Review of GRP for the 2010 PAN-GEWEX MEETING

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1. General

The GEWEX Radiation Panel (GRP)'s short-term mission is reprocessing global data for energy and water cycle studies and producing new GEWEX datasets complete with metadata and uncertainties. GRP presentations given at the 2nd Pan-GEWEX Meeting show that GRP fully meets this challenge, and the SSG recognizes the high standards established by GRP on data pre- and post-processing. We endorse and recommend GRP's practice of providing GEWEX data to the scientific community and suggest that this may be endorsed and recommended to the other GEWEX panels. GRP currently accommodates many activities, whose foci span radiative measurements and observations of clouds to many variables and phenomena of the atmosphere and Earth's surface, including clouds, precipitation, energy fluxes, water vapor, aerosols, and soil moisture. The recent emphasis of GRP is on providing coherent (over time) datasets of selected products (clouds, aerosols, water vapor, radiation) for the atmosphere and radiative and turbulent flux datasets - at the atmosphere-land and atmosphere-ocean interface. Although the initial focus of GRP is on satellite data, the panel also deals with different types of in situ observations needed for extended validation of remote sensing data and for the development of hybrid products, based on different data sources. Accordingly, GRP encompasses much more than "Radiation," and a new name for the panel could be appropriate.

Dataset production includes data reprocessing to create climate data records with new level-1 and level-2 algorithms, if required, with a focus on dataset homogeneity (i.e., with as little as possible impact of sensor/satellite change on a product time series), and consistent co-variables (so the products all belong to the same atmosphere). In general, the products are easily accessible and well documented. Further, software like the International Satellite Cloud Climatology Project (ISCCP) simulator allows convenient model observation inter-comparison by simulating ISCCP products from model input. The use of satellite data simulators such as the ISCCP simulator is a very positive development that facilitates the model-observation comparison by matching the characteristics of variables and their spatio-temporal representativeness. It has to be noted that data reprocessing is a major effort because, apart from the regular processing of large data volumes, it also comprises quality control and comprehensive evaluation of the impact of the changes introduced, such as by different sensors and satellites.

The individual product components such as cloud, precipitation, aerosol, and land- and ocean-fluxes originated from activities outside of GEWEX and are therefore at a different stage of maturity. However, GRP has a great deal of expertise and diversity represented in the panel that will eventually lead to mature products ready to be used by the community. It is likely that the first reprocessing will lead to another, that will be even better, and this seems to be recognized by GRP. New products such as soil moisture and snow/sea-ice need to be described in more detail in terms of planned activities, expected availability, quality, etc. Product delivery includes documentation and, in the case of ISCCP, a stand-alone and portable software package for data reprocessing that is being transferred to National Oceanic and Atmospheric Administration (NOAA)'s operations. GRP recognizes the need for better education of product users regarding product quality.

Imperatives for GRP are creating global data records and advanced diagnostics (i.e., higher-level data analysis targeting; for example, known global climate model, or GCM, deficiencies) to facilitate the identification of global model problems in interactions with GMPP. GRP could serve as a panel for defining error metrics to be imposed (as a requirement) on data products to

be managed by GEWEX. Assessments of cloud (Claudia Stubenrauch, lead), aerosol (by GAP, although this is going on outside of GEWEX), and water vapor (Joerg Schulz, lead) products are underway. The aerosol assessment has developed guidelines for disentangling product error sources and their propagation along the production chain. These guidelines are recommended to serve as a template for other products.

The GRP advanced diagnostics objectives may need to be spelled out better to facilitate the understanding of which additional information is introduced by higher-order analysis. The advanced diagnostics provide analyses of joint-probability density functions (PDFs) and are expected to support the understanding of the link between the key variables of the climate system, namely temperature, moisture, clouds, precipitation, radiation, and the underlying processes. The diagnostics should be equally applied to model simulations and observations (a role for employing the available simulators). They will, however, also require more careful and advanced interpretation to distinguish between true information on processes and model/observation problems (e.g., correlations between parameters introduced by the assumptions made in the retrievals). A proposal to host a session on advanced diagnostics at the 2011 WCRP Open Science Conference with a first demonstration of results, was made and should be supported.

The target for the upcoming years is a first consistency check of derived products attempting closure of water and energy budgets. GRP common products require ancillary datasets, some of which are associated with large uncertainties, namely sea-ice (Climate and Cryosphere Project, or CLiC, sea-ice product inter-comparison was considered weak), but most importantly aerosols and temperature/moisture in the atmosphere. There is some valid reluctance to use numerical weather prediction (NWP) model information and reanalyses, but GRP should recognize the value of some model fields (including information on assimilated observations), because of their multivariate character and regular sampling intervals of fewer than 6 hours, to diagnose sources of errors.

