Global Energy and Water Cycle Experiment

NEWS

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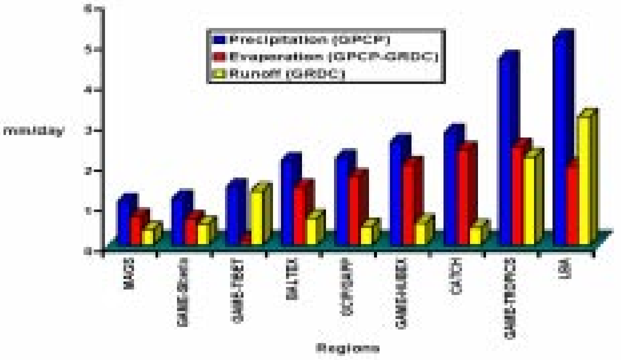
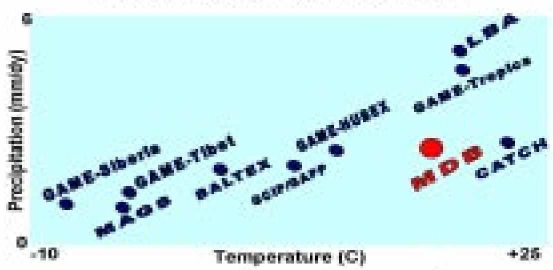
World Climate Research Programme–WCRP

GEWEX CSEs are Successfully Characterizing the Water Budget Across a Wide Range of Climatic Regimes

(See Article Below)





Murray-Darling Basin (MDB) Approved as a New GEWEX CSE

Will Fill Gap in Climatic Coverage

(See Article on Page 9)

CLOSING THE WATER BUDGET

John Roads
Scripps Institution of Oceanography

One of the goals of the GEWEX Continental Scale Experiments (CSE) is to accurately estimate or "close" the water budget on continental scales. Using the National Centers for Environmental Prediction and National Center for Atmospheric Research (NCEP/NCAR) reanalysis moisture convergence, the Global Runoff Data Center (GRDC) runoff, and the Global Precipitation Climatology Project (GPCP) precipitation, **the total <u>global</u> <u>annual</u> water budget (moisture convergence = runoff) can be closed to within 10%. However, relatively larger errors occur over smaller continental scale regions.**

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New GPCP Data Predict El Niño!
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COMMENTARY

GEWEX PLANS SUPPORTED AT RECENT GEWEX SSG AND WCRP JSC MEETINGS

Soroosh Sorooshian, Chairman
GEWEX Scientific Steering Group

Meetings of the GEWEX Scientific Steering Group (SSG) and WCRP Joint Scientific Committee (JSC) were held recently, and GEWEX received excellent support and guidance at both meetings concerning current and future plans. The GEWEX SSG has several new members this year who are providing a wider international representation from the hydrology community to further complement the existing strong modeling and atmospheric physics (cloud and radiation) breadth of experience. (New members will be profiled in the next issue of *GEWEX News*.)

As planned under Phase II of GEWEX and supported by the SSG, the GEWEX Radiation Panel (GRP) is moving forward in addressing the joint nature of our global representations with a stronger emphasis on diagnostics and a particular focus on forcings and feedbacks. This latter focus is the impetus for a workshop jointly sponsored by GRP with the JSC Working Group on Coupled Modeling on Feedbacks scheduled for this fall. The need for further emphasis on climate feedbacks was the subject of a special session at the JSC. A merging of some of the GEWEX data management groups within GRP is now underway, and we will also be taking a broader look at the processes that drive the prediction of precipitation, which will lead to added crosscutting activities among the three GEWEX Panels (Radiation, Hydrometeorology, and Modeling and Prediction). Increased emphasis on validation of model precipitation predictions (begun by a recent WGNE study) and consideration of "super parameterization schemes" (i.e., CRMs imbedded in NWP models) are also included in plans underway.

Both the SSG and JSC have provided strong support and encouragement for the advanced planning and implementation activities of CEOP. While the plans are being supported, the challenge now is to focus on the international and interproject coordination necessary to implement these plans. CEOP is building momentum, and related project activities are now requesting to be included. We need to build on this support with continued strong efforts to deliver the promised data sets and also initiate the research activities outlined in the CEOP Implementation Plan and updated recently at the CEOP meeting in Japan.

Another major initiative raised at the SSG by one of our members, Tony Hollingsworth, responds to the need to begin improving our predictive capabilities on a much larger scale. This concept has been called "The Grand Challenge of FGGE + 30 years: How to Integrate the New High Volume Satellite Data with Modern NWP Prediction Capabilities," and also, "The Global Climate Experiment." This has now been taken on by the JSC as a major planning activity for development over the next year. In various forms, this idea for a broad-scale global prediction initiative (with regional applications benefits) focusing on the 2010–2020 time frame is taking shape and, in many ways, CEOP may serve as a prototype for many of the concepts needed.

At the JSC, Sir Guy Green, the Governor of Tasmania, gave an excellent opening presentation on the science issues WCRP has been addressing, from the perspective of a policymaker who must use the results from our efforts to make decisions for the public good. His comments on (a) how uncertainty is a factor in all decisions and that he has a responsibility to assist the public in understanding the "myth of certainty," and (b) how "minority scientific conclusions" are presented by some as examples of significant division within the scientific community, provide the perspective we are finding from policymakers worldwide. These comments serve to re-emphasize how much we must focus on helping to reduce the uncertainties in our results, as well as placing them in proper perspective with other results in order for our policy leaders to make better use of them.

