CEOP). NEESPI also has been endorsed by iLEAPS, the Global Land Project (GLP), and the Climate and Cryosphere (CliC) project. In addition, the International Geosphere-Biosphere Programme (IGBP) has accorded more visibility to NEESPI as a regionally integrated project, giving NEESPI wider recognition and influence. These programs value NEESPI because it (1) provides people in the region with access to international expertise, such as capacity building and more effective problem solving; (2) facilitates the collection of and access to data not normally available in the region; (3) serves as a platform for observing a challenging and critical part of the world; (4) liaises between this part of the world and the international environmental science community; and (5) provides leverage for national investments and infrastructure. They also encouraged NEESPI to better integrate its activities, thereby making interactions with other global and regional programs and projects more effective.

Implementation of the NEESPI data set development and sharing has progressed over the past year although the need for a centralized database is still being discussed. NEESPI plans to explore the possibility of making greater use of the CEOP data system, new ways to get support for regional data systems (including one or more in the NEESPI region) and the logistical problems of research activities in the NEESPI area. It was noted that NEESPI could play a very important role in international science by facilitating the movement of instrumentation into and out of the Eurasian North, but it needs a dedicated coordination mechanism to provide this service.

The structure of NEESPI was reviewed at the Summit and the opportunities for integration at the regional and the theme levels were discussed. While the current structure of centers and theme leads have the potential to facilitate a great deal of collaboration and integration, it was felt that this full potential is not being fully realized due to a lack of financial support. One of the key elements needed is an international project office. As a result of the discussions in an executive breakout session, a preliminary agreement was reached between NASA and the European Space Agency (ESA) regarding support for a possible office based in Europe. Negotiations are underway to make such an office a reality using additional support of several European institutions and agencies.

The Summit considered a number of new opportunities for NEESPI. One potential link is a connection with Group on Earth Observations (GEO) and the possibility of sponsoring a GEO demonstration project in the Eurasian region. NEESPI has already had discussions about initiating a regional focus study within the Global Water System Project (GWSP); this type of activity could expand beyond a water focus and involve carbon and biological issues as well as governance and resiliency. NEESPI also has the potential to provide breakthroughs in understanding the role of atmospheric aerosols and air pollutants in climate change at the regional and global scales. Given the recommendations in the latest Intergovernmental Panel on Climate Change (IPCC) report, there is also considerable opportunity for NEESPI to study processes of change in the north and to provide leadership for climate change studies in this area.

It was agreed that the next Summit should be held in conjunction with a NEESPI Science Team meeting in May 2008.

GABLS WORKSHOP

19–21 June 2007
Stockholm, Sweden

Bert Holtslag[1] and Gunilla Svensson[2]

[1]Department of Meteorology and Air Quality, Wageningen University, The Netherlands, [2]Department of Meteorology, Stockholm University, Sweden

Twenty-five scientists attended the GEWEX Atmospheric Boundary Study (GABLS) Workshop to review results from GABLS2, the second GABLS intercomparison case. GABLS2 studied the representation of the diurnal cycle over land and is based on observations of the Cooperative Atmosphere-Surface Exchange Study (CASES)-99 (Poulos et al., 2002).

In the opening session, an overview was given on the current status of modelling the atmospheric boundary layer at regional and larger scales. One of the ongoing topics of GABLS is the issue that operational weather models show boundary layers in stable conditions that are too deep, which results in the erosion of low level jets (LLJs) and underestimation of the turning of wind with height. This is related to the enhanced mixing that models often use to have sufficient Ekman pumping and realistic pressure distributions on the larger scale, and perhaps also to compensate for model errors.

We are happy to report that the modelling groups at the European Centre for Medium-Range Weather Forecasts (Martin Koehler), the UK Met Office (Adrian Lock) and the High Resolution Limited Area Model (HIRLAM) Programme (Sander Tijm) have been inspired by GABLS results to study and possibly improve their representations of the stable boundary layer. It is clear that this issue has not been resolved and needs further attention. It also appears that changes in the mixing formulation may have strong impacts on the representation of fog and clouds.