In summary, the global GRP focus is on reprocessing and making available data sets and associated technical tools permitting the monitoring of atmosphere, land, and ocean and the processes involved in their interactions, and facilitating the interaction between climate diagnostics and activities related to prediction on regional and global scales. These datasets are also invaluable for other activities in GEWEX, and future interactions with modeling groups and the GEWEX Hydroclimatology Panel (GHP, formerly CEOP) should be fostered. GRP appears to be operating well and carrying out highly desirable objectives on behalf of GEWEX and is in line with the general GEWEX mission. The target for the upcoming years is a first consistency check and evaluation of the full set of derived products attempting closure of water and energy budgets. GRP common products require ancillary datasets, some of which are associated with large uncertainties, particularly aerosols and temperature/moisture in the atmosphere, for which the further effort is required. The ISCCP dataset processing is being transferred to NOAA, and such "technology transfer" is a desirable goal for other GRP products, at which stage the role of GRP may change to be more one of oversight and improvements. The SSG supports the GRP in its directions and notes the desirability of maintaining strong links to operational agencies.

Recommendations:

(i) Acknowledging the existing ISCCP simulator, it is recommended that the representation of simulators by GRP should be extended. Additional simulators like the CFMIP Observational Simulator Package (COSP) and the Goddard Satellite Data Simulator Unit (SDSU) should be added but will require representation by the respective development teams in the panel. COSP (contact point Steve Klein, SSG) facilitates the exploitation of A-Train data in numerical models by allowing the simulation of the signal that CloudSat/CALIPSO would observe from model output. SDSU (contact point Hiro Masunaga, GRP) has been developed

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through multi-institutional collaborations. The Goddard SDSU is an end-to-end satellite simulator unit, which can compute satellite-consistent Level-1 (L1) measurements (radiance or backscattering signals) from model-simulated or algorithm-assumed fields.

(ii) GRP successfully serves as a panel for defining observational product error metrics to be imposed (as a requirement) on data products that will be managed by GEWEX and should continue this mission. The focus can be extended to the assessment of aerosol products on which the first steps have been undertaken. Also, in certain cases, NWP model fields (including information on assimilated observations) can help to diagnose sources of product errors and can be considered.

(iii) GRP should continue to strengthen the interaction with operational data services in seeking partnerships for development and improvement of critical long-term datasets for global and regional energy and water cycles. GRP is also asking for a recommitment from space agencies to provide (reprocessed) data (and metadata) and continuous information on data problems to GRP.

It must be noted that GRP activities originate from externally funded projects outside of (but coordinated by) GEWEX, so that the recommendations made in this report represent guidelines for future work for which further external funding must be acquired. Undoubtedly, GRP is considered to be very successful and well planned, having an immediate impact on a wide user community and therefore of utmost importance for the effectiveness of GEWEX.

2. GRP Modules

2.1. Data Management

The chosen data management approach has served GRP very well, and resulted in long-term research quality datasets that are widely used by the science community for climate, energy budget, and water cycle studies. In general, the products are easily accessible and well documented. The Working Group on Data Management and Analysis (WGDMA) has determined the lists of common and ancillary data sets for topography and land/water mask, ozone, snow/ice, surface albedo, surface emissivity, sea surface temperature (SST), aerosols, atmospheric temperature, and humidity.

Recommendations:

(i) GRP is placing much importance on metadata and assignment of uncertainties, which is endorsed by the SSG. Global datasets need to be further tested and validated for use in regional water cycle studies across different climatic regions over land, covering monsoon-affected, arid, and semi-arid areas, continental mid-latitudes and subtropics, and in conjunction with other panels. In particular, GHP (formerly CEOP) should interact with GRP on these issues.

(ii) New products such as soil moisture, snow/sea-ice, groundwater stream flow and recharge produced under different GEWEX activities should also be accommodated by the GRP data management scheme and be described in more detail in terms of the planned activities, expected availability and quality, etc.

(iii) Timely provision of evaluation of data application and user feedback by GRP should be continued to serve the better planning and implementation of dissemination of GRP products.

2.2. Radiation-Related Activities

The progress of activities related to atmospheric and surface radiation is unequivocal, especially in the area of data collection and provision of data archives to users. For instance, the Baseline Surface Radiation Network (BSRN) currently covers 23 countries with 58 sites. Many data sets are accompanied by data summaries and metadata for users.

