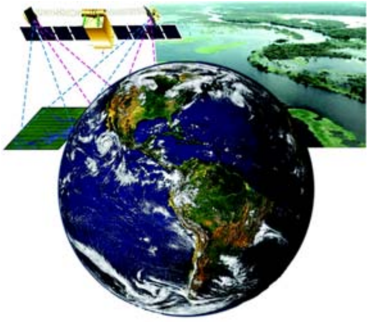
GEWEX NEWS
WCRP
World Climate Research Programme
(A Programme of WMO, ICSU and IOC)

Vol. 15, No. 2 **Global Energy and Water Cycle Experiment** May 2005

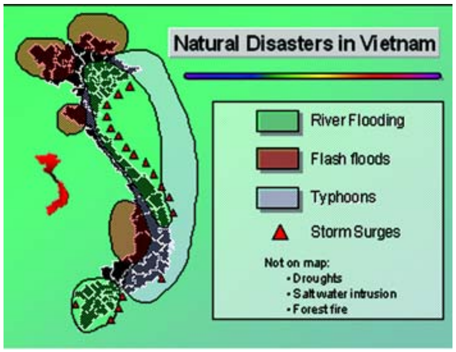
GEWEX AND EXTREME EVENTS

Extreme Events

Observations

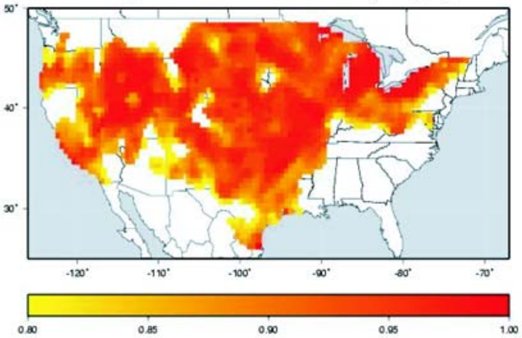


Planning and Response



Assimilation and Reanalysis

U.S. Drought Extent and Severity in July 1934



5th International Scientific Conference on the Global Energy and Water Cycle

160 Oral Presentations and 175 Posters on the Program (see page 4)

Newsletter Contents

COMMENTARY

A MORE FOCUSED AGENDA FOR GEWEX APPLICATION EFFORTS

Soroosh Sorooshian, Chairman
GEWEX Scientific Steering Group

When GEWEX was originally conceived by the World Climate Research Programme (WCRP) in the late 1980s, it established a number of scientific, observation, and modelling objectives to guide its contributions to society. With respect to the latter, the stated objective has been to **"develop the ability to predict the variations of global and regional hydrological processes and water resources, and their response to environmental change."** During the early years of GEWEX, and for obvious reasons of the required progression from *science to applications*, other GEWEX objectives received higher priority. The Continental Scale Experiments (CSE), under the GEWEX Hydrometeorological Panel (GHP) were given the lead, but their results were mixed and on the average did not meet expectations.

To better address this deficiency, GHP established the Water Resources Application Project (WRAP) with the mandate to explore how best the science, knowledge, and information generated by GEWEX can be transferred to the water resources management community. WRAP, under the able leadership of Lawrence Martz, has done a commendable job in sponsoring a number of sessions at various national and international conferences, and sharing the results of the various application projects. The experience thus far has shown that:

- While a number of water resources case studies and application projects have been supported [especially by the GEWEX Continental-scale International Project (GCIP)/ GEWEX Americas Prediction Project (GAPP)], it is not clear to what extent these projects benefited directly from GEWEX products (i.e., science, modelling and observations). Would the results and outcomes of these projects have been any different without GEWEX?

- While "politically appealing," the original GEWEX objective was simply too broad and provided no realistic roadmap. Furthermore, prior to WRAP, there was little input from the user side to articulate a realistic plan.

- The resources required to carry out this objective to a minimum level have never been sufficient. Allocating a few hundred thousand dollars or euros out of the science budget for GEWEX-related research will not do the job except to give a "good impression."

- Finally, GEWEX alone cannot fulfill this objective, even when it is defined more narrowly.

In GEWEX Phase II we are attempting to address the above issues. We have revised this objective by targeting the operational hydrometeorological services and hydrologic research programs as the primary user communities. We believe that it is much more realistic to infuse GEWEX products into hydrologic models and hence to improve the quality and reliability of hydrologic predictions so critical to the water resources management community. For example, Global Land Data Assimilation System and Global Soil Wetness Project products should be ideal candidates for initializing and updating the states of the hydrologic rainfall runoff models, as well as filling the void in some of the input data requirements of distributed hydrologic models. The high resolution land-surface models, a GEWEX achievement, can serve as a bridge to link longer term (up to seasonal-to-interannual) climate predictions to ensemble hydrologic forecasts to guide reservoir operators and drought management.

This new objective poses a challenge for WRAP and GEWEX/WCRP. WRAP must help the CSEs team up with the appropriate hydrologic services and develop some demonstration and pilot projects within their geographic regions. This is already happening through a partnership between GAPP and the U.S. National Weather Service Office of Hydrologic Development.

Perhaps a bigger challenge is to go beyond these demonstration projects and make a difference at the global scale. GEWEX needs closer collaboration with those hydrologic and water resources programs that coordinate hydrologic services and information gathering and dissemination among member nations. The World Meteorological Organization's (WMO) Hydrology and Water Resources Division and the United Nations Educational Scientific and Cultural Organization's (UNESCO) International Hydrology Programme are the two obvious partners for GEWEX.

As a first step, WRAP organized a workshop in Cairo between GEWEX/WCRP and UNESCO's Water and Development Information for Arid Lands-A Global Network (G-WADI) Initiative to assess the hydroclimate prediction needs of the world's semi-arid regions (see page 18). Furthermore, the recent hydrologic modelling workshop in April held in Roorkee, India assessed the hydrologic modelling needs of semi-arid regions and the barriers to using more advanced models, especially in developing countries.

While we are making good headway with UNESCO, our engagement with WMO's Hydrology Programme has yet to develop. There is a growing need to show the benefits of mutual cooperation between the two WMO programmes so that they can better serve the hydrologic prediction needs at the global scale. In addition to the WRAP efforts, the Directors of WCRP and the WMO Hydrology and Water Resources Programs need to initiate a dialogue.

RECENT NEWS OF RELEVANCE TO GEWEX

GEWEX Reaches Out to the European Science Community

Thanks to the efforts of Dr. Peter van Oevelen, a special side session on GEWEX was organized at the European Geophysical Union in Vienna in April 2005. The session featured presentations on many of the major projects within GEWEX as well as an overview of the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS). It is hoped that these efforts will encourage more members of the European scientific community to engage actively in addressing science questions that are central to the GEWEX endeavor. In addition, Ms. Catherine Michaut from the WCRP/Coordinated Observation and Prediction of the Earth System (COPES) Project Office distributed material on WCRP and its projects to attendees. A planning session for the GEWEX Hydrometeorology Panel Transferability study was organized by Dr. Eugene Tackle and chaired by Dr. William Gutowski.

ISLSCP Initiative II Workshop

On 3–5 May 2005 an international workshop was held at the University of Maryland, Baltimore County, to examine the results of early analysis carried out with the new International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data sets, and to discuss plans for the future of ISLSCP within GEWEX. The meeting, which drew scientists from the U.S. and Europe, endorsed the usefulness of the Initiative II products for model development and validation, and identified some areas where improvements and metadata are needed.

Discussions about ISLSCP Next explored the possibility of developing a data set that was targeted to a specific scientific thrust and ways to entrain European and other international activities such as the Global Monitoring for the Environment and Security into the process.

iPILPS First International Workshop

The isotopes in the Project for Intercomparison of Land-surface Parameterization Schemes (iPILPS), which is evaluating and refining isotope-enabled land-surface schemes in weather, climate and Earth system models was "kicked off" at a highly successful 5-day international workshop hosted at the Australian Nuclear Science and Technology Organization in Sydney, Australia in April 2005. This workshop featured presentations from respected international and local research leaders, and discussions aimed at evaluating and improving representations of stable water isotope processes in the land surface schemes of global climate models. Further information can be found on the iPILPS web page: http://ipilps.ansto.gov.au/.

GEWEX Outreach

In April, materials on GEWEX, the Coordinated Enhanced Observing Period, the Global Water System Project, and WCRP were distributed via information tables organized by the Integrated Global Observing Strategy-Partners and the Committee on Earth Observation Satellites at the Commission for Sustainable Development Meeting in New York City, New York, U.S.A. and the European Geophysical Union Meeting in Vienna, Austria.

NOTICE

Under "GEWEX AMS Honorees" in the February 2005 issue of *GEWEX News*, John Roads, Chair of the GEWEX Hydrometeorology Panel, should also have been recognized as a new American Meteorological Society Fellow.

