GEWEX Radiation Panel (GRP) Report

Reporting Period: 2008
URL: http://www.gewex.org/projects-GRP.htm and http://rain.atmos.colostate.edu/GRP/index.html
Chairs and Term Dates: Christian Kummerow (2008–2010)

Overview:
Within the World Climate Research Programme (WCRP) Global Energy and Water Cycle Experiment (GEWEX), the GEWEX Radiation Panel is organized to review theoretical and experimental knowledge of radiative processes in and for the study of the climate system. These processes are central to the climate's energy cycle: climate is determined by the imbalances of solar radiative heating and longwave radiative cooling. The circulation of the atmosphere and ocean, the environment on land, and the biosphere are all driven by local radiative imbalances. Changes in climate can be caused by alterations of the radiation budget at the top of the atmosphere or at the surface, such as those induced by changing amounts of greenhouse gases or aerosols in the atmosphere or by changing land surface properties. The sensitivity of the climate response to a change in radiative forcing is determined by many feedback processes that alter the radiation budget, especially those involving clouds and water vapor.

The main source of global information about the climate system comes from the analysis of satellite remote sensing data which requires detailed models of the interaction of radiation with the atmosphere and the ocean-land-ice surfaces, including the effects of vegetation, as a function of wavelength, polarization state and observing geometry. Water is unique in its role on Earth. Not only does it provide the necessary sustenance to support life, it also acts as an energy storage and transport mechanism as it changes phase from solid to liquid and vapor. Together with water vapor in the atmosphere, the reservoirs of water are continually exchanging mass. Water evaporates from the ocean and land surfaces, is transported by the atmosphere, forms clouds and returns to the surface as precipitation. Rainfall on land can return to the sea via rivers or be stored in lakes and aquifers. Snowfall on land can melt into rivers or build up into ice sheets, which can melt into rivers later. The cycle of water is thus inextricably linked with the cycle of energy by clouds, water vapor and precipitation, so it makes sense to study these water processes together with radiation processes.

The GPR focuses on answering the following specific questions:

- How can we better measure and characterize the state and variations of climate using satellite observations?
- What are the changes in radiative forcing that cause climate change?
- How do the interactions of radiation with changes of the internal state of the climate (radiative feedbacks) affect the climate's sensitivity?
- How do the internal water exchange and transport processes in the climate (water feedbacks) affect the climate's sensitivity?

Status:

International Satellite Cloud Climatology Project
The International Satellite Cloud Climatology Project (ISCCP) celebrated its 25th anniversary of data processing on 1 July 2008. A 2.5-day symposium was held at the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies on 23–25 July to mark the occasion, to review the status of knowledge about clouds and their role in the climate's radiation and water cycles, and to discuss future satellite cloud measurements and analyses.

The calibration of visible and infrared satellite radiances proceeded routinely over the past year: at the time of the GRP meeting, normalization of geostationary to polar orbiting radiometers was complete through May 2008 and the absolute calibration of the polar orbiters had been extended through December 2007. The main reduced resolution radiance data set (Stage B3) has been delivered to the archives for the period July 1983 – June 2007.

The primary set of cloud data products (DX, D1 and D2) and the two ancillary data products (atmospheric temperature and humidity, snow/ice cover) have been delivered for the period July 1983 – June 2007. The radiative flux product produced by ISCCP (called FD) is available for the period July 1983 – December 2006. Other specialized products (mesoscale convective tracking; tropical, low latitude and midlatitude weather states analysis; cyclone tracking) are currently being extended beyond 2004 through 2006. A new cloud particle size climatology, covering July 1983 – September 2001, will be released in early 2009.

All ISCCP data processing center funding is in place; however, Canada decided to withdraw from further participation as of October 2008. Fortunately the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) was already preparing to take over processing of the Geostationary Operational Environmental Satellite (GOES) in early 2009; this move also ends the participation of Colorado State University. Brazil is still working to supply GOES-10 data.

The extension of funding for the Global Processing Center has been approved. The first grant supporting continuing operations also specifically supports switching the cloud products from B3 radiance data (with 30 km spatial sampling) to the B1U radiance data product (with 10 km sampling). The second grant funds the re-engineering of the ISCCP processing system so that it can become "operational"; NOAA NCDC has agreed to take over the Global Processing Center role for the future. This re-engineering effort will be used as a pilot project to define and document the necessary features of a data processing system for producing climate data records.

