GEWEX
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Global Energy and Water Cycle Experiment
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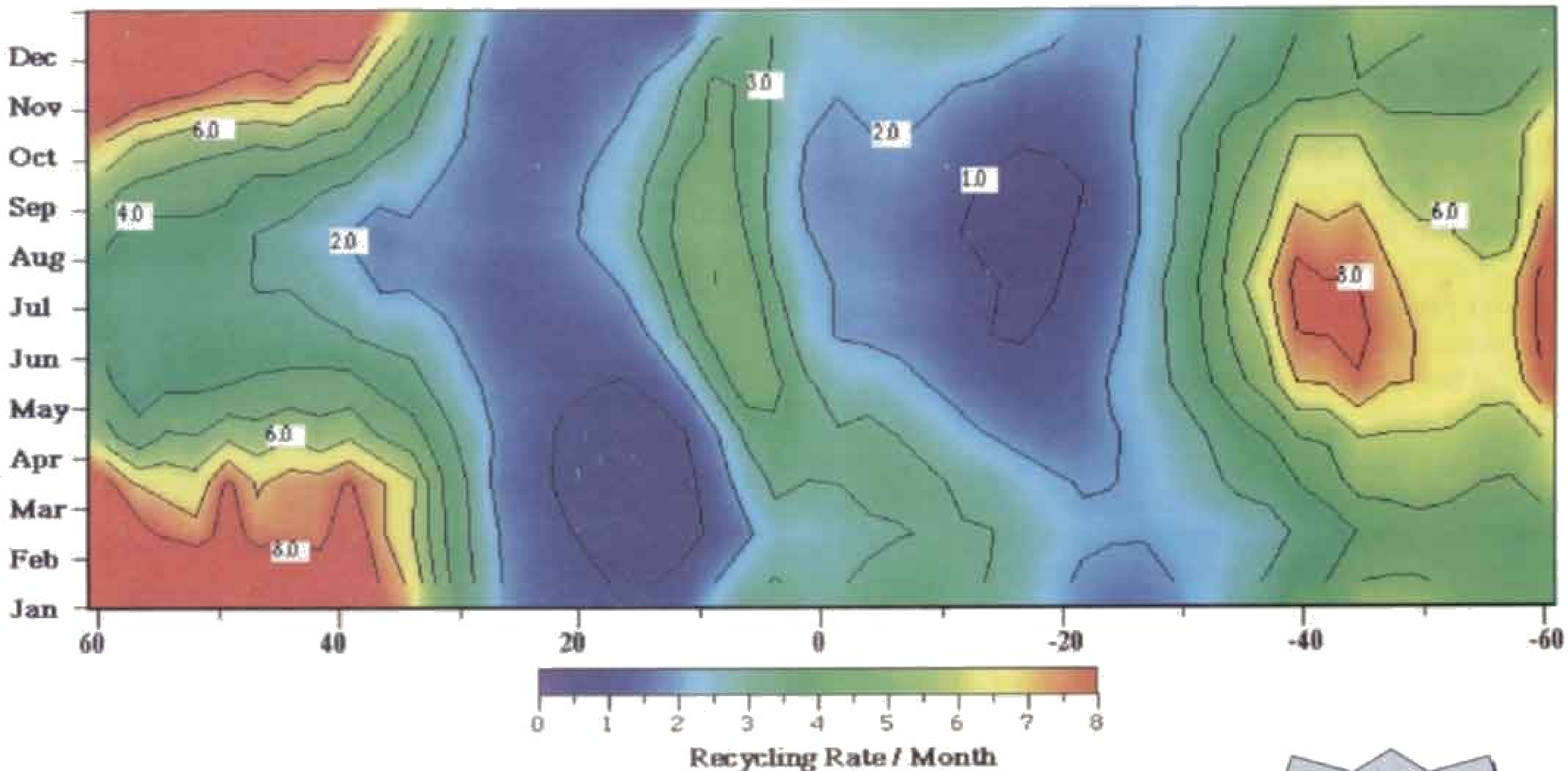
GEWEX ADDRESSING VARIATIONS OF THE HYDROLOGICAL CYCLE



Observed zonal average of the recycling rate per month of the total atmospheric precipitable water vapor for the period 1988–1994 between 60 °S and 60 °N (see Chahine et al. article below).

See What's New in GEWEX on back cover

OBSERVATION OF THE RECYCLING RATE OF MOISTURE IN THE ATMOSPHERE: 1988–1994

M. T. Chahine, R. Haskins and E. Fetzer
Jet Propulsion Laboratory
California Institute of Technology

The amount and loss through precipitation of atmospheric moisture can be determined from space observations with accuracies that permit determination of the mean residence time of atmospheric water vapor, or its recycling rate, on a monthly basis. The two main parameters needed are the

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ATMOSPHERIC MOISTURE RESIDENCE TIMES AND CYCLING: IMPLICATIONS FOR HOW PRECIPITATION MAY CHANGE AS CLIMATE CHANGES

Kevin E. Trenberth
National Center for Atmospheric Research

Characterizing all aspects of the hydrological cycle accurately from observations and analyses is a difficult task, so that there remain substantial uncertainties in precipitation, evaporation, the moisture transport in the atmosphere, and surface runoff. These uncertainties become magnified

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INTENSIFYING THE HYDROLOGICAL CYCLE

Graeme L. Stephens
Colorado State University

July 31, 1976, was a day tragically etched in the memories of most Coloradans. A severe thunderstorm formed over the otherwise scenic and peaceful alpine region of the Rockies just west of Estes Park located at the foot of the Rocky Mountain National Park. Heavy rain fell from this storm over an approximate 70 square mile region of the Big Thompson watershed. A devastating wall of water filled the canyon, killing 139 people, and resulted in

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COMMENTARY

GEWEX STRATEGIES AND GOALS ARE AFFIRMED BY JOINT SCIENCE COMMITTEE

Moustafa T. Chahine, Chairman
GEWEX Scientific Steering Group

In 1995 the Joint Scientific Committee (JSC) requested a full review of GEWEX to be conducted two years later. In its 1997 meeting in Toronto, the JSC completed the review and concurred with GEWEX plans and strategies for space observations, field experiments, and modeling and prediction. A set of long-range scientific goals were also presented which are very demanding but tenable. I would like to share those goals with you in this commentary.

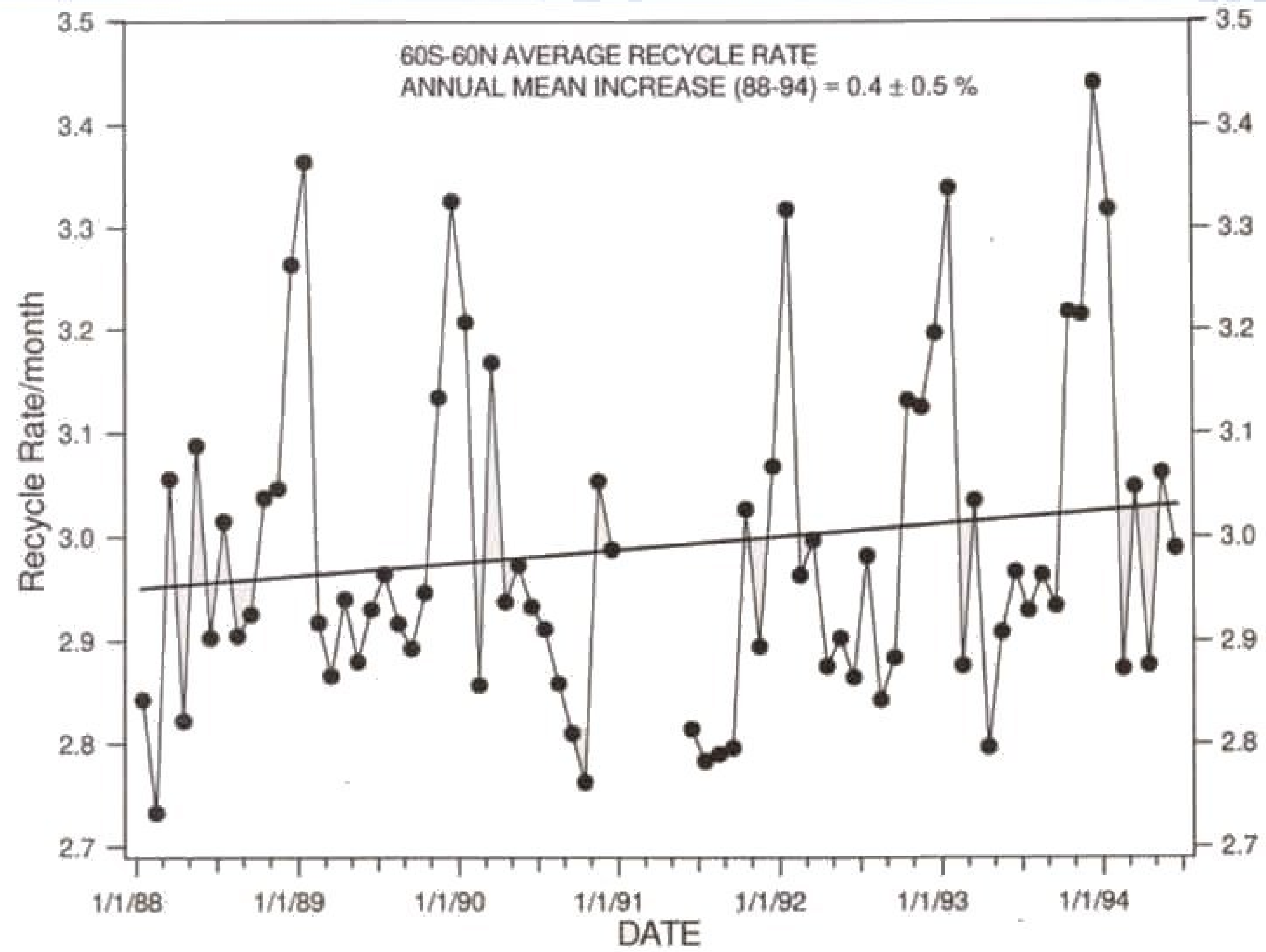
Hydrometeorological Research: The premise is that the prediction of regional precipitation and runoff anomalies over periods of several months is a possibility given improved understanding of water cycle processes. **The resulting goal is to demonstrate skill in predicting changes in water resources and soil moisture on time scales up to seasonal and annual as an integral part of the climate system**: (1) By the year 2000, quantify evaporation, precipitation and other hydrological processes as required to improve prediction of regional precipitation over periods of one to several months; and (2) by the year 2005, predict changes in water resources and soil moisture on time scales of seasonal to annual as an integral part of the climate system.