5th INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE

Costa Mesa, California, USA

ABBREVIATED PROGRAM

(for the complete program, see http://www.gewex.org/5thconf.htm)

Conference Themes and Presentation Foci:

Theme 1: Clouds and their Effect on the Radiation Budget
Theme 2: Predictions for Water Management
Theme 3: Roles of Land Fluxes in Water and Energy Cycles
Theme 4: The Role of Modelling in Predictability and Prediction Studies
Theme 5: New Strategies for Characterizing and Predicting Energy and Water Budgets
Theme 6: Measuring and Predicting Precipitation
GAPP: GEWEX Americas Prediction Project
CEOP: Coordinated Enhanced Observing Period

Sunday, 19 June 2005

1700 – 2000: Early Registration and Icebreaker

Monday, 20 June 2005

0700 – 0845: Conference Registration
0845 – 1025: Plenary Session
0845 – 0900: Introductions
0905 – 1025: Key Note Speakers

0905 – 0925: *COPES: An Integrative Strategy for WCRP,* Peter Lemke (Alfred Wegener Institute, Germany)

0925 – 0945: *Priorities for US Water Cycle Research (TBC)*, Kathie Olsen (Office of Science and Technology Policy, USA)

0945 – 1005: *Overview of NASA's Satellite Observations of Water in the Earth System,* Jack Kaye (NASA Science Mission Directorate, USA)

1005 – 1025: *The Contributions of ESA to Energy and Water Cycle Observations and Research,* Einar-Arne Herland (European Space Agency/ESTEC, The Netherlands)

1025 – 1040: Morning Break
1040 – 1220: Simultaneous Sessions, Themes 1 and 2
1220 – 1400: Lunch
1400 – 1530: Simultaneous Sessions, Themes 1 and 2
1530 – 1600: Afternoon Break
1600 – 1700: Simultaneous Sessions, Themes 1 and 2
1700 – 1800: Poster Viewing, Themes 1 and 2

Tuesday, 21 June 2005

0830 – 1020: Plenary Session
1020 – 1040: Morning Break
1040 – 1220: Simultaneous Sessions, Themes 1 and 3
1220 – 1400: Lunch
1400 – 1530: Simultaneous Sessions, Themes 2 and 3
1530 – 1600: Afternoon Break
1600 – 1700: Simultaneous Sessions, Themes 3 and 4
1700 – 2000: Poster Viewing, Themes 3, 4 and GAPP
1800 – 2000: GAPP Townhall Meeting and Reception

Wednesday, 22 June 2005

0830 – 1010: Plenary Session
1020 – 1040: Morning Break
1040 – 1220: Simultaneous Sessions, Themes 3 and 4
1220 – 1400: Lunch
1400 – 1530: Simultaneous Sessions, Themes 3 and 4
1530 – 1800: Side Sessions for Working Groups
1900 – 2130: Banquet
Speaker: Wes Bannister, Chairman, Board of Directors, Metropolitan Water District of Southern California, Topic: *Planning for Uncertainty in No Uncertain Terms: A Water Agency's Mission to Ensure Reliability*

Thursday, 23 June 2005

0830 – 1020: Plenary Session
1020 – 1040: Morning Break
1040 – 1220: Simultaneous Sessions, Themes 4 and 5
1220 – 1400: Lunch
1400 – 1530: Simultaneous Sessions, Themes 5 and 6
1530 – 1600: Afternoon Break
1600 – 1700: Simultaneous Sessions, Themes 5 and 6
1700 – 2000: Poster Viewing, Themes 5, 6 and CEOP
1800 – 2000: CEOP Townhall Meeting and Reception

Friday, 24 June 2005

0830 – 1010: Plenary Session
1020 – 1040: Morning Break
1040 – 1250: Simultaneous Sessions, Themes 5 and 6
1240 – 1400: Lunch
1400 – 1530: Panel Discussion: *GEWEX PHASE II: Providing Leadership for COPES,WCRP, IGBP and the Climate and Earth Observations Communities*
1530 – 1540: Conference Close

A FOCUS ON EXTREMES IN GEWEX

Ronald Stewart
McGill University, Canada

Importance of Extremes: One of the most critical aspects of the water and energy cycle is the occurrence of extremes such as droughts and extended wet periods. Not only do they have enormous impacts when and where they occur but they are also fundamental features of the climate system.

Extremes and GEWEX: The strategy of the GEWEX Hydrometeorology Panel (GHP) has concentrated on assembling relevant data sets, addressing long-term water and energy budgets, assessing sources and sinks of moisture, and interacting with the water resource community. GHP, along with the other GEWEX components, is now ready to examine extremes in a systematic manner. The primary objectives of this effort will be to *better understand and model the occurrence, evolution, and role of extremes within the climate system and to contribute to their better prediction*. These objectives will be addressed by determining the extent to which similar processes are responsible for extremes in different regions, and understanding the processes that link extremes in different regions and how they may be changing.

In part these activities will consider: (1) extremes as a natural follow-on to current water and energy budget related studies; (2) the Coordinated Enhanced Observing Period (CEOP) Phase I data period as a case study; and (3) trends in the occurrence of extremes through the analysis of long-term records.

To some extent a study of extremes would build on existing initiatives. In particular, it could expand the Water and Energy Budget Study (WEBS) with a focus on droughts and extended wet periods rather than on the average conditions occurring in those regions. During Phase I of CEOP (2001–2004), numerous extremes occurred, including a long-lasting drought over western North America, a devastating heat wave in Europe, and periods of drought as well as flooding over Asia, South America, Australia, and Africa. On longer time scales, multi-decade records assembled by GEWEX and other groups, including re-analysis efforts, can all be exploited to focus on trends in extremes.

Extremes are important to other climate and disaster related initiatives. Linkages will be developed with other WCRP projects and international efforts including disaster research.

USE OF INDICES IN CHARACTERIZING PRECIPITATION EXTREMES: A EUROPEAN EXAMPLE

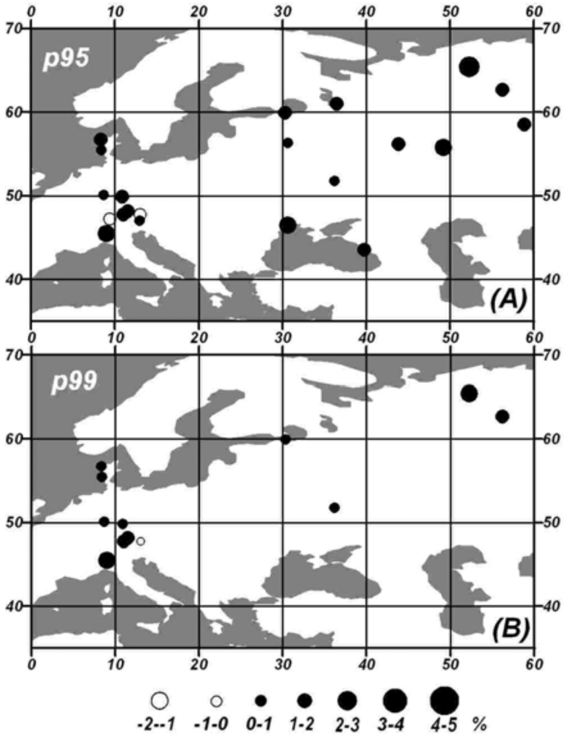
Olga Zolina[1], Clemens Simmer[1]
Alice Kapala[1], and Sergey Gulev[2]

[1]Meteorologisches Institut, Universitaet Bonn, Germany, [2]P. P. Shirshov Institute of Oceanology, Moscow, Russia

Accurate estimates of the changes in extreme precipitation from station measurements are very important for validation of model experiments aimed to quantify trends in extreme precipitation under global warming. The linear trend estimates in extreme precipitation indices over Europe show increasing probability of the occurrence of heavy precipitation for both stations and models. Although these indices may be qualitatively consistent with each other, they may, however, show some disagreement in their quantitative estimates of linear trends (Frei and Schar, 2001; Groismann et al., 2005; Klein Tank and Koennen, 2003). Moreover, when missing values of daily precipitation are inhomogeneously distributed they contribute additional uncertainty in the trend estimates.

In this study, we used daily rainfall data from the Royal Netherlands Meteorological Institute European Climate Assessment data set along with the collections of the Russian National Climate Data Center and the German Weather Service (Zolina et al., 2004). These data consist of 295 stations from 1804–2003 with 96 station records longer than 100 years and characterized by the homogeneity of the observational practices. Using 22 stations with records without gaps we derived the distributions of the number of missing values and of the durations of gaps, and developed sampling models which were used for the homogenization of centennial daily records for all 96 stations with complete records. From the homogenized time series we derived different precipitation indices and further analyzed linear centennial trends in these indices. The three indices used were the exceedance of 95% threshold *(G95)* (Groismann et al., 2005), the percentage of seasonal total during very wet (>95%) days (R95) (Klein Tank and Koenen, 2003) and the 95% percentile (p_{95}) of precipitation from the estimated Gamma distribution for the daily precipitation (Zolina et al., 2004).

Trend estimates (in percentage per decade) for R95 may exhibit locally significant differences with



Estimates of linear trends in annual values of (A) p_{95} *and* (B) p_{99} *in the locations where all three indices* (p_{95}, R95, G95*) computed from the homogenized time series are significant according to the chosen criteria.*

those for p_{95}, while trends in G95 are very close to p_{95}. During winter, trends in p_{95} and R95 are primarily positive in Central and Eastern Europe (2–7% and 3–10% per decade, respectively). In 43 locations the indices demonstrated significant changes. However, the trends in all three indices are significant and show the same sign at only 19 locations. In Western Europe in summer all three indices show negative trends in the northern part and positive changes in the Alps. Summer trends of these indices in Eastern Europe are less consistent. Significant linear trends with the same sign exist only for 12 of 34 locations where either index demonstrated significant changes. Considerable disagreement is also observed in Northern Europe where R95 indicates stronger negative changes.

In the figure above the estimates of linear trends in annual values of p_{95} are shown for the 22 locations where all three indices (p_{95}, R95, G95) computed from the homogenized time series are significant according to different statistical criteria, such as the Student t-test, the Hayashi criterion and the Wilcoxon test, and are simultaneously unaffected by the sampling density. In other words, these maps show the locations where trends in heavy European precipitation can be accepted with confidence. These trends are positive in most of Eastern Europe, where the strongest changes range from 3 to 5% per decade, and are somewhat weaker in Central Western Europe. The trends in p_{99} (see Panel B of the figure) are significant in 12 locations only, with primarily positive tendency and maxima of 3 to 4% change per decade in Northern European Russia. A general conclusion can be made that the use of more objective indices based on estimated PDFs for daily precipitation, appears to be the best strategy for estimating long-term tendencies in extreme precipitation.

Acknowledgements. This study was supported by the North Rhine-Westphalian Academy of Science under the project “Large Scale Climate Changes and their Environmental Relevance,” RFBR (Grants 03-05-64506 and 03-05-20016) and the NATO-SfP-981044 project “Extreme precipitation events: their origins, predictability and impacts.”