Overall, our GEWEX plans for Phase II are receiving great support, as well as suggestions and guidance for further improvement that will be incorporated into our implementation actions. This means that we are still on the right track with our plans, and it is now our job to implement these activities as well as possible, with your help.

Contents

RECENT CHANGES ON JOINT PLANNING STAFF OF WCRP

At the 14th Session of the GEWEX Scientific Steering Group (SSG), Sam Benedict (second from right) was recognized for his long dedication and significant contributions to GEWEX over the past 10 years as WCRP Senior Scientific Officer. Sam has recently retired from this position, but is maintaining his close ties to GEWEX as the new International Coordinator for the Coordinated Enhanced Observing Period (CEOP). Gilles Sommeria, shown at far left, attended his first SSG as the new WCRP Scientific Officer assisting in coordinating GEWEX activities. Professor Soroosh Sorooshian, Chair of the GEWEX SSG, is shown at far right. Also, shown are Paul Try, Director, International GEWEX Project Office and Anne Clark, Senior Secretary, WCRP.

CHANGES IN GEWEX

Dr. David Randall, Colorado State University, has been appointed as a member of the GEWEX Scientific Steering Group. Dr. Randall has a long history with GEWEX, and has served as chairman of the GEWEX Cloud System Study (GCSS), and most recently, the GEWEX Modelling and Prediction Panel (GMPP). Dr. Jan Polcher, Laboratoire de Météorologie Dynamique du CNRS, Chairman of the Global Land/Atmosphere System Study (GLASS), will assume the role as Chairman of GMPP.

GEWEX SCIENTIFIC STEERING GROUP MEMBERSHIP

New Members in Italics

Soroosh Sorooshian (Chair)
The University of Arizona
Hydrology and Water Resources
Tuscon, Arizona, USA

Thomas P. Ackerman
Pacific Northwest National Laboratory
Atmospheric Radiation Measurement Program
Richmond, Washington, USA

Robert Atlas
Data Assimilation Office
NASA/Goddard Space Flight Center
Greenbelt, Maryland, USA

Maria de Silva Dias
University de São Paulo
Instituto Astronomico e Geofisico
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Lars Gottschalk
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Department of Geophysics
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Anthony Hollingsworth
European Centre for Medium-Range Weather Forecasting
Reading, UK

Yann Kerr
CNES/CESBIO
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State Hydrological Institute
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David A. Randall
Colorado State University
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Ulrich Schumann
DLR-Institut für Physik der Atmosphäre
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Kuniyoshi Takeuchi
Yamanashi University
Department of Civil and Environmental Engineering
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Guoxiang Wu
Institute of Atmospheric Physics
Chinese Academy of Sciences
Beijing, CHINA

DETECTION OF CLIMATE CHANGE: WHEN AND WHERE?

Eric F. Wood
Princeton University

This brief note is a summary of the Horton Lecture presented at the Annual American Meteorological Society Meeting on 15 January 2002.

The Intergovernmental Panel on Climate Change (IPCC) reported (IPCC 1997, 2001a, 2001b) model predictions that in one case suggested a manifestation of global warming is an acceleration of the global hydrological cycle. Also, from NASA's ten year strategy documents it is stated: "According to model predictions, the most significant manifestation of climate change would be an acceleration of the global water cycle, leading to increased global precipitation, faster evaporation, and a general exacerbation of extreme hydrological regimes, floods, and droughts. Since the release of the latent heat associated with condensation is the principal source of energy for rapid cyclogenesis, a more active water cycle would generate more frequent and/or more severe weather disturbances" (NASA, 2000). One of the primary goals of GEWEX is to make long-term observations of the global water and energy budgets from which the effects of anthropogenic warming on these budgets could be quantified (WCRP, 1991)

The evidence suggests that some warming-related environmental change is already detectable. Analysis of surface temperature observations show a global mean warming of about 0.7°C over the past one hundred years. **However, with respect to intensification of the global hydrological cycle, the physical evidence is not yet strong enough to be forthright in acknowledging detectable trends in the major components, such as precipitation.** For example, Trenberth (2001) acknowledges that precipitation has probably increased as much as 1% per decade over most mid- and high-latitude continents of the Northern Hemisphere during the 20th Century. However, in a recent analysis of The Global Energy and Water Cycle Experiment (GEWEX) Global Precipitation Climatology Project (GPCP), there is little supporting evidence of a significant global trend in precipitation over the last two decades (Morel, 2001). Despite our inability to detect conclusive evidence in the current observational data record that supports global hydrological cycle intensification, many GCM studies of future climates predict substantial increases in globally averaged precipitation and related changes in other water balance variables (e.g., see IPCC, 2001a).

