GEWEX DAP (Data and Assessments Panel) Annual Report

Reporting Period: October 2013 – January 2015

Starting date: GDAP is the new brand of the Panel following the GEWEX Radiation Panel (GRP) since 2011. GDAP and GASS took joint ownership of the CIRC activity along with GDAP.

URL: http://gewex.org/GDAP.html; http://rain.atmos.colostate.edu/GDAP/index.html

Chair(s) and term dates: Christian Kummerow (end July 2014), Jörg Schulz (end March 2017)
Vice-Chair: Jörg Schulz (end July 2014), Matthew McCabe (end March 2017)

Panel Objectives

GDAP activities can be divided into Data Products, Product Quality Assessments, and Radiative Transfer Code Assessments. The product quality assessments commonly bring together a variety of in-situ measurements. Some of these are well coordinated and quality controlled while others exist largely in their own regional domains. The panel, therefore, sees a role as identifying such networks of in-situ observations and fostering the development of integrated global datasets that can be used to both construct and/or validate the global climate products.

The individual and the integrated GEWEX data products enable research related to Grand Challenges on changes in water availability, clouds, circulation and climate sensitivity and potentially for climate extremes. Within GEWEX a specific objective is to provide a better understanding of variability and change of the water and energy cycles and individual state variables mainly derived from satellite observations. To fulfil this objective global moderate space (~50 km) and high time (~3 hourly) resolution data sets with quantified and validated uncertainty are needed. Quantification and validation of uncertainty estimates becomes a major thrust of research performed in GDAP.

Major objectives of the product quality assessments are to provide independent and transparent quality assurance for existing data records, to endorse the use and the credibility of data records to a broader community not necessarily familiar with the data sources and methods used to generate the data records, to identify key limitations in data records to stimulate improvements, and to allow objective selections of appropriate data records, e.g., for evaluating climate models in Climate Model Intercomparison Projects (CMIP).

Radiative transfer code assessments performed as GEWEX projects had the objectives to provide a new standard for assessing the performance and potentially certifying GCM-style SW and LW RT codes, to compare performance of 3D radiative transfer codes and comparison of canopy radiative transfer models under controlled experimental conditions.

Status and Results

a) GEWEX Products

The production of GEWEX individual products for Clouds (ISCCP), Aerosols (GACP, MAC), Radiation Fluxes (SRB), Turbulent Fluxes (SeaFlux and LandFlux) as well as Precipitation (GPCP) continues with reasonable support from agencies except for GACP which remains unfunded. The Max Planck Institute für Meteorologie continues production of an Aerosol Climatology that is being adopted by GDAP instead. Some of the GEWEX reference products, e.g., ISCCP and GPCP have been transferred to NOAA for routine processing (keeping a timeliness of about 1 month). Others may follow depending on funding. Other sustained activities such as in Europe continue to produce data records on the energy and water cycle comparable in nature and quality to the standard GEWEX products but no real attempts on an integrated product have been made.

The Integrated GEWEX product is designed to ensure that geophysical signals and their covariance are tied to the data and products themselves rather than inconsistencies in their assumptions. Reviewing the progress in the production of the integrated product using common assumptions was the primary goal of the GDAP team meeting in The Hague, The Netherlands, on 16 and 18 July 2014. Some of the data products for the Integrated GEWEX Product, including radiative energy, turbulent fluxes, and condensation heating, were finalized over the past year. Other data to be included were

initially hampered by delays in individual components but are now nearing completion. However, the panel has encountered significant issues, of the scientific rather programmatic nature, as it has forged ahead to create this product. In particular, basic building blocks such as surface temperature, temperature and humidity profiles are not as good as hoped for. Large differences between products were found and little in terms of absolute validation is available. In addition, the profile data in the lower levels are significantly different from inputs used for individual products of turbulent heat and radiation fluxes, e.g., derived from passive microwave imager data over ocean or coming from reanalysis. In that sense the integrated product is an important step forward in that the very interdependence of the products makes it difficult to produce, but is also a very strict QC procedure. Due to these issues it is currently difficult to announce a delivery date other than as soon as possible.

