GEWEX WCRP

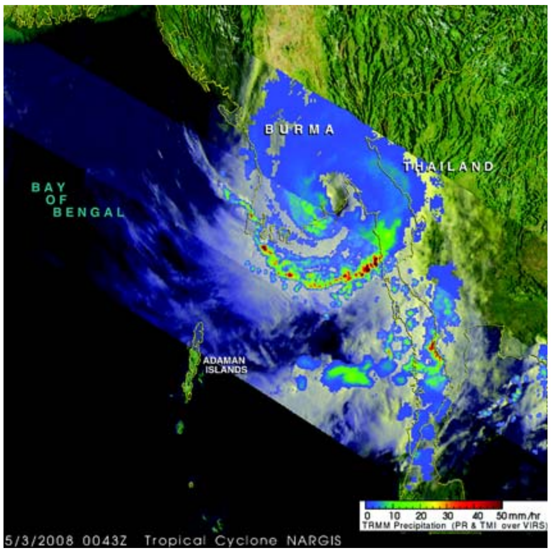
Global Energy and Water Cycle Experiment

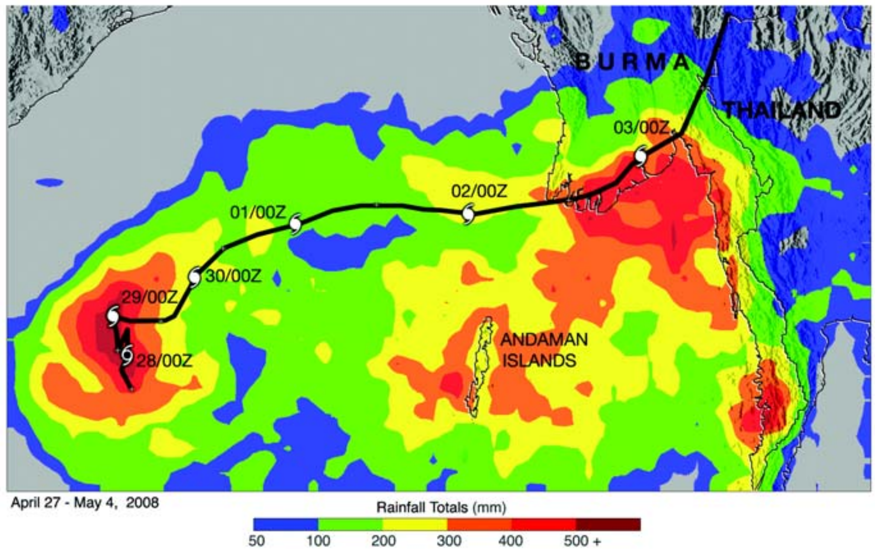
NEWS

Vol. 18, No. 2 WCRP World Climate Research Programme WMO IOC ICSU International Council for Science May 2008

Tropical Rainfall Measuring Mission (TRMM) Data are Improving Our Understanding of the Global Energy and Water Cycle

TRMM Tracks Cyclone Nargis Approach to Burma

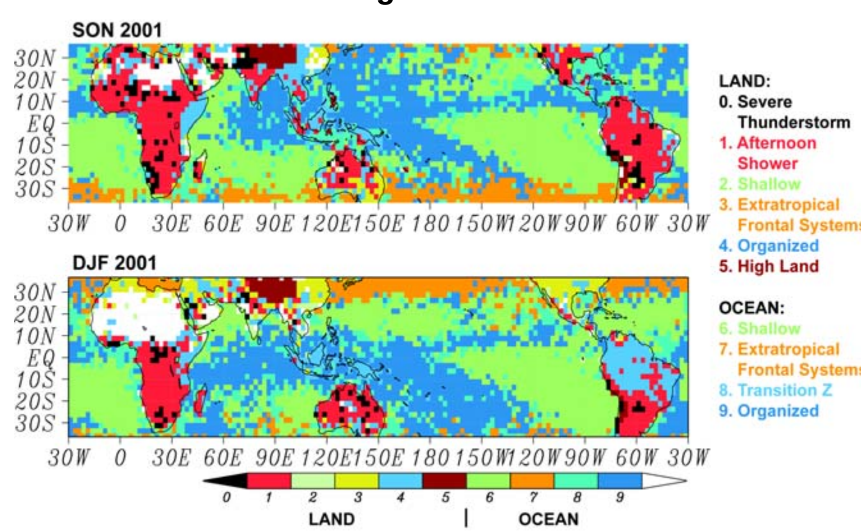




TRMM passes over Cyclone Nargis (left figure) as it moves along the southern coastal region of Burma on 3 May 2008. Instantaneous rainfall rates from the TRMM Microwave Imager (outer swath) and the Precipitation Radar (inner swath) are superimposed on the cloud imagery from the Visible Infrared Scanner. Total accumulated precipitation (right figure) for the period 27 April to 4 May 2008 from Nargis and precursor rain systems. Rainfall totals were derived from the TRMM multi-satellite 3-hourly precipitation product (images produced by Hal Pierce, National Aeronautics and Space Administration/Goddard Space Flight Center). ***See article by S. Braun on page 6.***

Contents

Characterizing Rainfall Regimes Using TRMM Data



Classified dominant rain systems using TRMM Precipitation Radar statistics in 100-km scale boxes along the orbit and rainfall per flash values for 3 months. ***See article by Y. N. Takayabu on page 9.***

Commentary

A Year of Change: The Future of WCRP AND GEWEX

Peter J. van Oevelen
Director, International GEWEX Project Office

This coming year should prove to be exciting, with many changes happening within the World Climate Research Programme (WCRP) and its core projects. It should also be an interesting challenge for our research community to capitalize on the increased media attention to climate change and the widespread acceptance of the importance of these and related issues. Mitigation and adaptation are important key words in the governmental response to climate change and we need to ensure that scientific research will continue to play an important role. An understanding of the global processes and their regional effects is crucial for mitigation and adaptation to be effective. GEWEX as a part of WCRP is at the core of these issues and needs to strengthen its role more now than ever. I look forward to bringing these matters to the forefront of attention.

It is with great pleasure that I welcome the new Director of WCRP, Dr. Ghassem Asrar. We at the International GEWEX Project Office (IGPO) look forward to working with Dr. Asrar in reshaping the future of WCRP and its core projects while ensuring that the research they represent is both maintained and strengthened. One of Dr. Asrar's first activities as Director was to attend the 29th WCRP Joint Scientific Committee (JSC) Meeting in Arcachon, France, held 31 March – 5 April. This meeting had a positive and cooperative spirit while addressing difficult issues, including the future of WCRP as a whole, and the role and place of the WCRP Strategic Framework. This issue will no doubt stir up controversies on where and how to prioritize, but I am confident that this will provide an excellent opportunity for GEWEX to continue its support and focus to activities in the long term.

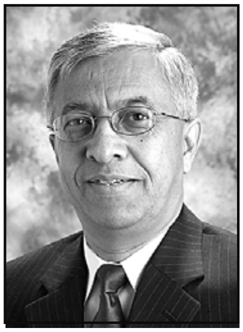
The JSC appointed a new chair, Dr. Antonio Busalacchi and I look forward to working with him. I will also take this opportunity to thank Dr. John Church for his leadership as the chair during the last few years. The JSC was very supportive of activities related to monsoons but at the same time asked for stronger coordination among all involved parties; many of these issues no doubt will be brought to the table at the next Pan-WCRP Monsoon meeting (to be held 20–25 October of this year in Beijing, China). Similarly, the Extremes cross-cut is to be expanded and a Task Force on Climate Extremes is to be formed with participation from the wider community. The JSC also approved the restructuring of the Working Group on Numerical Experimentation (WGNE), which will include as members the GEWEX Modelling and Prediction Panel (GMPP) Working Group Chairs (the Global Land Atmosphere System Study, the GEWEX Atmospheric Boundary Layer Study, and the GEWEX Cloud System Study) and the chair of GMPP, who will also become an *ex officio* co-chair of WGNE. This restructuring is aimed at endorsing, strengthening, and expanding parameterization efforts in the respective communities.

The reprocessing of currently available global data products with the purpose of making them more suitable for climate and trend analysis is highly welcomed and commended by the JSC, as evidenced by the article written by Dr. Ehrhard Raschke (et al.) on page 11 of this issue, highlighting one of the difficulties in reprocessing the International Satellite Cloud Climatology Project (ISCCP) and related products. These data sets, originally intended for process studies on shorter time scales, will become even more valuable when their long-term consistency has been addressed.

The IGPO with the help of the wider community is asked by the JSC to provide a legacy document that will assess and identify those activities which need to be further emphasized and those which can be downplayed in the intermediate term. This will no doubt pose a challenge for all of us, since making such choices will have both positive and negative impacts. With WCRP's core projects nearing their sunset dates, some reorientation is unavoidable and even necessary. I hope that we at the IGPO can continue to count on all of you as supporters of GEWEX research activities.

Recent News of Interest

GEWEX Welcomes New Director of WCRP Joint Planning Staff



Dr. Ghassem R. Asrar served as the Deputy Administrator for Natural Resources and Agricultural Systems with the Agricultural Research Service of the U.S. Department of Agriculture from 2006–2008. He was appointed to this position after 20 years of service with the U.S. National Aeronautics and Space Administration (NASA), where he served as Chief Scientist for the Earth Observing System in the Office of Earth Science at NASA Headquarters prior to being named as the Associate Administrator for Earth Science in 1998. For more information about Dr. Asrar, see *http://wcrp.wmo.int/documents/WCRPnews_20080221_Asrar.pdf*.

LANDSAT Imagery for Everyone

The U.S. Geological Survey (USGS) Landsat 35-year record of the Earth's surface will soon be available to users at no charge. Under a transition toward a National Land Imaging Program sponsored by the Secretary of the Interior, the USGS is pursuing an aggressive schedule to provide users with electronic access to any Landsat scene held in the USGS-managed national archive of global scenes dating back to Landsat 1, launched in 1972. By February 2009, any Landsat archive scene selected by a user will be automatically processed, at no charge, to a standard product recipe and staged for electronic retrieval. In addition, newly acquired scenes meeting a cloud cover threshold of 20 percent or below will be processed to the standard recipe and placed online for at least 3 months, after which they will remain available for selection from the archive. For details see *http://landsat.usgs.gov*.

Pierre Morel Honored at European Geophysical Union Meeting

Pierre Morel was awarded the EGU Alfred Wegener Medal for his outstanding contributions to geophysical fluid dynamics and his leadership in the development of climate research and the applications of space observation to meteorology and Earth system science. Throughout his 40-year career, Dr. Morel was one of the most active scientists initiating and developing tools and international programs for meteorological and climatic research. From 1982 to 1994, as Director of the World Climate Research Programme, he steered a broad interdisciplinary research program in global climate and Earth system science, involving the participation of atmospheric, oceanic, hydrological, and polar scientists worldwide.

GCSS Stratocumulus Large-Eddy Simulation Intercomparisons Targeting Climate Model Uncertainties

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Marine boundary-layer clouds exert a substantial shortwave radiative forcing on the global heat budget. Due to problems in representing these clouds in general circulation models, they contribute a leading-order uncertainty in cloud feedbacks in global climate models (Bony and Dufresne, 2005).