Radiation Research: The premise is that accurate determination of the energy fluxes in the atmosphere and at surfaces, as required for seasonal-to-interannual climate prediction (e.g. El Niño), is a possibility with improved observations and understanding of cloud, precipitation and water vapor processes. **The resulting goal is to demonstrate the ability to determine radiation fluxes and radiative heating of the atmosphere with the precision needed to predict transient climate variation and decadal-to-centennial climate trends**: (1) By the year 2000, determine radiation fluxes in the atmosphere and at the Earth's surfaces with an accuracy of 20 W/m^2, as required to support improved weather forecast; (2) by the year 2005, achieve an accuracy of 15 W/m^2 as needed for prediction of climate anomalies like ENSO and (15 W/m^2); and (3) by the year 2010, achieve an accuracy of 10 W/m^2 as required for prediction of climate change in response to anthropogenic changes.

Modeling and Prediction: In collaboration with Working Group on Numerical Experimentation, use the scientific insight from GEWEX global data and process studies to develop accurate model formulations of: (1) The water budget and transport in the climate system; and (2) The energy budget and radiation transfer in the climate system. **The goal is to demonstrate the capability for prediction of precipitation, water storage and runoff over continental regions, as an element of seasonal-to-interannual climate predictability and demonstrate capability for prediction of the radiation budget and fluxes, as an element of decadal-to-centennial climate variability and response to changes in external forcing parameters.**

These goals and the strategies to achieve them via GEWEX programs underway or planned were approved by the JSC. This means that GEWEX is recognized as a mature, well-organized WCRP program, having in place the means to achieve the goals set forth. GEWEX will invite regular reviews of its progress in these areas, not only at the JSC, but in open, scientific workshops. In this way, GEWEX continues to make major contributions to the study of hydrological cycle processes in the climate system.

Contents



Observed monthly variations and trend of the global recycling rate of the total precipitable water vapor for the period 1988–1994 between 60 °S and 60 °N. (Note missing precipitation data in 1991).

OBSERVATION OF THE RECYCLING RATE OF MOISTURE IN THE ATMOSPHERE: 1988–1994

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atmospheric moisture (mm) and the precipitation (mm/month). In this study we have used the total precipitable atmospheric water vapor data derived from the NOAA weather satellites sounding system TOVS Pathfinder by Susskind et al. (1997) and the precipitation values derived under the GEWEX Global Precipitation Climatology Program (GPCP) as described by Huffman et al. (1997).

The precipitable water vapor data are derived by a combined infrared and microwave retrieval process that allows the determination of moisture under cloudy conditions over both land and oceans, except under heavy precipitating clouds. The results agree very well with the SSM/I data over oceans for the period of observations discussed here. The satellite observations are made twice daily globally. A close examination demonstrated that the running average of the TOVS Pathfinder data over any grid shows both stability and convergence to a steady state over monthly periods of time. This is an important property of the observed moisture data which allows us to study regional recycling rates. However, for this study, we have limited our coverage to 60 degrees latitudes because of the scarcity of reliable humidity and precipitation data in the polar regions.

We define the recycling rate per month for any grid point as the ratio of the total monthly precipitation over the (steady state) mean precipitable water vapor for the same month. The resulting zonal average recycling rates per month are shown in the figure on page 1, for a grid size of 2.5 x 2.5 degrees. The large range of variations of the recycling rates, apparently due to the influence of the land masses in the northern hemisphere, is clearly visible.

Similarly, we define the global mean recycling rate per month as the simple ratio of the corresponding total global mean precipitation over the global mean precipitable water vapor for the same month. The results in the figure above show the monthly variations in the recycling rate, with the maximum recycling values occurring around January. The figure also shows a small trend toward an increase in the recycling rate. A similar trend was also noted when we repeated the calculations using another water vapor data set—the blended NVAP data set (1988–92) by Randel et al. (1996). The reasons for the increase in the recycling rate may be attributed to the fact that the precipitation data used showed a constant trend for the period 1988–1994, while the two water vapor data sets examined showed a slight decrease in the global precipitable water vapor. However, it must be cautioned that the short period of time examined in this study (seven years) includes the transient effects of El Niño, so a more extended period of observations is needed before reaching a definite conclusion on the trend.

References:

Susskind, J., P. Piraino, L. Rokke, L. Iredell and A. Mehta, 1997: Characteristics of the TOVS pathfinder path A data set. Accepted for publication in *the Bull. Amer. Meteor. Soc.*

Huffman, G.J., R.F. Adler, P. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolf and U. Schneider, 1997: The global precipitation climatology project (GPCP) combined precipitation data set. *Bull. Amer. Meteor. Soc.* Vol.78, No.1, 5-20.

Randel, D.L., T.H. Vonder Haar, M.A. Ringerud, G.L. Stephens, T.J. Greenwald, and C.L. Combs, 1996: A new global water vapor data set. *Bull. Amer. Meteor. Soc.* Vol.77, No.6, 1233-1246.

SECOND STUDY CONFERENCE ON BALTIC SEA EXPERIMENT (BALTEX)

25–29 May 1998
Juliusruh, Island of Rugen, Germany

Themes for the conference will be: data collection and climatology studies, process studies and field experiments, remote sensing applications, modeling, data assimilation and coupled modeling, and results from other GEWEX Continental-Scale Experiments.

GCIP MISSISSIPPI RIVER HYDROMETEOROLOGY CONFERENCE

Predicting Climate Variability and its Implications for Water Resource Management
8–12 June 1998
St. Louis, Missouri, USA

Topics for this conference include: precipitation, water budgets, energy budgets, soil moisture, hydrologic modeling, regional coupled modeling, climate prediction and water resources, and international land surface issues.

For contacts on these conferences see calendar on page 15.

ATMOSPHERIC MOISTURE RESIDENCE TIMES AND CYCLING: IMPLICATIONS FOR HOW PRECIPITATION MAY CHANGE AS CLIMATE CHANGES

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in attempts to project what changes may occur in any of these quantities as the climate changes. Nevertheless, the availability of new data sets from GEWEX and from the reanalyses have allowed new estimates to be made of quantities important for understanding the hydrological cycle and its role in climate change. In this study (for a more complete report, see Trenberth, 1997) we make use of the monthly Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) fields of precipitation P from Xie and Arkin (1996, 1997), precipitable water from NVAP (Randel et al., 1996) based primarily on Special Sensor Microwave Imager (SSM/I) over the oceans and rawinsonde measurements over land plus TIROS Operational Vertical Sounder (TOVS), and evaporation E and moisture transport from the National Centers for Environmental Prediction (NCEP)/NCAR reanalyses.

In particular, we have made new estimates of the e-folding time constants of moistening of the atmosphere through evaporation at the surface and of the drying through precipitation. For precipitation, local values of the depletion rate of atmospheric moisture are about 1 week in the tropical convergence zones but they exceed a month in the dry zones in the subtropics and desert areas. The restoration rate shows largest values over northern Africa, Saudi Arabia, Iran, and Australia. Values average about 12 days in the tropical convergence zones and are lowest in the subtropical highs where evaporation is a maximum, yet moisture is trapped at low levels by subsidence and so precipitable water is limited. Overall, globally, the e-folding residence time for atmospheric moisture is just over 8 days. Note that this is the global mean of the inverse time constant expressed as a residence time, not the residence time computed from global means (which is a day or so longer).

These computations do not take into account atmospheric moisture transport. Therefore, we have also made new estimates of how much moisture that precipitates out comes from horizontal transport versus local evaporation, referred to as "recycling" (see Brubaker et al., 1993, Eltahir and

Bras, 1996). The results depend greatly on the scale of the domain under consideration. A new formulation of the recycling allows it to be computed locally and mapped by making assumptions of uniformity (that do not exist in practice); however, the very heterogeneity of the land surface and the catchment basins makes this approach useful. We have produced global maps (as shown on the back page) of the recycling for annual means for 500 km and 1000 km scales. For the 500 km scale, global annual mean recycling is 9.6%, consisting of 8.9% over land and 9.9% over the oceans. Over the Amazon, the average is about 5% and over the Mississippi basin about 7%. For 1000 km scales the mean recycling is 16.8% globally, 15.4% over land and 17.3% over the oceans. Over particular river basins, our results are not incompatible with those of previous studies. It is worth pointing out that the larger values previously obtained for the Amazon versus the Mississippi are mostly a result of the scale of the domain (see Brubaker et al., 1993). Thus we find that even for 1000 km scales, less than 20% of the annual precipitation typically comes from evaporation within that domain.