GDAP has begun to explore the expansion of GEWEX standard products to include terrestrial water budget terms. With Wouter Dorigo (Soil Moisture) and Felix Landerer (GRACE Observations of water storage) two experts on these topics joined the Panel advising on best ways to incorporate potential data sets. The very short GDAP meeting in The Hague in summer 2014 decided to start a formal data set quality assessment on soil moisture and expects an outline paper for the 2015 GDAP meeting. Ground water storage related activities were postponed to 2015 as Felix Landerer could not participate in the GDAP meeting 2014.

b) Data Set Quality Assessments

Currently, GDAP has two running data set quality assessments on water vapour and aerosol optical depth. Both are crucial elements of the integrated product and were originally designed to provide information on different existing data sets derived from satellite data.

The aerosol assessment was concentrating on a level 3 type comparison (retrievals mapped to geographical grid) but was not able to finalise it in 2014, mostly because of too little time available and lacking motivation by the leaders of the assessment. The assessment is considering new interesting aspects, e .g., trends in aerosol optical depth over the last decade and satellite data – climate model comparisons but struggles with delivering a report to GDAP. It is a major concern of GDAP for 2015 to find a way forward for this assessment.

The water vapour assessment (www.gewex-vap.org) has continued to make progress and here it clearly helped to have a written agreed assessment plan at the beginning of the workshop. The 4th G-VAP workshop was hosted by the Institute of Space Sciences at FU Berlin, Berlin, Germany on 09+10 October 2014. More than 30 scientists from all over the world participated and nearly everybody contributed with a presentation. The willingness of the participants to take over responsibility in WCRP report drafting is noteworthy and highly acknowledged.

Trend analysis was used as a tool to compare total column water vapour (TCWV) and water vapour profiles on global scale. The TCWV trends were found to be significantly different, in particular in tropical land regions which led to the recommendation to the Global Reference Upper Air Network (GRUAN) co-chairs to consider a tropical land surface station during GRUAN network expansion (www.gruan.org). Using homogeneity tests these differences in TCWV were found to be caused by break points in the time series which temporally coincide in almost all cases with changes in the observing system. Results are also available from the comparison of short-term data records using PDF analysis. The analysis included the nnHIRS temperature and water vapour profile product which is input to the GEWEX Integrated Product. Largest differences were found for the satellite-based data sets, especially over high pressure areas over the ocean. The assessment has managed to agree on the structure of the final report and distributed responsibilities for the chapters.

Some new directions such as an enhancement of the evaluation of water vapour and temperature at the surface and in the boundary layer to strengthen the evaluation of energy fluxes (land and ocean) and of the planetary boundary layer and enhanced quality analysis of profile data records over open ocean, in particular over subsidence areas was discussed. In addition, at a later stage water vapour transport products could be used to analyse atmospheric dynamics and to evaluate the assumption of constant relative humidity in the upper troposphere.

At present the assessment expects to finalise its report in 2016 and not in 2015 as originally planned. The reason for the delay lies in the fact that comparisons of temperature and humidity profile data cannot be finished in time. A transfer of resources from Europe to the US to support activities at NOAA was finally failing due to too high administrative hurdles.

GDAP provided a draft of Data Set Quality Assessments: Needs, Benefits, Best Practises and Governance to the WCRP Data Advisory Council. The document was endorsed but needs further update to include the perspective concerning the link of data product quality assessments and obs4mips. The update is planned to be finished prior to the WCRP JSC in April 2015.

c) Radiative transfer model assessments

Radiative transfer code and satellite simulator assessments have not been considered in detail during recent GDAP meetings mostly because lack of time and funding of the individual projects. The Continual Intercomparison of Radiation Codes (CIRC) project that formerly reported to GDAP is now jointly owned with the GASS project Radiative Processes in Observations and Models. The needs for activities concerning 3D radiative transfer models and the still active RAdiation transfer Model Intercomparison (RAMI) initiative that proposes a mechanism to benchmark models designed to simulate the transfer of radiation at or near the Earth's terrestrial surface, i.e., in plant canopies and over soil surfaces need to be discussed at the next GDAP meeting.