The GEWEX Cloud System Study (GCSS) Boundary Layer Cloud Working Group (BLCWG) has conducted a number of workshops devoted to idealized case studies of low-lying clouds simulated with a range of models. The BLCWG intercomparison of large-eddy simulations (LES) focused on the first research flight of the Dynamics and Chemistry of Marine Stratocumulus Phase II (DYCOMS-II) field project in which very dry air overlays a stratocumulus-topped marine boundary layer with no measurable precipitation below the cloud base (Stevens et al., 2005a). Models that reduced subgrid-scale mixing at the cloud top were found best able to maintain sufficient radiative cooling while concurrently limiting entrainment at the cloud top, resulting in a well-mixed boundary layer topped by an optically thick cloud layer. Cloud-water sedimentation and drizzle were ignored in those simulations, as is traditional in studies of non-precipitating clouds.

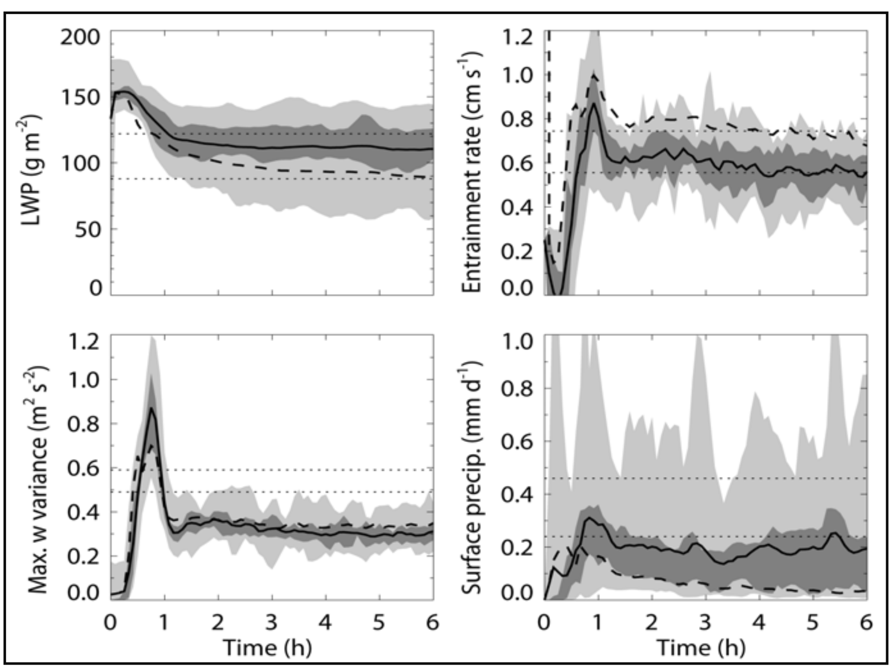
While the importance of drizzle on the stratocumulus-topped boundary layer has been long acknowledged, only recently has the significance of cloud-water sedimentation been recognized in large-eddy simulations of stratocumulus (Ackerman et al., 2004; Bretherton et al., 2007). The BLCWG workshop focused on the roles of cloud-water sedimentation and drizzle in a final ensemble of eleven LES models, two of which used bin microphysics while the rest used parameterized cloud microphysics. The simulation specifications were based on an idealization of the second research flight of DYCOMS-II, which sampled a bimodal cloud population with pockets of heavily drizzling open cells among a deck of closed-cell stratocumulus that was drizzling lightly (vanZanten and Stevens, 2005; Stevens et al., 2005b; Petters et al., 2006). Six-hour simulations were run with and without drizzle, each with and without cloud-water sedimentation. Highlights of the results are presented here (a paper describing the results and implications has been provisionally accepted for publication in *Monthly Weather Review* and is available upon request from the author). The BLCWG has also compared single-column models using the same specifications developed for the LES intercomparison, as described by Wyant et al. (2007).

The air overlying the boundary layer is slightly cooler and moister in this case compared to that in the previous intercomparison (Stevens et al., 2005b), which evidently allowed the model ensemble to do a much better job of reproducing the observed entrainment rate and liquid water path (LWP). For example, LWP varied by less than a factor of two among the models, whereas LWP varied by more than an order of magnitude among the models in the previous case. This improvement in model agreement does not require cloud-water sedimentation or drizzle (which were not considered in the previous intercomparison), as the ensemble ranges of LWP are comparable both with and without those processes.

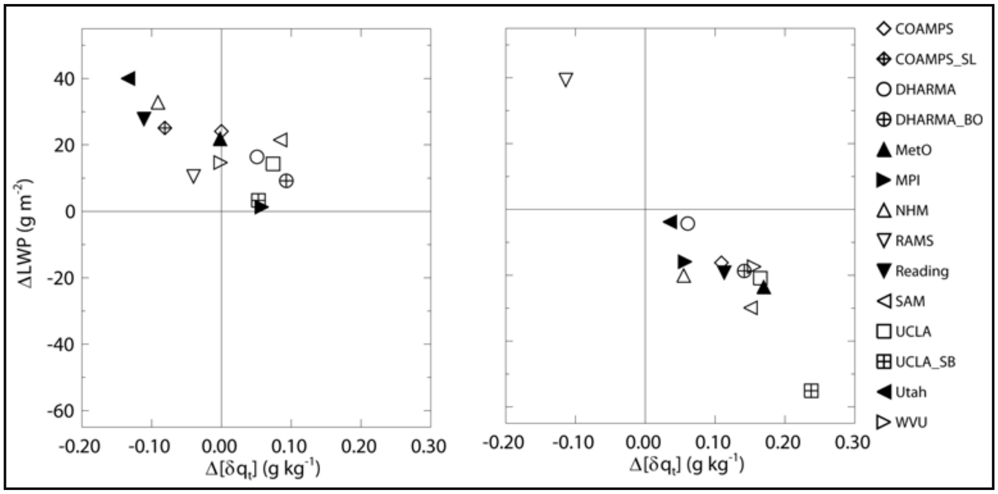
Time series characterizing the ensemble of simulations with cloud-water sedimentation and drizzle are compared with the observations found in the figure below. After a transient spin-up of boundary-layer convection, the ensemble settles into a quasi-steady state in which the mean LWP reproduces the observed mean LWP remarkably well, while the mean entrainment rate is at the lower end of the observations and the ensemble-average maximum vertical wind variance is roughly half of that measured. On average, precipitation at the surface and at the cloud base is smaller, and the rate of evaporation greater than measured. Comparison of the simulated and measured profiles provides further evidence that the simulated boundary layers are not as well mixed as in the observations.

An indicator of the structure of the turbulent mixing—the mean third moment of *w,* the vertical wind—was observed to be negative near the cloud base, indicating downdrafts stronger than updrafts. In contrast, the skewness of *w* was positive near the cloud base in the simulations. Cloud-water sedimentation leads to an increase in the third moment of *w* near the cloud base for all the simulations with drizzle; thus the apparent disagreement between the measured and simulated third moment of *w* can be attributed to this process. Unfortunately the strength of this process was exaggerated by roughly a factor of two in the models that parameterize cloud microphysics (the specified breadth of the cloud droplet size distribution was broader than measured, in retrospect), thus amplifying its impact in the majority of simulations.

Sedimentation of cloud water was found to consistently result in decreased entrainment and increased LWP, as found in other recent studies that have considered the role of this process; however, there are some differences with previous findings. For instance, Bretherton et al. (2007) considered the conditions from the first research flight of DYCOMS-II and found that convective intensity (as measured by the variance of *w*) increased throughout the bulk of the boundary layer in response to cloud-water sedimentation reducing entrainment. In this intercomparison, which considered a much thicker cloud layer with less than half the droplet concentration—factors that together enhance the parameterized cloud-water sedimentation flux by up to a factor of five, cloud-water sedimentation was instead found to reduce convective intensity in most of the models. A sensitivity test with one of the models, in which drizzle is omitted and cloud-water sedimentation is parameterized, shows that this reduction of convective intensity nearly vanishes when the strength of cloud-water sedimentation is halved. The stronger cloud-water sedimentation results in a marked increase in the volume of unsaturated air within the cloud layer, most pronounced near the cloud base. Thus, the evidence suggests that strong cloud-top sedimentation flux divergence of cloud water not only reduces the efficiency of entrainment—as found by Bretherton et al. (2007)—but also can result in dry, buoyant, and energetically unfavorable downdrafts above the mean cloud base, as found by Stevens et al. (1998) in simulations of heavily drizzling stratocumulus.



Evolution of domain average liquid water path (LWP), entrainment rate, maximum variance of vertical wind, and surface precipitation for simulations that include cloud-water sedimentation and drizzle. The ensemble range, middle two quartiles, and mean are denoted by light and dark shading and solid lines, respectively. Ensemble mean from simulations that include drizzle but not cloud-water sedimentation are denoted by dashed lines. Approximate ranges of measurement averages are denoted by dotted lines.



Change of LWP versus change of difference in total water mixing ratio between the sub-cloud and cloud layers of (äq_t) associated with cloud-water sedimentation (left) and drizzle (right), averaged over last 4 hours of simulations. Drizzle is included in simulations on the left, and cloud-water sedimentation is included in simulations on the right.

Turning from the effects of cloud-water sedimentation to those of drizzle (as models with bin microphysics make no distinction between cloud droplets and drizzle drops, a radius cutoff of 25 μm was used in the analysis), LWP was found to decrease in response to drizzle in all but one of the models, despite a very slight reduction in entrainment. Thus, while the effects of cloud-water sedimentation and drizzle conspire with respect to entrainment, their effects on LWP are opposed for all but one of the models, as seen in the figure above. Taken together, the effect of cloud-water sedimentation on LWP dominates in all but two cases. That is, the inclusion of both processes results in a net LWP increase in nearly all the models. However, drizzle is not that strong in the simulations, and cloud-water sedimentation is exaggerated relative to the observations in the models that parameterized it.

The changes in LWP and the vertical gradient of total water mixing ratio (i.e., vapor plus condensate) are strongly correlated in response to cloud-water sedimentation or drizzle, as seen above. The trend is also strong when considering the effect of both processes combined. Drizzle is thus seen to increase boundary-layer stratification in all but one of the models, while the effect of cloud-water sedimentation on stratification is more varied within the ensemble, with stratification decreasing in nearly as many models as those in which it increases.

In summary, the results here reinforce recent findings regarding the importance of cloud-water sedimentation to boundary-layer entrainment (and thereby cloud liquid water path), in this case reducing the entrainment rate by approximately 25 percent or more (with or without drizzle included). It was also found that differences in model dynamics dominate the spread in entrainment rates, which is of the same order as the changes in entrainment rates induced by cloud-water sedimentation. Models that entrain rapidly with microphysics omitted tended to entrain rapidly with microphysics included.

Acknowledgements

Thanks to M. C. vanZanten (KNMI), B. Stevens (UCLA), V. Savic-Jovcic (UCLA), C. S. Bretherton (U. Washington), A. Chlond (MPI), J.-C. Golaz (NOAA-GFDL), H. Jiang (NOAA-ESRL), M. Khairoutdinov (Stony Brook U.), S. K. Krueger (U. Utah), D. C. Lewellen (West Virginia U.), A. Lock (MetO), C.-H. Moeng (NCAR), K. Nakamura (JAMSTEC), M. D. Petters (Colorado State U.), J. R. Snider (U. Wyoming), S. Weinbrecht (U. Reading), and M. Zulauf (U. Utah) for participating in the intercomparison.