Recent findings were presented for stable boundary layers over land (Bas Van de Wiel), the possible importance of unresolved terrain-induced gravity wave drag (Gert-Jan Steeneveld), and the relevance of surface heterogeneity on various scales (Adrian Lock). In addition, talks were given on the climatology of LLJs at Cabauw (Peter Baas) and the modelling of marine boundary layers (Kay Suselj). The representation of the boundary layer is also very important for atmospheric chemistry and Earth system studies (as presented by Laurens Ganzeveld), and as such has important links with International Geosphere-Biosphere Programme projects such as the Integrated Land Ecosystem-Atmospheric Processes Study (iLEAPS).

Gunilla Svensson presented a recent analysis of model results by the second GABLS experiment on the diurnal cycle over land. It is clear that the models produce very different results in all parameters and that they all differ substantially from the observations of CASES-99. In particular, the underestimated diurnal cycle in the 10-m wind speed is noted, as well as the large variety for sensible heat fluxes (Svensson and Holtslag, 2007).

Given the large variation of model results, to what extent does the setup of the case influence the results? Bert Holtslag addressed this question, discussing the impact of both the forcing and boundary conditions on the variability of model results. It appears that the variability in model results is typically smaller when the boundary layer schemes are coupled to the land surface. Thus, prescribing the surface temperature as in GABLS2 seems to be a more critical test for the boundary layer than allowing surface interaction. The lower boundary condition for the experiments has been debated for a long time and is now being examined in a Large Eddy Simulation (LES) study where simulations using either prescribed surface temperature or heat flux are used (Vijayant Kumar). The influence of the constant versus variable geostrophic forcing was also examined, providing useful information as an independent check of the column model outputs. The results from GABLS2 have also inspired researchers to run the case for advancing their own models (Venjamin Perov and Matteo

Participants at the GABLS Workshop.

Buzzi) and for mesoscale model intercomparisons (Steeneveld).

GABLS2 tackles more realistic and increasingly difficult cases of atmospheric boundary layers, such as inertial oscillations and LLJs. LLJs are of great importance to the dynamics of the stable boundary layer and the transport of atmospheric constituents. Moreover, these LLJs may influence the morning time transition. Since the inertial oscillation is part of the prognostic equations of Single Column Models (SCM), these models are in principle able to simulate. However, given the GABLS2 results, it is very difficult to accurately represent the details of decoupling around the time of sunset and mixing during the morning-time transition. Suggestions made by GABLS2 participants for further investigation include (1) conducting a consistency test on the variety of results; (2) studying the impact of the initial conditions; and (3) studying the impact of the LLJ of the previous night on the momentum mixing in the morning.

The setup of a new intercomparison case was discussed on the basis of data gathered by the Royal Netherlands Meteorological Institute (KNMI) at the Cabauw tower (Fred Bosveld). The Cabauw site with its 200-m meteorological tower is situated in a very flat environment dominated by grassland (for more information, visit *http://www.knmi.nl/research/climate_research.html*). As such, it has a relatively simple land surface. On many nights a LLJ develops due to decoupling and inertial oscillation. Currently the observational program includes profiles of wind speed, wind direction, temperature, humidity and CO_2 along the tower, the full surface radiation budget and the full surface energy budget. Moreover, the tower is equipped with turbulence instruments at four different heights, including profiles of the turbulent fluxes of momentum, heat, water vapor and CO_2. A wind profiler/Radio Atmospheric Sounding System allows for observations of wind speed, wind directions and virtual temperature at levels exceeding the tower. Radio soundings twice a day are available from the nearby (25 km) synoptical station De Bilt. Appropriate estimates of Planetary Boundary Layer height and advection terms should be possible as well.

Although it seems possible to use the CASES-99 and even the Wangara data (well-established and almost 40 years old), the outcome of the discussions was to set up the new LES intercomparison on the basis of the Cabauw data. As such, we expect a more direct comparison with observations to be possible. Special care should be given to good forcing conditions and to initial profiles and spin-up. In addition, LES and SCM runs with same model levels as each other and the tower are of interest.