d) In situ networks

The BSRN network reported improved data submissions for several sites. In total about 50 station years are currently in the BSRN archive. In addition a significant uptake of BSRN data in scientific publication has been found with a 12% growth from 2011 to 2012 and a further 32% growth from 2012 to 2013. BSRN performed a network workshop in Bologna, Italy from 9-12 September 2014 that had about 70 registered participants showing ongoing strong interest in BSRN (see GEWEX News November 2014 for the full report). However, despite this success BSRN is suffering also from station closures (see below under Issues and Recommendations) and may need renewed support.

The International Soil Moisture Network (ISMN) (https://ismn.geo.tuwien.ac.at/) includes soil moisture in situ measurements from 42 networks (active and historical) with ~1600 stations. The ISMN has become successful and indispensable for validation of satellite estimates. Improvements on the quality control procedures taking into account co-varying variables such as air/soil temperature, precipitation, snow depth, etc. It was reported at the last GDAP meeting in The Hague that issues exist with funding after 2016 with the danger that the ISMN would deteriorate in the following years.

The water vapour assessment has created a link to the GRUAN network and is providing recommendations to the network related to usability for validating satellite derived products.

New directions:

a) Products

With regard to the usage of GEWEX and other data sets in particular the integrated product further, analysis, application and development activities will be needed. As first analysis of the integrated product is pointing at issues in particular with atmospheric temperature and humidity we certainly need to assess the potential role of global reanalysis for the integrated product which should be done on the basis of the water vapor assessment results that include reanalyses data. Considering the inherent uncertainties in individual products one way forward might be to create data product ensembles out of products that have taken part in GEWEX assessments. Further, we need to foster the analysis of parameter covariance statistics in order to evaluate flux and budget statistics as close as possible to the native processes.

In terms of applications, GDAP will make an attempt to bring the integrated product and also a more complete set of GEWEX products to the CMIP-6 activities by interrogating with the obs4mips activity. It is expected that such a usage will create valuable feedback for further developments of the integrated product. For individual products we need to further study items that are currently not included such as interception loss for evapotranspiration. This requires looking into new data sources such as the recently launched SMAP mission as well.

Another more long-term issue is to better characterise the uncertainty of products that includes the provision of uncertainty estimates with the products and their evaluation. Currently, SeaFlux products contain estimates from systematic and random effects in the measurements and retrievals that are propagated to mapped air-sea turbulent flux products. In addition some initial activities exist to assess the uncertainty budget for some precipitation data sets in the Tropics. However, GDAP needs to follow up the uncertainty characterisation more systematically for all products to resolve random,

systematic, and so called structural (situation and magnitude dependent) uncertainty. The provision of uncertainty measures with the products will certainly trigger needs for new reprocessing activities.

In addition, terrestrial water and energy budget closure at scales important to climate processes is a key area that GDAP will focus its energy on in the next 5-10 years. This includes questions about precipitation cycling and feedbacks between soil moisture and precipitation.

b) Assessments

Provision of information about existing data sets related to the energy and water cycle in form of scientific quality assessment will remain an important activity of GDAP. It has been very challenging to perform assessments basically with only marginal or no funding. The still running water vapour assessment benefitted very much from space agency funding which established a core activity that keeps momentum for several years. It has been recognised that because of the funding situation assessments take far too long to deliver results. Thus, one objective will be to organise upcoming assessments in a different way.

It is important that assessments activities and their results become better known to those who should benefit from the results, e.g., climate modellers, etc. It is indicative to not only produce a very big report at the end of an assessment as it was done for clouds and radiation fluxes but to keep the audience interested with regularly updated information, e.g., every two years. Assessment plans/white papers should structure the activities in near, medium and long term goals and then publish results and receive feedback early in the process. It may also help to be responsive to specific applications such as process studies or climate model evaluation which may necessitate very different perspectives for an assessment.