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10+ Years of TRMM Precipitation Data

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Launched in 1997, the Tropical Rainfall Measuring Mission (TRMM), a joint U.S. National Aeronautics and Space Administration (NASA) and Japan Aerospace Exploration Agency (JAXA) program, has provided unique information on precipitation structure and distribution for more than 10 years. The first-time use of both active and passive microwave instruments and its precessing, low inclination orbit (35°) have made TRMM the world's foremost satellite for the study of precipitation and associated storms and climate processes in the tropics. TRMM has met and exceeded its original goal of advancing our understanding of the distribution of tropical rainfall and its relation to the global water and energy cycles. It has evolved from an experimental mission focusing on tropical rainfall climatology into the primary satellite used for analyzing precipitation characteristics on time scales from 3-hourly to interannually and beyond.

The primary TRMM instruments are the Precipitation Radar (PR), the first and only rain radar in space, and the TRMM Microwave Imager (TMI), a multi-channel passive microwave radiometer that complements the PR by providing total hydrometeor (liquid and ice) content within precipitating systems. The Visible Infrared Scanner (VIRS) provides the cloud context of the precipitation structures and is used as part of a transfer strategy to connect microwave precipitation information to infrared-based precipitation estimates from geosynchronous satellites. These three instruments, which form the original TRMM rain package are used singly and jointly to understand precipitation processes, structure, and climatology. In addition, the Lightning Imaging Sensor (LIS), an Earth Observing System (EOS)-funded instrument, complements the rain sensors, improving understanding of convective dynamics and providing a climatology of global lightning flash rates. The TRMM orbit altitude originally was 350 km with an inclination of 35° for coverage of the tropics and the southern portions of both Japan and the United States. The precessing orbit also passes through all the hours of the day, thereby giving a unique data set for observing the diurnal cycle of rainfall. In order to conserve fuel and extend the mission of TRMM, the orbit was boosted to 402.5 km in August 2001 and TRMM has operated at that altitude ever since.

Significant scientific accomplishments have been made from TRMM data resulting in more than 800 refereed journal articles. These accomplishments include reducing the uncertainty of mean tropical oceanic rainfall; documentation of regional, diurnal, and interannual variations in precipitation characteristics; the first estimated profiles of latent heating from satellite data (see article on page 8); improved climate simulations; increased knowledge of characteristics of convective systems and tropical cyclones; and new insights into the impacts of humans on rainfall. The availability of real-time TRMM data has led to significant applications and the operational use of the data, primarily in monitoring tropical cyclones, in hydrological applications, and in the assimilation of precipitation information into numerical forecast models. As the key satellite over the past decade dedicated to precipitation observations, TRMM has contributed significantly to the goals of GEWEX and the World Climate Research Programme (WCRP). For example, TRMM data are being compared to current tropical estimates under the GEWEX Global Precipitation Climatology Project (GPCP) and will be extensively used in new versions of GPCP products being planned.

The recent devastation in Burma by Tropical Cyclone Nargis highlights the need for high-quality space-based observations of cyclone track, structure, and rainfall. Nargis made landfall in Burma with 115 knot winds and produced rainfall upwards of 200 mm. The situation was exacerbated by the fact that, in the days prior to landfall, heavy precipitation embedded in the southerly flow ahead of Nargis dropped nearly 300 mm of precipitation in the region. The value of the TRMM data is seen at the top of page 1, illustrating the information on storm structure from the orbit data and estimates of total rainfall from the TRMM multi-satellite precipitation product (Huffman et al., 2007).

TRMM data (primarily TMI) are used by both the National Oceanic and Atmospheric Administration's National Hurricane Center and the Department of Defense Joint Typhoon Warning Center in the United States, as well as tropical cyclone centers in Japan, India, Australia, and other countries for detecting the location and intensity of tropical cyclones. In 2004, more than 600 tropical cyclone fixes were made by these agencies using TRMM data. Because of TRMM's finer spatial resolution as compared to the Special Sensor Microwave Imager (SSM/I), these fixes are usually considered among the most accurate of satellite-based locations. In addition, TRMM's orbit in the tropics provides data at different times than the sun-synchronous microwave instruments, with its best sampling in the cyclone-important 10–37 degree latitude bands. TRMM data are also used (often in time histories with other satellite data) to detect changes in convection, eyewall formation, and other features related to intensity change and are frequently mentioned in warning center discussions.

TRMM has provided an invaluable data resource for tropical cyclone research as its TMI and PR data have been used to establish for the first time key characteristics of the distribution and variation of rainfall in tropical cyclones as a function of intensity, basin, stage of development, and environmental conditions (e.g., shear) (Lonfat et al., 2004; Chen et al., 2006). TRMM PR and TMI data have been used to derive vertical profiles of precipitation ice and liquid water content in tropical cyclones (Jiang and Zipser, 2006). The ability of TRMM to see within cloud systems enables us to detect the eye of topical cyclones much more consistently than with infrared sensors (89 percent vs. 37 percent) (Kodama and Yamada, 2005) while observations of deep convective towers in the eyewall have been linked to the subsequent deepening of storms (Kelley et al., 2004). TRMM data have also been used to validate mesoscale model simulations of hurricanes (Braun, 2006) and have been demonstrated to have made positive impacts through data assimilation on simulations (Atlas et al., 2005; Ma et al., 2006) and forecasts (Benedetti et al., 2005) of tropical cyclones.

TRMM instantaneous rain estimates have been used to calibrate or adjust rain estimates from other satellites to provide analyses at higher time resolution than available from one satellite (Adler et al., 2000). TRMM currently provides a 3-hour multisatellite precipitation analysis product (Huffman et al., 2007) that is the most frequently downloaded product from the TRMM data archive (see the TRMM 3B42 product at *http://disc.sci.gsfc.nasa.gov/data/datapool/TRMM*). This product is used to validate models (Bauer and Del Genio, 2005), estimate rainfall associated with tropical cyclones, and identify regions susceptible to floods and landslides (Hong et al., 2006).

After 10 years of operation, all TRMM instruments are performing well and the spacecraft has sufficient fuel to maintain operations until at least late 2013 and potentially through 2014. Continuation of TRMM data until 2014 will allow the community to better link the TRMM data set to that of the Global Precipitation Measurement (GPM) mission scheduled to be launched in 2013. TRMM and GPM together will produce a 20-year plus high-quality rainfall record that will allow scientists to determine the time and space varying characteristics of tropical rainfall, convective systems, and storms and how these characteristics are related to variations in the global water and energy cycles. Such work has long been a primary goal of TRMM and is at the heart of NASA's Earth Science strategy. It will help to answer key science questions for both the water and energy cycle and weather focus areas, including "How are global precipitation, evaporation, and the water cycle changing?" and "How can weather forecast duration and reliability be improved?" The presence of a long, accurate record of quasi-global precipitation characteristics will greatly advance precipitation science and result in: (1) an improved climatology of precipitation characteristics, especially extremes; (2) improved diagnosis and closure of global (and regional) water cycles; (3) diagnosis and testing of inter-decadal and trend-related processes in the water cycle; (4) better assessment of the impact of humans on rainfall characteristics and processes (e.g., cities, deforestation, and aerosols); (5) robust determination of convective system, tropical cyclone, and lightning characteristics; (6) advances in hydrological applications over land (basin-scale assessments, water management); (7) improved modelling of the global water/energy cycles for weather/climate predictions; and (8) improved monitoring and forecasting of tropical cyclones, floods, and other hazardous weather.

Key web sites related to TRMM and its observations of tropical cyclones include: *http://www.trmm.gsfc.nasa.gov* (U.S. TRMM), *http://www.eorc.jaxa.jp/TRMM/index_e.htm* (Japanese TRMM), and *http://www.nrlmry.navy.mil/tc_pages/tc_home.html* (Naval Research Laboratory).

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Retrieved Latent Heating From TRMM

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Latent heating (LH) is the heat released or absorbed by the atmosphere as a result of phase changes in water associated with condensation or evaporation of cloud droplets and raindrops, freezing of raindrops, melting of snow and graupel/hail, or the deposition and sublimation of ice particles. The Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) and Microwave Imager (TMI) provide measurements of rainfall as well as an estimate of the four-dimensional structure of latent (diabatic) heating over the global tropics (Simpson et al., 1988, 1996). Because the PR and TMI cannot directly measure LH profiles, they have to be determined indirectly from the application of physically based models to TRMM precipitation measurements. The general approach is to apply models ranging in complexity from simple profile shapes to cloud-resolving models (CRMs) to the PR and/or TMI data (Tao et al., 2006).

Five TRMM LH algorithms have been developed, compared, validated, and applied during the past decade and are listed below in Table 1. The CSH, GPROF, and SLH algorithms require the full complement of cloud model data generated by a CRM. Since May 2001, five TRMM LH workshops (Tao et al., 2007) have been held to (1) review LH algorithm designs and planned improvements, (2) assess validation schemes and results with diagnostic-type analyses, (3) identify LH requirements and applications issues, (4) determine the uncertainties of LH products, and (5) identify issues pertaining to use of TRMM and other satellite LH data for global-scale modelling and tropical convection studies. A recommendation from these workshops was to conduct a TRMM LH intercomparison and validation project.

	TRMM Data Needed	Heating Products	Key References in Algorithm Description	Algorithm Developers
CSH (Convective-Stratiform Heating)	PR, MI, PR-TMI	Q_1, LH	Tao et al. (1993; 2000, 2001)	W.-K. Tao and S. E. Lang
SLH (Spectral Latent Heating)	PR	Q_1, Q_1-Q_R	Shige et al. (2004)	S. Shige and Y. N. Takayabu
GPROF (Goddard Profiling Heating)	PR-TMI	Q_1, Q_1-Q_R	Olson et al. (1999, 2006)	W. S. Olson and C. D. Kummerow
HH (Hydrometeor Heating)	PR-TMI	LH	Yang et al. (1999, 2006)	E. A. Smith and Y. Song
PRH (Precipitation Radar Heating)	PR	LH	Satoh and Noda (2001)	S. Satoh and A. Noda

Table 1. Key characteristics of five different heating algorithms in terms of data requirement and retrieved products. Note that the relationship between Q_1 (apparent heating source, which can be diagnostically determined from an intensive sounding network), LH, Q_1–Q_R and Q_R is: Q_1–Q_R=LH+Eddy transport by clouds. The vertically integrated eddy transport by clouds is zero (no explicit effect on surface rainfall). Complete references can be obtained from the authors.

	Sampling Ratio (Satellite/diagnostic)	Area Size (km x km)	Date
Case 1a: SCSMEX NESA	53%	665 x 1100	18 May - 30 June 1998
Case 1b: SCSMEX SESA	48%	880 x 880	1 May - 30 June 1998
Case 2: LBA	19%	190 x 190	24 Jan - 28 Feb 1999
Case 3: KWAJEX	16%	175 x 175	24 July - 14 Sept 1999
Case 4a: ARM 2000	38%	400 x 400	1 March - 21March 2000
Case 4b: ARM 2002	39%	400 x 400	25 May - 15 June 2002
Case 5: Bonnie	N.A.	~500 x 500	1806 UTC, 22 August 1998
Case 6: Jelawat	N.A.	~500 x 500	1151 UTC, 2 August 2000
Case 7: Ocean	N.A.	4,440 x 9,900	Jan 1998 - Dec 2000

Table 2. Satellite sampling and domain size of sounding network for intercomparison cases. The first four cases are validated with the apparent heating (Q_1) derived from diagnostic budget calculations based on observations from special radiosonde or combined radiosonde-Doppler radar networks. The two tropical cyclones (Cases 5 and 6) allow for the algorithm-generated instantaneous LH profiles to be compared—but without validation information. In the final case, the intercomparisons focused on a hierarchy of space-time scale variations (including inter-annual variations) over large-scale regional domains involving tropical ocean environments.