References

Frei, C., and C. Schär, 2001. Detection probability of trends in rare events: theory and application to heavy precipitation in the Alpine region. *J. Climate*, 14, 1568–1584.

Groisman, P. Y., R. W. Knight, D. R. Easterling, T. R. Karl, G. C. Hegerl, and V. N. Razuvaev, 2005. Trends in intense precipitation in the climate record. *J. Climate*, 18, *in print*.

Klein Tank, A. M. G., and G. P. Koennen, 2003. Trends in indices of daily temperature and precipitation extremes in Europe, 1946-99. *J. Climate*, 16, 3665–3680.

Zolina, O., A. Kapala, C. Simmer, and S. K. Gulev, 2004. Analysis of extreme precipitation over Europe from different reanalyses: a comparative assessment. *Glob. Planet. Change*, 44, 129–161.

GEWEX SSG Chair Receives Highest NASA Honor

On 27 April 2005, Prof. Soroosh Sorooshian, chair of the GEWEX Scientific Steering Group, received the Distinguished Public Service Medal, the highest honor that the National Aeronautics and Space Administration (NASA) awards to someone who is not a government employee. The award is granted only to individuals whose distinguished accomplishments contributed substantially to the NASA mission. Prof. Sorooshian received this award for his distinguished record in providing scientific leadership for global water cycle research and assuring that NASA science is well integrated into international programs.

PRECIPITATION EXTREMES OVER VIET NAM

Dang Thi Mai and Nguyen Tan Thanh

Mid-Central Regional Hydro-Meteorological Center of Viet Nam

Historically, the mid-central region of Viet Nam experiences annual severe weather events, including typhoons, hurricanes, floods, and droughts that lead to the loss of life and property. In recent years, these events have become more severe and are occurring in new areas. This article describes extreme rain events that occurred on 1–6 November 1999 and 23–27 November 2004, where rain rates exceeded historical expectations and forecast information, leading to unusually large impacts

The mid-central region of Viet Nam is located from 14°32' to 18°06'N and 105°37' to 109°05'E, and includes five provinces, Quang Binh, Quang Tri, Thua Thien Hue, Quang Nam, Quang Ngai and Da Nang City. This coastal region contains a narrow flat area with some low hills on the east and a part of the Truong Son high mountain ridge on the west that is cut by many mountain passes. The topography is quite steep from west to east and the rivers are short and flow rapidly. Monsoons and Truong Son Mountain Range, play important roles in the precipitation regime. The northeast monsoon, the southwest monsoon and the prevailing trade winds give the region two seasons: dry (January to August), and rainy (September to December). Rainfall is heavier in the mountain areas than in the flat areas.

Event 1: 1–6 November 1999. On 1 November a northeast monsoon and a cold front occurred at 18–19°N and a tropical convergent zone occurred in the south at 11–12°N. In the upper atmosphere the easterly wind field developed strong winds with velocities of over 10 m/s. The humidity was high for most of the mid-central region. All stations from Thua Thien Hue to Quang Ngai recorded daily rainfall averages more than 100 mm for 1–6 November. For 1–3 November, more than 50% of the stations recorded rainfall greater than 300 mm (about 20% more rainfall than 500 mm for a 24-hour period). **In particular, Hue City experienced 1,422 mm of rainfall from 6 a.m. on 2 November to 6 p.m. on 3 November with a peak rainfall intensity of 120 mm every 60 minutes**. On 2 November Nam Dong had a maximum daily rainfall of 593 mm, almost 20% more than the previous maximum daily rainfall record (500 mm). Over 700 deaths and a loss of property totaling $250 million resulted from this event.

Event 2: 23–27 November 2004. For 23–25 November, the weather in the mid-central region was influenced in the southern part by high pressure and the typhoon Muifa in the northern part. From 25–27 November a strong northeast monsoon event impacted the area and in the upper levels the easterly winds were very strong at 10–15 m/s. Three hundred people narrowly escaped a flash flood which occurred in the Suoi Luong, a small stream in the suburb of Da Nang City. During the same period a flash flood in Tay Tra (Quang Ngai province) caused a landslide that killed five people. A total of 37 people were killed in the mid-central region by flooding during this 23–27 November event.

The analysis of these severe rainfall events showed that the interaction between the northeast monsoon and typhoon circulation (Intertropical Convergence Zone) created unstable air masses in the South China Sea. Easterly winds carried that unstable air mass with high amounts of precipitable water towards land, where it was then blocked by the Truong Son Range, resulting in heavy rainfall in the region’s mid-central territory.

Analysis also shows that in recent years, flooding and in particular, flash flooding, is occurring more frequently and appears to be related to deforestation. Heavy rainfalls can be predicted 12–24 hours in advance and flooding 6–12 hours in advance. However, Viet Nam does not have techniques available to predict flash floods. The information available to forecasters in Viet Nam includes synoptic maps of the surface to 500 hPa height, meteorological data, satellite images, radar products and numerical models. The precipitation forecasted in numerical models averages 50–100 mm less than actual precipitation. Additional rain gauges are needed in the mid-central region surface observation network, especially in the narrow river basins where flash flooding often occurs, as well as more satellite rainfall measurements.

Heavy rain is a very complex phenomenon with every event having different characteristics, which require detailed analysis. To effectively understand, monitor and predict these extreme events, the National Hydro–Meteorological Service of Viet Nam and the Mid-Central Regional Hydro–Meteorological Center (like many other meteorological services in other parts of the world) are seeking to improve their capacity and develop a long-term modernization plan for rainfall monitoring and prediction.

A WATER BALANCE INVESTIGATION OF THE 2002 DROUGHT IN THE MURRAY-DARLING BASIN

C. S. Draper, and G. A. Mills

Bureau of Meteorology
Melbourne, Australia

In 2002, southeast Australia experienced one of its worst droughts on record, resulting in the widespread loss of rural livelihood as well as the loss of several lives. One area that was particularly hard hit by the drought was the Murray-Darling Basin (MDB). The MDB is one of Australia’s major agricultural regions, providing 40% of Australia’s agricultural production from just 14% of its land mass. The Basin is largely semi-arid, and has limited available water supplies, with over 80% of divertible surface water being consumed within the Basin. The climate of the Basin is typified by long dry spells, punctuated by episodic wet events. The regular occurrence of long dry spells places enormous pressure on the Basin’s water resources. As a result, both the MDB and the Australian economy are sensitive to climatic fluctuations in the region.

The atmospheric water balance of the MDB is currently being investigated as a part of the GEWEX MDB Continental-Scale Experiment. The investigation is based on output from the Australian Bureau of Meteorology’s operational forecast model, the Limited Area Prediction System (LAPS). The 2002 drought has received particular attention in this investigation, with the goal of determining the important processes occurring in the water cycle, as well as testing the performance of LAPS during extreme dry events. What follows is a summary of the 2002 drought and its impact on southeast Australia, and an overview of the methodology of the MDB Water Balance Project and its main results. One of the most interesting findings of the Project is that LAPS is not accurately representing extreme dry events, and the reasons for this—and likely consequences—have also been presented.

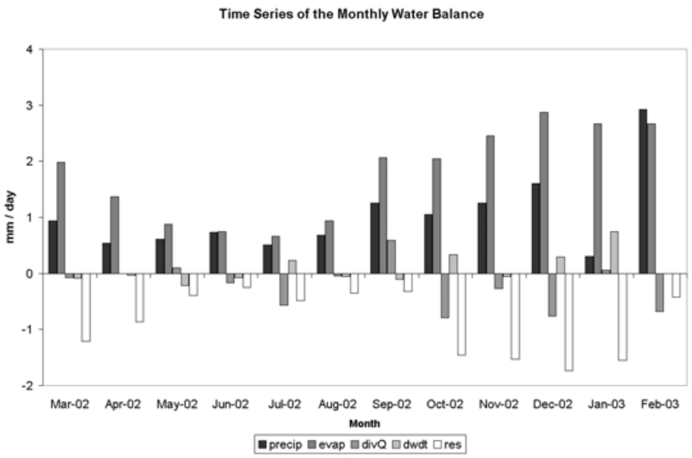
The 2002 drought was primarily the result of strong El Niño conditions in the later half of the year, which suppressed precipitation across southeast Australia. However, the low precipitation (in the lowest decile) does not alone account for the severity of the drought. In fact annual precipitation was lower several times in the last half century (e.g., 1982 and 1994), during which drought symptoms were less severe than in 2002. The impacts of low precipitation in 2002 were greatly enhanced by two factors. Firstly, the preceding few years had been consistently dry, and secondly, record high temperatures were experienced throughout 2002. The all-Australia maximum temperature anomaly was +1.65°C for the 9 months from March to November, which is the warmest on record by a margin of +0.63°C (Watkins, 2002).

The 2002 drought had a major impact on Australia’s agricultural sector, which was felt by the larger economy. The Australian Bureau of Agriculture and Resource Economics estimated that agricultural production in 2002 was 57% of the tonage produced the previous year. Production in the state of New South Wales, 75% of which is within the Murray-Darling Basin, was estimated to have dropped from 8.9 million tons in 2001 to 1.3 million tons in 2002 (Watkins, 2002). The Governor of the Reserve Bank of Australia estimated that the dry conditions reduced Australia’s annual Gross Domestic Product (GDP) by one percentage point (Watkins, 2002).

The 2002/03 bushfire season was particularly severe. In December there were more than 58 individual fires burning in New South Wales, which were estimated to have caused $100 million of damage (Watkins, 2002). In early 2003 the situation worsened and 3 million hectares were burnt in southeast Australia during January and February, resulting in huge stock and infrastructure losses. Fires in and around Canberra in mid-January burned 500 houses and resulted in five deaths (Council of Australian Governments, 2004). The Canberra fires were the most expensive ever in terms of insurance payments.