Cloud Assessment

The GEWEX Cloud Assessment was initiated by GRP in 2005 to evaluate the reliability of available global, long-term cloud data products. In 2008, monthly averages of cloud temperature, cloud emissivity and optical thickness, as well as water path and effective particle size, were made available to all assessment participants via the web site. With ten teams participating, the comparisons were presented at the GEWEX cloud assessment meeting held in July 2008 in New York, USA, hosted by W. B. Rossow (program available at http://climserv.ipsl.polytechnique.fr/gewexca/). The general seasonal cycles of different cloud properties agree well among the participating groups. Varying instrument sensitivities and spatial resolutions explain differences in absolute values of cloud amount, especially of thin cirrus. To move forward in the understanding of such differences, it was concluded that variability as well as distributions of the cloud properties are needed in addition to the monthly averages. At present the participating teams are preparing data sets in a common format (netCDF) with all this information. The data sets will be made available for all participants to continue the comparisons, and later to the public.

Surface Radiation Budget

The Surface Radiation Budget project (SRB) has completed the following since October of 2007:

- Processed ISCCP DX for all codes from July 2005 – June 2007.
- Extended ozone profiles from July 2005 – June 2007 with NOAA Stratosphere Monitoring Ozone Blended Analysis products.
- Improved algorithms accordingly:
    - GEWEX Shortwave (SW): added new background aerosol that limits effective optical depth over ice surfaces to more realistic values (i.e., the algorithm retrieves effective optical depth to match clear-sky top-of-atmosphere (TOA) albedo on a 3-hourly basis); other improvements were made related to products.
    - SW Quality Check (QC) algorithm: improved surface albedo and background aerosol representations.
    - LW QC algorithm: improved surface skin-temperature/near-surface discontinuity issues causing spurious fluxes over hot surfaces.
    - GEWEX Longwave (LW): upgraded trace gas histories and surface emissivities and evaluated new ice treatments and day/night cloud assumptions.
- Produced and archived a 23-year SRB Release 3.0 data set spanning July 1983 – June 2007 for the GEWEX SW, SW Quality Check (QC), and LW QC flux algorithms. 3-hourly, monthly averaged 3-hourly, daily averaged and monthly averaged data sets are now available at the NASA Langley Atmospheric Sciences Center (ASDC).

- Delivered data sets to numerous users and contributed to several scientific papers, the most notable of which supported the GEWEX Seaflux project.
- Implemented procedures to reproduce Swiss Federal Institute of Technology, Zurich data quality flags for Baseline Surface Radiation Network (BSRN) measurements and other networks. Used the paper by Long and Shi (2008) and extended the method for fluxes < 50 W m^{-2}. This action was required since new BSRN data do not have such quality control.
    - re-ran all validation using new procedures.
- Compared latest gridded flux products to the Center for Environmental Remote Sensing (CERES), ISCCP-Flux Data Set (FD) TOA and other surface radiative fluxes provides for GEWEX Radiative Flux Assessment (RFA).
- Completed long-term analysis relative to surface measurements and submitted as a paper.

Global Precipitation Climatology Project

The Global Precipitation Climatology Project (GPCP) continues to process data smoothly with research products approximately coming out 3 months after observation time. While processing is on temporary hold until new gauge analysis is incorporated, products are generally available through May/June 2008.

Monthly = Jan. 1979 – June 2008
Pentad = Jan. 1979 – May 2008
Daily = Oct. 1996 – June 2008

Some of the significant accomplishments of GPCP include:

- Published Precipitation Assessment report. WCRP-128 Global Precipitation Assessment: A Project of the GEWEX Radiation Panel. Available from http://wcrp.wmo.int/documents/AssessmentGlobalPrecipitationReport.pdf
- Reached 29 years of records with the monthly and pentad products.
- Daily product reached 11 years (Oct. 1996 – present).
- Successfully continued the routine collection of satellite data and the production of analysis products in a timely manner.
- Discussions continued at the Working Group on Data Management and Analysis **(**WGDMA) and elsewhere on refining the plan for GPCP Version 3 re-processing.
- Examined possible procedures for a “quick-look” GPCP monthly product (to occur a week or so after the end of the month). A remaining roadblock has been identified as ocean/microwave processing with an “early” version of RSS SSM/I Tb’s producing different results—still investigating.
- GPCP products are cited in over 900 journal papers. Citation list is available at: ftp://precip.gsfc.nasa.gov/pub/gpcp-v2/doc/gpcp_citation_list.pdf.