Seven separate data sets and four field experiment cases are considered for this intercomparison project (see Table 2 above): the South China Sea Monsoon Experiment (SCSMEX), the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), the Kwajalein Experiment (KWAJEX), and the U.S. Department of Energy-Atmospheric Radiation Measurement (ARM) Southern Great Plains-Cloud and Radiation Test Bed; two tropical cyclone cases: Atlantic Hurricane Bonnie and Pacific Typhoon Jelawat; and one large-scale regional case: a tropical ocean domain.

The intercomparison results are illustrated here using the SCSMEX south enhanced sounding arrays (SESA) case (see figure at the top of page 20). The sounding-estimated Q_1 (two different averaging areas) and satellite-derived Q_R are also shown for comparison. The CSH (Q_1) and SLH (both Q_1–Q_R and LH) algorithms agree with the sounding-estimated Q_1 in terms of amplitude of peak heating and having a broad heating peak. However, their retrieved peak heating level is slightly higher than that estimated from the soundings. GPROF-retrieved heating (Q_1 and Q_1–Q_R) also agrees with the sounding estimates, but has smaller amplitude (especially in the lower troposphere) compared to the other algorithms. The LH-retrieved heating agrees with that estimated from sounding data in terms

	Heating Products Used for Applications	> Ten Applications - 5 papers
Drs. Krishnamurti, Rajendran (FSU, MRI)	CSH	Global Model Assimilation
Dr. A. Del Genio (GISS)	CSH	Large-Scale Modeling Validation (Level of Max Heating)
Dr. A. Hou (GSFC)	GPROF	Global Model Assimilation
Dr. D. Waliser (JPL)	CSH/GPROF	Comparison between Global Model (ECMWF) and TRMM Derived for MJO
Dr. C. Zhang (U. Miami)	CSH/SLH	LH and Large-Scale Dynamic (MJO and Shallow Meridional Circulation)
Dr. X. Zhang (U. Colorado)	CSH	Relationship between LH and Mesosphere and Low Thermosphere Solar Tides
Dr. W. Lau (GSFC)	CSH	Evolution of MJO
Dr. R. Small (U. Hawaii)	GPROF/CSH	Tropical Circulation Response to LH Anomalies
Dr. P. Webster (Georgia Tech.)	GPROF/CSH	Monsoon
Drs. J. Morita, Y. N. Takayabu (CCSR/U. Tokyo)	SLH	LH Structures of MJO

Table 3. Key scientists using TRMM-derived LH products for specific applications. MJO stands for Madden-Julian oscillation.

of altitude of maximum heating and having positive heating in the upper troposphere (above 10 km). Its retrieved heating is larger than the other algorithms. The PRH-retrieved heating profile has the lowest maximum heating altitude. These preliminary results are quite encouraging despite sampling issues (see Table 2), because each algorithm's retrieved heating structure captured some of the major characteristics estimated from the sounding network.

In the last decade, standard LH products from TRMM measurements have been developed for scientific research and applications (Table 3). Such products enable new insights and investigations of the complexities of convective life cycles, the diabatic heating controls and feedbacks of meso-synoptic circulations and their forecasts, the relationship of patterns of tropical LH to the global circulation and climate, and of strategies for improving cloud parameterizations in environmental prediction models. The distributions of rainfall and inferred heating can be used to advance understanding of the global energy and water cycle. In addition, this information can be used for global circulation and climate models for validating and improving their parameterizations.

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Observing Rainfall Regimes Using TRMM PR and LIS Data

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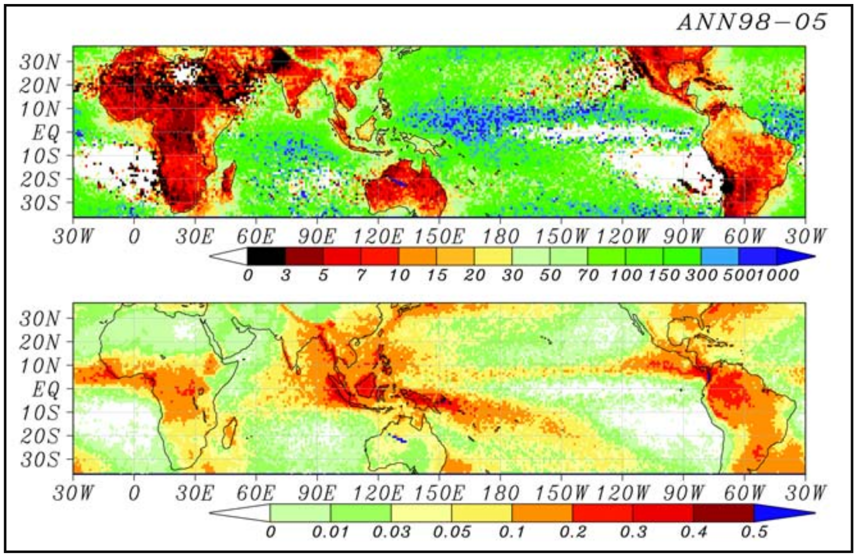
Rainfall is often referred to in terms of "oceanic" and "continental" regimes of precipitation, the latter having more vigorous convection and lightning activity. Williams et al. (1992) introduced the concept of Rainyield per Flash (RPF), showing a large contrast between RPF values of monsoon active and break periods. Petersen and Rutledge (1998) showed that this difference is attributed to the rainfall characteristics being more continental for the monsoon active period and more oceanic for the break period. This article describes how Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) and Lightning Imaging Sensor (LIS) data were used to characterize rainfall and classify the dominant rainfall systems using the value of RPF.

The upper panel in the figure at the top of page 10 shows the 8-year averaged RPF distribution calculated using PR and LIS data, and the lower panel shows the 8-year average PR-based rain rate (Takayabu, 2006). The reddish colors of RPF show more lightning and bluish colors show less lightning for an equal amount of rain. It is readily noticeable that while the rain amount distribution is relatively continuous between land and ocean, significant land-ocean contrast emerges in the RPF distribution. Smaller values are found over land than over ocean. Considering that the RPF is the rain amount normalized with the lightning flash numbers, it is an "intensive" variable which represents characteristics of rain independent from the amount. RPF values show a clear contrast between the oceanic rainfall characteristics and the continental rainfall, with average values of $2.0\text{x}10^9\text{kgfl}^{-1}$ for the former and $3.9\text{x}10^8\text{kgfl}^{-1}$ for the latter for the entire TRMM observation region between 36N and 36S.

This figure also shows some interesting regional characteristics. RPFs over continental rainy regions such as the Amazon and the Indian and southeast Asian monsoon regions exhibit intermediate values (orange). When the seasons are separated, the RPF values in monsoon regions are continental in the premonsoon season, while in the wet season they are oceanic. The figure at the bottom of page 10 contrasts the RPF values over South America in the premonsoon September-November season with those in the wet March-May season. While the RPF is as small as that of the annual-mean equatorial Africa in the relatively dry September-November season, it is as oceanic as that of the coastal ocean in the wet March-May season.

The region with intermediate RPF values (green) can be defined as "transition zones," where RPF is less than the threshold of $50\text{x}10^7\text{kg fl}^{-1}$ over the ocean.



Global distributions of 8-year mean Rainyield per Flash (RPF) calculated from Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) and Lightning Imaging Sensor (LIS) data (top panel) and total rain observed from TRMM PR (bottom panel). Units for the color scales are 10^7 kg fl^{-1} (top) and mm hr^{-1} (bottom). RPF averages are obtained by dividing the total precipitation amount by the total flash number for the averaging period.

This transition zone is found mostly around the continents. RPF correlates well with the rainfall amount from very high (<–20°C) rain top height (RTH) for continental rainfall, but the correlation disappears for oceanic rain. The rainfall in the transition zone shows a good correlation with the high rain amount, even though it is oceanic rain. It is interesting to consider how rainfall in the transition zone acquires continental characteristics.

These RPF values are used along with the statistics of PR2a25 data in ~100 km mesoscale boxes (21x21PR pixels) along the orbit to classify the rainfall types in terms of associated dynamical processes. Rainfall amount, rainfall area, and RTH statistics are used together with the RPF to determine the dominant rain type in 2.5x2.5 degree grid boxes for every 3 months (Takayabu et al., in preparation). The figure at the bottom of page 1 shows an example of rain type classification for September-November and December–February 2001. Grids are assigned to different rain types over land (severe thunderstorm, afternoon shower, shallow rain, extratropical frontal systems, organized rain, or high land rainfall), and over the ocean (shallow rain, extratropical frontal systems, organized rain, and transition zone). These results are used in the Global Satellite Mapping of Precipitation (GSMaP), a project sponsored by the Japan Aerospace Exploration Agency (JAXA) to produce high precision and high resolution global precipitation maps using satellite data. Statistics of rainfall based on such rain type classifications will also be used in the evaluation of precipitation systems in climate models.

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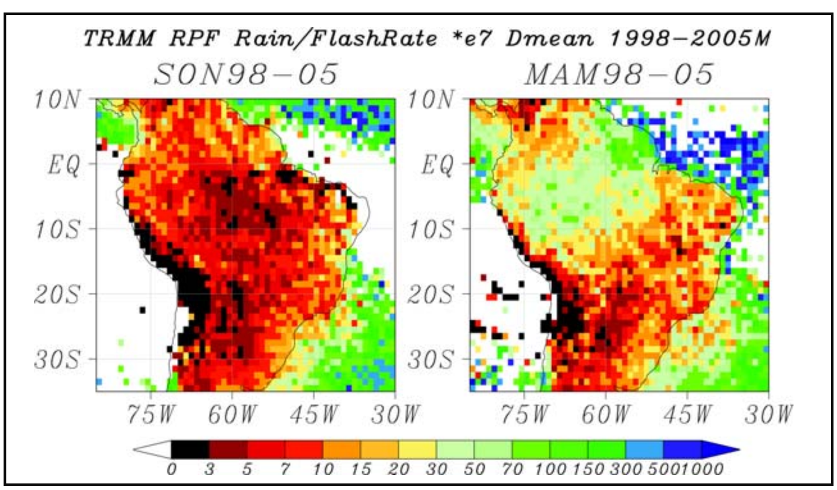

RPF distributions over South America for 8-year average September–November season and March–May season.