Recommendations:

(i) BSRN achieved great progress in collecting and archiving new data sets, in particular in support of International Polar Year (IPY) and analysis of dimming/brightening. It is recommended that GRP support BSRN's initiatives on continued international maintenance of basic calibration standards for irradiance means, in particular the request to the Commission on Instruments and Methods of Observation (WMO) supporting radiation measurements.

(ii) The validation of radiation products should continue and is considered to be a high priority. The GEWEX Radiative Flux Assessment (RFA) assembled a draft of a comprehensive report (the final version is planned to come out at the beginning of 2011), which will be a useful reference for the development of future climate system observation requirements for radiative fluxes as well as for understanding current data limitation and uncertainty for future Intergovernmental Panel on Climate Change (IPCC) reports. It is recommended to continue evaluation of ingested datasets against surface site data as well as intercomparisons on different space- and time-scales.

(iii) Radiation and radiative transfer models were not discussed, owing to the absence of the respective activity leaders. GRP does not see itself as a radiation/radiative transfer model developer but recognizes the need for radiative transfer modeling, radiative transfer model evaluation through intercomparison projects, and for retrieval algorithm development. These models are fostered by GRP, which provides information on model availability and access to code. Radiation models for the calculation of radiative heating/cooling in atmospheric models are beyond the scope of GRP and could be integrated with the atmospheric model developments under the GEWEX Modeling and Prediction Panel, GMPP (or its successor).

2.3. Air-Sea and Air-Land Fluxes

GRP flux-related activities (SeaFlux and LandFlux) represent the efforts centered on developing global products and support the understanding of physical processes. However, the major challenge of the development of new flux products is still the treatment of sampling biases in poorly sampled regions, the capture of extreme turbulent fluxes that occur over periods of a few hours and days, and the strongly localized and unrealistic representation of surface flux variability. For different types of products, some of the problems lie in satellite retrieval algorithms (related to surface temperature and near-surface humidity) and in the realistic representation of fluxes in NWP models. The LandFlux dataset is important for studies of land surface processes. However, problems in the quantitative estimation of surface fluxes over land with high resolution still remain unresolved, implying the need for building long-term merged satellite-derived and ground-based observed homogenized datasets and interactions with GHP (formerly CEOP).

Recommendations:

(i) We suggest that SeaFlux validation activities should be better coordinated with the relevant Climate Variability and Predictability Project (CLIVAR)'s Global Synthesis and Observations Panel (GSOP) activities (GSOP is taking the lead on surface fluxes over the ocean with the demise of the WG on surface fluxes).

(ii) The structure of LandFlux requires the effective flow of information among different activities and a close co-operation with other GRP and GEWEX activities. Co-operation among satellite missions, regional high-resolution instrumental datasets, and land surface process modeling is required as well.

2.4. Cloud Observation and Data Provision

ISCCP is one of the most well known GRP projects providing global cloud data and radiative fluxes over periods of decades. Software like the ISCCP simulator allows a convenient model-observation intercomparison by simulating ISCCP products from model output. ISCCP-FD radiative fluxes are subordinated with error estimates; however, these estimates are still large enough to become useful for climate applications. The ISCCP common products require ancillary datasets, some of which are associated with large uncertainties, such as sea-ice (the CliC sea-ice product inter-comparison effort was considered weak by GRP), but most importantly aerosols and temperature/moisture in the atmosphere.

ISCCP cloud products, especially over oceans, contribute to the validation of cloud characteristics in NWP and climate models and should be more extensively engaged in model studies, especially once the products have been reprocessed to hopefully have much reduced error bars. GRP should collaborate with modelers to solicit requirements for further improvement and development of GRP cloud products. Currently there are various inconsistencies between model and satellite cloud products which often hamper a direct comparison. Simulators [ISCCP, CFMIP (Cloud Feedback Model Intercomparison Project) Observation Simulator Package (COSP), Goddard Satellite Data Simulation Unit (SDSU)] should support this effort, but need wider application. The advanced diagnostics activity represents an important step towards better communication.

Recommendations:

(i) Closer co-operation of the GEWEX modeling activities (formerly GMPP) with providers of cloud products through concerted diagnostics efforts, also providing simulator packages.

(ii) Initiation of a sustained interaction of GRP with CliC is necessary, particularly for an understanding of the quality of sea-ice products and their usefulness within GRP.

(iii) Enhanced activity on obtaining and evaluating supporting data sets (aerosols, temperature, moisture) to better constrain cloud/radiative flux retrievals is required.