The GDAP meeting in The Hague in July 2014 decided to embark on two new product quality assessments that will cover precipitation and soil moisture data sets. For precipitation already a white paper has been drafted (see Annex). For soil moisture a similar draft is expected for discussion at the next GDAP meeting late September 2015. The latter assessment may also consider consistency between soil moisture, precipitation and evaporation at the surface. A third topic for an assessment might be groundwater related products but this needs to be explored and suitable people need to be found.

Future: Next year foreseen activities:

- Assess the status of all GDAP related projects and activities – revive those which are needed;
- Carefully consider GDAP membership to secure long term future of the Panel;
- Finalise the production of the integrated product and start evaluating its quality by using it for energy and water budget studies. It needs to be understood that during such studies it is expected that several shortcomings in the integrated product will be detected. Depending on the quality of the integrated product GDAP may even start to plan a next production cycle for the integrated product and try to embed this is in ongoing product generation activities such as SCOPE-CM. Without appropriate funding progress will be very limited;
- Foster relation with obs4mips and start to bring the integrated product to the ESG. This topic was discussed at the last GDAP and availability of funding to provide needed meta data structure and format can become a major issue;
- Consider link with GEWEX PROES and define what GDAPs contribution could be;
- Assess and may reinforce relation with SCOPE-CM by clearly address mutual benefits of collaboration;
- Define routes to close out the aerosol and water vapour assessments that lasts since a couple of years;
- Discuss and start two new data set quality assessments on precipitation and soil moisture
- Evaluate the feasibility of formalizing the Satellite Simulator Assessment started in 2012 and decide at next GDAP meeting in the autumn of 2015;
- Discuss if GDAP may engage into support of the WMO Rolling Review Requirements process. GEWEX has provided requirements to this process in back in 1998. The WCRP Data Advisory Panel considered this in 2013 but was not launching any activity. Key is to be clear about how requirements should be constructed along the applications relevant for GEWEX. Maybe providing some quite broad ranges (relevant to various applications) would be most practical, rather than focusing on single numbers. It might be useful if rather data product users engage in the requirement process than producers;
- Support WDAC task team on turbulent heat fluxes by contributing to the GEWEX WG on fluxes;

Issues and Recommendations:

In situ data sets:

- In-situ datasets of radiation, precipitation, clouds properties, water vapour soil moisture and turbulent fluxes are important reference data for satellite Climate Data Records. Almost all are under funding pressure with little international visibility or status. As anchors to many of the global products, it would be good to see WCRP and possibly WMO elevate these measurements to a level where we can get national commitments to their maintenance as well as capacity building that is desperately needed in underdeveloped regions of the world. WCRP might consider a concerted effort to foster small but highly characterized networks (similar to BSRN) that can be used to assess stability of satellite data records over very long periods.
- Recent examples for specific networks:
  - GDAP received a report from Norman Loeb that the BSRN site at the Chesapeake Lighthouse, 25 km off the coast of Virginia Beach will disappear. The CERES team has been maintaining and operating BSRN and AERONET instruments there since 2000. The Department of Energy took over the lighthouse from the Coast Guard in October 2012 with plans to construct a 100 m tower with an array of instruments for wind research. Unfortunately, DOE recently concluded that the cost of repairs to the platform and 100-m tower exceeds their cap so they've decided to scrap their plans and return the platform to the U.S. General Services Administration (GSA), who will put the lighthouse up for auction. Because of safety concerns, DOE has asked to remove all instruments from the platform ASAP. NASA has no interest in acquiring the platform (we explored this possibility a few years ago). It's really unfortunate as there is no other BSRN site that far away from a coast. Although the BSRN site in Darwin continues operations funded by the Australian Government we are seeing the effects of decaying support for BSRN and we need to renew the support for both sites and analysts to make these data available to support the whole range of things that GEWEX (and the rest of WCRP) is working on.
  - It was reported at the last GDAP meeting in The Hague that issues exist with funding after 2016 with the danger that the ISMN would deteriorate in the following years. It is suggested to bring this item to the attention of the WDAC and maybe also the JSC to ask for continued support of the ISMN network;

Support to sustain assessment activities:

- The EUMETSAT CM SAF may offer the opportunity to provide long term services for updating water vapour assessment results due to the sustained funding scheme via EUMETSAT. A support letter for their next proposal to EUMETSAT by the GEWEX chairs is appreciated.