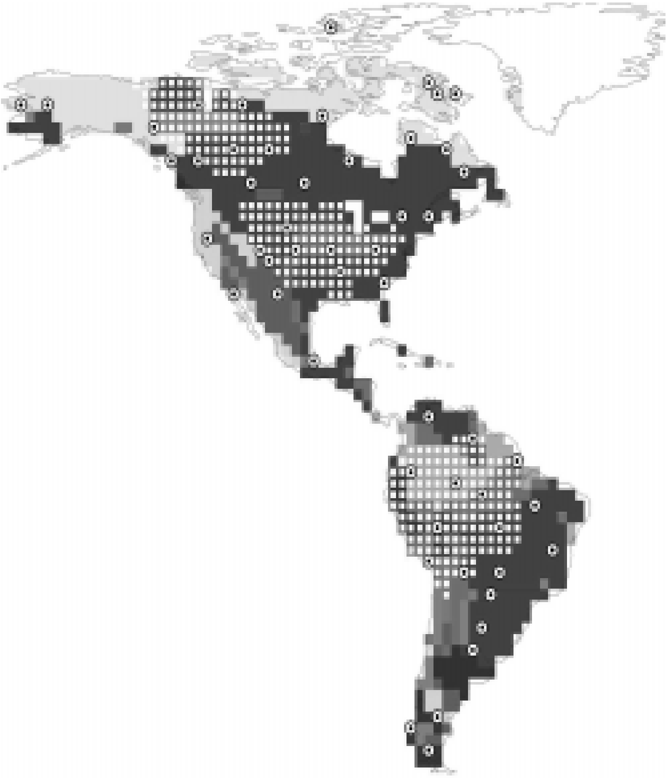
Two reasonable questions that can be addressed are: (i) Given natural variability, can estimates be provided of the number of years required to detect plausible changes in three major components of the terrestrial hydrological cycle; namely precipitation (P), evaporation (E), and runoff (Q)? And, (ii) given that we can't monitor everywhere, can we develop a strategy based on 'indicator basins,' space-borne observation platforms, and modeling that could provide a basis for determining whether change in the global hydrological cycle is occurring, and in doing so, evaluate whether the Continental Scale Experiment (CSE) basins of WCRP/GEWEX fulfil this role.

To address the first question, two measures of 'natural' variability of the terrestrial water balance terms were used: one is from the Parallel Climate Model (PCM) control run B4.10 (Washington et al., 2000) and the other is from hydrologic simulations by the University of Washington - Princeton Land Surface Model (LSM) Variable Infiltration Capacity (VIC), forced by daily observations for the period 1979–1993 (Nijssen et al., 2001a, b). The trends in the water balance components due to anthropogenic warming were from the PCM, transient run B6.20. The continental averaged trends from this run are 0.6 mm/yr for precipitation (P), 0.4 mm/yr for evaporation (E), and runoff, computed as P-E, is 0.2 mm/yr. The years of detection of precipitation trends, predicted by PCM run B6.20, range from more than 170 years for Africa to about 50 years for North America.

The back page figure shows the pattern of trends, variability, and years to detection by continent. For scale, the precipitation trend for North America is 0.71 mm/yr and evaporation for Africa is 0.32 mm/yr. The results show that in general the variability and years to detection of the PCM trend are consistent using the variability based on VIC and PCM. The results also show that the greatest variability occurs in the tropics, and variability is lower at higher latitudes, resulting in longer times to detection in the tropics. The exception to this is Europe, due to the low trend in the P-E from PCM for that region.

The second question posed is whether climate change 'indicator' basins can be identified. These basins would collectively mimic the continental-scale terrestrial water balance terms. A related question is the representativeness of the GEWEX Continental Scale Experiments (CSE) basins to their continents. Using the criteria of observing 5% of the grids, the figure below shows the location of the 'indicator' basins in the Western Hemisphere. The locations of the indicator basins were determined through optimization, where the objective function was to minimize the total squared difference of P, E, and Q for the indicator basin grids and all the grids that comprise the continental region

The results for detecting global climate change for the Western Hemisphere GEWEX CSE basins indicate that the Mississippi River Basin (GEWEX/GCIP) has trends close to the North America average but higher variability, suggesting longer time-to-detection (e.g., for precipitation, ~100 years over GCIP versus ~50 years for North America), while the Mackenzie River Basin(GEWEX/MAGS) has both a larger trend and variability, resulting in similar time-to-detection as the continental average. For the Amazon River Basin (GEWEX/LBA), the larger trend is offset by higher variability, resulting in similar detection times (e.g. for precipitation, ~80 years over LBA versus ~100 years for South America). For the 'indicator' basins the trends, variability and time-to-detection are within 10% of the continental values.



Location of the identified indicator basins (circles) for detecting climate change for the Western Hemisphere. The size of the indicator basins are on the order of 10,000 km^2. The white background areas depict approximate Mackenzie, Mississippi, and Amazon regions. The solid shaded areas, not discussed here, indicate climatic zones.

Discussion

The result of the analyses presented in the AMS Horton Lecture indicate that, due to anthropogenic warming, decades to more than a century may be required to detect the trends in the terrestrial water balance terms as predicted by one GCM, the PCM. The analysis also indicates that the GEWEX CSEs in the western hemisphere (Mackenzie, Mississippi, and Amazon Basins) may not be representative of the entire continental-scale water balance and trends in the balance terms, but appropriate for being used in detection studies.

Acknowledgments

I would like to thank the American Meteorological Society for the honor of presenting this Horton Lecture. I would like to recognize that this lecture utilized research carried out by Alan Ziegler and Justin Sheffield of Princeton University. Their work and our lively discussions have greatly enhanced this effort. I would also like to recognize the contribution of Dennis P. Lettenmaier, and his students Bart Nijssen and Ed Maurer, at the University of Washington, who have collaborated on the global modeling and provided valuable insights to this research. Finally, the research on which this lecture is based was supported through NASA Grant NAG5-9486.