While overall atmospheric moisture depletion and restoration must balance, precipitation falls only a small fraction of the time. Thus it is important to also consider the depletion rate conditional on when it is raining and so we also examine precipitation rates (also called precipitation intensity). Over the United States we use a dataset from Higgins et al. (1996). One hour intervals with 0.1 mm or more are used to show that the frequency of precipitation ranges from over 30% in the Northwest, to about 20% in the Southeast and less than 4% just east of the continental divide in winter, and from less than 2% in California to over 20% in the Southeast in summer. Overall, in midlatitudes, precipitation typically falls only 10% of the time, and so rainfall rates, conditional on when rain is falling, are much larger than evaporation rates.

All the above highlight the mismatches in the rates of rainfall versus evaporation which imply that precipitating systems of all kinds feed mostly on the moisture already in the atmosphere. Over North America, much of the precipitation originates from moisture advected from the Gulf of Mexico and subtropical Atlantic or Pacific a day or so earlier.

How should rainfall, or precipitation, change as climate changes? Why are the patterns predicted from different models under increased greenhouse gas scenarios so different? What is the relationship among changes in evaporation, changes in moisture content of the atmosphere, and changes in precipitation? What are the factors that should be taken into account to explain the changes? The IPCC 1995 report (IPCC, 1996), in dealing with future climate prospects with increased greenhouse gases in the atmosphere, states that "**Warmer temperatures will lead to a more vigorous hydrological cycle; this translates into prospects for more severe droughts and/or floods in some places...** Several models indicate an increase in precipitation intensity, suggesting a possibility for more extreme rainfall events." Therefore, we have made use of the above results in an attempt to explain the processes involved and address some of the questions. In particular, we note the importance of examining rainfall rates (or intensity) and rainfall frequency, not just accumulated amounts.

Increases in greenhouse gases in the atmosphere produce global warming through an increase in downwelling infrared radiation, and thus not only increase surface temperatures but also enhance the hydrological cycle, as much of the heating at the surface goes into evaporating surface moisture. Global temperature increases signify that the water-holding capacity of the atmosphere increases and, together with enhanced evaporation, this means that the actual atmospheric moisture should increase. It follows that naturally occurring droughts are likely to be exacerbated by enhanced potential evapotranspiration. Further, globally there must be an increase in precipitation to balance the enhanced evaporation. Observations confirm that atmospheric moisture is increasing in many places, for example, at a rate of about 5% per decade over the United States (Ross and Elliot, 1996). Based on the above results which show that perhaps 70% of the moisture in an extratropical storm comes from moisture stored in the atmosphere, we argue that increased moisture content of the atmosphere therefore favors stronger moisture convergence in all precipitating weather systems, whether they be thunderstorms or extratropical rain or snow storms. This leads to the expectation of enhanced rainfall or snowfall events, thus increasing risk of flooding—a pattern observed to be happening in many parts of the world (Karl et al., 1996).

Moreover, because there is a disparity between the expected rates of increase of atmospheric moisture and precipitation [the latter is limited by the surface heat budget; see Trenberth (1997) for details], there are implied changes in the frequency of precipitation and/or efficiency of precipitation (related to how much moisture is left behind in a storm). In particular, if rain rates increase faster than rain amounts, then the frequency of rain could decrease. However, an analysis of linear trends in the frequency of precipitation events for the United States corresponding to thresholds of 0.1 and 1 mm/h shows that the most notable statistically significant trends are for increases in the southern United States in winter and decreases in the Pacific Northwest from November through January, which may be related to changes in atmospheric circulation and storm tracks associated with El Niño-Southern Oscillation trends (Trenberth and Hoar, 1996).

The above arguments suggest that there is not such a clear expectation on how total precipitation amounts should change, except as an overall average. Therefore, we suggest that a great deal more attention should be paid to the rates (or intensity) of precipitation, both in observations, and in models, conditional on when it is falling, and the frequency of precipitation. It is further suggested that the focus should be on 1-hour average rates as a useful compromise that is reasonably compatible with the lifetime of the main precipitating systems in nature, but which goes beyond instantaneous values and is feasible from global climate models, which typically have time steps of about half an hour. This would facilitate a detailed analysis of the diurnal cycle of precipitation both in models and in nature, which should be very enlightening. These topics should fit well under the GVaP program.

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SELECTED GLOBAL WATER VAPOR DATA SETS NOW AVAILABLE ON CD-ROM

The GEWEX Global Water Vapor Project (GVaP) Pilot Study; National Aeronautics and Space Administration Water Vapor Project (NVAP) (1988-1994) CD-ROM is now in distribution. The 1°x1° global grids of daily, pentad and monthly averages of merged global product of precipitable water or water vapor derived from radiosonde and satellite observations are included on this CD-ROM (see page 8). For information on this CD-ROM and to order copies contact the International GEWEX Project Office, 1100 Wayne Avenue, Suite 1210, Silver Spring, Maryland, 20910, Tel: 301-427-2089 ext. 521, Fax: 301-427-2222; E-mail: gewex@cais.com.

GEWEX DATA SETS (Updated 8/97)

PROJECT NAME	DATA SET NAME/ TIME PERIOD/DESCRIPTION	MEDIA	SOURCES
International Satellite Cloud Climatology Project (ISCCP)	ISCCP C2/July 1983–June 1991/Global monthly cloud products at 280-km resolution, 72 variables derived from polar orbiting and geostationary satellites.	9-track/1600-6250 bpi tape or IBM 3480 cartridges (CD-ROM available for July 1983–Dec 1991)	ISCCP DATA IS AVAILABLE FROM THE FOLLOWING SOURCES: National Climatic Data Center Satellite Services Group Federal Building 151 Patton Avenue Asheville, NC 28801-5001 Tel: 704-271-4800 Option #5 Fax: 704-271-4876 E-mail: satorder@ncdc.noaa.gov Langley DAAC Mail Stop 157D NASA Langley Research Center Hampton, VA 23681-0001 Tel.: 757-864-8656 Fax: 757-864- 8807 E-mail: larc@eos.nasa.gov WWW: http://eosweb.larc.nasa.gov/
	ISCCP C1/July 1983–June 1991/Global cloud products at 280 km, 3-hr resolution,132 variables, derived from polar orbiting and geostationary satellites.	9-track/1600-6250 bpi tape or IBM 3480 cartridges	
	ISCCP B3/July 1983–June 1994 (will continue through June 2000) / Satellite radiance data at 30 km, 3-hour intervals, separately from imaging radiometers on polar orbiting and geostationary satellites.	•	
	ISCCP D2/1986 and 1989–1992 (will cover July 1983–June 2000)/ Global monthly cloud products at 280 km resolution, 130 variables derived from polar orbiting and geostationary satellites.	•	
	ISCCP D1/1986 and 1989–1992 (will cover July 1983 through 2000)/Global cloud products at 280 km, 3-hr resolution, 202 variables from polar orbiting and geostationary satellites.	•	
	ISCCP DX/1986 and 1989–1992 (will cover July 1983–June 2000)/Satellite radiance and cloud retrieval data at 30 km, 3-hr intervals, separately from imaging radiometers on operational polar orbiting and geostationary satellites.	•	
Surface Radiation Budget (SRB)	SRB Version 1.1 WCRP/SRB SW /March 1985–Dec 1988/ Shortwave surface radiation parameters	CD-ROM/FTP/TAPE	Langley DAAC,Mail Stop 157D, Hampton, VA 23681-0001 Tel: 757-864-8656; Fax: 757-864-8807 Email: larc@eos.nasa.gov WWW:http://eosweb.larc.nasa.gov/
Baseline Surface Radiation Network (BSRN)	BSRN Surface Radiation Budget - surface based network; 35 stations planned; 24 sites are collecting data. Downward components of solar and thermal irradiance from a globally distributed surface based network. Ancillary data at some sites include: upwelling irradiances, meteorological observations, aerosol optical depth, UV and PAR. Cloud-based lidar may be installed at some sites in the future.	Internet, other on request.	http://bsrn.ethz.ch Special requests can be made to Herman Hegner at bsrnadm@geo.umnw.ethz.ch