Issues for attention by the SSG:

- The BSRN project manager Joe Mickalsky has retired at the end of 2014. He provided the GDAP with two applications to succeed him. GDAP considered the applications and asks the SSG to formally appoint Charles N. Long, Senior Research Scientist at Pacific Northwest National Laboratory Richland, Washington, USA as new BSRN chair;
- The current chair and vice chair of GDAP plan to pass on the responsibility after the SSG 2017. SSG is asked to support the search for new leaders of GDAP during the next two years;
- Changes to the membership of GDAP are needed and the GDAP meeting 2014 indicated that additional expertise in the field of reanalysis and climate modelling is needed to fully exploit the integrated product and potentially to improve it. In addition, expertise on top of the atmosphere radiation budget and integrated analysis with sea level rise needs to be reinforced. SSG is asked to support the GDAP chair and vice-chair in finding appropriate candidates;
- GDAP members have been hampered to participate in GDAP meetings in the last two years due to travel restrictions in the USA which is of concern as this often means that they also cannot contribute to the work.

Contributions to WCRP Strategic Themes/Grand Challenges (preferably with indication towards GEWEX Science Questions):

The individual and the integrated GEWEX data products enable research related to Grand Challenges on changes in water availability, clouds, circulation and climate sensitivity and potentially for climate extremes.

Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity is supported by the GDAP Integrated Product. Science articles GDAP plans to publish go directly to answering questions about the interactions of clouds precipitation and the radiation balance. The data sets are made specifically to test co-variance and climate sensitivity

On changes to water availability GDAP can certainty help with past precipitation amounts and the distribution of rain rates that might be viewed as important for water availability, the panel has no particular information on water availability or changes therein.

The re-engineered GDAP products (1 degree, 3 hourly time steps) may allow detecting extremes and processes related to extremes in the data. The publication by Lockhoff et al. (2014) has already found some skill at large scales in GPCP 1DD products.

In addition the products can be used to perform process studies at regional scales that would be essential to verify that the regional climate models are indeed capturing the key elements of each region's unique physics.

Summary for GEWEX report:

Will be provided after the SSG meeting.

List of key publications:

Individual data products continue publications that continue to have high citation rates. The given list of publications is only a small excerpt of what has been published since 2013. We would benefit from having a central publication screening at the GEWEX office.

L'Ecuyer, T. S., H. Beaudoing, M. Rodell, W. Olson, B. Lin, S. Kato, C. A. Clayson, E. Wood, J. Sheffield, R. Adler, G. Huffman, M. Bosilovich, G. Gu, F. R. Robertson, P. R. Houser, D. Chambers, J. S. Famiglietti, E. Fetzer, W. T. Liu, X. Gao, C. A. Schlosser, E. Clark, D. P. Lettenmaier, and K. Hilburn, 2015**:** The Observed State of the Energy Budget in the Early 21st Century, J. Climate, Submitted

Rodell, M., H. K. Beaudoing, T. S. L'Ecuyer, W. S .Olson, J. S. Famiglietti, P. R. Houser, R. Adler, M. Bosilovich, C. A. Clayson, D. Chambers, E. Clark, E. Fetzer, X. Gao, G. Gu, K. Hilburn, G. Huffman, D. P. Lettenmaier, W. T. Liu, F. R. Robertson, C. A. Schlosser, J. Sheffield, and E. F. Wood, 2015: The Observed State of the Global Water Cycle in the Early 21st Century, J. Climate, Submitted

Brown, P. J. and Christian D. Kummerow, 2014: An Assessment of Atmospheric Water Budget Components over Tropical Oceans. J. Climate, 27, 2054–2071.