In addition to the Cabauw data, data gathered by the German Meteorological Service (Deutscher Wetterdienst, DWD) at and around the Lindenberg site was presented in comparison with model results (Frank Beyrich). The observations from this site are attractive to study for future intercomparisons, because the site is located in a more heterogeneous landscape that provides additional complexity for boundary-layer and land-surface modelling.

It was strongly argued that the GABLS community needs to better integrate with modellers at weather forecast and climate centers. This can perhaps best be achieved by facilitating regional model intercomparisons such as in the Arctic Regional Climate Model Intercomparison (Michael Tjernström) and by acquiring and comparing short-term forecasts from full GCM models for the study point on interest. This issue will require further discussion and coordination within the GEWEX.

It is anticipated that the new intercomparison case for LES and SCM on the basis of the Cabauw data will be released by November 2007. Please consult the GABLS website (*http://www.met.wau.nl/projects/Gabls*) for updates. The aim is that the first results of the next case will be presented in June 2008 at the next American Meteorological Society/Boundary Layers and Turbulence (AMS-BLT) conference in Stockholm, Sweden.

Acknowledgements: The authors thank the International Meteorological Institute, Stockholm University Climate Research Environment and Department of Meteorology at Stockholm University for providing funds and facilities for the organization of the workshop.

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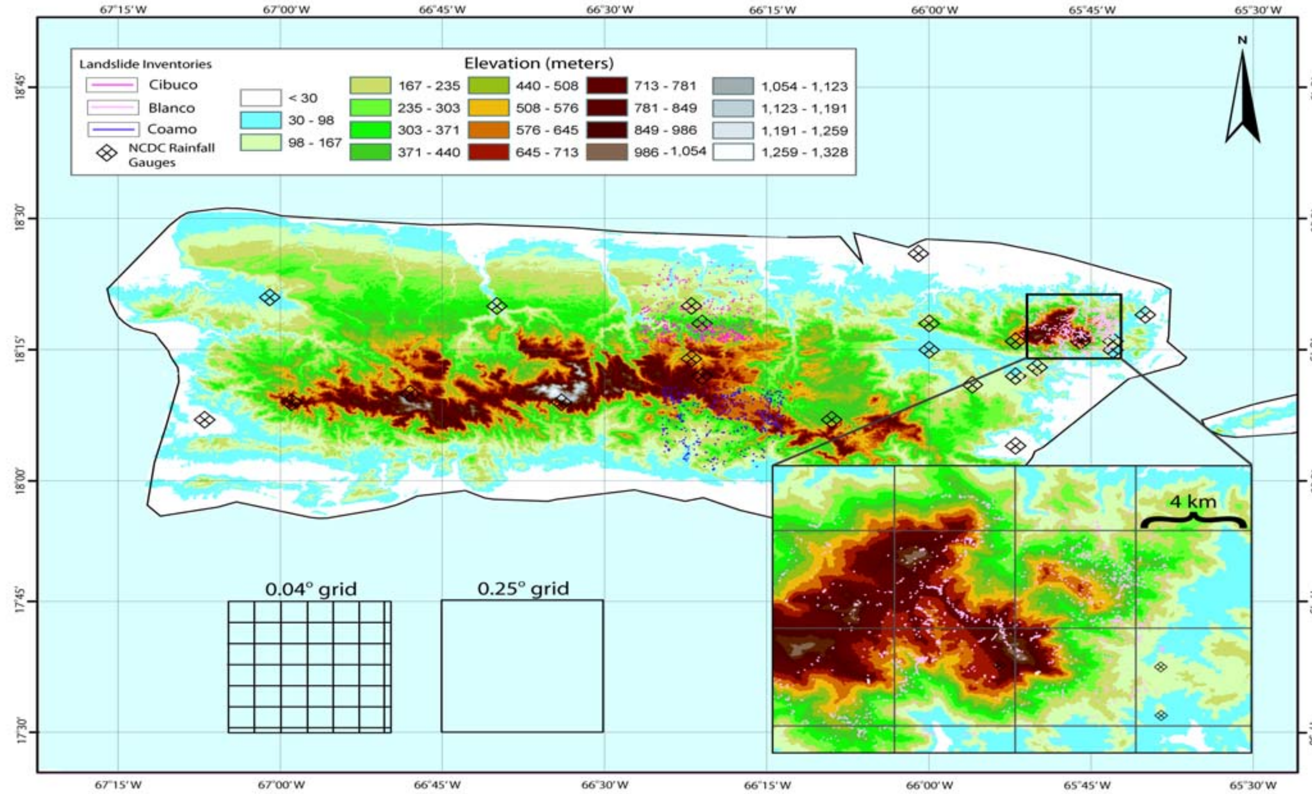
GEWEX/WCRP MEETINGS CALENDAR