PROJECT NAME	DATA SET NAME/ TIME PERIOD/DESCRIPTION	MEDIA	SOURCES
Global Water Vapor Project (GVaP)	NVAP/1988–1994/Blended global water vapor and cloud liquid water data sets using radiosonde, microwave and infrared satellite data with 1 x 1-degree resolution, daily, pentad and monthly averages.	TAPE/FTP	Langley DAAC NASA/Langley Research Center Mail Stop 157D Hampton,VA 23681-0001, USA Tel: (757) 864-8656 ; Fax: (757) 864-8807 E-mail: larc@eos.nasa.gov WWW: http://eosweb.larc.nasa.gov/
	Nov–Dec 1991/ Raman Lidar water vapor profiles from Coffeville Kansas Experiment .	TAPE	
	Selected NVAP data sets, including animations of daily averaged global fields; monthly averaged data and sample months of daily averaged fields.	CD-ROM	International GEWEX Project Office, Suite 1210, 1100 Wayne Avenue, Silver Spring, MD 20910 Tel: 1-301-427-2089 ext. 521; Fax: 1-301-427-2222 E-mail: gewex@cais.com
Global Precipitation Climatology Project (GPCP)	Global Precipitation/July 1987–Dec 1995/Monthly 2.5-degree global gridded precipitation data set produced by blending gauge, infrared and microwave satellite estimates of precipitation.	FTP	National Climatic Data Center, Asheville, North Carolina Tel: (704) 271-4800; Fax: 704-271-4876 E-mail: satorder@ncdc. noaa.gov WWW: http://www.ncdc.noaa.gov/wdcamet.html#GPCP ALSO AVAILABLE FROM: Global Precipitation Climatology Centre c/o Deutscher Wetterdienst, Postfach 10 04 65 D-63004 Offenbach am Main, Germany Tel: +49 69 80 62 29 81; Fax: +49 69 80 62 29 93 or 2880 E-mail: rudolf@k7-wzn.za- offenbach.dwd.d400.de ftp://ftp.ncdc.noaa.gov/pub/data/gpcp/gpcc
	Global Precipitation for ISLSCP Initiative I /Jan 1987–Dec 1988/Monthly terrestrial gridded precipitation data sets on a 1-degree grid. There are two files for each month: The area-mean precipitation and the number of stations per grid.	CD-ROM	NASA/Goddard Space Flight Center, Mail Stop 902.2 Greenbelt, MD 20771, USA Tel: (301) 614-5224 ; Fax: (301) 614-5268 E-mail: gsfc@eos.nasa.gov WWW: http://daac.gsfc.nasa.gov/
GEWEX Cloud System Study (GCSS)	Wking Group 1 (Boundary Layer Clouds)Case study data sets	WWW	WG1 - 1995 Smoke case + ASTEX Lag.: http://amath.washington.edu/~breth/GCSS/ 1996 ASTEX: http://www.fys.ruu.nl/~wwwimau/ASTEX/astexcomp.html; 1997 BOMEX: http://www.knmi.nl/~siebesma/bomex.html
	Wking Group 2 (Cirrus Clouds)Case study data sets	WWW	WG2 - WWW: http://eos913c.gsfc.nasa.gov/gcss_wg2/
	Wking Group 3 (Extra-Tropical Layer Clouds)/Sept 30, 1994 BASE data sets and Feb 26, 1992 CASPII data sets	CD-ROM	WG3 - Email: Robert.Crawford@ec.gc.ca
	Wking Group 4 (Precipitating Convective Clouds)	CD-ROM	WG4 - WWW: http://www.cnrm.meteo.fr:8000/gcss/
Global Runoff Data Centre (GRDC)	Variable time period/daily and monthly discharge data for 3,680 stations from 2,854 rivers (including sub-basins). 71,109 data sets of mean monthly data; 389,693 data sets of mean daily discharge.	Diskette/email/paper	GRDC, Federal Institute of Hydrology Bundesanstalt fur Gewasserkunde , Kaiserin-Augusta-Anlagen 15-17 , 56068 Koblenz, Germany ; Tel.: 49 261 1306-224; Fax: 49 261 1306-280; E-mail: grdc@koblenz.bfg.bund400.de; WWW: http://www.wmo.ch/web/homs/grdchome.html

PROJECT NAME	DATA SET NAME/ TIME PERIOD/DESCRIPTION	MEDIA	SOURCES
International Satellite Land Surface Climatology Project (ISLSCP)	Initiative I/1987–1988/ Vegetation, hydrometeorology, soils, snow and ice, meteorology and radiation parameters and variables required for initialization, forcing and validation of global biosphere-atmosphere models. All but the river basin runoff data and the NOAA/NESDIS snow cover provide global coverage on a common 1 x 1-degree grid. Monthly and 6-hourly forcing fields provided.	CD-ROM	NASA/Goddard Space Flight Center Mail Stop 902.2, Greenbelt, MD 20771, USA Tel: (301) 614-5224 ; Fax: (301) 614-5268 E-mail: gsfc@eos.nasa.gov WWW: http://daac.gsfc.nasa.gov/
	First ISLSCP Field Experiment Data (FIFE)/ Summer 1987;1989 (Follow-up Experiment)/FIFE was conducted on the Konza Prairie in Kansas during the summer of 1987. A follow-up experiment at the same location took place in 1989. Data includes surface observations and non-image data sets; satellite Imagery; Thematic Mapper Simulator (aircraft) imagery; spectro-radiometer and microwave radiometer (aircraft) Imagery; and vegetation index, soil moisture, terrain reference, surface temp., and digitized site photographs.	CD-ROM	ORNL DAAC Oak Ridge National Laboratory P.O. Box 2008 Mail Stop 6407 Oak Ridge, TN 37831- 6490 Tel: (423) 241-3952 Fax: (423) 574-4665 E-mail: ornl@eos.nasa.gov WWW: http://www-eosdis.ornl.gov/
GEWEX Continental-scale International Project (GCIP)	GCIP Initial Data Set (GIDS-1)/1 Feb–30 April 1992/ Atmospheric, hydrolologic, satellite and radar composites, and surface data for the Central Mississippi River Basin.	CD-ROM	UCAR/Joint Office for Science Support P.O. Box 3000 Boulder, CO 80307 Tel: 303-497-8987; Fax: 303-497-8158 Email: sfw@ncar.ucar.edu WWW: http://www.ofps.ucar.edu/gcip/gcip_in_situ.html
	GCIP Reference Data Set (GREDS)/No time period/ Topography, land use and other types of data which are expected to change little, if any, during the next several years.	CD-ROM	ALSO AVAILABLE FROM: GCIP Project Office,1100 Wayne Avenue, Rm 1225, Silver Spring, MD 20910; Tel: 301-427-2089 ext 511; Fax: 301-427-2222; E-mail: gcip@ogp.noaa.gov
	GIDS-3/1 April–31 August 1994/Consists of data collected during the GCIP Integrated Systems Test (GIST) in the Large Scale Area - SW (Arkansas Red River basin) and provides an initial data set for the warm season.	On-line	UCAR/JOSS CODIAC System WWW: http://www.ofps.ucar.edu/ or http://www.ogp.noaa.gov/gcip/ (select in situ data source module)
	GIDS-3 (subset)/1 April–31 August 1994/Subset of GIDS-3 data which includes imagery (GOES-7 IR and Visible data, radar composites, surface/upper air maps, and vegetation index), surface meteorological composites, rawinsonde and profiler data, hydrologic data (streamflow), observing station lists and complete file documentation.	CD-ROM/ On-line	UCAR/Joint Office for Science Support

PROJECT NAME	DATA SET NAME/ TIME PERIOD/DESCRIPTION	MEDIA	SOURCES
GCIP *Continued*	GIDS-4/1 April–30 Sept 1995/Consists of data collected during the Enhanced Seasonal Observing Period (ESOP-95) as a second GCIP warm season data set in the Large Scale Area-SW (Arkansas-Red River Basin)	On-line/ CD-ROM (in prep)	UCAR/Joint Office for Science Support
	ESOP-96/1 April–30 Sept 1996/Consists of data collected during the Enhanced Seasonal Observing Period for a third GCIP warm season data set in the Large Scale Area-SW (Arkansas-Red River Basin)	On-line/ CD-ROM (in prep)	UCAR/Joint Office for Science Support
Mackenzie GEWEX Study (MAGS)	HYDAT/historical-present/Water Survey of Canada daily streamflow, lake level and sediment data for all Canadian stations.	CD-ROM	Linda M. Stirling, Climate Information Branch, AES, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 Tel: 416-739-4399; Fax: 416-739-4446 E-mail: Linda.Stirling@ec.gc.ca
	Canadian Daily Climate Data (CDCD) /historical-present/ Daily temperature and precipitation data for all Canadian stations.	CD-ROM	Climate Information Branch, Atmospheric Environment Service
	Canadian Weather and Engineering Data Set (CWEEDS)/ 1950-present/Hourly weather for 143 Canadian stations.	CD-ROM	Climate Information Branch, Atmospheric Environment Service
	Related data sets/no time period/basin monthly means; corrected precipitation archive of 78 stations; snow course and snow depth data bases, reference data, land cover.	WWW	MAGS Home Page: http://www.tor.ec.gc.ca/GEWEX/MAGS.html
	CMC special model output archive for MAGS - RFE 50-km, Sept-Dec 95 - RFE 35-km, Jan 96-Mar 97 - GEM 35-km, Apr 97-?	WWW	Canadian GEWEX Archives: http://www.cmc.doe.ca/cmc/CMOI/htmls/Gewex_archa.html
	Beaufort and Arctic Storms Experiment (BASE)/Sept 1–Oct 15, 1995/MC2 mesoscale model output, RFE regional model output, surface meso-network measurements, special rawinsonde launches, precipitation photography and chemistry, Doppler radar measurements at Inuvik, radar measurements at Tuktoyaktuk, Convair 580 aircraft measurements, special aircraft dropsonde data, CCGS Arctic Ivik cruise report, ocean current and pack ice data, with internet link to NCAR C-130 aircraft data.	WWW	MAGS Home Page: http://www.tor.ec.gc.ca/GEWEX/MAGS.html or BASE Home Page http://www.tor.ec.gc.ca/BASE/base_homepage.html
	Welsh CMC RFE 50-km archive (with additional variables), May 94-Apr 96	CD-ROM	Canadian GEWEX Archives E-mail: Robert.Crawford@ec.gc.ca

INTENSIFYING THE HYDROLOGICAL CYCLE

(Continued from page 1)

millions of dollars in damage. Twenty-one years later, almost to the day, tragedy struck at nearby Fort Collins, my adopted home town. Over the space of 5 hours, in excess of 8 inches of rain fell in the vicinity from a broad-scale system fed by moisture from the southwest. The tiny Spring Creek that bisects the city swelled at an unfathomable rate. At the time of writing, five people were counted dead in the flooding tragedy. The damage was enormous, with roads cut, homes lost, businesses washed away, irreplaceable CSU library materials destroyed and the entire stock of books for the upcoming new academic year lost.