2.5. Precipitation

GRP's Global Precipitation Climatology Project (GPCP) provides a synthesis of many products and delivers a hybrid product for the further analysis of the climatological variability of precipitation totals. An important issue for the validation of these data is comparisons of point measurements to the cell averaged data. Continental data from GPCP combining satellite and in situ data are likely to be more accurate than those over oceans, while there is only limited validation data available over oceans. Through NASA's Precipitation Measurement Mission (PMM) project, Tropical Rainfall Measuring Mission (TRMM) precipitation radar data is employed for validation of radiometer derived products, but is not very prominent in GRP. TRMM precipitation has uncertainties in representing light rains and warm rains. Cloudsat is providing insights into precipitation that may be missed by current GPCP approaches.

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Over land, it would be desirable for GPCP to extend the use of alternative higher resolution precipitation data for the estimation of precipitation PDFs, frequency, duration, diurnal cycle, and extreme precipitation statistics. The latter is an area where GPCP daily products may have

problems since extreme precipitation events are captured typically with less accuracy than mean fields.

Recommendations:

(i) It would be desirable if GRP together with GPCP would consider the possibility of building a comprehensive strategy for the validation of GPCP precipitation products over both land and ocean. This strategy could be targeted at the quantitative estimation of regional uncertainties and the use of GPCP data for a validation of NWP products.

(ii) GPCP in interaction with GPCC should consider potential collaboration with GEWEX and CLIVAR communities for enlarging the area of potential use of their products. This can be prepared in co-ordination with groups of experts in the areas of precipitation diagnostics, case studies, extreme events, and high resolution modeling, and should also include a time line for producing products at daily, even hourly resolutions and a well justified resolution in space with known methodologies including error estimation.

(iii) GPCP should continue to sponsor evaluations and intercomparisons and verification of their products using the full water budget (including soil moisture and runoff over land) concept.

(iv) GPCP should continue to sponsor and participate in intercomparisons and evaluations of the multitude of other precipitation products.

3. Interactions with GMPP and GHP

GRP has collaborated with the GEWEX Cloud System Study (GCSS)/Global Land Atmosphere System Study (GLASS) on defining a set of advanced diagnostics, both globally and regionally, that can be used to validate model performance and provide pathways for model physics improvement. To enhance this effort during the 2013+ period, GRP can consider, in co-operation with GEWEX SSG and in conjunction with GHP, the initial planning for the selection of appropriate Regional Hydroclimate Project (RHP) sites to use both GRP and RHP data to conduct a comprehensive evaluation of the regional water and energy cycles, as well as the related processes.

There have been some concerns over GRP's lack of interest in including specific products from other groups such as CliC and GHP. Conversely, there may also be a lack of interest or incentive for other groups to provide their data to GRP. We recommend that there is much to be gained by fostering closer interactions with CliC and GHP to capitalize on their regional strengths. However, past experience suggests the need for carefully targeted joint projects that have at least one person taking responsibility on each side. One key possible area is solid precipitation.

During the joint discussion with GMPP, the importance of GCSS's focus on cloud and precipitation data was found to define the framework for the most desired GRP product range. The coupling of physics with dynamics may be more difficult for GRP to support. GMPP expressed its interpretation that the cloud-radiation feedback is dominated by atmospheric processes rather than by land/ocean-atmosphere interaction. GLASS also mentioned the role of data assimilation (LDAS) for confronting models with data and expressed particular interest in LandFlux data. The GLASS group stated its preference for being a diagnostics/tools provider in support of model development rather than a model developing activity, an aspect that may evolve in the context of the intended change from GMPP to the Framework for Atmospheric Model Enhancement (FAME). The concept of advanced diagnostics will be shared among groups and should be strongly supported.

During the joint discussion with GHP, the GRP focus on global evaporation-minus-precipitation (soil moisture and snow to follow, but no products are available yet) was emphasized. The SSG

recognized the importance of co-operation starting from the present embryonic product stage towards closure of the entire water and energy budgets. A proposal to identify one or two (perhaps one simple and one complex case) continental-scale catchments from selected RHPs for regional closure testing was put forward. This will require substantial support from GHP for budget/component evaluation, which may depend on how well GHP will be developed in the future.

With respect to the interaction between both GMPP and GHP, it may be advisable to define a special meteorological topic [e.g. monsoons, or land regions affected by the Madden-Julian Oscillation (MJO), or land regions with unique diurnal features] that is not well simulated in global models and where both observations and RHPs can contribute information. This meteorological topic should include cloud/precipitation process interaction with large-scale dynamics and land surfaces.