The results of operational forecast models are of particular interest during extreme events, such as the drought of 2002. The MDB Water Balance Project is based on LAPS model output at a 3-hour temporal resolution, with a horizontal resolution of 0.375°. There are two forecasts made each day, at base times 12 and 00 UTC. For each time step, the relevant fields have been calculated from the average of the most recent forecast from each of the base times. The average daily value per month of each water balance term is shown in the figure on page 9 for the year preceding the end of the 2002/2003 summer.

A number of interesting observations can be made in the figure on page 9. The low precipitation in 2002 can be observed by comparison to other years (1999–2004 have been calculated, but are not shown). In February 2003 there is a rapid increase in precipitation, indicating the end of severe drought



Monthly water balance terms (mm/day) averaged over the Murray-Darling Basin for March 2002 to February 2003. Precip = precipitation, evap = evaporation (positive upwards), dwdt = change in atmospheric water vapour storage, divQ = water vapor flux divergence, res = residual, calculated as prec – evap + dw/dt + divQ.

conditions, due partly to the weakening of El Niño conditions. This follows a recent trend towards high February rainfall in Australia. February is the only month in the figure above during which precipitation exceeded evaporation. An evaporation excess (over precipitation) is unusual during the cooler months and all other years studied have shown a consistent, although not necessarily large, precipitation excess in winter. While evaporation excesses are typical during the warmer months, the monthly excesses calculated for 2002 are much higher than in other years, with January being particularly extreme. The divergence is not a leading term in the water balance, indicating that recycling of evaporated water is providing source vapor for precipitation, rather than convergence of water from external sources.

Perhaps the most striking feature in the figure is the large negative residual calculated during spring and summer. These residuals were not unexpected, as it is well known that budget studies based on numerical weather prediction (NWP) models, and associated analyses contain an inherent error which is not small (Kanamitsu and Saha, 1996). This error is related to the systematic tendency of the model to drift towards a 'model climate,' which is determined by its internal physics and parameterizations. Water balance studies based on several NWP models (and associated analyses) around the globe have calculated significant residuals (e.g., Roads et al., 2002). The negative residual here indicates that LAPS has a tendency to accumulate excess moisture in its atmosphere, which must then be artificially removed (nudged) during each assimilation cycle. This process is clearly illustrated in the diurnal cycle of the forecast atmospheric water storage, which shows a general increasing trend through the 24 hours of each forecast, and then drops abruptly to meet the newly assimilated value at the introduction of the next forecast. The residuals during spring and summer are large, both in comparison to the other water balance terms, and to the monthly residuals calculated for other time periods. The residual is one of the leading terms across the months in question, and the residual term for January 2003 contributes half of the net residual for 2003.

Preliminary investigations indicate that the tendency in LAPS towards accumulating excess atmospheric moisture during extreme dry events is caused by an over-prediction of evaporation in these conditions, and the reasons for this are currently being investigated. Possible contributors are the atmospheric moisture assimilation process, the method used to update soil moisture during each assimilation cycle, and/or the land surface parameterization of evaporation. A positive evaporation bias during dry events could have significant consequences for the performance of LAPS, although these consequences are difficult to predict. It would be reasonable to expect a cool bias to occur, which would have many consequences. The excess evaporation would certainly affect the humidity field, which would impact the skill of fire weather predictions, as these become extremely sensitive to small changes in relative humidity at the extreme dry end of the humidity range.

The consequences of drought in southeast Australia can be devastating, as was demonstrated by the events of 2002. Within this context, the result that the LAPS model has a systematic tendency to drift away from the observed climate during extreme dry events is unsettling, and experiments are under way to identify methods to improve this representation.

References

Council of Australian Governments, 2004. *Report of the National Inquiry on Bushfire Mitigation and Management*, by Ellis, S., P. Kanowski, and R. Whelan, Australian Government Publishing Service, Canberra.

Kanamitsu, M. and S. Saha, 1996. Systematic Tendency Error in Budget Calculations, *Monthly Weather Review*, 124, 1145–1160.

Roads, J. O., M. Kanamitsu, and R. Stewart, 2002. CSE Water and Energy Budgets in the NCEP-DOE Reanalysis II, *Journal of Hydrometeorology*, 3, 227–248.

Watkins, A. B., 2002. 2002 Australian Climate Summary: Dry and Warm Conditions Dominate, *Bulletin of the Australian Meteorological & Oceanographic Society*, 15, 109-114.

EUROPEAN PRECIPITATION EXTREMES: CAN WE EXPECT MORE?

O. B. Christensen[1], J. H. Christensen[1], and C. Frei[2]

[1]Danish Meteorological Institute
[2]Atmospheric and Climate Science, ETH-Zürich, Switzerland

In recent years Europe has been hit by several severe floods, like the Odra flooding in 1997 and the Elbe and Rhone floodings in 2002. In the search for plausible expectations of future probabilities of this kind of events, a key issue is the evolution of precipitation extremes. Most global climate simulations will predict strong reductions in summer precipitation over central and southern Europe. However, the warmer climate will enable the air to contain more water and should, everything else being equal, result in more severe extreme events. An evaluation of how these two effects will balance, requires quantitative calculations.

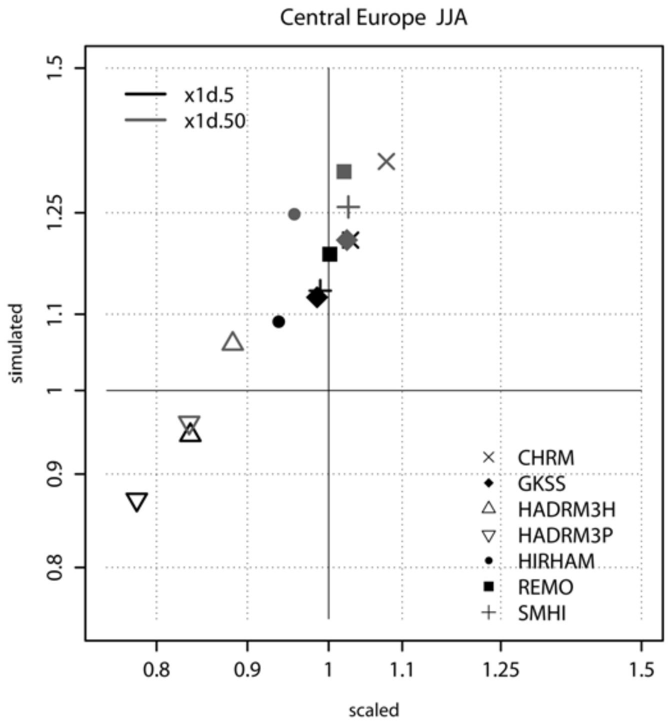
Global climate models (GCM), which have grid distances of hundreds of kilometers, are not well suited to directly deliver useful information about extreme precipitation, particularly, in smaller regions with complex terrain. One method to extract the essential information from these GCMs is dynamical downscaling, where regional climate models (RCM) with grid distances of 50 km or less provide better spatial and temporal resolution.

Even though this strategy is computationally expensive, a recently finished European Union (EU) funded project, PRUDENCE, has managed to collect a large database of results from nine different RCM models applied to a set of 30-year long experiments covering past (1961–1990) and future (2071–2100) conditions. The canonical boundary conditions that were used by all participating RCMs use sea surface temperatures and sea ice extent for the current conditions, and add a climate signal in these quantities as calculated by the Hadley Centre GCM, HadCM3, for future conditions corresponding to the SRES A2 scenario. Global atmospheric information for these 30-year long time slices is calculated with the help of the Hadley Centre high-resolution global atmospheric model HadAM3H.

The influence of the choice of a regional model on the resulting climate is very dependent on the season in question in Europe. Weather systems during winter are mainly determined by the large-scale circulation and hence predominantly determined by the GCM delivering boundaries. In contrast there is a large degree of variation between RCMs during the summer, when local feedbacks are very important.

Results from one participating model about European summer precipitation was reported in Christensen and Christensen (2003 and 2004), the main result being that the strong projected decrease in average precipitation did not prevent extreme precipitation values like the 99th percentile of daily precipitation from increasing over most of Europe. In the top figure on page 20, which originates from Christensen and Christensen (2004), results from the canonical PRUDENCE downscaling with the HIRHAM model in 50 km resolution is shown. Average precipitation and the exceedence of the 99th percentile (roughly equivalent to the 1-year return value) of daily precipitation are shown. Even though there are large reductions in average precipitation, the extreme precipitation is generally increasing over most of Europe. The reduction of average precipitation tracks a corresponding reduction in the probability of precipitation; average intensity changes only slightly in this simulation.

A recent analysis of several of the PRUDENCE experiments yields some interesting results (Frei et al., 2005). All simulations yield reductions in average precipitation of varying magnitude during summer. Extreme values, however, show positive changes for some models but negative changes for others. In order to further describe the simulated changes in precipitation intensity probability density function (PDF), Frei et al. (2005) fit a General Extreme Value distribution to describe the extreme tail of daily precipitation during summer (JJA). They compare the changes of extremes simulated by the RCMs with a hypothetical change that would result from a uniform scaling of the control PDF by the simulated change in precipitation probability (frequency of wet days) and average precipitation intensity. The figure on page 11 shows results for Central Europe and two different return values (5 and 50 years) in the form of a scatter plot of simulated change against a hypothetical (i.e., scaled) change. For all seven different RCMs the simulated extremes increase more or decrease less than would be expected from a uniform scaling of the control PDF. There seems to be two conceptual components of the simulated change: One component, which is very coherent among the models, tends to



Simulated change in return levels (ratio scenario/control) against the expected change from simple scaling of the control PDF by the changes in wet-day frequency and intensity for summer (JJA). Black symbols are 5-year return levels, grey symbols are 50-year return levels. Different symbols are different downscalings of PRUDENCE experiments. Both axes are logarithmic. From Frei et al. (2005).

increase the occurrence of extremes. The second component, which expresses the effect of changes in precipitation probability and intensity partly compensates for the increase, but its magnitude varies considerably among the models.