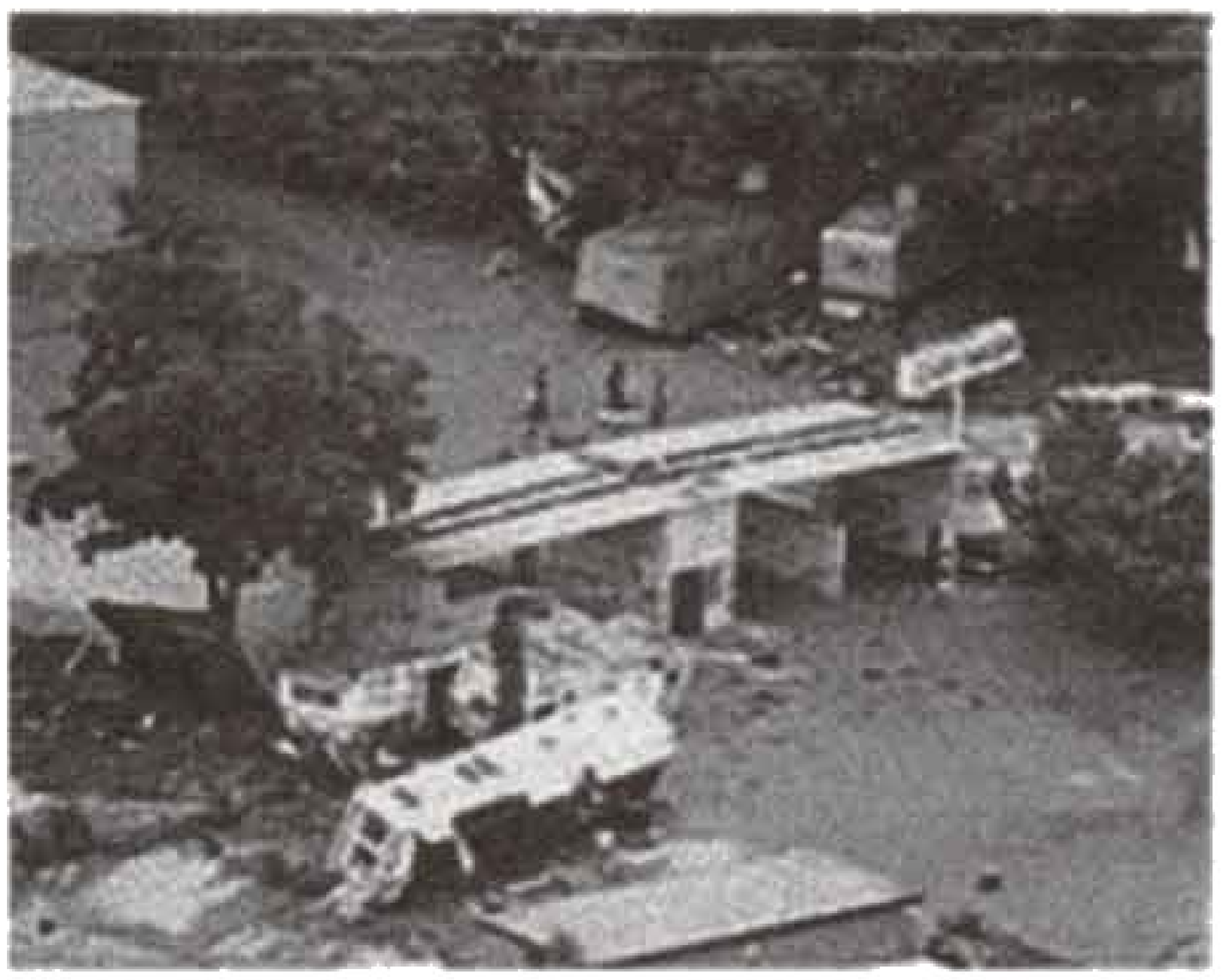

Figure 1: Will extreme events like the July 1997 flood in Fort Collins, Colorado, become more common under the scenario of global warming? Photograph courtesy of Rocky Mountain News, Denver, Colorado, Cyrus McCrimmon, Photographer, July 30, 1997.

These tragedies are poignant examples of the angry face of nature and serve to remind us of the dangers associated with severe hydrological events (here hydrology is taken to be an all-embracing term that includes water in the atmosphere). Whether or not the frequency and/or intensity of extreme events increases or not under the scenario of global warming is a matter of conjecture. The 1995 IPCC report suggests more severe events will occur under global warming. This speculation underscores what may be the most pressing science and policy issue of the global change problem, namely, how will the hydrological cycle adjust to external forcings. Is our understanding of the various processes that govern the hydrological cycle adequate at this point to allow us to predict these changes even in a gross way?

To consider these issues, let us take the familiar scenario of global warming as predicted by contemporary coupled ocean-atmosphere GCMs forced by transient increases in carbon dioxide. Under a 1% per year increase in CO_2, these models predict a global warming (these results are from Garratt et al., 1997) as shown in Figure 2a. A major contribution to this warming is the increase in long-wave emission to the surface associated with an increase of column water vapor (Figure 2b). Taken at face value, the increase of infrared opacity associated with the enhancement of water vapor leads directly to an increase in the radiative cooling of the column (Figure 2c). (The relation between cooling and column water vapor

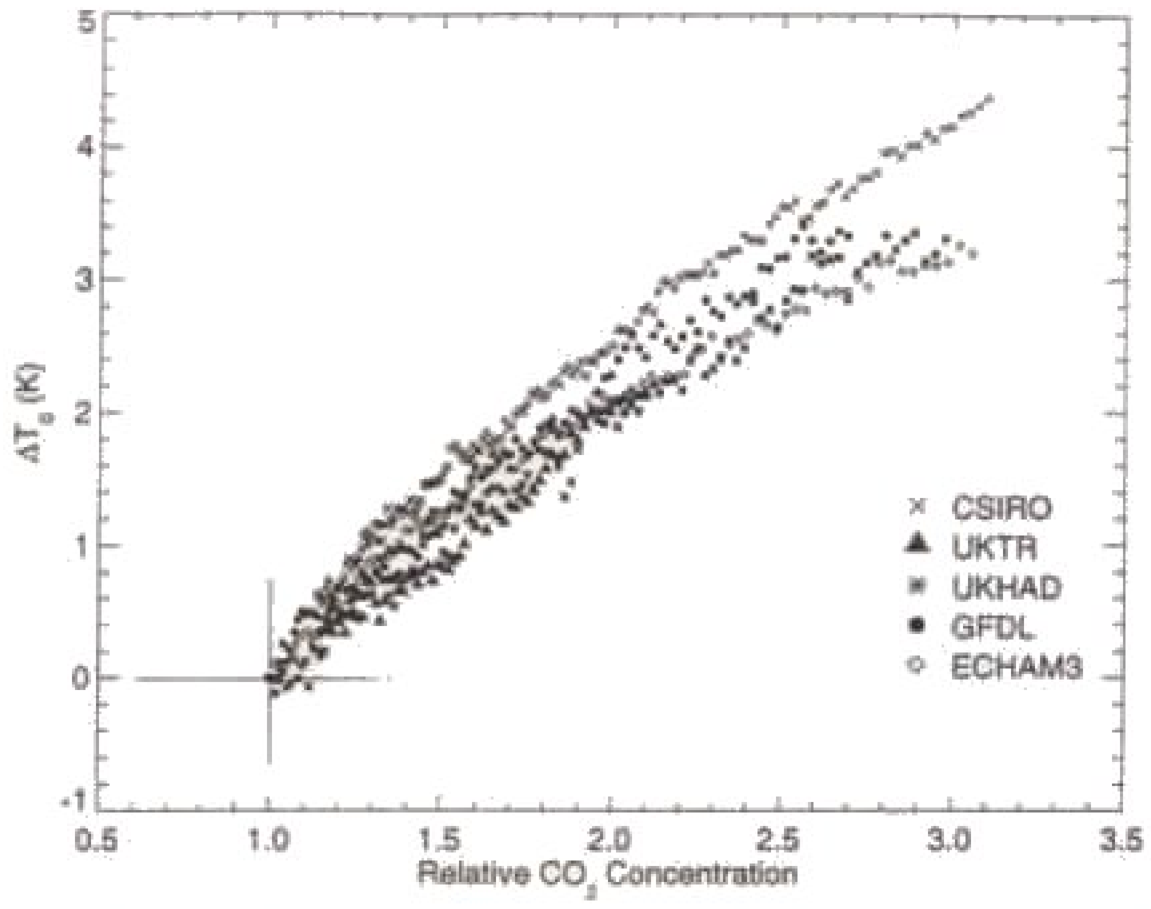

Figure 2a: The change in global-mean surface temperature as predicted by a number of climate models under the scenario of increasing atmospheric CO_2 from Garratt et al. (1997).