LandFlux

LandFlux activities continued during the past year with two topical workshops, one on the retrieval of land surface skin and air temperatures (7–9 April, Asheville, NC, USA) and one on retrieval of land surface properties from microwaves, including soil moisture and flooding extent (20–22 October, Oxnard, CA, USA). Both workshops are being followed up with comparisons of products and investigations into their differences. The next event will be a 1-day workshop held in conjunction with the GEWEX-iLEAPS Scientific Conference in August 2009, where an inventory of available global surface latent and sensible heat flux products will be made—including observationally-based (in situ and satellite), model-based and mixed observation-model—and plans for systematic comparisons initiated. The idea is to conduct these comparisons and investigate causes of differences over the coming year, leading up to the production of revised products and preparation for the systematic processing of long-term global products.

Continuous Intercomparison of Radiation Codes

The Continuous Intercomparison of Radiation Codes (CIRC) effort was advanced in several important ways in 2008, including: (1) calculations for Phase I cases were finalized; (2) the CIRC web site (http://circ.gsfc.nasa.gov) was created; (3) Phase I was launched and the first submissions received; (4) CIRC-themed talks were given at various meetings, such as the Atmospheric Radiation Measurement (ARM)

annual Science Team Meeting and working group meetings and the International Radiation Symposium (IRS) 2008; (5) a short paper intended to advertise the effort was submitted to the Bulletin of the American Meteorological Society (BAMS); and (6) a CIRC working group was established within the International Radiation Commission (IRC) and is being considered as a potential successor to the Intercomparison of Radiation Codes used in Climate Models (ICRCCM). A brief summary on those advances was given at the annual GRP Meeting held on Jeju Island, South Korea.

The CIRC web site is a focal point of the project and is the central repository from which data involving the validation of radiative transfer models can be obtained. We are currently hosting the data and description of Phase I cases, as well as general information about the scope and modus operandi of the effort. On 4 June 2008, the announcement of the web site and an invitation to participate in CIRC was sent via e-mail to 100+ radiative transfer modelers. Requests for registration and submissions followed soon thereafter; so far we have received 15 requests for registration and submissions from 5 participants. Preliminary results with our own test codes and the first submissions were presented in ARM meetings and IRS'08. An extended abstract will appear in the proceedings of the latter. Our initial analysis has focused on the effects of the exact specification of spectral surface albedo and its subsequent spectral degradation, and the behavior of radiation models when carbon dioxide is doubled under dry conditions. These issues are also discussed to some extent in the BAMS article. But the main thrust of the article is to make a convincing case for the necessity of a community-oriented project such as CIRC and the expected benefits to radiation modelling. It is not entirely clear how the suggestion by IRC leadership that CIRC absorb ICRCCM will materialize, especially since a phase of ICRCCM focusing on thermal infrared effects of cloud inhomogeneity (somewhat outside the scope of CIRC at this point) is currently active. The suggestion seems to draw from the original purview of ICRCCM to compare approximate global climate Model (GCM) radiation schemes with accurate line-by-line algorithms for simple synthetic atmospheres, which may be also included in the roster of our future cases.

Global Aerosol Climatology Project
The Global Aerosol Climatology Project (GACP) has been relatively inactive but received funding in 2008 to re-energize both the program itself (led by Michael Mischenko) and the product assessment (led by Sundar Christopher).

SeaFlux
SeaFlux intercomparisons were essentially completed in 2008. Version 1.0 of the sea surface temperature and version 0.5 of the latent and sensible heat fluxes are available for testing. Much of 2008 was spent on comparing available products against one another and against very limited *in situ* data. A novel aspect of the current validation strategy is that each input into the flux products is being assessed independently so that parameters such as wind and humidity can be evaluated separately.

Key Results:

- All data generation and assessment projects are currently funded to continue.
- CIRC has completed Phase I; intercomparsions against real data collected at the ARM site are now possible.
- GRP products continue to set the standard for quality products and independent assessment activities. GPCP alone has over 900 references in journal publications to date.
- All projects have begun preparations for coordinated reprocessing to begin in 2010 in order to address smaller space/time issues as well as the Extremes focus identified by GEWEX.
- All projects are detecting trends in climate data and are being used in publications related to climate change.

Plans for 2009:
All GRP products are preparing for the reprocessing cycle to begin in 2010. Key activities within each project are geared towards that goal.

ISCCP will focus on: (1) obtaining a "Moderate Resolution Imaging Spectroradiometer (MODIS) anchor" for the radiance calibration; (2) improving polar cloud detection by testing against Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO); (3) refining optical thickness retrieval for ice clouds to make it more precise; (4) installing a treatment of land surface bi-directional reflection and non-unit infrared emissivity; (5) accounting for aerosols in the retrieval; and (6) removing or reducing interannual artifacts in the ancillary data sets used. Current open issues that will be addressed in 2009 include: (1) incorporating Chinese and Brazilian data into the products; (2) investigating anomalies in the new series of Advanced Very High Resolution Radiometers (AVHRR), including scan-angle effects, bi-linear VIS response, and non-linear infrared calibration; (3) finding an adequate atmospheric temperature and humidity dataset to replace the operational TOVS product (required to provide coverage of whole ISCCP time period and continue into the future, to provide adequate daily coverage, at least, of the globe, at least as accurate as the original TOVS and more homogeneous over the whole record than TOVS); and (4) finding an adequate description of the geographic and temporal variations of aerosols.