Though this analysis still lacks a thorough understanding of why the simulations behave this way, there seems to be an overall agreement that there is an effect that enhances the PDF tail in the simulations representing future conditions. There is still a lot of work to do in order to determine more exactly the relative changes of the two competing effects. There is also an agreement that the climate change signal will be more likely to be positive for longer return periods.

Obviously, these results do not tell the whole story about the changes in flood frequency that can be expected in the future. First of all, no systematic validation of RCM performance with respect to simulation of present-day extremes has been performed on a continental scale. European validation is currently limited to smaller areas like the Alps (Frei et al., 2003, 2005) Denmark (Christensen et al., 2002) and the German state of Baden-Württemberg (Semmler and Jacob, 2004).

Heavy precipitation is hard to measure accurately, and it would be beneficial to compare results of coupled-model simulations including both regional climate models and hydrological models to observed river runoff. This is an interdisciplinary field of research where little has happened yet; results from the PRUDENCE project will be published as Graham et al. (2005). The future improvement of the present kind of climate projections will require interdisciplinary work where both hydrological and meteorological models are included.

References

Christensen, O. B., J. H. Christensen, and M. Botzet, 2002. Heavy precipitation occurrence in Scandinavia investigated with a Regional Climate Model, in *Climatic Change: Implications for the hydrological cycle and for water management*, M. Beniston (ed.), Kluwer Academic Publishers.

Christensen, J. H. and O. B. Christensen, 2003. Severe summertime flooding in Europe. *Nature*, 421, 805–806.

Christensen, O. B. and J. H. Christensen, 2004. Intensification of extreme European summer precipitation in a warmer climate. *Glob. Plan. Change*, 44, 107–117.

Frei, C., R. Schöll, S. Fukutome, J. Schmidli, and P. L. Vidale, 2005. Future Change of Precipitation Extremes in Europe: An Intercomparison of Scenarios from Regional Climate Models. Submitted to *J. Geoph. Res*.

Frei, C., J. H. Christensen, M. Déqué, D. Jacob, R. G. Jones, and P. L. Vidale, 2003. Daily precipitation statistics in regional climate models: Evaluation and intercomparison for the European Alps. *J. Geophys. Res*., 108 (D3), 4124, doi:10.1029/2002JD002287.

Graham, L. P., S. Hagemann, S. Jaun, and M. Beniston, 2005. On interpreting hydrological change from regional climate models. Submitted to *Climatic Change*.

Semmler, T. and D. Jacob, 2004. Modeling extreme precipitation events – a climate change simulation for Europe. *Glob. Plan. Change*, 44, 119–127.

U.S. HISTORIC DROUGHT CHARACTERISTICS ESTIMATED USING N-LDAS

Konstantinos M. Andreadis[1], Dennis P. Lettenmaier[1], Justin Sheffield[2], and Eric F. Wood[2]

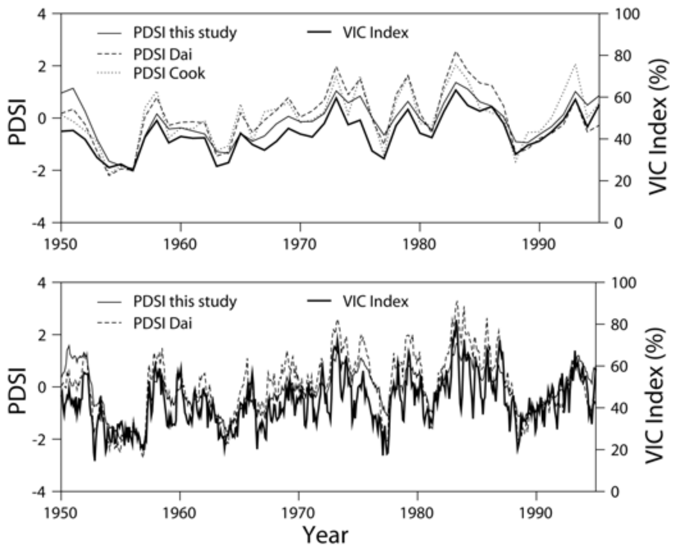
[1]University of Washington, Seattle, Washington, USA, [2]Princeton University, New Jersey, USA

Drought is a pervasive natural hazard. According to a recent report of the Western Governors Association (2003), an “extreme” or “severe” drought has been experienced in some part of the United States in every year since 1895. Among U.S. natural hazards, drought is the most costly. A 1995 report by the Federal Emergency Management Agency (FEMA, 1995) estimated that the annual cost of U.S. droughts was in the range $6-8B. The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC, 2003) estimates that since 1980, there have been 10 droughts among the 57 natural disasters costing over $1B, and that the average annual cost to the U.S. of these $1B or larger droughts has been almost $6B. The 1988 drought alone, in 2002 dollars, cost almost $62B. This compares with losses of about $27B for the 1993 Mississippi River floods and about $36B for Hurricane Andrew. Among disasters with costs exceeding $1B, drought losses are about equal to the sum of losses associated with floods and hurricanes, and droughts are responsible for almost 40% of the total losses due to natural hazards (NCDC, 2003).

Methods for characterizing past droughts, and in turn the basis for evaluating ongoing droughts in a historic context, are not as well developed as they are for other natural hazards, such as floods (e.g., estimation of flood return periods). A key problem is the spatial dimension of droughts. While drought intensity and duration can be measured at a point, droughts are regional phenomena whose spatial characteristics vary over time. Nonetheless, the spatial extent of droughts is of equal, or greater, importance than drought intensity and duration. Many studies of drought have made use of the Palmer Drought Severity Index (PDSI) as a point drought indicator. However, inherent shortcomings of PDSI (including not only its failure to characterize drought extent, but also other specifics such as lack of cold land processes representation) have limited its applicability. Other drought indicators, such as soil moisture in the case of agricultural drought or runoff as a measure of hydrologic drought, provide a better physical basis for interpreting drought, however, they are constrained by data availability. In particular, soil moisture multi-decadal data are virtually non-existent, while streamflow data are integrated over drainage areas that are specific to particular gauges, and make resolving the spatial variability of drought difficult.

An approach that overcomes these limitations is the use of gridded land surface model simulations that are forced with carefully quality controlled climatological data. These methods have been developed in the context of the North American Land Data Assimilation project (N-LDAS; Mitchell et al., 2004). Maurer et al. (2002) describe long-term retrospective land surface data sets developed as part of N-LDAS that include the main land surface forcings (e.g., precipitation, temperature, and downward solar radiation), state variables (soil moisture, snow water equivalent) and fluxes (evapotranspiration, runoff). These data have been the basis for studies of land-atmosphere teleconnections, hydrologic forecast initialization, and coupled land-atmosphere model initialization. The context is somewhat similar to land surface reanalysis products (e.g., most recently from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-40 global reanalysis, and the NCEP North American Regional Reanalysis (NARR), but a key difference is that the surface forcings are based on observations, and the model-predicted runoff (at least at specified calibration points) is constrained to match observations, at least approximately. Furthermore, by construct the surface energy and water balances are closed, hence at least for long-term averages, evapotranspiration, and latent and sensible heat, should be correct. As for reanalysis products, the simulated land surface variables are spatially and temporally continuous. If the forcing data sets are carefully quality controlled, the model-predicted variables (e.g., soil moisture and runoff) can be used to reconstruct drought histories. This spatial continuity allows for a more consistent way of estimating the spatial extent of drought, while the temporal continuity and the resulting temporal resolution facilitates the capturing of short-term changes of drought conditions, as well as longer-term variations.

The 50-year Maurer et al. (2002) data set was used by Sheffield et al. (2004) to evaluate drought evolution over the continental U.S. Seeking a method that would allow direct comparison of drought severity over the conterminous U.S., they estimated monthly soil moisture quantiles by fitting beta distributions to the simulated soil moisture data. The soil moisture quantiles were used as a measure of drought occurrence and intensity [Variable Infiltration Capacity (VIC) drought index].



Comparison of annual (upper panel) and monthly (lower panel) time series of VIC drought index and three different PDSI data sets for 1950–99 averaged over the U.S. Figure from Sheffield et al. (2004).

The use of quantiles is more appropriate than absolute soil moisture values, because anomalies of absolute magnitude reflect different drought severities over different regions and cannot be used for direct comparison of drought across the study domain. Sheffield et al. (2004) identified a number of dry events over the continental U.S. in the past 50 years. The most notable included a multi-year drought in the southwest during the mid-1950s, two less severe events during the 1960s, a moderate drought over the western U.S. in 1977, and finally a short-term drought in 1987–88 that covered a large area of the study domain. On average, 30% of the U.S. experienced severe droughts with the peak occurring during the 1950s drought with over 70% of the domain covered by drought.

The regional characteristics of drought were also examined, and it was found that the western U.S. exhibited less variability and much higher persistence than the eastern U.S. Comparison of the model-derived drought index with three different PDSI data sets for the same time period showed good correspondence between the VIC and PDSI-based drought indices in terms of their year-to-year variability and trends. This can be seen in the figure above which shows annual (top panel) and monthly (lower panel) time series of the VIC drought index and PDSI averaged over the U.S. However, the limitations of the PDSI over mountainous regions were reflected in low correlations with the VIC drought index over the western U.S. (arguably the VIC index is more realistic, given the model's representation of snow-related process which dominate the hydrology of the region), while in the eastern U.S. the correlation is much higher. In general, the simulated drought index was able to capture most of the variability of soil moisture in the context of drought identification over the 1950–1999 period.

Recently, NCDC has made station archives available in electronic form from the beginning of the recorded record (in most cases, around 1900 or later). Methods have been developed (see Hamlet et al., 2005) for eliminating temporal heterogeneities in the data sets by tying trends in the gridded data to those in the smaller long-term station data (about 1200 stations) in the Historical Climatology Network (HCN). Essentially, the method adjusts the gridded (daily precipitation and temperature) forcing data to have decadal-scale temporal variability comparable to that of the HCN stations, while retaining the spatial variability of the NCDC station data. As in the Maurer et al., 2002 data set, other model forcings (downward solar and longwave radiation, surface humidity) are estimated using algorithms that relate them to the daily temperature and/or temperature range. The NCEP-NCAR reanalysis data, which Maurer et al., 2002 used for the wind forcing, are absent prior to 1949, and so we used average wind (varying by month) for the entire 1915–2003 period.