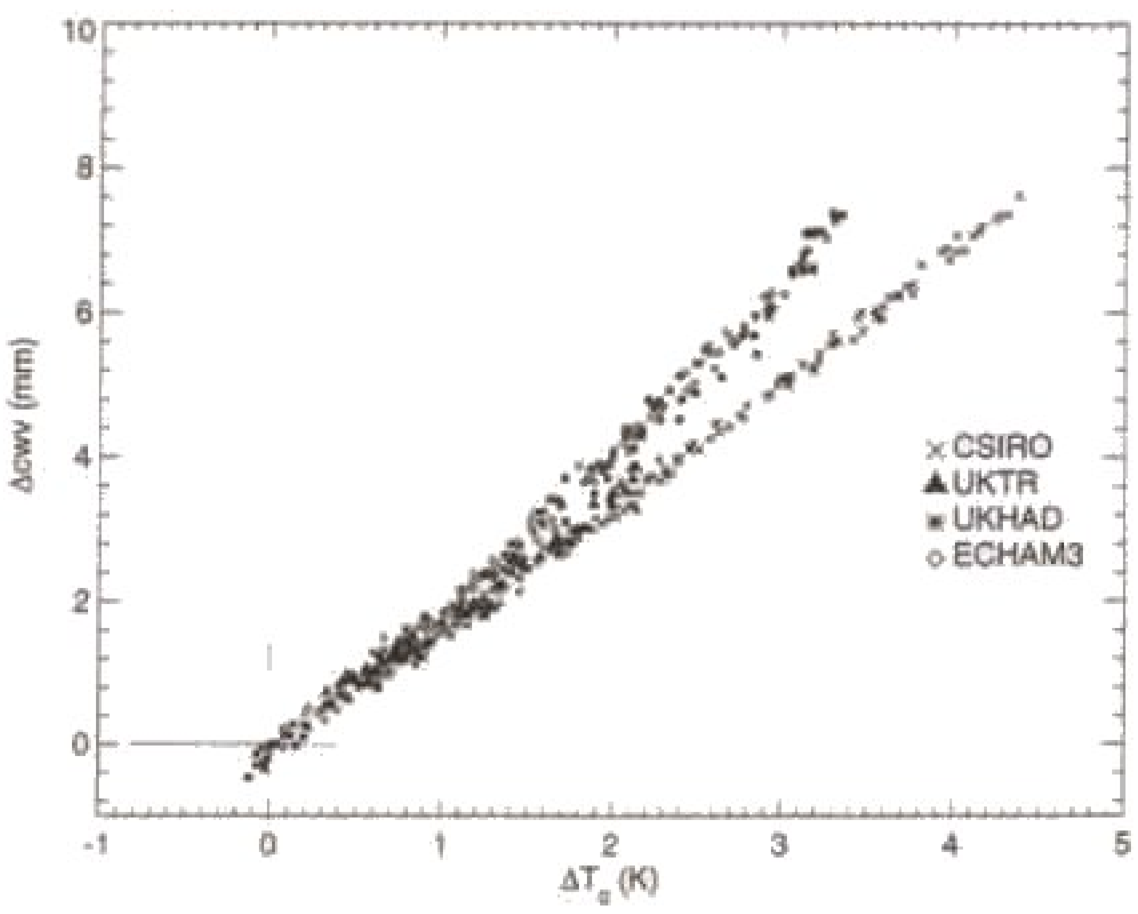

Figure 2b: The associated change in column water vapor, from Garratt et al. (1997).

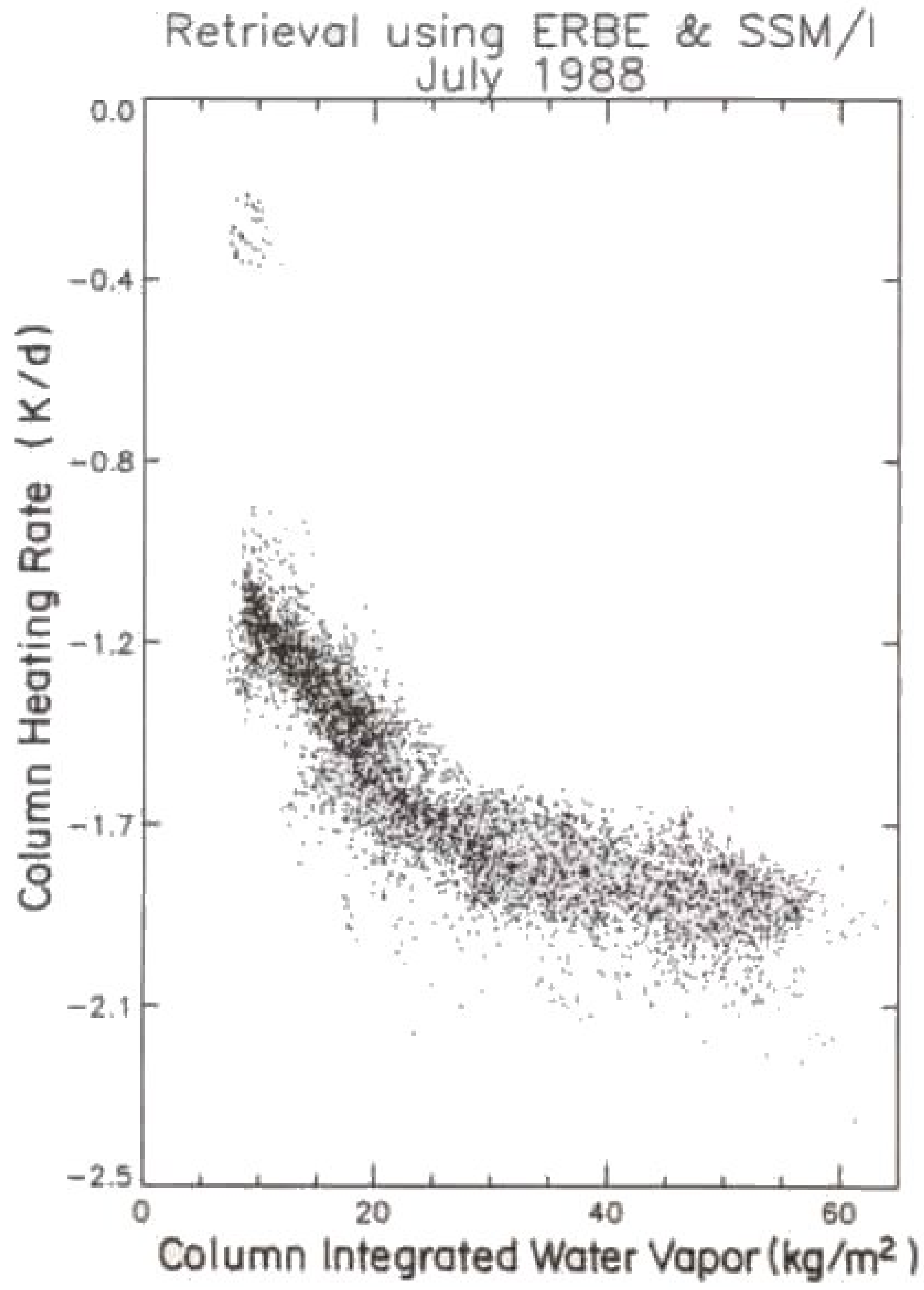

Figure 2c: The observed relationship between column longwave cooling rate (clear sky) and column water vapor, from Stephens et al. (1994).

is based on global data, and as such does not strictly represent climate change. It is governed by well understood radiative transfer principles which, too, should not change. [These results are from Stephens et al. (1994), a paper that also described how clouds affect the column heating.] Since in the global-mean sense this cooling is largely balanced by latent heating associated with precipitation to the ground, we might expect that global precipitation will also increase as suggested by Trenberth in this issue. The problem with this analysis is that a number of other processes associated with the hydrological cycle come into play to substantially change the cooling of the atmospheric column. Most notable are increases in the amount of high cloud that significantly heats the atmospheric column, leading to a feedback on convection and a reduction in global precipitation. This feedback has been shown to be strong in a number of GCM modelling studies (Slingo and Slingo, 1988; Liang and Wang, 1977; Fowler and Randall, 1994; and Ma et al., 1994). These studies show the same basic type of feedback. Three of the reports present results from GCMs with fixed seas surface temperatures. In each case upper-tropospheric heating was induced by local increases in the opacity of the atmosphere associated with increasing upper-level clouds. Recent observational studies (Stephens et al., 1997) also suggest that this feedback may be part of a more complicated influence on the hydrological cycle of the tropical atmosphere that allows it to act as a self-regulating oscillator.

The point of this discussion is that we expect that there are many controls on the climatology of precipitation (both its mean and variability). We have yet to unravel and identify which of these processes are the most important to understand and thus be properly represented in models. The feedbacks mentioned above are one example of why it is not obvious that precipitation will necessarily increase globally. As further amplification of this point, we know that in those regions of the globe where the heaviest rains occur, precipitation demonstrates distinct cycles of variability, exemplified by both diurnal variations of precipitation and marked intraseasonal variations. The processes that shape those variations are complex and not well understood. Even in the case of the diurnal variation, which at first hand might be taken to be the simplest of the cycles with an obvious source of forcing, we are presented with a confusing picture as we dig deeper into the phenomena (Gray and Jacobson, 1977; Rickenback and Rutledge, 1997). Intraseasonal variability of convection has been studied extensively over the past decade but we cannot yet identify a definitive process or set of processes that define this variation.

Understanding the variability of the hydrology cycle is complex, and managing these variations, either from natural or from anthropogenic causes, is perhaps the most important challenge confronting human society in the global change arena. It is clear that we do not yet understand well enough these hydrological systems and what governs their character to make learned comments on how they may change in the future, even in an ensemble mean sense. Our weakness in advancing this topic lies squarely with our lack of global observing systems designed to measure not only precipitation, but related hydrological parameters. Present data sets use less than ideal methods to derive precipitation and are largely based on indirect approaches. The observing systems of today and, alas, those of the near future, are put together in piece-meal fashion with hydrology often appearing, either by design or for other reasons, low in the priorities of space programs. Some of these programs are excluding the very microwave sensors that provide the most direct (although still inadequate) view of liquid water in the atmosphere (either as precipitation or cloud water). An exception to this state of affairs is the upcoming Tropical Rainfall Measurement Mission, which is to be launched later this year. We as scientists have dwelt too long on global change in terms of surface temperature. It is perhaps more meaningful and relevant to contemplate global change in terms of the changing face of hydrology. This will be a difficult task, but too often the difficulty of a topic is taken as a reason for lack of action. The hydrological cycle issue is too important to let it continually slip from the global change agenda.

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INTERACTIVELY COMPARE YOUR PRECIPITATION ANALYSES WITH GPCP ANALYSES

Alan McNab
National Climatic Data Center

A new method to access the Global Precipitation Climatology Project's (GPCP) precipitation analyses has been established at the National Climatic Data Center. The method provides the novel ability to interactively compare a user's monthly, gridded precipitation analyses with corresponding GPCP gridded analyses.

The user's analysis must be available as monthly precipitation values on the GPCP 2.5 degree x 2.5 degree grid. The comparison is accomplished in two steps:

Step 1. The user converts his data set to a fixed, ASCII format, and sends it by ftp to the NCDC anonymous ftp upload area.