The Cloud Assessment Project is working on the final World Meteorological Organization (WMO) report (in one or two parts) that should be finished at the end of 2009. It discusses the existing long-term climatologies and also comparisons with climatologies from improved instruments aboard the NASA Earth Observing Satellite (EOS) and the A-Train. Climatology averages as well as their regional, seasonal and diurnal variations will be presented, and differences between results from the various data sets will be discussed.

SRB plans to complete the processing and archival of V3.0 LW and cloud/ancillary 3-hourly data sets containing inputs to SRB processing codes through June 2007, as well as update the archive as ISCCP continues processing. Algorithm upgrade activities include:

- Develop improved parameterizations for the conversion of narrow-band radiance to flux in GEWEX SW model using new CERES information in collaboration with Dr. Rachel Pinker of University of Maryland.
- Assess and select new temperature and humidity meteorology for processing in collaboration with NASA Goddard Institute for Space Studies (GISS). A new High Resolution Infrared Radiation Sounder (HIRS)-based data set and the Modern Era Retrospective-analysis for Research and Applications (MERRA) will be evaluated. This will improve the homogeneity between ISCCP and SRB products.
- Improve aerosol treatment in SW and LW codes in collaboration with NASA Goddard Space Flight Center (GSFC) and GISS; assess relative to GISS, GACP and the Global Ozone Chemistry Aerosol Radiation Transport (GOCART).
- Improve various cloud and boundary layer assumptions in the GEWEX LW code.

Intercomparison of surface and top-of-atmosphere (TOA) flux estimates continue against satellite and surface measurements. The plan is to extend intercomparsions between other surface and TOA flux data sets such as the CERES Surface and Atmospheric Radiation Budget (SARB) / Surface-Only Flux Algorithms (SOFA) and ISCCP-FD as required for the GEWEX-RFA report. Surface analysis to direct, diffuse, and photosynthetically active radiation fluxes with an emphasis on validation under various sky conditions will also be extended. Perform an enhanced error and sensitivity analysis to better characterize uncertainties. SRB will also continue time series analysis relative to surface measurement time series of the Global Energy Balance Archive (GEBA) and BSRN, and a new emphasis on polar fluxes validation will be made. The Radiation Flux Assessment activity will focus on analyzing long-term variability in relation to estimates of other meteorological and cloud parameters to assess characteristics of variability in relation to large-scale atmospheric processes.

GPCP's plans, aside from continuing to process data on a timely manner, include the following:

- Complete plans for Version 3 of GPCP products with a 3-hour or fine scale incorporating the Tropical Rainfall Measuring Mission, the Advanced Microwave Scanning Radiometer and others, and begin calculating alternate procedures for a test period (~1 year). Reprocessing will hopefully start during 2010.
- Test using B1 geo-infrared data to extend daily (or 3-hour) product before October 1996. Test on the same 1-year test period.

- Incorporate the Global Precipitation Climatology Centre 50-year gauge analysis into merged analysis, replacing monitoring and other gauge products

SeaFlux plans to finish Version 1 by spring of 2009. Version 1 is to include more satellites in order to improve the diurnal cycle of sea surface temperature, improve the determination of q and Ta and use better intercalibrated Special Sensor Microwave Imager (SSMI) brightness temperatures than the current Tracking and Data Relay (TDR) satellites. There is a reluctance to use the commercially available RSS data set, as it is expensive and not well documented.

CIRC intents to hold a workshop within the year and is currently considering dates and location options. One possibility is to hold the meeting just before the Gordon Conference on Radiation and Climate (New London, NH) in a nearby location such as Boston in early July. The rationale is to attract some of the international participants that may otherwise be reluctant to travel to the U.S. for a CIRC workshop. Efforts will be extended to establish a closer working relationship with the radiation modellers of Intergovernmental Panel on Climate Change (IPCC)-participating GCMs. In addition to analysis of Phase I submissions, we will start exploring the appropriate ARM data sets for possible Phase II cases that can offer new insights on the performance of the radiation algorithms.

Science Highlights:

Some of the scientific highlights in this reporting period come from the Cloud Assessment activity that has benefited from the recent launch of CloudSat/CALIPSO. Climatological averages as well as seasonal variabilities among products reveal relatively uniform results across platforms.