Andreadis et al. (2005) used the 1915–2003 derived data (at one-half degree spatial resolution), following an approach similar to that used by Sheffield et al., 2004 for drought identification—specifically, soil moisture and runoff were expressed as percentiles relative to the VIC climatology. To include the spatial dimension of droughts, and to allow direct comparison of different droughts in the long-term record, a method termed Severity Area Duration (SAD) analysis was developed. SAD simultaneously captures the fundamental characteristics of drought (intensity, duration, and spatial extent). It is similar to Depth Area Duration analysis widely used for the estimation of precipitation for design purposes, where precipitation depth is replaced with an appropriate measure of drought severity.

Both agricultural and hydrological drought can be examined using reconstructed long-term hydrologic characteristics, in conjunction with the SAD method. SAD facilitates direct comparison of droughts in the historic record that have varying duration and spatial extent. The envelope of the SAD curves from all events allows examination of the most severe droughts for different durations and areas. For instance, application of the SAD method to the 1915–2003 reconstructed hydrology of the continental U.S. shows that the droughts of the 1930s and 1950s were the most severe for large areas (interestingly, the "Dust Bowl" years of the 1930s lie on the envelope curve for more intense, high severity events, but for shorter durations than the parts of the curves occupied by the 1950s drought). Other notable events included the 1988 Midwest drought, the 1977 drought over the western U.S., and the mid 1960s drought over the eastern U.S. The 2000 western U.S. drought was among the most severe in the period, especially for short durations and (relatively) small areas.

An interesting feature of the temporal evolution of areas experiencing drought and drought severity is that the eastern U.S. generally exhibits much larger month-to-month variability than the central and western U.S. which indicates the lower persistence of soil moisture. The bottom figure on page 20 shows the spatial patterns of three major agricultural drought events of the 20th century along with the associated SAD curves for each drought (1930s, 1950s, and 2000s). Results for agricultural and hydrological droughts were similar, although the 2000 drought occupies a larger portion of the hydrological envelope SAD curve. This apparently is indicative of the faster response of runoff to precipitation and the presence of short wet spells during the 1930s and 1950s but not during the 2000 drought when precipitation anomalies exhibited longer persistence over the western U.S.

References

Andreadis, K. M., E. A. Clark, A. W. Wood, A. F. Hamlet, and D. P. Lettenmaier, 2005. 20th Century Drought in the Conterminous United States, *J. Hydrometeorology* (accepted).

Federal Emergency Management Agency, 1995. National Mitigation Strategy: Partnerships for Building Safer Communities, Federal Emergency Management Agency, Washington, D.C., 40 pp.

Hamlet A. F. and D. P. Lettenmaier, 2005. Production of temporally consistent gridded precipitation and temperature fields for the continental U.S., *J. of Hydrometeorology* (in press).

Maurer, E. P., A. W. Wood, J. C. Adam, D. P. Lettenmaier, and B. Nijssen, 2002. A long-term hydrologically-based data set of land surface fluxes and states for the conterminous United States, *J. Climate*, 15, 3237-3251.

Mitchell, K. E., D. Lohmann, P. R. Houser, and E. F. Wood, 2004. The Multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system. *J. Geophys. Res.*, 109, Art. No. D07S9010.1029/2003JD003823.

National Climatic Data Center, 2003. A Climatology of 1980-2003 Extreme Weather and Climate Events, Technical Report 2003-1.

Sheffield J., G. Goteti, F. H. Wen, and E. F. Wood, 2004. A simulated soil moisture based drought analysis for the United States. *J. Geophysical Research*, 109, Art. No. D24108.

GEWEX RELEVANT PUBLICATIONS OF INTEREST

Detectability of Anthropogenic Changes in Annual Temperature and Precipitation Extremes

Reference: Gabriele C. Hegerl, Francis W. Zwiers, Peter A. Stott, and Viatcheslav V. Kharin, 2004. Detectability of Anthropogenic Changes in Annual Temperature and Precipitation Extremes. *J. Climate*, Vol. 17, No. 19, 3683–3700.

Summary/Abstract: This paper discusses a study of temperature and precipitation indices that may be suitable for the early detection of anthropogenic change in climatic extremes. Anthropogenic changes in daily minimum and maximum temperatures and precipitation over land simulated with two different atmosphere–ocean general circulation models are analyzed. The use of data from two models helps to assess which changes might be robust between models. Indices are calculated that scan the transition from mean to extreme climate events within a year. Projected changes in temperature extremes are significantly different from changes in seasonal means over a large fraction (39–66%) of model grid points. Therefore, the detection of changes in seasonal mean temperature cannot be substituted for the detection of changes in extremes. Both models simulate extreme precipitation changes that are stronger than the corresponding changes in mean precipitation.

Terrain and Multiple-Scale Interactions as Factors in Generating Extreme Precipitation Events

Reference: Roberto Rudari, Dara Entekhabi and Giorgio Roth, 2004. Terrain and Multiple-Scale Interactions as Factors in Generating Extreme Precipitation Events. *J. Hydrometeorology*, Vol. 5, No. 3, 390–404.

The Mediterranean region is often affected by flooding and landslides due to heavy precipitation events. The authors combine data from a dense network of surface precipitation gauges over northern Italy and a global atmospheric analysis at a coarser scale to develop a multiscale diagnostic model of the phenomenon. Composite maps are formed based on departures from climatology and standard deviation of sea level pressure, 500-hPa geopotential, wind, and water vapor flux. A diagnostic model is built based on the evidence that shows the spawning of secondary mesoscale features in the steering synoptic flow. The mesoscale features draw moisture and energy from local sources and cause extreme precipitation events over adjoining areas. It is shown that longitudinal blocking frequency over a larger region strongly differs from climatology. A low pressure center tracking algorithm is used to follow the evolution of some events.

WORKSHOP/MEETING SUMMARIES

IGWCO/GEWEX/UNESCO WORKSHOP ON TRENDS IN THE GLOBAL WATER CYCLE

3–5 November 2004
UNESCO, Paris, France

Rick Lawford[1] and William Rossow[2]

[1]International GEWEX Project Office
[2]NASA Goddard Institute for Space Science

More than 50 experts from the water cycle community attended the Workshop, which was held to identify significant advances in understanding trends and to make recommendations that could be taken under consideration by GEWEX, the Integrated Global Observing Strategy–Partners (IGOS-P) Integrated Global Water Cycle Observations (IGWCO) Theme, and the Intergovernmental Panel on Climate Change. Presentations and discussions indicated that the assessment of climate trends from data is much more complex than it would first appear. For example, detection of climate change on a global scale requires that rigorous data standards be met. In particular, data sets must be global (to preclude misinterpretation of regional changes as global changes), long-term (data records that are too short cannot distinguish between longer term variability and a true trend), and of sufficient accuracy (to distinguish the signal in the large volume of noise). It is also important to know the type of change for which one is looking.

Based on model projections associated with a doubling or a quadrupling of carbon dioxide, experts expect to see increases in surface temperatures, particularly at higher latitudes over land areas. They also expect to see an acceleration of water cycle processes on the order of 1 to 3% in evaporation and precipitation over the last 50 years. Models indicate that the relative humidity remains roughly constant producing an increase of precipitable water at about 7% per degree Celsius of warming.

In most parts of the world, the predicted trends are relatively small in comparison to signals such as the annual cycle. Given that the available data systems were not designed to address long-term trend detection and rarely are accompanied by published uncertainty estimates, few significant trends are indicated, and these are mainly confined to regional rather than global manifestations. Workshop participants unanimously accepted that there is evidence that surface temperatures are increasing on a global basis, but there were differences of opinion on some of the other global trends in shorter-term water cycle variable records.

Regional trends are more frequently observed. For example, seasonal shifts in runoff timing (but not runoff amounts) have been documented in midlatitude areas especially where spring streamflows are dependent on snow melt. Only two to three decade time period regional trends exist in precipitation patterns, although most of these tendencies currently are within the bounds of observational uncertainty. Natural variability is characterized by interannual variations and longer-term (decadal to centennial) variations that must be separated from the effects of anthropogenic forcing. Several presentations demonstrated that data sets based on the current suite of satellites can be used to document and diagnose the causes of this shorter-term variability and to better understand key processes influencing the water cycle.

Another approach used in the past few years to identify trends involves the use of model simulations and reanalyses as tools to obtain trend estimates. Examples given at the Workshop included a study showing how an increase in lower stratospheric water vapor simulated with models is the same order as *in situ* balloon observations at Boulder, Colorado since 1980. Other studies showed that there had been an increase in specific humidity and changes in extreme precipitation events. Although these techniques show trends, they need to be confirmed with the analysis of data because the results from reanalysis systems are affected by the quality of the input data sources and by the model physics.

Ongoing cross-comparisons of available data products that are globally extensive and have records exceeding 1 to 2 decades suggest that the uncertainties in these data products can be significantly reduced. A comprehensive reanalysis of a combination of satellite and *in situ* measurements should be undertaken to obtain more homogeneous water cycle data products for trend and variability analysis.

Preliminary conclusions from the workshop follow.

- While there is considerable confidence in the trends derived from *in situ* data records for temperature, the same confidence does not exist for water cycle variables (i.e, precipitation or clouds).
- Some of the strongest trends seen in hydrologic variabilities (glacier retreat, changes in the seasonality of runoff) are to a large extent, responses to global warming rather than responses to changes in the global water cycle variables (i.e, precipitation).