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CLOSING THE WATER BUDGET

(Continued from page 1)

The budget cannot be closed on monthly time scales since there are no reliable estimates of surface water and we know from previous studies (e.g., Roads et al., 1999) that the surface water tendency is an important component of the monthly cycle. There are also no comprehensive monthly observations of evaporation for continental scale regions. However, the budget can be closed on an annual, or multiyear, basis because at that point the surface water tendency (as well as the atmospheric precipitable water tendency) should be small and the evaporation can be theoretically deduced as a residual of observed precipitation and runoff. On the average, the land evaporation, precipitation, runoff, and moisture convergence have values of 1.24, 2.01, 0.77, and 0.69 mm/day respectively. However, errors in the annual mean NCEP/Department of Energy (NCEP/DOE) reanalysis evaporation, precipitation, runoff, and moisture convergence are significant at 0.56, 0.27, 0.17, and -0.08 mm/day, respectively.

Of course, models close the water budget automatically since they are based upon fundamental laws such as conservation of mass, but each of the model processes is likely to have some error, especially if the model climate is dramatically different from observations. In that regard, a four-dimensional data assimilation analysis, which is forced to be close to observations, may provide the best closure. Although, as discussed by Kalnay et al. (1996), some analysis processes like moisture convergence are likely to be close to observations; others, like precipitation, which are strongly dependent upon the reanalysis model parameterizations, are likely to have less verisimilitude.

Hydroclimatological processes

The atmospheric, surface, and total water mass conservation equations are:

Atmospheric Water

$$\frac{\partial Q}{\partial t} = -P + E + MC$$

Surface Water

$$\frac{\partial W}{\partial t} = P - E - N$$

Total Water

$$\frac{\partial (Q + W)}{\partial t} = MC - N$$

Here Q and W are the atmospheric precipitable water and surface water; P, E, MC, N are the precipitation, evaporation, moisture convergence and surface runoff.

Moisture convergence, MC, is a nonlinear term dependent upon the divergence of atmospheric winds and moisture. Problems arise from trying to calculate this term from sparse radiosonde observations and even gridded analysis products. In fact, given that modern analysis systems are now including additional satellite observations and have extensive quality control, they are likely to provide the best estimates of moisture convergence (see Roads et al., 2002 for full details about this calculation for the NCEP/NCAR reanalyses). However, global and even regional analyses probably do not adequately describe various low level jets that may have a large influence on the local hydrologic cycle.

The moisture convergence calculated (see e.g. Roads et al., 2002) from the NCEP/NCAR reanalysis (Kalnay et al., 1996) is compared here with the Global Runoff Data Center's runoff estimated by Fekete et al. (1999). In addition, precipitation from the Global Precipitation Climatology Precipitation (GPCP; Huffman et al., 1997) project is compared to the NCEP/DOE reanalysis (Kanamitsu et al. 2000) precipitation. GPCP precipitation, along with the GRDC runoff is used to estimate the observed annual mean evaporation.

All of these "observations" are likely to have some error associated with them and an even larger error might be expected for a residual evaporation calculated from the difference between GPCP precipitation and GRDC runoff. Again, the NCEP/DOE reanalysis parameterized processes like precipitation, evaporation, runoff are likely to have larger errors and it, therefore, makes some sense to compare the reanalysis precipitation, evaporation, moisture convergence, and runoff with the currently "observed" precipitation, runoff, and evaporation.

Regional Continental-Scale Closure

The GEWEX Hydrometeorology Panel (GHP) coordinates the CSEs and affiliated experiments, which now include nine representative world climate regions. The CSE regions over the Americas include the Mackenzie (MAGS, see Stewart et al., 1998), Mississippi (GCIP/GAPP, see Lawford 1999), and Amazon (LBA, see Marengo et al., 2001) river basins. In Europe, there is an experiment for the Baltic Sea Region (BALTEX, see Raschke et el., 2001) and in Asia there are four GAMEs (see GAME international science panel, 1998) with sites in Siberia (GAME-SIBERIA), China (GAME-HUBEX), Tibet (GAME-TIBET), and Thailand (GAME-TROPICS). An affiliated experiment, Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH, see D'Amato and Lebel, 1998) has begun over western equatorial Africa. About half of the CSEs are major river basins (Mackenzie, Mississippi, Amazon, Lena), one is an inland sea (Baltic), and the rest cover large-scale regions (CATCH, GAME-HUBEX, GAME-Tibet, GAME-Tropics). Other CSEs are under development (see page 9). The table on page 8 summarizes a comparison of the budget parameters for the CSEs.

Note that over the land, the annual mean error (MC-GRDC)/GRDC is relatively small (~10%). Even over some of the continental scale experiment regions such as the Mississippi River Basin, Lena River Basin, BALTEX, Tibet and GAME-Tropics, the errors are still smaller than 20%. Unfortunately the closure is less over the Mackenzie, GAME HUBEX, and the monsoon regions (Amazon and western tropical Africa) where the errors can be almost as large as the associated runoff. It should also be mentioned that except for Mackenzie and Mississippi, the moisture convergence is less than the runoff, which suggests (assuming that the GRDC is the better observation) that coarse scale global models have too little land moisture convergence.