Lockhoff M.,, O. Zolina, C. Simmer, and J. Schulz, 2014: Evaluation of Satellite-Retrieved Extreme Precipitation over Europe using Gauge Observations. J. Climate, 27, 607–623. doi:http://dx.doi.org/10.1175/JCLI-D-13-00194.1

Mueller, B. , M. Hirschi, C. Jimenez, P. Ciais, P. A. Dirmeyer, A. J. Dolman, J. B. Fisher, M. Jung, F. Ludwig, F. Maignan, D. G. Miralles, M. F. McCabe, M. Reichstein, J. Sheffield, K. Wang, E. F. Wood, Y. Zhang, and S. I. Seneviratne, 2013, Hydrol. Earth Syst. Sci., 17, 3707–3720, 2013.

Stone, T.C., W.B. Rossow, J. Ferrier, and L.M. Finkelman, 2013: Evaluation of ISCCP multisatellite radiance calibration for geostationary imager visible channels using the Moon. *IEEE Trans. Geosci. Remote Sens.*, 51, 1255-1266, doi:10.1109/TGRS.2012.2237520.

Tselioudis, G., W. Rossow, Y.-C. Zhang, and D. Konsta, 2013: Global weather states and their properties from passive and active satellite cloud retrievals. *J. Climate*, 26, 7734-7746, doi:10.1175/JCLI-D-13-00024.1.

List of meetings, workshops:

- Third Meeting of the GEWEX Data and Assessments Panel (GDAP), The Hague, The Netherlands, 16 and 18 July 2014.
- 13th Baseline Surface Radiation Network Scientific Review and Workshop, Bologna, Italy 9–12 September 2014.
- GEWEX Water Vapor Assessment workshop, Berlin, Germany, 9-10 October 2014.

Planned meetings, workshops:

- GDAP chair will present on GDAP work to a GCOS and GEO joint Session on "Global Environmental Research and Policy" at the International Symposium on Remote Sensing of Environment (ISRSE), Berlin. Germany, 12 May 2015;
- GDAP chair will present GDAP science to special IAMAS session on IRC Working Groups in IUGG/IAMAS session Radiation in the Climate System, Paragues, Czech republic, 22 June – 2July 2015.
- 4th Meeting of the GEWEX Data and Assessments Panel (GDAP), Xiamen, China, 29 September – 2 October 2015.
- GEWEX Water Vapor Assessment Workshop, Madison, Wisconsin, USA, 4-5 November 2015.

List of members and their term dates where appropriate (including changes)

Christian Kummerow	2008 – present (chair since July 2015)
Joerg Schulz	2010 – present (chair from July 2015 – present)
Wouter Dorigo	2013 – Present
Carlos Jimenez	2010 – present
Felix Landerer	2013 – present
Norman G. Loeb	2005 – present
Hirohiko Masunaga	2010 – present
Matthew McCabe	2008 – present (vice-chair from January 2015 – present)
Axel Schweiger	2008 – present
Sonia Seneviratne	2008 – present
B.J. Sohn	2007 – present
Claudia Stubenrauch	2007 – present
Susan Van den Heever	2008 – present
Tianjun Zhou	2011 – present
Andrew Heidinger	2012 – present

Annex I

05/Dec/2014

GDAP Precipitation Assessment: Proposal Outline (draft)

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Christian Kummerow (Colorado State University)

Introduction

The GEWEX Data and Assessments panel, meeting in The Hague in July 2014, decided that the increased availability of climate precipitation products, coupled with uncertainties in the global Water and Energy budget terms available from these products, merited a new assessment of the precipitation products. The GDAP assessment reports recently published include the cloud assessment and radiative flux assessment, which are both remarkably thorough and detailed. The cloud assessment report is a 176-page document and the radiative flux assessment report consists of two volumes each containing more than 200 pages and took nearly a decade to complete. It is a demanding task to complete such a comprehensive report in a practical timeframe. While it remains important to publish a full assessment report, it would be beneficial to quickly deliver a concise interim report (or a series of interim reports) in order to address the urgent needs of broad science community in a timely manner. This document is an attempt to sharpen the assessment strategies so that such an interim report is kept useful and informative despite its conciseness. The envisioned timeframe for this report is approximately 2 years from the charter to completion.