- Current reanalysis products from models do not provide an adequate basis for identifying trends in climate variables due to uncertainties in data, including inputs, model physics, and resolution.
- While global maps derived from satellite data are reaching the point where they have long enough time series for confirming trends, many of these products have not been optimized for homogeneity of record and for climate analysis. These satellite products need to be reprocessed on an urgent basis to provide a reliable basis for future assessment of recent climate trends.

Specific recommendations (partial list) include:

1. An assessment of the utility of data sets for climate change detection should be undertaken by identifying limitations and artifacts of the analysis procedures.
2. The global climate modeling community should provide "fingerprints" of the changes in water cycle variables expected as the climate changes.
3. A better process for bringing the observational community together with the climate diagnostics community is needed to improve data sets.
4. Data providers should have a more consistent approach to the use of radiance data.
5. A strategy is needed for dealing with the heterogeneity of *in situ* and satellite data and for merging these data to generate long-term data sets.
6. An analysis should be carried out to assess the consistency of trends in the full range of water cycle variables.
7. The Earth Observation Summit ad-hoc Group on Earth Observations (GEO), IGOS-P, and WMO need to encourage the development and acceptance by nations of common data standards and data sharing practices. These standards also should address regional radar precipitation data sets.
8. The global, long-term data sets, including older versions of these data (by data rescue) should be evaluated (by cross-comparison and investigation of differences) and reprocessed.
9. Satellite agencies should make long-term commitments to producing principal climate data products.

FOURTH CEOP PLANNING MEETING AND FIRST IGWCO WORKSHOP

28 February – 4 March 2005
Tokyo, Japan

Sam Benedict
International CEOP Coordinator

The Fourth International Implementation/Science Planning Meeting for the Coordinated Enhanced Observing Period (CEOP) and the First Integrated Global Observing Strategy Partners (IGOS-P) Integrated Global Water Cycle Observations Theme (IGWCO) Implementation Workshop, was held at the Sanjo Kaikan facility on the Hongo Campus, of the University of Tokyo. The meeting was held jointly in recognition of the fact that CEOP had earlier been endorsed as the first element of the IGWCO theme within the framework of IGOS-P. The CEOP Lead Scientist, Toshio Koike, reported on actions taken in 2004 to strengthen the connections between the two communities including developing a plan for the second phase of CEOP during this joint planning event.

The participants addressed several important issues including: (a) a concept for finalizing the CEOP Phase 2 Implementation Plan; (b) maximizing the science and technology benefits from both CEOP and IGWCO; and (c) a framework for oversight of the science, implementation plans and results during the initial phase of IGWCO and CEOP Phase 2. The joint meeting also resulted in a number of specific recommendations for efficient organization and management of both activities to ensure they would achieve their main objectives. The scope of the initial implementation of IGWCO and the second phase of CEOP will be coordinated with the needs of the World Climate Research Programme Coordinated Observation and Prediction of the Earth System (COPES) framing strategy and connections to the 10-year implementation plan for a comprehensive, coordinated, and sustained Global Earth Observation System of Systems (GEOSS).

This meeting included a CEOP Phase I Science and Data Results Workshop with 42 technical papers and a similar number of posters. Participants covered issues associated with model and satellite instrument algorithm validation and intercomparison work; water and energy budget variations and their role in climate; monsoon characteristics studies, including diurnal variations, transferability of model results and downscaling. Extended abstracts of these presentations have been published as a separate meeting document and can be viewed at www.ceop.net. Many of the studies used the CEOP data sets, while others were examples of the type of research and data handling that need CEOP's unique capabilities to succeed. Highlights of these capabilities include:

- A prototype of the global water cycle observation system of systems based on the reference site network, the experimental and operational satellite systems, and the numerical weather prediction model outputs.
- A well organized data archive system that was established in cooperation with the World Data Center for Climate at Max Planck Institute for Meteorology in Hamburg, Germany; the University Cooperation for Atmospheric Research in Colorado, U.S.A.; the University of Tokyo in Japan; and the Japan Aerospace Exploration Agency in Tokyo, Japan.
- A cooperative framework for providing distributed-and centralized-data integration functions for use by the scientific and remote sensing communities. CEOP international information sharing and dissemination standards that are compliant with existing standards and capabilities, such as the International Organization for Standardization (ISO), and other appropriate technologies.

The discussions also focused on the links between IGWCO and other IGOS themes with the Global Water System Project (GWSP). In particular the data needs of GWSP were examined along with a possible prototype application of the ICSU paper on socio-economic data. The status of plans for an IGWCO related indicator workshop, findings and the status of follow-up to earlier workshops on indicators, remote sensing and water quality, and specific plans within IGWCO for work in this area were reviewed. Several cross-cutting topics related to improved integration of IGOS-P themes were discussed including disasters (e.g., tsunamis) and climate. Opportunities for capacity building activities were presented and reviewed by representatives from various countries.

The actions and recommendations related to these discussions are being drafted into a report of the joint meeting. The next CEOP meeting will be coordinated with IGWCO and will also include representatives of COPES. It is scheduled for 27 February to 3 March 2006 in Paris, France.

TWENTY-SIXTH JSC MEETING

14–18 March 2004
Guayaquil, Ecuador

Rick Lawford
International GEWEX Project Office

The meeting of the Joint Scientific Committee (JSC) for the World Climate Research Programme (WCRP) was held at the Escuela Superior Politechnica del Litoral Center and was hosted by Dr. Pilar Cornejo and her colleagues. A primary issue for discussion at the meeting was the Coordinated Observation and Prediction of the Earth System (COPES) strategy and its implementation. The report of the framing task force was reviewed and other reports were given by the COPES Task Force and Panels. The Task Force on Seasonal Prediction outlined its plans for an interactive modeling system for prediction studies. The role of COPES as an integrating framework for WCRP was adopted and its relationship to existing projects is being clarified.

Three priority issues were discussed as an early implementation of COPES: sea level rise, anthropogenic climate change (ACC), and monsoons. The sea level rise discussion focused on plans for a workshop dealing with the factors contributing to sea level rise. Issues such as the development of an ability to remotely measure changes in the quantity of water stored on land are important for these discussions. Progress in understanding ACC is critical to achieving WCRP's objectives and an effective initiative is needed to address this issue. After presentations on monsoon activities in the Climate Variability (CLIVAR) Project and GEWEX, the JSC encouraged closer collaboration in the monsoon work research underway in the various parts of WCRP. The Pan-WCRP Monsoon Workshop planned for 15–17 June 2005 should provide a basis for this collaboration.

Based on a self-assessment of its activities, CLIVAR is reorganizing into four major themes: El Niño/Southern Oscillation, ACC, monsoons, and thermohaline circulation/decadal. The Cryosphere and Climate (CliC) Project is broadening its linkages with programs outside WCRP and uncovering some new science issues such as uncertainties in the lags between the climate forcing of the cryospheric system and the system's response. The Stratospheric Processes and their Role in Climate (SPARC) Project reviewed their progress over the past year and provided rationale for collaborative studies with other WCRP projects, including work with GEWEX in using cloud resolving models to address questions related to the dehydration of the upper troposphere in areas around clouds, and in assessing aerosol distributions and the ability of the radiation codes in climate models and satellite algorithms to account for the wide variety of aerosol types and measurements.

GEWEX highlighted its progress in incorporating land characteristics into seasonal prediction models; new initiatives related to cloud process studies in support of climate model development; new data products including the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data sets, and the adoption of the Baseline Surface Radiation Network (BSRN) as a baseline network for the Global Climate Observing System (GCOS). Modifications to the GEWEX Phase II objectives were presented and approved. The JSC will review the Coordinated Enhanced Observing Period (CEOP) Phase II Science and Implementation Plan and has recommended that CEOP report on observational issues to the WCRP Observations and Assimilation Panel.

A number of projects associated with WCRP reported on their progress. GCOS outlined its research needs for support to observing programs being enhanced in its implementation plan. More than 350 preproposals have been received for the International Polar Year covering topics related to Arctic change, global linkages, human dimensions, and data sets. An overview of The Observing System Research and Predictability Experiment (THORPEX) emphasized the longer term weather prediction research that has interest for WCRP. Planning is underway to increase collaboration between WCRP and the International Geosphere-Biosphere Project (IGBP). GEWEX has been paired with the IGBP Integrated Land Ecosystem–Atmosphere Processes Study as part of this review. The Global Water System Project has adopted a number of fast track projects including the preparation of an electronic "water atlas" and participation in the Northern Eurasia Earth System Processes Initiative. WCRP efforts that are contributing extensively to the Earth Observation Summit ad-hoc Group on Earth Observations, the preparation of an Integrated Global Observing Strategy Cryospheric Theme and the implementation of the Integrated Global Water Cycle Observations Theme.

The JSC meeting marked a major step in the development of COPES and increased collaboration between WCRP projects.

WORKSHOP ON THE APPLICABILITY OF CLIMATE RESEARCH FOR WATER RESOURCE MANAGEMENT IN SEMI-ARID AND ARID REGIONS

18–20 April 2005
Cairo, Egypt

Lawrence Martz
University of Saskatchewan
Saskatoon, Canada

In response to a request from the Arab states to the World Meteorological Organization, a special Workshop was held to examine the applicability of climate research and information for water resource management in semi-arid and arid regions. The workshop was hosted by the World Climate Research Programme (WCRP) and the United Nations Educational Scientific and Cultural Organization (UNESCO), and organized by the GEWEX Water Resources Applications Project (WRAP), and the UNESCO-International Hydrological Programme (IHP) Cairo Office.

The program opened with an official welcome on behalf of the Egyptian Ministry of Water Resources and Irrigation, an introduction from the co-chairs Radwan Al-Weshah (UNESCO) and Lawrence Martz (GEWEX-WRAP), and a welcome from Gilles Sommeria on behalf of WCRP. Mohamed Abdulrazzak, Director of the IHP Cairo Office, and Abdin Salih, Director of the IHP Tehran Office actively participated in the workshop.