Trends or Artifacts? Temporal Changes in Cloud and Radiation Data from ISCCP, SRB, AND CERES

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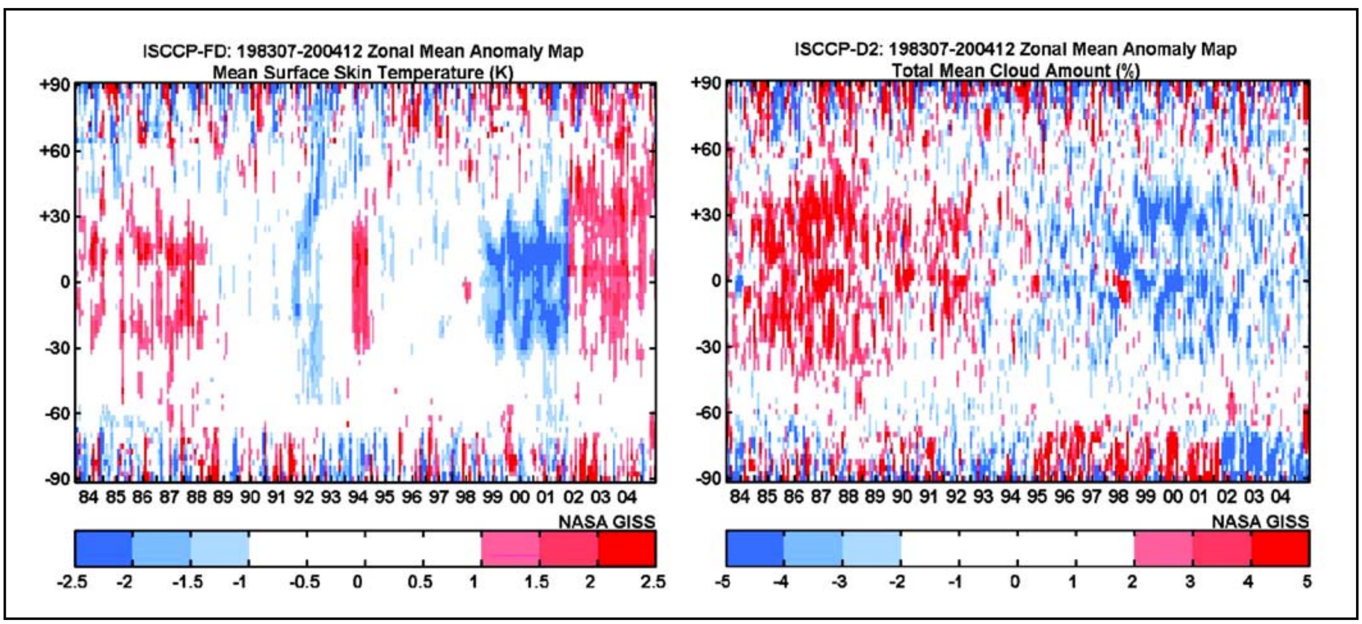
Since 1983, the International Satellite Cloud Climatology Project (ISCCP) (Rossow and Duenas, 2004) has processed visible and infrared images from polar and geostationary satellites to produce monthly 2.5 degree data sets of global cloud cover and radiative properties. Global monthly cloud products at 280-km resolution with 72 variables and 3-hour intervals, derived from polar orbiting and geostationary meteorological satellites now form an extensive 25-year global family of data sets. These resulting data sets and analysis products are being used to improve our understanding and modelling of the role of clouds in climate, with the primary focus of studying cloud and radiation process on shorter time scales where the magnitude of variations is large, as opposed to small long-term variations of the climate. These data are also being used to support many other cloud studies, including the hydrological cycle. While ISCCP was not originally designed as a "climate data record," there has been increasing interest in that use due to the growing length of data record. There are, however, a number of features that make the current products less useful for that purpose. Investigating the sources of inconsistencies is a necessary precursor to a careful re-analysis of all these data products. Approval has been obtained to re-engineer the ISCCP processing system to attempt to improve the quality enough to form a cloud Climate Data Record

Some recent papers have proposed interpretations of broad temporal changes—or "trends"—in the ISCCP cloud products and in the related radiation products of ISCCP, which include the GEWEX Surface Radiation Budget (SRB) Project (Stackhouse et al., 2004), and the Clouds and the Earth's Radiant Energy System (CERES) Experiment (Loeb et al., 2007). Some interpretations of these important data sets are controversial and demand a second look. For example, some correlations to changes in input ancillary data are found when assessing time series of cloud climatology and radiation products. This suggests that some or all of the broad temporal changes in these products may be artifacts caused by various input data.

Essential ancillary data to radiation products are clouds, surface properties of solar albedo and skin temperature, and atmospheric data on air temperature, trace gases, and aerosol. The figure below gives an example of how inconsistencies in input ancillary data might influence the radiation products. The left panel shows that larger changes for skin temperature occur in the subtropical and tropical regions. Clearly noticeable is a cooling following the Mt. Pinatubo eruption in 1991 by more than 1 K, whereas the real cooling at ground level was less than 0.5 K (Reynolds, 1993). After 1994 there is a significant decline of the skin temperature, which ends abruptly with a sharp increase by more than 3 K in 2001. Similar structures are found in other ancillary data, including atmospheric temperature, water vapor, and even surface reflectance (see *http://ISCCP.giss.nasa.gov*, and Zhang et al., 2006, 2007). These tropical temperature anomalies are an artifact related to changes in



Time-series of deseasonalized zonal monthly averages of the skin temperature at the surface (left panel) and of the total amount of clouds (right panel) from the period of July 1983 to June 2004.

the analysis algorithm used to produce the atmospheric temperature and humidity data used for ISCCP retrieval.

The ISCCP total cloud cover in the right panel, which is between 50° northern and southern latitude, seems to decrease almost continuously from 1988 to 2001. It has been proposed but not yet demonstrated that at least some of this variation is an artifact; we are still studying this question. Both of these parameters are used to produce the ISCCP-FD and GEWEX SRB radiative flux products, so that artifacts in these and possibly other inputs would cause artifacts in the radiation products that may be mistaken as trends.

The Pinatubo aerosols (1991) do not increase the total cloud cover much but they do change the partitioning of cloud amount between low and high clouds. There are some other correlations that are not yet understood, such as why the higher skin temperature since 2001 coincides with more high level clouds and fewer low level clouds.

Inconsistencies in ancillary data are not just limited to ISCCP: they also appear in climatologies such as SRB and CERES. CERES data are available only since the year 2000. Thus, direct comparisons of applied ancillary data for these three climatologies are available for a only a few years. Comparisons for the ancillary data of solar surface albedo and infrared surface emission fluxes are given in the figure on the bottom of page 20, displaying the differences in annual averages between data sets of SRB and CERES climatologies with respect to ISCCP data. The figure shows that SRB uses lower surface reflectances at extratropical latitudes, especially in areas where snow cover is expected. CERES surfaces are slightly brighter than ISCCP over continents, with the exception of Central Asia. The surfaces in the SRB and CERES algorithms are warmer over all the oceans than the ISCCP surfaces during the years 2000 and 2001, becoming colder in the following two years due to the sharp temperature rise discussed in the figure on page 11. Only southern oceans and parts of the Northern Pacific and Northern Atlantic remain warmer.

Such inconsistencies propagate into all radiation products of the three GEWEX radiation projects. A careful inspection of all ancillary data with respect to artifacts and spurious trends is required. Furthermore, it would be desirable to set up an ancillary data set time series for common use in such climatologies to allow researchers to focus their analyses on the more complex factors influencing radiation products and at the same time increase the potential to identify real trends.

This work is a contribution to the official assessment of GEWEX water vapor, cloud, aerosol, and radiation products.

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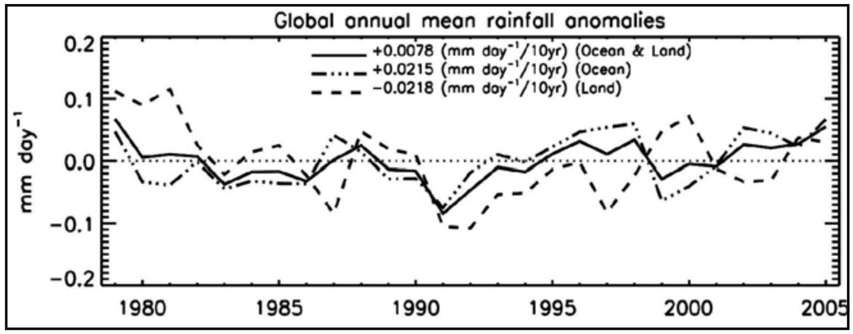
ISCCP CELEBRATES 25TH ANNIVERSARY

In July 2008, the **International Satellite Cloud Climatology Project (ISCCP)**, the first project of the World Climate Research Programme, will mark its 25th Anniversary. The original concept for ISCCP was to collect and distribute enough global satellite data to facilitate research on the role of clouds in climate, specifically their effects on the radiation budget and their role in the atmospheric water cycle. These data were to be sampled at sufficiently fine space-time intervals to capture the mesoscale-to-global scale and diurnal-to-interannual variations of cloud physical properties.

In addition to calibrating, navigating, quality checking and distributing the satellite radiance data for the whole research community to use, ISCCP conducted a comparison of the then-existing cloud algorithms and participated in comparisons of radiative model representations of clouds—work that is on-going today. Based on these results, a new algorithm was designed, borrowing ideas from all the existing algorithms, and the radiance data processed to provide several different cloud data products that could be used for the research mentioned above. As more pointed questions have been asked involving clouds, the ISCCP product line has continued to expand, now including radiative flux profiles, cloud particle sizes and several subsets concerning specific cloud system types (convective tracking, cyclone tracking, pattern recognition analysis for tropics and midlatitudes). The ISCCP products have now developed into one of the longest time records of global cloud variations and have become part of the Global Climate Observing System (GCOS).

GPCP 27-Year Record Shows Regional/Global Trends and Correlation With Temperature

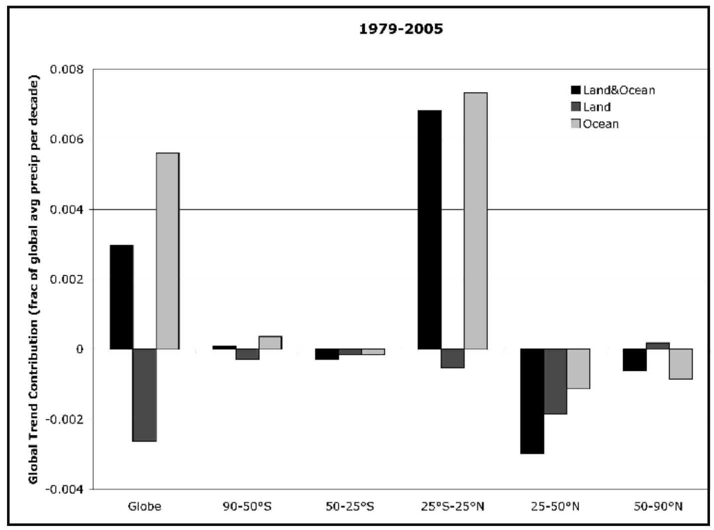
Two recent papers based upon the GEWEX Global Precipitation Climatology Project (GPCP) 27-year data set highlight the strong tropical but weak global trends for increasing precipitation, as well as a correlation with increasing surface temperature. The following abstracts and papers provide more in-depth analyses of the trends and correlations derived from the GPCP data sets.



Annual mean global rainfall anomalies over ocean, land, and both ocean and land. Also shown are the estimated slopes of the linear fits.

Tropical Rainfall Variability on Interannual to-Interdecadal/Longer-time Scales Derived from the GPCP Monthly Product. Gu, G., R. F. Adler, G. Huffman, and S. Curtis, 2007. *J. Climate*, 20, 4033–4046.