- 70 percent (±5%) clouds: ~40 percent high clouds and ~40 percent single-layer low clouds. In general, geographical cloud structures agree quite well:
- Maximum of high clouds in Inter-Tropical Convergence Zone (up to 60%)
- Few single-layer midlevel clouds in the tropics (5%), most in Northern Hemisphere midlatitude winter (15%); CALIPSO data confirm this
- Infrared sounders [TOVS/HIRS, the Atmospheric Infrared Sounder (AISR), the Infrared Atmospheric Sounding Interferometer (IASI)] are passive instruments most sensitive to cirrus; they only miss 10 percent / 5 percent subvisible cirrus in the tropics / midlatitudes. ISCCP misses further 15 percent / 10 percent in the tropics / midlatitudes.
- Pathfinder-Atmosphere (PATMOS-X) and MODIS are still in the validation process, but will miss more thin cirrus than the infrared sounders.
- Active instruments CALIPSO and CLOUDSAT give insight to the vertical structure of clouds and help to evaluate the cloud properties determined from passive remote sensing. For further progress in climate research, the synergy of different variables and data sets is very important.
- Microphysical cloud properties:
- Effective droplet size of water clouds is smaller over land than over ocean.
- Effective ice crystal size of cirrus is slightly larger when obtained from infrared than from NIR-VIS observations.

New Directions:

GRP is best known for its global long-term products and this focus will be maintained. However, it can be enhanced. Once the SeaFlux and LandFlux products are in production, GRP will focus on creating composite Global Water and Energy products that combine the various individual products into a consistent product containing all the water and energy states and fluxes. This composite product is envisioned to usher in a new era of interaction between GRP and the modelling community as well as other satellite providers *vis à vis* closure of the water and energy budgets at both global and regional scales.

In preparation, there are a number of activities being encouraged: the first is to revisit the GEWEX water vapor project the Global Water Vapor Project (GVaP). It is not clear at this time whether such a product can or should exist separate from the data assimilation community that has so successfully brought in diverse data sets into a coherent framework. GRP is exploring this issue and may hold a joint workshop with the International TOVS Working Group. At the same time, the NASA MERRA reanalysis is also being assessed as a consistent source of vapor for the next reprocessing of all GRP products.

Related to the unification of water and energy variables, GRP continues to foster the Cloud, Aerosol, Precipitation Initiative (ACPC). While not independent of the modelling activity, GRP sees potential in collecting simultaneous global scale data on aerosols, clouds and precipitation in order to provide global scale observations to what otherwise tends to be a very case-oriented analysis.

Finally, GRP feels that it should get involved in the data stewardships activities that are springing up, as a consistent, high-quality data set is critical for the long-term products being produced by GRP. Unfortunately, each calibration/intercalibration and stewardship activity has its own objectives that only sometimes fit GRP needs. As a panel, we want to encourage communities to use GRP algorithms to assess the stability of their long-term data products.

Recommendations and Issues for Attention of the SSG:
GRP in general, but GPCP in particular, needs a closer working relationship with the Climate and Cryosphere (CliC) Project for joint evaluation of products in high latitudes.

Data stewardship activities—particularly calibration and intercalibration—are springing up everywhere under different acronyms. Coordinating these activities seems critical.

New members of GRP feel that at some point, the GRP name itself should be revisited as global water and energy flux products have eclipsed radiation as the key activity within GRP.

Contributions to WCRP Strategic Themes:
The production of global data sets is a strategic theme that GRP addresses directly.

Summary:
GRP projects have all been funded and are making plans for a reprocessing cycle starting in 2010. This reprocessing will focus not only upon improvements within individual products, but also upon using common ancillary data across all products in order to bring uniformity to the data. Aside from using common ancillary data, GRP will also begin to produce an integrated water and energy cycle product that combines basic elements from each of its stand-alone products. The integrated data should be useful for process studies. Details regarding exact space/time resolution, time span and data fields are still being worked out in the panel.

The radiation code intercomparison activity is up and accessible through the web. Unlike previous efforts, the current CLiC activity uses actual observations from the ARM site and LBL calculations as a reference. It is available to all participants including IPCC modellers if they wish to avail themselves of this opportunity.

Planned Meetings in 2009:
- LandFlux workshop with GEWEX/iLEAPS conference in August.
- Potential Water Vapor Workshop with the International TIROS Operational Vertical Sounder Working Group
- CiRC Workshop around July
- WGDMA meeting in Americas; typically September
- GRP meeting, Oct. 13–16, Bonn, Germany