The relationship between the Earth climate system and the hydrology and water resources of arid and semi-arid regions of the world is of particular interest to the decision makers and stakeholders in these regions. With the projected population growth in the semi-arid regions and the increasing demand for adequate water resources, these stakeholders wish to know information that is useful for water resources management.

The workshop addressed this overarching issue by bringing together operational hydrology and water management stakeholders from the arid/semi-arid regions of North Africa and the Middle East with hydro climate scientists engaged in observation, modeling, and analysis. Presentations included descriptions of regional water issues and examined the current state of knowledge about the climate system relevant to water management in arid/semi-arid regions. Specific regional presentations were made on the major water issues in the region, including representatives from Lebanon, Jordan, Sudan, Syria, the United Arab Emirates, Egypt and Iran.

Gaps in understanding, data availability and regional capacity were identified in reviews of hydroclimatological data products and modelling achievements, including activities undertaken under the Water and Development Information for Arid Lands-A Global Network (G-WADI) Initiative.

The principal actions identified in the workshop discussions include:

- Increase awareness of the significance of climate change and variability in water resource planning and management across the region;
- Improve sharing of hydroclimatological data across various national and intra-national jurisdictions;
- Access and develop tools to bring global and regional data into a form suitable to support decision-making;
- Apply climate forecasts and data products to specific water management and planning issues; and
- Improve the interface between regional institutions and the international community, in order to enhance the regional capacity to address the above issues.

The Workshop participants recommended that on a priority basis, a regional network of professional and academic scientists be formed. Existing institutional capacity within the region should be used as much as possible to develop and support such a network and UNESCO was identified as having a lead role in this regard. The initial tasks of the network would be to: (1) inventory expertise within the region; (2) inventory of hydroclimatological observation sites across the region; (3) examine the feasibility of developing a reference site under the CEOP program; and (4) develop a proposal for a demonstration project that applies GEWEX/CLIVAR data products or models to the solution of a specific water management issue.

The workshop established a foundation for future enhanced collaboration and the application of WCRP products to the solution of pressing water management problems.

GEWEX/WCRP MEETINGS CALENDAR

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

26 May 2005—IGOS PARTNERS MEETING, Geneva, Switzerland.

1–3 June 2005—WCRP OBSERVATION AND ASSIMILATION PANEL, New York, USA.

13–17 June 2005—AMS JOINT CONFERENCES ON ATMOSPHERIC AND OCEAN FLUID DYNAMICS, MIDDLE ATMOSPHERES AND CLIMATE PREDICTABILITY, Cambridge, Massachusetts, USA.

15–17 June 2005—PAN-WCRP MONSOON WORKSHOP, Irvine, California, USA.

20–24 June 2005—5TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE, Costa Mesa, California, USA.

19–22 July 2005—2005 WATERSHED MANAGEMENT CONFERENCE, Williamsburg, Virginia, USA.

26–28 July 2005—1ST INTERNATIONAL SYMPOSIUM ON TERRESTRIAL AND CLIMATE CHANGE IN MONGOLIA, Ulaanbaatar, Mongolia.

2–11 August 2005—IAMAS SCIENTIFIC ASSEMBLY, Beijing, China.

24–26 August 2005—GEWEX EXECUTIVE MEETING, Maryland, USA.

29 August – 1 September 2005—IGU CONFERENCE ON ENVIRONMENTAL CHANGE AND RATIONAL USE OF WATER, Buenos Aires, Argentina.

14–16 September 2005—3RD WCRP OFFICERS, CHAIRS AND DIRECTORS MEETING, Geneva, Switzerland.

19–21 September 2005—JOINT GABLS/GLASS WORKSHOP ON LOCAL COUPLED LAND-ATMOSPHERE MODELLING, De Bilt, The Netherlands.

19–23 September 2005—LOCO/GABLS WORKSHOP, De Bilt, The Netherlands.

21–23 September 2005—6TH GLASS PANEL MEETING, De Bilt, The Netherlands.

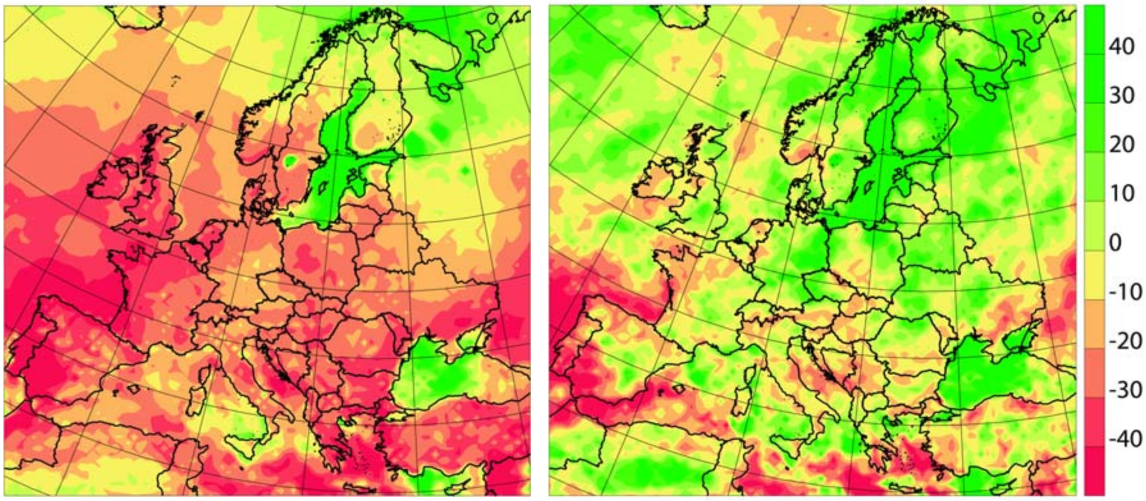
26–30 September 2005—11TH MEETING OF THE GEWEX HYDROMETEOROLOGY PANEL, Melbourne, Australia.

3–6 October 2005—16TH SESSION OF THE GEWEX RADIATION PANEL, Paris, France.

3–5 October 2005—9TH SESSION OF WGCM AND JOINT WGCM-WMP MEETING, Exeter, UK.

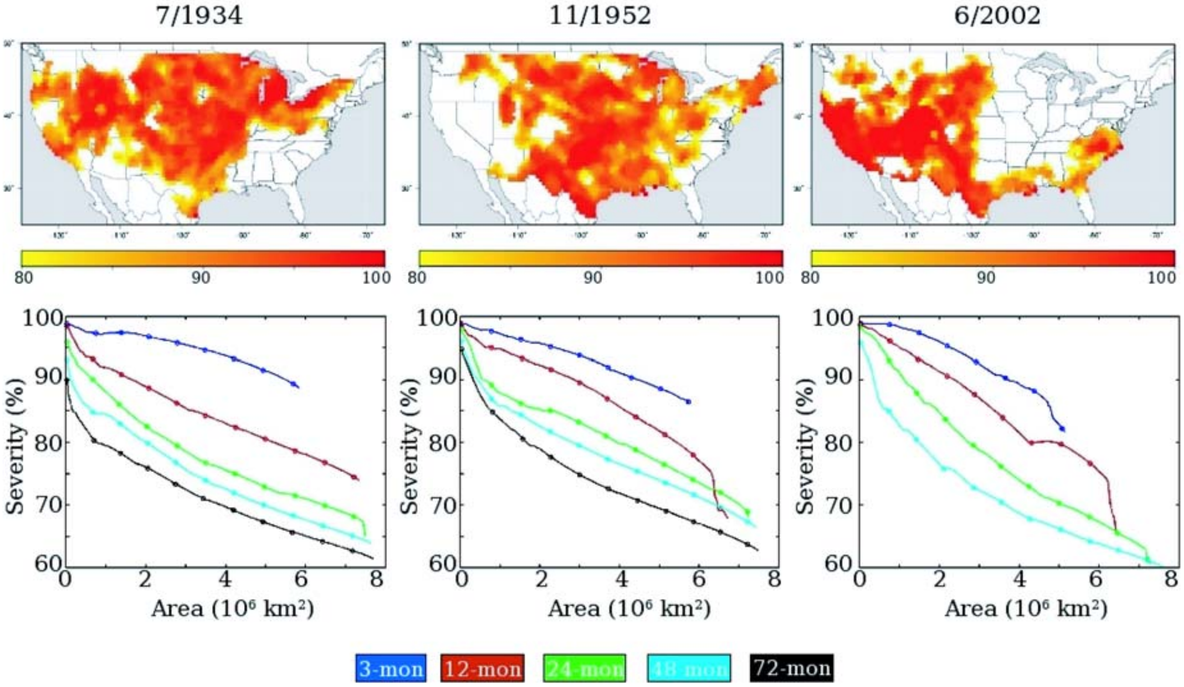
6–7 October 2005—1ST SESSION OF THE WCRP MODELLING PANEL, Exeter, UK.

RESULTS FROM "PRUDENCE" EXPERIMENT SHOW EXTREME PRECIPITATION INCREASING OVER EUROPE



Relative precipitation change in percent between control and scenario for the HIRHAM downscaling of the HadAM3H simulation during late summer (JAS). Left panel: average precipitation. Right panel: exceedence of the 99th percentile. From Christensen and Christensen (2004). See article on page 10.

SPATIAL DISTRIBUTION OF THREE MAJOR US DROUGHTS



Maps of spatial patterns of 3 major droughts (1930s, 1950s, 2000s). Each map corresponds to the month of highest severity and spatial extent (upper panel). The lower panel shows the Severity Area Duration (SAD) analysis curves for the respective droughts, for selected durations. See article on page 12.

GEWEX NEWS
Published by the International GEWEX Project Office (IGPO)
Richard G. Lawford, Director
Dawn P. Erlich, Editor

International GEWEX Project Office
1010 Wayne Avenue, Suite 450
Silver Spring, MD 20910, USA

Web Site: http://www.gewex.org

Tel: (301) 565-8345
Fax: (301) 565-8279
E-mail: gewex@gewex.org