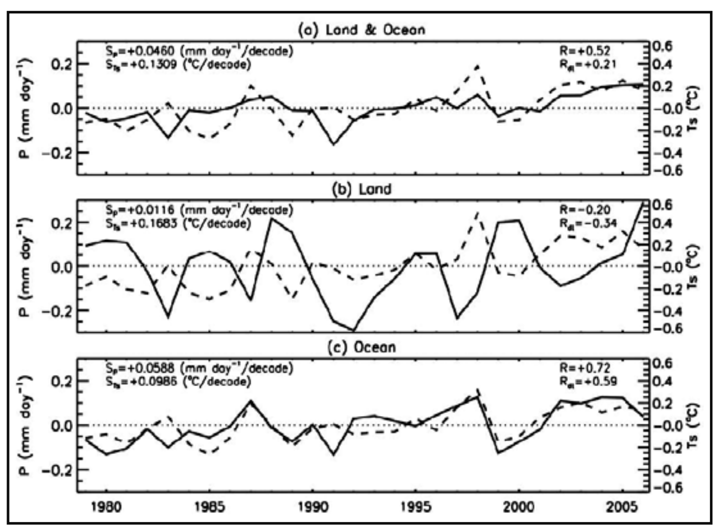
Summary/Abstract: Global and large regional rainfall variations and possible long-term changes are examined using the 27-year (1979–2005) GPCP monthly data set. Emphasis is placed on discriminating among variations due to ENSO, volcanic events, and possible long-term climate changes in the tropics. Although the global linear change of precipitation in the data set is near zero during the time period (top figure), an increase in tropical rainfall is noted in the data set, with a weaker decrease over the Northern Hemisphere middle latitudes. Focusing on the tropics (25S–25N), the data set indicates an upward linear change (0.06 mm day^{-1}/decade) and a downward linear change (–0.01 mm day^{-1}/decade) over tropical ocean and land, respectively. This corresponds to about a 5.5 percent increase (ocean) and 1 percent decrease (land) during the entire 27-year time period (middle and bottom figure).



Volume contributions to long-time change/linear fit during 1979–2005.

Relationships Between Global Precipitation and Surface Temperature on Interannual and Longer Time Scales (1979–2006). Adler, R. F., G. Gu, J. Wang, G. J. Huffman, S. Curtis, and D. Bolvin (submitted to *Journal of Geophysical Research-Atmospheres*, June 2008).

Summary/Abstract: Associations between global and regional precipitation and surface temperature anomalies on interannual and longer time scales are explored for the period of 1979–2006 using the GPCP precipitation product and the National Aeronautics and Space Administration Goddard Institute for Space Studies surface temperature data set. Positive (negative) correlations are generally observed between these two variables over tropical oceans (lands). The El Niño Southern Oscillation (ENSO) is the dominant factor in these interannual, tropical relations. The ratios between the linear changes in zonal mean rainfall and temperature anomalies over the period are estimated. Globally, the calculation results in a 2.3 percent/°C precipitation increase, although the magnitude is sensitive to small errors in the precipitation data set and to the length of record used for the calculation (bottom figure).



Tropical (25S–25N) annual mean precipitation (solid lines) and temperature (dashed lines) anomalies. Sp and STs denote linear changes for precipitation and temperature anomalies, respectively. R and Rdt represent the correlations between precipitation and temperature anomalies with and without the respective linear changes.

Meeting/Workshop Reports

18th Meeting of the GEWEX Radiation Panel

9–12 October 2007
Buzios, Brazil

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The GEWEX Radiation Panel (GRP) meeting was hosted by Luiz A. T. Machado, of the Centro de Previsao de Tempo e Estudos Climaticos (CPTEC) Instituto Nacional de Pesquisas Espaciais (INPE). The main goals of the meeting were to review plans for completing the data product assessments, discuss plans for reprocessing all global data products, review the progress of the SeaFlux and LandFlux activities, and discuss creating a polar data initiative. Discussion also focused on assessing the goals and overall progress of GRP and its projects and on future directions, as the chairmanship of GRP is passed from William Rossow to Chris Kummerow.

W. Rossow opened the meeting with a review of GRP objectives that he outlined in 2001 as incoming chairman: (1) fostering advances in remote sensing analysis; (2) evaluating global climate model (GCM) radiative flux codes; (3) advancing 3-D radiation modeling to investigate scale-dependent coupling of the atmosphere and land surface; (4) fostering studies of cloud and aerosol interactions; (5) fostering studies of clouds and precipitation; (5) developing remote sensing-based inferences of ocean surface turbulent fluxes; (6) developing remote sensing-based inferences of land surface turbulent fluxes; (7) advancing analysis of natural climate variability and feedback; (8) diagnosing atmospheric energy and water transports; and (9) diagnosing oceanic energy and water transports. Progress has been made on all of these objectives, especially on objectives 2, 3, 5, 8, and 9.

C. Kummerow followed with his ideas for GRP activities in the next few years. Continuing work on global data projects could be usefully directed towards objectives 4 and 5—as well as 7, 8, and 9—by producing merged products that bring together the separate parameter-centric products at the highest feasible space-time resolution for global process studies. The planned reprocessing of the global data products should focus on improving "long-time-record" quality so they can be used more confidently for climate monitoring studies. This activity should begin to make plans for the long-term stewardship of these products, while continuing to lead efforts to convert research analyses to climate operations.

Reports from INPE and the Korea Aerospace Research Institute, as well as reports from the Japan Aerospace Exploration Agency (JAXA), the European Space Agency, and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), were given. Brazil recently took over data collection when the National Oceanic and Atmospheric Administration Geostationary Earth Orbit Satellite (GOES)-10 moved to 60E; these data will be contributed toward the International Satellite Cloud Climatology Project (ISCCP). B. J. Sohn reported on the development of a Korean geostationary weather/communication satellite (COMS) to be launched in 2009. T. Iguchi presented the status of the JAXA Earth observation program, including Greenhouse Gases Observing Satellite (GOSAT) (2008 launch), a cloud profiling radar for the EarthCare mission and a dual-frequency precipitation radar for the Global Precipitation Mission (GPM). P. van Oevelen described the ESA Earth Explorer missions, including Gravity field and steady-state Ocean Circulation Explorer (GOCE) (2008 launch) and Soil Moisture and Ocean Salinity (SMOS) (2008 launch). Y. Govaerts presented the status of EUMETSAT satellite operations.

A special briefing on the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) program was presented by J. Mather, who described the new ARM Mobile Facility (AMF) that has been deployed for two field experiments, notably for the African Monsoon Multidisciplinary Analysis (AMMA) Project in coordination with measurements from the Geostationary Earth Radiation Budget (GERB). AMF goes to China in 2008; like the rest of the AMF sites, includes active profiling sensors for clouds, aerosols, and atmospheric properties. ARM is creating a Best Estimate Data Set for Climate Modellers that will merge many of the clouds and radiation products into a common product. W. Rossow reported on the Working Group on Data Management and Analysis activities during the past year (see the report on page 10 of the February 2008 *GEWEX News*).

Two guest scientific lectures were presented. M. Yamasoe described a field experiment in Brazil to investigate the coupling between biomass burning and aerosol production with a consequent reduction of surface solar heating and vegetation activity. This experiment was conducted in the Amazon Reserva Biologica do Jaru in August 2007. Early conclusions are that, although the fire-produced aerosols do reduce solar radiation at the surface (which reduces sensible and latent fluxes), the effects on vegetation activity were much more complex. L. Machado reported on the use of high time resolution geostationary satellite cloud observations in severe weather nowcasting: the satellite images can detect and track the motions of large storm systems and also measure their growth rate, which has improved short-range precipitation forecasts.

R. Adler reported on the status of the Global Precipitation Climatology Project (GPCP). While production of Version 2 products continues routinely and is up to date, studies continue to develop improvements to be implemented in Version 3. Such improvements concern precipitation underestimates in mountainous areas, modernizing the microwave algorithm to increase time sampling frequency to once or twice daily and incorporating more recent precipitation measurements (such as the 10-year Tropical Rainfall Measuring Mission record) to anchor the product's time record, and increasing the sampling homogeneity of the gauge data set used to produce the products. Version 3 (2009) will have smaller time sampling intervals (at least daily) and space sampling intervals (at least 50 km).

J. Schulz, on behalf of U. Schneider, reported on activities at the Global Precipitation Climatology Centre (GPCC). Several new products have been produced from the gauge collection, including ones that have measurements from the maximum number of sites and from the most homogeneous collection of sites. The latter now covers a 50-year period with 9,400 sites. P. Arkin reported on an activity to evaluate new high-resolution precipitation products organized by the International Precipitation Working Group of the Coordination Group for Meteorological Satellites (CGMS). T. Iguchi described a new high resolution (10 km, 1 hr) precipitation product being produced in Japan.

J. Schulz reported on progress in producing improved global water vapor products, particularly activities at the EUMETSAT Climate Monitoring Satellite Application Facilities (CMSAF). The current focus is on the analysis of combinations of newer instruments. The Advanced TIROS Operational Vertical Sounder (ATOVS) product provides daily global temperature and humidity profiles at 90-km intervals; this product is currently based on the High Resolution Infrared Radiation Sounder (HIRS)/Advanced Microwave Sounding Unit (AMSU) combination; efforts are underway to incorporate Infrared Atmospheric Sounding Interferometer (IASI) and GPS measurements. In the next phase of the CMSAF, a long-term, global water vapor product will be produced.

D. Barber, a new GRP member, described research on sea ice climate change and provided some background information on International Polar Year (IPY) plans and activities. In addition to the widely publicized indicators of dramatic sea ice changes there are also noticeable changes in the atmospheric weather systems. As part of IPY, Canada has planned a number of ambitious field campaigns over the next few years, including the Circumpolar Flaw Lead Study, Hudson Bay ice studies, research on the impact of these changes in partnership with Inuit communities, and participation in other IPY projects. D. Barber suggested that the GRP data products could be useful in supporting these studies and that GEWEX might consider a field study, like the Baltic Sea Experiment or the Mackenzie GEWEX Study for the Hudson Bay region.

T. Uttal described other IPY activities underway, including a network of observing sites with cloud radar systems, plans for organizing standard data sources into a special Arctic-focused subset, a polar aerosol optical depth study, and a polar aerosol-chemistry-meteorology study. She highlighted the fact that most of these projects did not employ satellite observations, focusing totally on surface measurements, and suggested that a focused GRP initiative might prove useful to bring the satellite products together with the extensive surface observations being collected for IPY. GRP members decided to undertake a small pilot activity to extract a subset of the GRP global products coincident with the main surface sites active for IPY and cover a time period when observations are available from both CloudSat/the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (Calipso) and the Atmospheric Infrared Sounder (AIRS)/IASI. GRP will also organize a workshop to advertise this data collection and foster studies using it and the surface measurements.

D. Winker presented an update on the status and activities of the Calipso and CloudSat missions, which have received approval to extend the original 22-month mission through 2011. A merged Calipso-CloudSat cloud mask is nearing release and the next release of basic Calipso products is being prepared. An intriguing result from Calipso is a stronger than expected effect of "plate-like" cloud/precipitation particles on the lidar returns when pointed at nadir, which is especially notable in the polar regions.

C. Stubenrauch, a new GRP member, described research on the vertical distribution of cirrus clouds and atmospheric properties obtained from infrared sounder instruments, especially contrasting the changes from "channel radiometers" like HIRS to spectrometers like AIRS/IASI. Analyses of these products are now providing information about the microphysical properties of cirrus and their association with upper tropospheric humidity and how both of these are influenced by atmospheric motions from convective to planetary scales.

W. Rossow summarized the status of ISCCP, now in its 25th year (see articles on page 11 and 12). All products have been delivered through June 2006 and processing is underway on the next year of data. New funding will allow a switch of the processing from the 30-km-sampled radiances to a 10-km-sampled version, thereby increasing the value of the ISCCP products for cloud process studies. For the first time, the radiance data being contributed to ISCCP come from more satellites than needed—the number could soon be 10.