The errors are large in many of the hydroclimatological terms, and for all regions evaporation is clearly too high and provides the largest error to the land average. The next highest contributor is precipitation, which is too large everywhere, except for the CATCH and BALTEX regions, and is the largest contributor to the error over the GAME Tropics. The next largest error is the reanalysis runoff, which is too large in most places, excepting the Lena River Basin and the Amazon River Basin (where it is too low). Moisture convergence has the smallest overall error, although this might not be unexpected given that moisture convergence is based upon primary reanalysis variables. However, there are clearly problems over the Amazon River Basin where the error in the moisture convergence is almost as large as the error in the evaporation. The sum of these errors,

$$RSQ=-(-P+E+MC)=(P-GPCP)-(E-(GPCP-GRDC))-(MC-GRDC)$$

$$RSW=-(-P-E-N)=-(P-GPCP)+(E-(GPCP-GRDC))+(N-GRDC)$$

appears in 4-dimensional data assimilation (4DDA) analysis water budgets (e.g. Kanamitsu and Saha, 1996, Roads et al., 1998) in order to implicitly force the analyses' state variables close to observations. In the atmospheric part of the analysis, this artificial forcing occurs as the model is adjusted to the available observations of atmospheric moisture, temperature and winds every analysis time. At the surface, some implicit analysis adjustment occurs for the snow correction as well as the surface moisture, which uses observed precipitation instead of model precipitation to keep the soil moisture realistic (Kanamitsu et al., 2000). Because of these implicit adjustments (or residual forcings or analysis increments), one might think that reanalyses cannot be used to study hydrometeorological budgets. However, it is worth stressing again that since all models are designed to produce accurate budgets, individual process errors are likely to be much larger in models that do not have an artificial forcing to an observed climate. It had previously been hoped (Roads et al., 1998) that longer-term forecasts (say 24 hours) initialized from the reanalysis would decrease these residuals; unfortunately even longer term forecasts seemed to be required, which would eventually result in more unrealistic values for other components at the expense of reducing the analysis residuals. There is not likely a quick fix for these residual forcings, which are indicating fundamental errors in the model physical parameterizations. An overall modeling goal should be the production of an analysis with small budget residuals as well as small errors for primary values.

Note that RSQ is mainly negative, which indicates that if MC is adjusted upward, then RSQ will be even more negative. By examination, it is clear that evaporation is a principal problem. For example observed land precipitation shows 2.01 mm/day and using estimates of land runoff (0.77 mm/day) estimated land evaporation is 1.24 mm/day. By contrast

	T	P	E	MC	N	RSW	RSQ	GPCP	GPCP-GRDC	GRDC
GAME-SIBERIA	-7.28	1.36	1.30	0.49	0.38	0.32	-0.43	1.15	0.64	0.51
MAGS	-2.91	1.79	1.76	0.67	0.72	0.69	-0.64	1.08	0.70	0.38
GAME-TIBET	-2.40	2.63	1.41	1.13	2.12	0.90	0.08	1.44	0.10	1.34
BALTEX	4.63	1.87	1.90	0.65	0.66	0.69	-0.68	2.09	1.42	0.67
GCIP/GAPP	10.32	2.30	2.34	0.55	0.53	0.57	-0.58	2.15	1.69	0.46
GAME-HUBEX	13.59	2.75	2.31	0.09	0.79	0.35	0.35	2.54	1.99	0.55
LBA	23.14	5.28	3.91	1.72	2.08	0.71	-0.35	5.13	1.95	3.18
GAME-TROPICS	23.34	7.94	3.93	2.06	4.41	0.40	1.95	4.62	2.43	2.19
CATCH	26.83	2.36	2.28	-0.07	0.84	0.76	0.15	2.79	2.36	0.43
LAND	8.48	2.28	1.80	0.69	0.94	0.46	-0.21	2.01	1.24	0.77
OCEAN	17.15	3.45	3.65	-0.27			0.07	2.81		
GLOBAL	14.69	3.12	3.13				-0.01	2.58		

Reanalysis (T, P, E, MC, N, RSW, RSQ) annual means (1988–1999) in comparison to GPCP and GRDC (climatology) for ocean, land, and global, as well as the individual CSEs including the Lena River Basin (GAME-Siberia), GAME-Tropics, BALTEX, GAME-HUBEX, LBA, Mackenzie (MAGS), GAME-Tropics, Mississippi River Basin (GCIP/GAPP), CATCH, and GAME-Tibet.

the NCEP/DOE reanalysis precipitation, evaporation, and runoff are 2.28 (10% error), 1.8 (50% error), and 0.94 (20% error) mm/day. Globally the situation is somewhat reversed since the GPCP precipitation is 2.58 mm/day whereas the NCEP/DOE precipitation and evaporation are more like 3.12 mm/day, which is an error of 0.54 mm/day (25%).

To go further and close the water budget on monthly to interannual time scales will require estimates of the seasonally varying evaporation and surface water tendencies. In that regard, our best estimates should eventually come from regional reanalyses as well as regional and global land data assimilation systems. As these systems are developed, it would be important to again examine just how well the water budget can be closed on regional to global scales.

Acknowledgments

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NEW GEWEX CSE IN AUSTRALIA

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The Murray-Darling Basin Water Budget Project (MDB) was approved as a GEWEX Continental Scale Experiment (CSE) at the 14th Session of the GEWEX SSG. The Project aims to enhance the capability of numerical weather prediction models to provide a real-time surface water budget over the Murray-Darling for application by water authorities. The MDB involves both modelling and field studies, and was initiated through collaboration between the Bureau of Meteorology Research Centre (BMRC) and the University of Melbourne's Department of Civil and Environmental Engineering, under the auspices of the Cooperative Research Centre for Catchment Hydrology. The project now includes contributions from the Commonwealth Scientific and Industrial Research Organization Land and Water, Macquarie University, and the Australian Nuclear Science and Technology Organization.