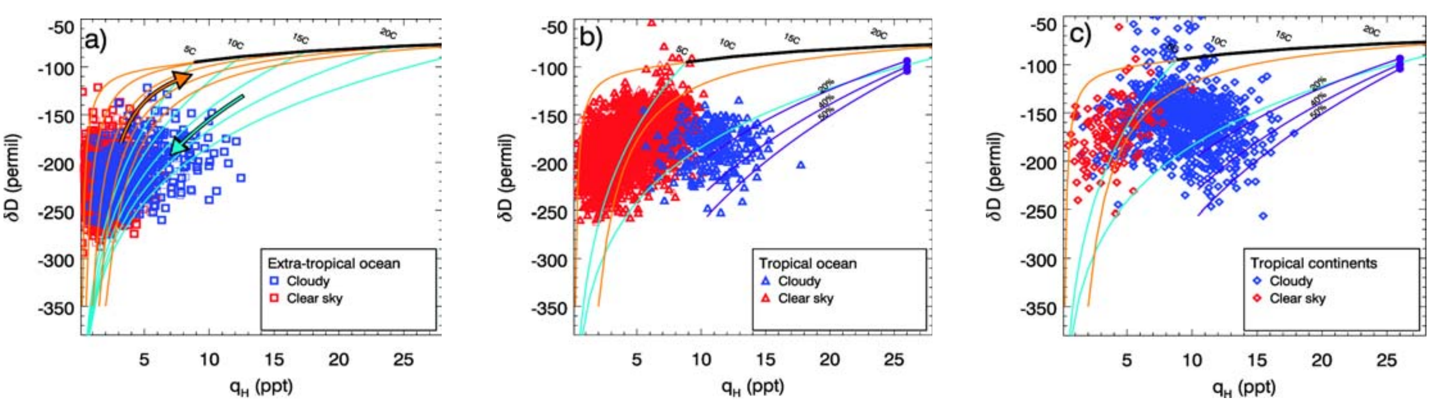
For a complete listing of meetings, see the GEWEX web site: http://www.gewex.org.

RAINFALL PRODUCTS SHOW POTENTIAL FOR USE IN LANDSLIDE HAZARD ASSESSMENT IN THE CARIBBEAN REGION



Comparison of satellite data resolution differences over Puerto Rico to land slide inventories. Map shows a 30-m digital elevation model and location of rainfall gauging stations. The grid boxes indicate the resolution of the current satellite precipitation products. The three landslide inventories were done by Larsen and Torres-Sanchez (1998). See article by D. Bach et al. on page 5.

TES ISOTOPIC OBSERVATIONS ARE PROVIDING A BASELINE AGAINST WHICH HYDROLOGIC CHANGES CAN BE MEASURED



The deviation of the observed isotope ratio (δD) as a function of water vapor volume mixing ratio (q_H) between October 2004 and March 2005 for (a) extra-tropical oceans, (b) tropical oceans, and c) tropical continents. Moist (blue) observations more closely follow cyan condensation curves while dry (red) observations follow evaporation lines, as indicated by the arrows in (a), and represent the water cycle. Evaporation of falling rain causes more depletion (purple curves), while values enriched relative to the ocean source (black curve) signify transpiration (adapted from Worden et al., 2007). See article by D. Noone et al. on page 9.