C. Stubenrauch reported on the continuing cloud product assessment activity, a comprehensive set of results that is beginning to emerge, including the total global cloud amount, its partitioning among low/middle/high levels, geographic distribution, and seasonal and diurnal variations. There are systematic differences in total cloud amount but it is understood that these differences depend on variations in cloud detection sensitivity among different instruments. Calipso results will be examined this coming year. A third workshop planned in 2008 will compare other cloud properties.

W. Rossow reported on the status of the Global Aerosol Climatology Project on behalf of M. Mishchenko.

The aerosol climatology (monthly mean values of optical depth and size index over global oceans) now covers the period from August 1981 through June 2005; this record will be extended to June 2007 as soon as the ISCCP processing is completed. See M. Mischenko's May 2007 article in *GEWEX News*.

B. J. Sohn presented comparisons of water budgets inferred from satellite observations and the weather reanalyses. The intensity of the Hadley-Walker circulation has a well-known seasonal variation but may also begin to change in a warming climate. This study aims to develop methods for deriving the water vapor transports by the general circulation and to relate variations in changes in other water-related quantities such as precipitation, evaporation, and clouds. Both regional studies (e.g., Asian monsoon) and global studies are underway. The mean water vapor transports determined in the reanalysis data sets agree well with those inferred from microwave-based precipitation-evaporation differences. These SSM/I-based results and the reanalyses all show an increase in the wintertime Hadley circulation strength over the past decade, whereas the Walker circulation strength shows a weakening.

R. Chahalan reported on research involving 3-D radiative transfer under two groups, one focusing on clouds (I3RC) and one focusing on vegetation canopies (RAMI). I3RC is completing its Phase 3 experiments comprised of 12 models to evaluate 3-D photon transport by cloud scattering (no absorption). As a result, several codes considered to be the "industry standard" have been released on a web site for other researchers to use.

R. Chahalan also reported on the status of research being done since 2003 with measurements of the solar irradiance from the Solar Radiation and Climate Experiment (SORCE). The total solar irradiance value obtained from SORCE (1,361 Wm^{-2}) is 5 Wm^{-2} lower than from the Active Cavity Radiometer Irradiance Monitor (ACRIM) series of instruments, which were themselves lower than earlier measurements by about the same amount. This has triggered intense calibration and instrument characterization studies to determine the cause or causes of this difference. National Institute of Standards and Technology (NIST) calculations of the aperture diffraction in ACRIM—already determined for the Total Irradiance Monitor (TIM) on SORCE—suggest a reduction of its solar irradiance values by nearly 2 Wm^{-2}. The SORCE mission also started the first systematic spectral measurements of solar irradiance, confirming that there is a more complex and larger variability of the sun at wavelengths shorter than visible, which has implications for variations of the upper atmospheric chemistry. Although the SORCE mission was recently approved to continue to 2011, the launch of the next instrument to measure total (but not spectral) solar irradiance on the GLORY mission has suffered some delay and is now scheduled for 2009. More importantly, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program removed the solar irradiance instrument, putting the future of these measurements in doubt.

L. Oreopoulus reported on the status of the Continuous Intercomparison of Radiation Codes (CIRC) Project. CIRC, which is sponsored by ARM, is evaluating GCM radiation codes by the Intercomparison of Radiation Codes used in Climate Models (ICRCCM). CIRC is working to establish an online capability for testing such radiative transfer codes by providing synthetic and observation-based test cases as well as the fluxes calculated by a few state-of-the-art line-by-line codes. ICRCCM had developed an incomplete set of synthetic test cases, but another observation-based set is being developed from ARM site observations that provide a complete set of measured atmospheric properties—including clouds—together with directly measured fluxes at the surface.

P. Stackhouse reported that all Surface Radiation Budget (SRB) project products have been delivered through June 2005. Minor changes to the shortwave algorithm were implemented during the past year to better account for low sun angles in the polar regions and to use a more accurate solar emphemeris, as well to report clear sky aerosol radiative effects. The SRB products are being evaluated as part of the Radiation Assessment, along with products from ISCCP, the Earth Radiation Budget Experiment (ERBE), the Center for Environmental Remote Sensing (CERES), GERB, and the Baseline Surface Radiation Network (BSRN). One notable result of the assessment is that the differences in cloud radiative effect calculated by SRB and ISCCP-FD are about three times smaller than the differences among the 20 Intergovernmental Panel on Climate Change climate models.

E. Dutton reported that BSRN is now comprised of 60 active stations. There are now 3,850 station-months of data archived at 1-min resolution, an average of 8.2-years per site for 39 sites. Two issues have been investigated during the past year: (1) it was found that photosynthetically active radiation (PAR) is not precisely or even well defined, and (2) the Surface Ocean-Lower Atmosphere Study (SOLAS) is not specifically collecting PAR measurements. In addition, current PAR measurements are being made with ill-defined commercial instruments. Hence, if BSRN (and others) are to collect PAR data sets, a standard definition will have to be developed. BSRN is working with SOLAS to define measurement specifications and procedures.

C. A. Clayson reported that two SeaFlux Project workshops were held in 2007 and that there is continued progress towards completing the comparison of a common year of global products, based on "old" and "new" instruments; comparisons for 1999 not only allow for the overlap of different kinds of instruments but have a good collection of *in situ* surface flux measurements for continual improvement of flux formulae.

Version 1 of a new sea surface temperature (SST) product that resolves diurnal and weather-scale variations of skin temperatures has been produced and is being tested. Most previous SST products were estimates of bulk temperature and provided only the variations on weekly to monthly time scales.

W. Rossow reported on activities of the LandFlux project to obtain turbulent fluxes over land (and ice) surfaces. The first international workshop was held in May 2007. After reviewing possible methodologies and the status of land remote sensing more generally, the workshop participants agreed that future work should pursue two parallel pathways: (1) systematic data products (global, long-term) for the basic properties of the land surface (albedo, emissivity, temperature, some vegetation indicator, possibly soil moisture information) need to be evaluated and brought up to the same standard as other GRP products; and (2) the different methods for estimating surface turbulent fluxes need to compared and the differences investigated.

A consensus was reached that a main activity of GRP would continue to be the set of projects leading to a complete description of weather-to-climate scale variations of the global energy and water cycle. An assessment of more mature products (precipitation, radiation, clouds, and aerosols) should be completed. With SeaFlux nearing readiness to produce a new product, the focus should now be on bringing LandFlux to the same status using polar initiative activities to include frozen surface processes. The coordinated reprocessing of all current global products will focus not only on increasing the physical consistency of the products (using common ancillary data sets) but also on reducing spurious variations in the long-term record (based on the assessment results), moving these products towards climate data record quality.

GRP will continue to work with space agencies and international groups to define a climate observing system and climate data records. With these continuing activities as a foundation, more emphasis now needs to be focused on determining atmospheric and oceanic transports of energy and water, which should also involve further interaction with general circulation modeling groups. It was concluded that a smaller, more focused working group needs to be organized to investigate cloud processes, aerosol interactions, and precipitation using the global satellite products and field experiment data sets.

The 2008 GRP meeting will be hosted by B. J. Sohn and the Seoul National University in South Korea on 14–17 October 2008.

The GEWEX Radiation Panel Assessment of Global Precipitation Products is available at:
http://wcrp.wmo.int/documents/AssessmentGlobalPrecipitationReport.pdf.

North American Mountain Hydroclimate Workshop

17–19 October 2007
Boulder, Colorado, USA

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Approximately 60 experts gathered in the Foothills Laboratory of the National Center for Atmospheric Research to attend the workshop, which was sponsored by GEWEX, the U.S. National Oceanic and Atmospheric Administration, and U.S. National Aeronautics and Space Administration. The goal of the workshop was to entrain United States experts and programs as well as incorporate the interests of Canada and, possibly, Mexico and South America in an assessment of the potential needs and benefits of a focused research effort on the mountain hydroclimate of western Cordillera in North America. Workshop participants were asked to assess the state of knowledge of the mountain hydroclimate and develop priority science questions to be addressed in a large-scale study. They were also invited to comment on the extent to which existing research and operational programs address these issues and any missing elements that could be addressed by a new initiative.

On the observation and modelling of orographic precipitation, significant challenges remain in simulating both cold season and warm season orographic precipitation. These challenges are partly due to the difficulty in representing scale interactions (i.e., the influence of large-scale circulation on regional precipitation, and the influence of local condensation and microphysical processes on upstream flow stability), and the inadequate representation in models of processes such as embedded convection in mesoscale clouds. Although higher spatial resolution is desired, physics parameterizations are resolution dependent, and the appropriate scale for modelling and analysis of the mountain hydroclimate is not well defined. These difficulties also exist for regional analyses of the mountains, where inequitable spatial distribution of observations and a lack of boundary layer data to constrain forward modelling add to the difficulties. The analysis of *in situ* measurements and remote sensing of precipitation also face specific challenges in the mountains because of scaling, technical limitations (e.g., radar beam blockage and overshoot), and issues with deployment and maintenance that warrant special considerations.

On the observation and modelling of surface/subsurface and ecological processes, much progress has been made with one-dimensional models to simulate hydrological and ecological processes; however, challenges remain in translating skill from point modeling to correctly capture the simultaneous spatial distribution of multiple variables such as snow and streamflow. Since many processes are tightly coupled, they should be studied with models and observations from strategically placed ground-based instrument clusters and satellite data. These complex studies are necessary to develop a systems approach to understanding the relationships between climate patterns, landscape attributes, and spatially distributed hydrological and ecological processes. Monitoring land water balance and ecosystem health is increasingly important in the context of climate change, and this requires advances in both *in situ* and remote sensing measurements and long-term commitments to the maintenance of these observational systems.

A number of recent field projects conducted in the United States, Canada, South America, and Europe that have focused on orographic processes were presented at the workshop. A common need exists for greater temporal frequency and spatial sampling to understand process evolution and response to forcings, and identify specific model deficiencies that guide data requirements. The coordination of the interests and needs of subdisciplines, related science communities, and potential partners can maximize results.

Progress has been made on hydrologic predictions and water applications across a range of forecast lead times using statistical and physically based hydrologic models with inputs from weather forecasts, seasonal climate prediction, and long-term climate projections. A particular challenge for hydrologic prediction in the mountains is associated with uncertainty in precipitation forecasts, which is dependent on both the spatial and temporal scale. Ongoing research efforts are assessing the benefits of distributed hydrologic models versus lumped models or statistical models in providing increased simulation or forecast accuracy. Physically based tools may have important advantages in the context of an evolving climate system. For the western United States, warming alone may lead to myriad changes that will challenge water management including rain versus snow ratios, storm intensities, snowmelt and streamflow timing, flood risk, and longer growing seasons.

Based on the reports from the discussion groups, there is a clear consensus for conducting a focused study on the hydroclimate of the mountains of western North America, especially in view of the potential impacts of climate change on these areas and our limited ability to predict hydroclimate conditions in these environments. Specific science questions that require more attention range from climate prediction to climate impacts on mountain ecology. In particular, there is a need to understand how climate variability and change associated with warming temperatures affect the hydrology and ecology of the mountain regimes and the evolution of drought conditions, as well as the implications of climate change for seasonal predictions. There is also a growing need to improve our ability to predict the water and energy cycle components in complex terrain on seasonal time scales. This predictive capability can only be improved by understanding the large-scale water balance and its variability in mountainous terrain by improved measurement programs that will lead to enhanced data sets with error estimates for use in improving hydrologic models and predictions. Although there are a number of ongoing studies in western Cordillera, most of them are independent. A jointly planned effort would make a substantial contribution to better coordination. The lack of data collection programs and comprehensive unified representative data has limited our ability to evaluate the error characteristics of climate and hydrologic models for model development.