The Murray-Darling Basin covers a catchment area of 1×10^6 km^2 or about 14% of Australia. Both the Murray and Darling Rivers have lengths greater than 2,500 km, and so the Basin is one of the world's major river systems. **A key feature of the Basin is that it largely represents a semi-arid zone, and so its ratio of discharge to precipitation is extremely low (less than 0.05) due to the potential evaporation rate being more than twice the precipitation rate.**

The Basin is complicated not only by the high evaporation rate, but also by the large interannual variability of the rainfall, mainly due to the impact of the El Niño - Southern Oscillation (ENSO) on the climate of southeastern Australia. This variability in rainfall is amplified in the annual runoff figures, which are more variable than runoff elsewhere in the world (except for parts of Southern Africa that experience a similar climate). The Basin includes the three longest rivers in Australia. The Darling is 2,740 km long from its source in the north to its confluence with the Murray at Wentworth, the Murray is 2,530 km long from its source in the Australian Alps to its mouth on Encounter Bay in South Australia, and the Murrumbidgee is 1,690 km long.

There is a range of climatic conditions across the Basin, with cool humid conditions on the eastern uplands supporting areas of rainforest, and sub-tropical conditions in the northeast. The climate to the southeast is temperate, while the large western plains are semi-arid and arid areas. The Murray-Darling Basin is the food bowl of Australia with rich irrigation, farming and grazing land. The Basin accounts for 40% of Australia's agricultural production, utilizing about 70% of all water used for agriculture across the nation. The 1,500,000 hectares under irrigation for crops and pastures represents 70% of the total area under irrigation in Australia. More than 80% of the divertible surface water resource is consumed in the Basin. The Basin holds a population of 2 million people, which is about 10% of the national population. **The Basin has a naturally saline environment due to its soils and geology. However, human activities have exacerbated these conditions such that high salinity levels in water are causing problems for agricultural, industrial and domestic users.**

Objectives of the Murray-Darling Basin Water Budget Project:

- To monitor and predict key components of the daily water budget across the Basin
- To develop real-time products on key components of the water budget for use by water agencies
- To observe, understand and model the processes controlling soil moisture in the Basin
- To improve the representation of land surface processes in weather and climate models

These objectives are being achieved through a program of combined observation and modeling studies. Core data for the project are collected and managed through the Bureau's real-time systems, where satellite *in situ* data are processed through the National Meteorological Operations Centre. The Bureau's observation program involves the collection of data from both surface-based and space-based instruments. Surface data are obtained from 59 Bureau-staffed stations and from 456 automatic weather stations around the country. The measurement of rainfall is enhanced through an additional 1,690 real-time sites and 3,745 climatological raingauge sites operated by volunteers. Other surface data are obtained from remote-sensing instruments, such as weather watch radars, wind profilers and lightning-detection systems.

The MDB project will benefit from other collaborative activities in BMRC. Of special significance is the recent establishment of a US Department of Energy Atmospheric Radiation Measurement (ARM) site at the BMRC research station in Darwin. Under the ARM project, BMRC will use data from Darwin to improve the parameterization of cloud-radiation interactions in models.

Acknowledgment

Murray-Darling map on cover is courtesy of the Murray-Darling Basin Commission.

GPCP PRECIPITATION ANOMALIES IN THE INDIAN OCEAN AS PRECURSORS TO EL NIÑO

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Pentad precipitation data from the Global Precipitation Climatology Project (GPCP) under GEWEX have been used to uncover a link between rainfall patterns in the Indian Ocean and the initiation of El Niño. This relationship, described in detail in Curtis et al. (2002), is summarized here. The second combined Empirical Orthogonal Function (CEOF) of precipitation and 1000 mb wind at a 5-day resolution in the Indian Ocean is characterized by a gradient of precipitation anomalies between the middle of the basin and the southwestern coast of Sumatra, coinciding with strong equatorial wind anomalies. For five out of the six El Niño events from 1979–1999 (see figure on back cover), there was significant power in the 30–60 day oscillation of the gradient around 3 months before the central Pacific became warmer than normal. This work led to a prediction index (PI), based on the power of the 30-60 day oscillation and the background climate. The PI was set to zero if the 6 month trailing mean of the gradient was negative, in other words, dry to the southeast and wet to the northwest (usually accompanied by easterly wind anomalies). This prediction scheme has been running in real time since early 2001 and during January 21–25, 2002 the PI reached a significant threshold (see figure on back cover) to forecast an El Niño starting the summer of 2002. This estimated lead-time is based on the average of the five past events.

The physics behind this statistical relationship is not fully understood. There appears to be a connection to the Madden-Julian Oscillation (MJO). The MJO also has a 30–60 day time scale, affects the entire tropical troposphere, and is the dominant intraseasonal variation in the Indian and western Pacific Oceans. The gradient may be a manifestation of anomalous rainfall propagation during the MJO, where the preferred path during boreal winter is through the gradient and into northern Australia and the South Pacific Convergence Zone, at the southern edge of the Australian monsoon. The background climatology of the Indian Ocean seems to be important for the subsequent connection to El Niño. A mostly positive gradient over several months would be conducive to westerly wind anomalies at the equator, which may help condition the sea surface for El Niño development. Furthermore, the MJO disturbances are likely to enter the western Pacific where they can generate Kelvin waves. These waves traverse across the Pacific basin to the coast of South America and are often followed by warming.