Step 2. After the user's file is in the NCDC upload directory, the user connects to the National Climatic Data Center's "GPCP Comparison Page" on the Internet. This page leads to a "form" where the time periods, geographic areas and types of comparison can be entered. The types of comparisons include scatter plots and difference maps between the user data and the GPCP Version 1A data or the GPCP reference data. The GPCP Version 1A data consist of near-global merged satellite-gauge analyses. The reference analyses are derived from high resolution gauge analyses at five locations around the world (each of the locations covers one to seven grid cells).

The purpose of providing a method to do interactive comparisons with GPCP analyses stems from the need to compare the results of many satellite precipitation estimation algorithms. Typically such intercomparisons are accomplished by comparing each researcher's estimate to a reference estimate (e.g., a GPCP estimate). The problem arises that it is difficult to have each researcher compare his estimate with the GPCP estimate in a uniform manner. It is also difficult to distribute the comparisons to all interested researchers. The above interactive comparison form provides a method to achieve uniform comparisons. Currently, the types of comparisons are quite limited and the results of the comparisons are directly available only to the person submitting the form. However, if this approach is found useful, it would be possible to provide additional types of comparisons and to include an option to save the results for others to view.

The GPCP Comparison page is at http://www.ncdc.noaa.gov/otter/gpcp_comp/quasi.html and includes a detailed description of the required format, ftp procedures, and use of the comparison form. The Version 1A analyses are available for the period July 1987 to December 1996; the reference data set analyses are for the period January 1986 to December 1995. More detailed information about the GPCP is available at http://orbit-net.nesdis.noaa.gov:80/gpcp/. In addition to the above method, GPCP analyses can be viewed without the interactive comparison feature at http://www.ncdc.noaa.gov/cgi-bin/otter/current/live_access (select the GPCP Precipitation Series data set). Also, all GPCP analyses can be downloaded from the NCDC via anonymous ftp (ftp.ncdc.noaa.gov/pub/data/gpcp).

CHINA LAUNCHES GEOSTATIONARY SATELLITE

James C. Dodge
National Aeronautics and Space Administration

The news of the launching by China on 10 June 1997 of the geostationary satellite Feng Yun-2 (meaning "wind-cloud") was communicated by Professor Fang, Deputy Director, National Satellite Meteorological Center of the China Meteorological Administration at a satellite conference held 10–12 June 1997 in Annapolis, Maryland, USA. The conference in the United States was the National Oceanic and Atmospheric Administration (NOAA) Polar Orbiting Environmental Satellite System (NPOESS), User's Conference. The conference participants also learned that China has graciously offered unconstrained world use of the FY-2 data through unlimited direct broadcasts from the satellite.

The FY-2 satellite is very much like the Japanese GMS-5 satellite in its observing characteristics and thus should provide GEWEX investigators with additional information on clouds, infrared rainfall estimates, water vapor distributions, cloud drift and water motion winds, regions of subsidence, storm tracks and their climatic variability, and a growing list of other new practical uses for geostationary satellite data. The similarity to the GMS-5 is an advantage, since the interpretation of that data is well understood, and algorithms are available to make estimates of geophysical parameters in the near term.

NASA has opened discussions with the Chinese and has been encouraged to proceed with plans for a receiving station in Australia to support researchers needs for frequent, high resolution meteorological satellite data over the Asian Hemisphere. NASA is working with the University of Hawaii, Goddard Space Flight Center, and the University of South Australia in Adelaide to establish a ground receiving site for FY-2. The antenna and hardware are in place for viewing the Equatorial plane at 105 degrees East. Site preparations for reception of the raw data through conventional direct broadcast are proceeding to be ready for the initial transmissions from the satellite. Satellite data from this part of the world is the only missing element for full global coverage of the world by geostationary weather satellites. NASA and WCRP hope to incorporate these new data in GEWEX components such as the Global Precipitation Climatology Project (GPCP) and the International Satellite Cloud Climatology Project (ISCCP); in addition, several NASA researchers wish to study the high time-resolution details of cloud variability over the Asian continent and adjoining oceans. Studies of variability in cloudiness during the day (diurnal) will eventually help to improve the cloud parameterizations in predictive numerical models and, hence, lead to more appropriate atmospheric energy conversion estimates for better regional and, perhaps, longer lasting forecasts.

NASA is planning to use the Internet to bring the data from Australia to the U.S. for distribution to near real-time users. There are no plans within NASA to undertake the archiving and distribution of retrospective data, nor to support operational users. These later efforts are normally tasks for operational agencies such as NOAA.

The National Satellite Meteorological Center of China has established a web site at http://ocean.gcn.ou.edu/xhufy2.htm for updates on the spacecraft. The first visible image of 21 June 1997 is on the internet at the FY-2 web site.

MEETING SUMMARIES

MAGS WORKSHOP
23-26 March 1997

Geoff Strong
Canadian GEWEX/MAGS Secretariat

A major MAckenzie-basin GEWEX Study (MAGS) workshop was held at Saskatoon, Sasketchewan, Canada, in late March. There were more than 35 presentations, followed by two days of working sessions. The presentations reviewed 1996 progress on process and modeling studies. The main objectives of the working sessions were to identify gaps in MAGS science, describe critical data gaps and to modify the enhanced data collection plan to reduce these gaps.

The next MAGS workshop will be held in Toronto on 17-19 November 1997. This meeting will focus on the analysis of two historical "water years", 1994-1995 and 1995-1996, and on finalizing plans for a 14-month enhanced data collection period commencing in July, 1998. For more information on MAGS, readers can visit the MAGS web site directly at: http://www.tor.ec.gc.ca/GEWEX/MAGS.html, or link through GEWEX web site at: http://www.cais.com/gewex/.

WCRP/GEWEX MEETINGS CALENDAR

For calendar updates consult GEWEX Web Site http://www.cais.com/gewex/gewex.html

8-12 September 1997—THIRD GEWEX HYDROMETEOROLOGY PANEL MEETING, Sapporo, Japan. For further information contact Tetsuzo Yasunari, Univ. of Tsukuba, Tsukuba, Ibaraki, Japan; Tel: 81-298-53-4399; Fax: 81-298-51-9764; E-mail: yasunari@atm.gev.tsukuba.ac.jp.

15-19 September 1997—EUROPEAN AEROSOL CONFERENCE, University of Hamburg, Germany.

26-29 October 1997—SYMPOSIUM ON CLIMATE VARIABILITY, CLIMATE CHANGE AND WATER RESOURCE MANAGEMENT, Colorado Springs, Colorado, USA. For more information, consult Web Site: http//civil.colorado.edu/climate or GCIP Office, 1100 Wayne Avenue, Suite 1210, Silver Spring, Maryland, 20910, USA.

27-31 October 1997—WCRP FIRST INTERNATIONAL CONFERENCE ON REANALYSES, Washington, D.C. For information contact: International GEWEX Project Office, 1100 Wayne Avenue, Suite 1210; Silver Spring, Maryland, 20910, USA; Tel: (301) 427-2089 ext. 33; Fax: (301) 427-2222; E-mail: gewex@cais.com. For the Conference Web Site and links to reanalysis projects web sites: http://www.cais.com/gewex/gewex.html.

3-6 November 1997—POLAR PROCESSES AND GLOBAL CLIMATE, Orcas Island, Washington, USA (about 120km Northwest of Seattle). For further information contact ACSYS International Project Office, P.O. Box 5072 Majorstua, 0301 Oslo, Norway. Tel: 47-22-95-96-05; Fax: 47-22-95-96-01, or ACSYS web site: http://www.npolar.no and the ACSYS office E-mail is: acsys@polar.no.

3-7 November 1997—13TH SESSION OF WGNE, NOAA Science Center (World Weather Building), National Centers for Environmental Prediction, Camp Springs, Maryland, USA.

17-19 November 1997—THIRD CANADIAN GEWEX/MAGS WORKSHOP, Toronto, Canada. More information at http://www.tor.ec.gc.ca/GEWEX/MAGS.html, or contact Secretariat at Geoff.Strong@ec.gc.ca.

1-5 December 1997—GCSS SCIENCE PANEL MEETING, Boulder, Colorado, USA.

10-16 January 1998—AMERICAN METEOROLOGY SOCIETY ANNUAL MEETING, Phoenix, Arizona.

2-6 February 1998—GEWEX SCIENTIFIC STEERING GROUP, Brazil.

24-29 May 1998—OCEAN CIRCULATION AND CLIMATE: THE 1998 WOCE CONFERENCE, Halifax, Nova Scotia, Canada. For conference information contact Andrea Frische, WOCE International Project Office, Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, UK, Tel: 44 1703 596789; Fax: 44 1703 596204; E-mail: woceipo@soc.soton.ac.uk; or Conference Web Site: http://www.soc.soton.ac.uk/OTHERS/woceipo/wconf.

25-29 May 1998—2ND STUDY CONFERENCE ON BALTEX, Island of Ruegen, Germany. For information contact Dr. Hans-Joerg Isemer, International BALTEX Secretariat, GKSS Forschungszentrum Geesthacht, Germany. Phone: +49 4152 87 1536, Fax: +49 4152 87 2020, E-mail: isemer@gkss.de.

8-12 June 1998—GCIP MISSISSIPPI RIVER HYDROMETEOROLOGY CONFERENCE, St. Louis, Missouri, USA. For information contact Adrienne Calhoun or Rick Lawford, GCIP Project Office, NOAA Office of Global Programs, 1100 Wayne Avenue, Suite 1210, Silver Spring, Maryland, 20910, USA. Tel: 301-427-2089 ext. 511; Fax: 301-427-2222, or for general information on the Mississippi River Celebration visit the web site at: http://www.opg.noaa.gov/gcip/ miss/missceleb.html.