There was considerable discussion on the scope of a new North American mountain project and a plan was proposed that would include an area ranging from a large river basin to the entire western United States with a small number of embedded intensive research basin networks (e.g., along topographic transects) that would acquire detailed, high-resolution hydrological and ecological data. Ideally, the measurement program would consider the full annual cycle and continue for 10 years.

In terms of science, there is a need to study the relationships between topography, precipitation, and runoff in complex terrain. A link to the Intergovernmental Panel on Climate Change assessment activities is also important. This research would be directed to improving climate monitoring and prediction in the mountains with a focus on analyses and models to understand the implications of variability and change for mountain hydrology and ecology. It was also recognized that mountains posed a major problem for Earth system modelling and the development of a regional Earth system model that fully represents mountain processes with built-in diagnostic and analysis components could serve as a major longer-term goal for this work. It is also important to understand the full range and role of scale interactions in a mountain environment—that is, the upscaled effects of mountains and the downscaled effects of large-scale variability and change on regional and local scale mountain processes.

It was agreed that the workshop organizers explore the possibility of developing a concept paper as a means to seek funding support for a project of the scope outlined here. The workshop was videotaped by Greg Greenwood and the video and workshop presentations are available at: *http://www.eol.ucar.edu/projects/cppa/meetings/200710/*.

2nd Meeting of the International Soil Moisture Working Group

14–15 November 2007
Beijing, China

Peter J. van Oevelen
International GEWEX Project Office, Silver Spring, Maryland, USA

The 2nd International Soil Moisture Working Group (ISMWG) Meeting was hosted by the Institute of Applied Physics of the Chinese Academy of Sciences in Beijing, with a total of 20 registered participants plus 15 students and post-doctorals. This meeting was intended to increase the awareness of working group activities among those institutions and scientists operating soil moisture networks in Asia, as well as to build upon the outcomes of the First ISMWG meeting. Both the first and the second workshop sparked interest among various types of participants and institutions dealing with *in situ* soil moisture and resulted in a very cooperative spirit. The ISMWG has two main objectives: To support the development of an *in situ* global soil moisture network, and to support international cooperation in research and applications in support of soil moisture satellite missions.

One of the first key results in 2007 was that a data-hosting center would be established by the Instituto de Meteorologia in Lisbon, Portugal, with the support of the European Space Agency (ESA) through the Soil Moisture and Ocean Salinity (SMOS) mission project. This data-hosting center will support the soil moisture data collection activities that are organized in the framework of the SMOS Calibration-Validation activities, as well as act as the global data-hosting center for other soil moisture collection activities.

The data hosting center will open in 2008. Besides the development of a web-based data hosting system, the center will initiate an inventory of the requirements regarding soil moisture data collection, dissemination, etc. through a questionnaire sent out to an extensive list of potential collaborators. The center will act as a focal point for working group activities and will make information on soil moisture measurements and installation protocols available to a wider audience.

Some of these measurement and network design requirements have been established since the first ISMWG meeting and will be disseminated through this system. The open access data policy of the network is one of the key pillars in establishing a global network of soil moisture measurements and is received favorably by many of the currently existing operational regional networks.

GEWEX/WCRP Meetings Calendar

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

2–6 June 2008—**4th PAN-GCSS Meeting: Advances on Modelling and Observing Clouds & Convection**—MeteoFrance, Toulouse, France.

2–6 June 2008—**NEESPI Science Team Meeting**—Helsinki, Finland.

25–27 June 2008—**LOCO/Watch Workshop**—De Bilt, The Netherlands.

7–11 July 2008—**10th Science and Review Workshop for the Baseline Surface Radiation Network**—De Bilt, The Netherlands.

9–13 July 2008—**15th International Conference on Clouds and Precipitation (ICCP2008)**—Cancun, Mexico.

23–25 July 2008—**International Satellite Cloud Climatology Project 25th Anniversary Symposium**—NASA, GISS, New York, NY, USA.

25–29 August 2008—**GEWEX Executive Meeting**—Silver Spring, Maryland, USA.

15–17 September 2008—**CEOP International Planning Meeting**—Geneva, Switzerland.

22–24 September 2008—**5th GEWEX Radiation Panel Working Group on Data Management and Analysis Meeting**—Hong Kong, China.

22–24 September 2008—**12th Session of the Working Group on Coupled Modelling**—Paris, France.

29 September–2 October 2008—**3rd Session of the WCRP Observation and Assimilation Panel**—Boulder, Colorado, USA.

14–17 October 2008—**GEWEX Radiation Panel Meeting**—South Korea.

3–7 November 2008—**Working Group on Numerical Experimentation/GEWEX Modelling and Prediction Panel Meeting**—Montreal, Canada.

19–23 January 2009—**GEWEX Scientific Steering Group Meeting**—Irvine, California, USA.

14–28 August 2009—6th International Scientific Conference on the Global Energy and Water Cycle, 2nd iLEAPS Science Conference, and joint sessions—Melbourne, Australia.

GEWEX NEWS

Published by the International GEWEX Project Office

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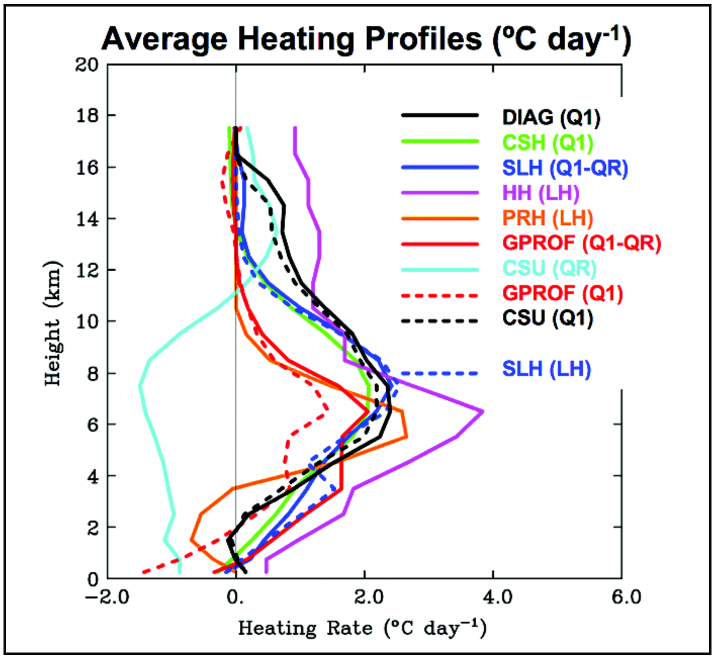
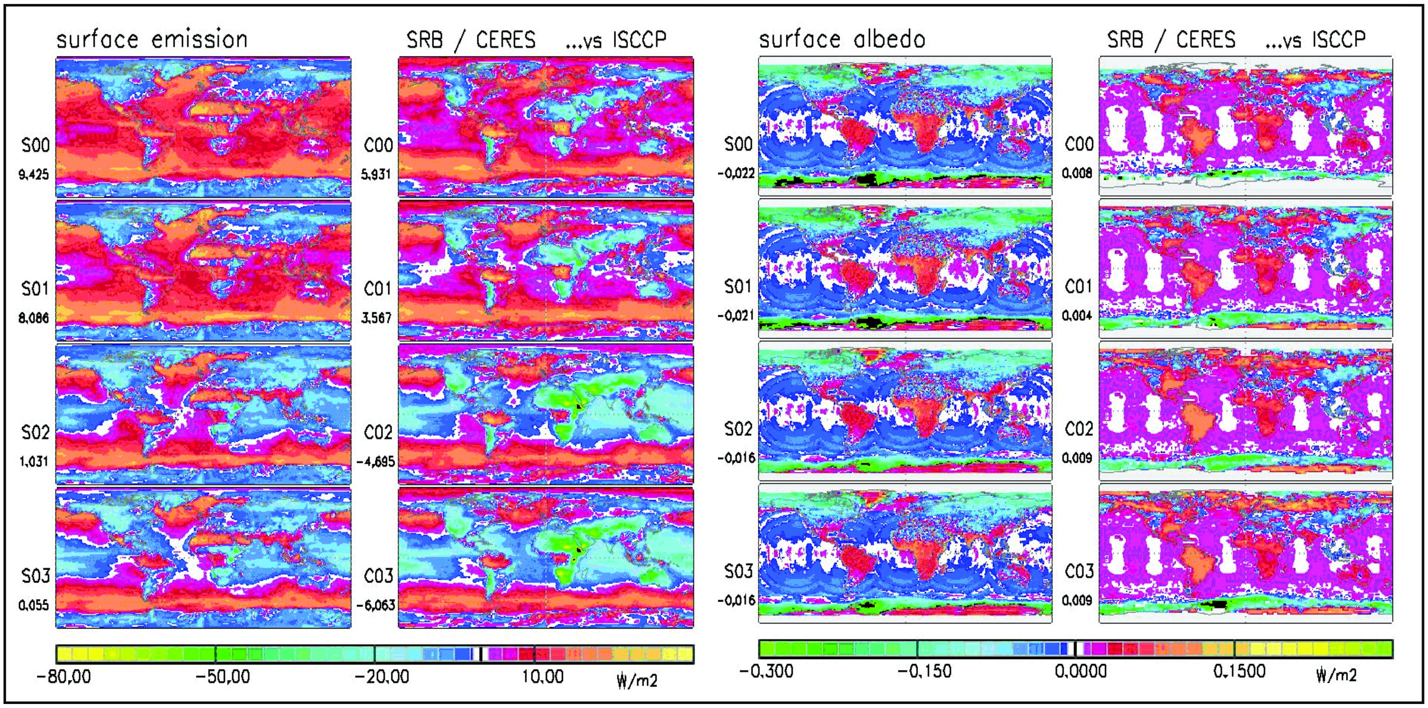
Retrieved Latent Heating from the Tropical Rainfall Measuring Mission



Space/time-averaged heating profiles, Case 1b: South China Sea Monsoon Experiment (SCSMEX)-South Enhanced Sounding Arrays (SESA) regions. Profiles for different heating terms are obtained from five different satellite algorithms [i.e., Convective Stratiform Heating (CSH), Hydrometeor Heating (HH), Goddard Profiling Heating (GPROF), Spectral Latent Heating (SLH), and Precipitation Radar Heating (PRH)]. Q_1 profiles from Colorado State University's (CSU) diagnostic calculations are presented for two different averaging areas (i.e., DIAG from within SESA sounding arrays and CSU from SESA study area rectangular gridded arrays]. Satellite-derived Q_R profiles from CSU are also associated with gridded arrays. ***See article by Wei-Kuo Tao on page 8.***

GEWEX Radiation Data Assessment Shows Inconsistencies in Ancillary Data



Comparison of annual averages (March 2000 to February 2004) of differences between the effective solar surface albedo (left: dimensionless ratio of upward to downward clear-sky solar fluxes) and emission fields (right: in Wm^{-2}) used in SRB and CERES to those of the ISCCP. ***See article by E. Raschke et al. on page 11.***