A preliminary extension of the analysis back to 1916 has been performed using gauge data from the Cocos Islands. This analysis covers only the southeast dipole of the gradient. A measure of intraseasonal variability for this location still shows a good connection to the initiation of El Niño (as measured by the SOI) back to the mid-1960s. However, the relationship is much weaker earlier in the record. This change may be due to interdecadal variations in El Niño development or gauge quality. Overall, the analysis predicts wintertime conditions well, capturing 10 out of the 13 strongest December–January events since 1916.

Reference

Curtis, S., G. J. Huffman, and R. F. Adler, 2002: Precipitation anomalies in the tropical Indian Ocean and their relation to the initiation of El Niño. *Geophys. Res. Lett.*, in press.

WORKSHOP/MEETING SUMMARIES

AMS MEETING

Orlando Florida USA
13–18 January 2002

At the 82nd Annual American Meteorological Society (AMS) meeting many presentations reported on GEWEX research results. There were eleven major symposia and conferences plus special smaller symposia workshops, forums, and town meetings. Most of the GEWEX topics for the 2000 plus registrants were presented in the Conference on Hydrology, the Symposium on Observations, and the Symposium on Global Change and Climate Variations. Choosing a particular session where GEWEX results were reported was difficult. For example, on the first day of technical sessions there were four simultaneous invited addresses. They were by Kevin Trenberth, discussing components of the climate observing system; Kenneth Mitchell speaking about land surface interactions; Anthony Hollingsworth reporting on ECMWF status on data assimilation and ensemble prediction, and Keith Browning reviewing cyclogenesis research. In addition to the traditional scientific presentations there were special invited lectures. This year the Horton Award Lecture was presented by Eric Wood, a long term member of the GEWEX community. To read a summary of his lecture, please see article "Detection of Climate Change: When and Where?" on page 4.

GEWEX/WCRP MEETINGS CALENDAR

For calendar updates, see the GEWEX Web site:
http://www.gewex.com

21–26 April 2002—EUROPEAN GEOPHYSICAL SOCIETY XXVII GENERAL ASSEMBLY, Nice, France.

13–17 May 2002—MISSISSIPPI RIVER CLIMATE AND HYDROLOGY CONFERENCE, New Orleans, USA. Contact Rick Lawford at lawford@ogp.noaa.gov.

13–17 May 2002—16TH GPCP-WGDM MEETING, Tokyo, Japan.

20–24 May 2002—GCSS-ARM WORKSHOP ON THE REPRESENTATION OF CLOUD SYSTEMS IN LARGE-SCALE MODELS, Kananaskis Village, Alberta, Canada.

22–25 May 2002—THE NORTHERN ENVIRONMENT, CMOS - 36TH CONGRESS, Rimouski, Quebec, Canada.

28–31 May 2002—7TH BSRN SCIENTIFIC AND REVIEW WORKSHOP, Regina, Canada.

28–31 May 2002—AGU SPRING MEETING (SPECIAL SESSION ON THE GLOBAL WATER CYCLE), Washington, DC, USA.

7–10 July 2002—2ND LBA SCIENCE CONFERENCE, Manaus, Brazil.

5–19 July 2002—15TH AMS SYMPOSIUM ON BOUNDARY LAYERS AND TURBULENCE, Wageningen University, The Netherlands.

22–26 July 2002—INTERNATIONAL TRMM SCIENCE CONFERENCE, Honolulu, Hawaii, USA.

28 July–1 August 2002—SECOND FEDERAL INTERAGENCY HYDROLOGIC MODELING CONFERENCE, Las Vegas, Nevada, USA.

31 July–2 August 2002—13TH SESSION OF THE WCRP/GEWEX RADIATION PANEL (GRP), ETH, Zurich, Switzerland.

2–6 September 2002—WMO/WWRP INTERNATIONAL CONFERENCE ON QUANTITATIVE PRECIPITATION FORECASTING, Reading, UK

9–13 September 2002—8TH SESSION OF THE GEWEX HYDROMETEOROLOGY PANEL, IRI, Palisades, New York, USA.

3–5 October 2002—5TH INTERNATIONAL STUDY CONFERENCE ON GEWEX IN ASIA AND GAME, Nagoya, Japan.

10–19 October 2002—34TH COSPAR SCIENTIFIC ASSEMBLY (Special Session on Properties of the Earth-Atmosphere-Ocean System as Inferred from the New Generation of Earth Science Satellites), Houston, Texas, USA.

12–15 November 2002—2ND INTERNATIONAL ATMOSPHERIC MODEL INTERCOMPARISON PROJECT (AMIP) CONFERENCE, Meteo-France, Toulouse, France.

20–25 January 2003—15TH SESSION OF THE GEWEX SSG, Bangkok, Thailand.

June 2004—5TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE, Tuscon, Arizona, USA.