17-21 August 1998—INTERNATIONAL CONFERENCE ON SATELLITES, OCEANOGRAPHY AND SOCIETY, Lisbon, Portugal. For information contact D. Halpern, Jet Propulsion Laboratory, MS 300-323, California Institute of Technology, Pasadena, CA 91109-8099; Fax: 818/393-6720; E-mail: halpern@pacific.jpl.nasa.gov.

GEWEX NEWS

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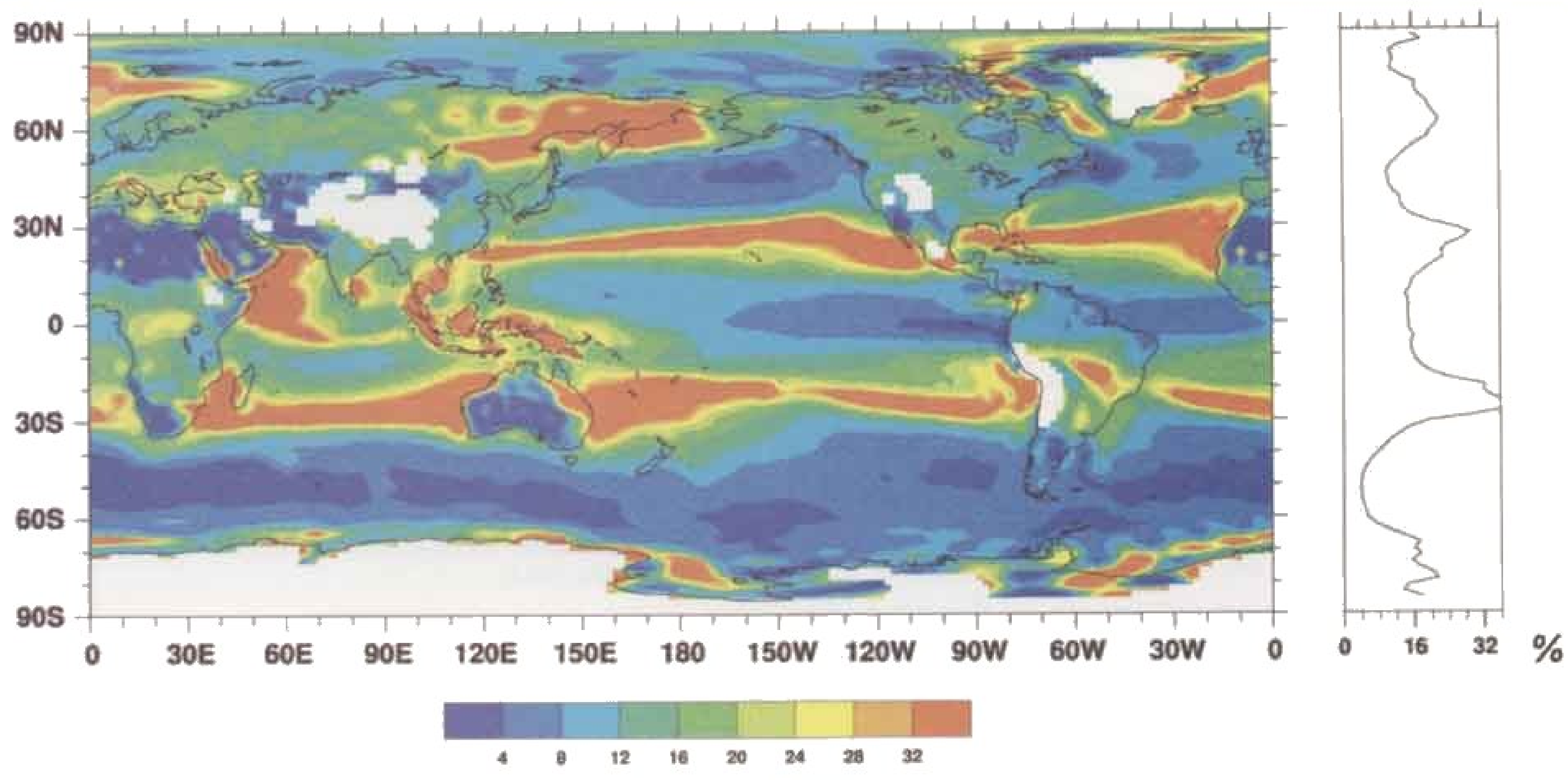
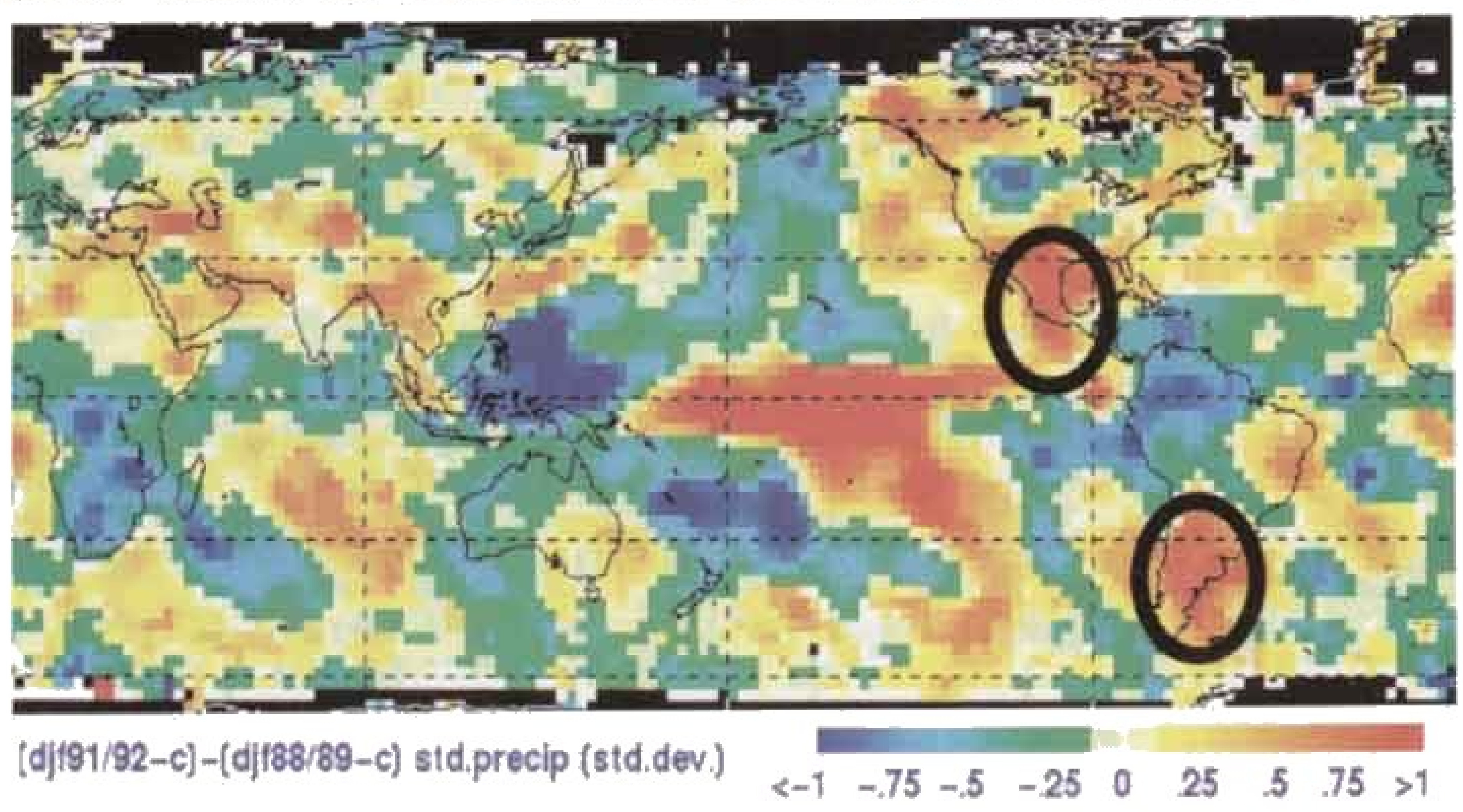


Atmosphere moisture recycling in percent, for annual mean conditions (1979–1995), computed for a length scale of L=1000 km (see Trenberth article on page 1).

GPCP Shows El Niño-La Niña Precipitation Differences



Difference in precipitation patterns between an El Niño winter and a La Niña winter. The difference is computed from the GPCP Satellite-Gauge combination fields as [(average of December 1991 through February 1992 with climatology removed) – (average of December 1988 through February 1989 with climatology removed)] and then scaled by the (spatially varying) interannual standard deviation of the corresponding months to produce standardized precipitation anomalies. The units are multiples of local interannual standard deviation. This display allows scientists to identify regions with similar levels of significance, regardless of the intensity of the local rain rate. **For example, the positive regions in Mexico and coastal Argentina are stronger than one would anticipate by considering the unscaled precipitation differences** (see circled regions). The central pattern in the tropical Pacific Ocean is reminiscent of previous studies, although it is only for one pair of events. The transformation from standardized precipitation anomalies to significance levels has not yet been computed for this case.

Illustration provided by George Huffman, NASA Goddard Space Flight Center and Science Systems and Applications, Inc.. For additional information contact George Huffman, Fax: 301-286-1762, or E-mail: huffman@agnes.gsfc.nasa.gov.

WHAT'S NEW IN GEWEX

GEWEX Strategies and Goals Affirmed

New Analyses of Hydrological Cycle Variations Studied

GPCP Initiates Interactive Data Comparisons

New Chinese Metsat Fills Data Gap

Global Water Vapor CD-ROM Available

GEWEX Data Sets Updated (Pages 7–10)