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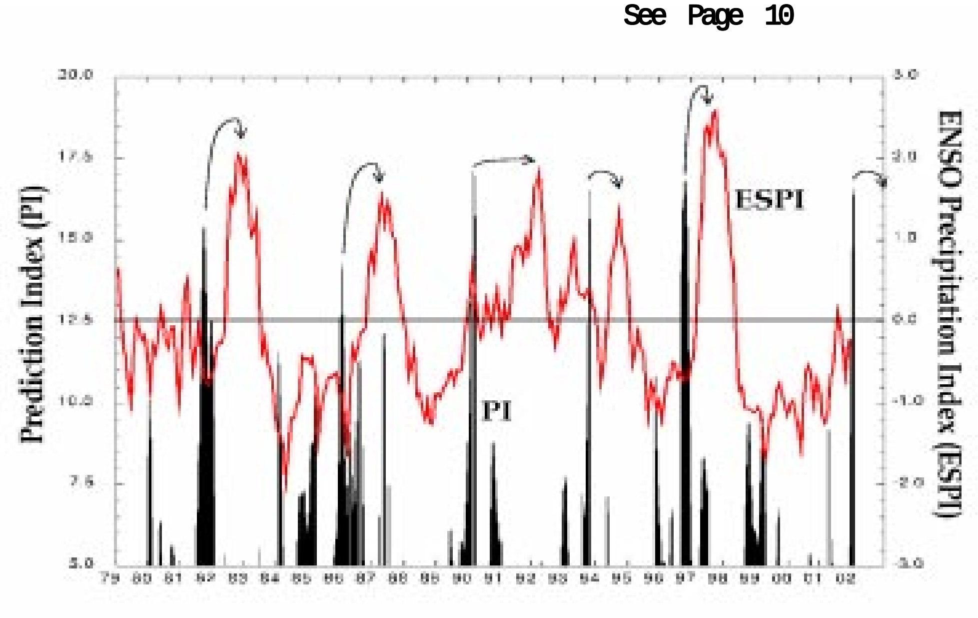
PREDICTING EL NIÑO WITH PRECIPITATION INFORMATION

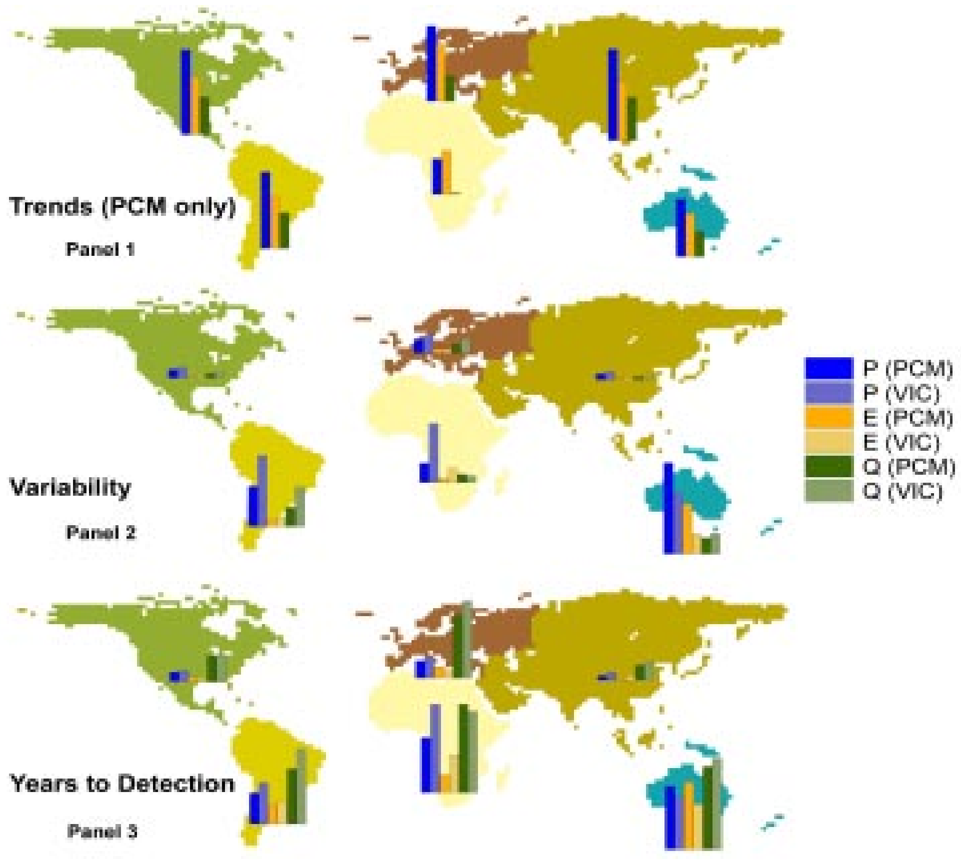
See Page 10



Satellite rainfall estimates predict a 2002–2003 El Niño. Shown are hindcasts of El Niño events since 1979 and an experimental forecast. Red curve represents the ENSO Precipitation Index, where positive (negative) values indicate El Niño (La Niña). Black bars denote the prediction index derived over the Indian Ocean. Large positive values indicate a forthcoming El Niño (arrows).

CONTINENTAL ENVIRONMENTAL TRENDS AND YEARS FOR DETECTION

See Page 4



Trends based on PCM:
N. America: P=0.71, E=0.45, Q=0.26
S. America: P=0.63, E=0.40, Q=0.24
Africa: P=0.04, E=0.32, Q=-0.09

Variability based on VIC:
N. America: P=433, E=70, Q=217
S. America: P=2912, E=337, Q=1609
Africa: P=2721, E=609, Q=283

Variability based on PCM trends and VIC variability:
N. America: P=48, E=35, Q=73
S. America: P=97, E=65, Q=152
Africa: P=173, E=91, Q=162

Panel 1 results from left to right are Precipitation (P), Evaporation (E), Runoff (Q). Variability (Panel 2) and Years to Detection (Panel 3) results are, from left to right, P(PCM), P(VIC), E(PCM), E(VIC), Q(PCM), Q(VIC). Some examples for trends (mm/yr), variability (mm^2/yr^2), and years to detection (yr) are given above.