Strategies for timely delivery of the assessment reports

First, the foci of assessment should be clearly identified in advance. A tentative list of the proposed foci is presented below. Second, the identified foci must be prioritized to select the ones that can be addressed within a reasonable period of time. The foci that are important but require a substantial effort to address may be excluded from interim reports and left for a full report. Finally, unessential sections may be omitted from interim reports. For instance, a detailed description of individual data products, retrieval algorithms, and satellite instruments should be available elsewhere and does not need to be entirely repeated. Such information would be useful and even indispensable for a full report, but may be substantially shortened and only provided as needed in an interim report.

Datasets

This section briefly summarizes global precipitation products broadly that are in broad use. The first step of a new assessment would be to review and edit this list to focus on all available products being used or designed for Climate Research Purposes.

1) Combined products from multiple satellites w or w/o ground data

- GPCP: 2.5ºx2.5º, monthly/pentad/daily, 1979-present
- CMAP: 2.5ºx2.5º, monthly/pentad, 1979-2014
- CMORPH: (8 km, 30 min)/(0.25 ºx0.25 º, 3-hourly/daily), late 2002-present
- GSMaP: 0.1 ºx0.1º, hourly, data periods vary among product types (MWR/MVK/NRT)
- TRMM 3B42 or TMPA: 0.25 ºx0.25º, 3-hourly/daily/monthly, 1998-present

2) Individual satellite products

*The list below is sorted by satellite missions. Each mission may have multiple products constructed with different algorithms.

- Aqua (AMSR-E): 2002-2011
- CloudSat (CPR): 2006-present
- GCOM-W (AMSR2): 2012-present
- GPM (DPR, GMI, combined, and the whole constellation): 2014-present
- DMSP series (SSM/I and SSMIS): 1987-present
- TRMM (PR, TMI, and combined): 1998-present

3) Rain gauge analysis datasets

- GPCC: 0.5ºx0.5º/1ºx1º/2.5ºx2.5º, monthly, 1901-2010

Basic guidelines

Precipitation estimates disagree among different products for different reasons. Best satellite measurements are not guaranteed to compare well with rain gauge data even if the spatial and temporal matching was perfect, owing to the non-uniform beam filling effect. Precipitation estimates are sensitive to spatial resolution and temporal sampling because of the highly sporadic nature of precipitation. While satellite data have retrieval uncertainties in addition to sampling and sensor noises, rain gauge networks are limited in spatial representativeness. In-situ data are not literally a ground "truth" but an estimate with its own sources of uncertainties. The goal of precipitation assessment therefore should not be a validation against an absolute reference but inter-comparison of data products (regardless of satellite-based or ground-based) that have different error characteristics in nature from one another. It is particularly important to separate sampling noise from structural errors. The latter arises from assumptions in the inversion models as discussed later.

Sampling noise would be mitigated by spatial and temporal averaging to a common resolution to the extent that the errors are random. Sampling errors are however *not* entirely random in that the frequency of precipitation occurrence has a negative correlation with precipitation intensity (i.e., the heavier the rarer). Averaging operation would smear out extreme events preferentially compared to modest rainfall. This effect will not seriously affect the climatological assessment of precipitation, but could be problematic for some hydrological applications (river runoff etc.) and high-impact weather monitoring. The probability distribution function (PDF) rather than the mean would be instrumental when extremes are the target.

Assessment Foci

(a) Global and Regional Climatology (long-term mean and trend)
Reliable estimates of precipitation climatology are crucial for quantifying its long-term trend associated with climate change. It is critical that the data are as unbiased as possible so that subtle changes over decades are precisely captured. The main focus for this assessment focus is to carefully identify the relative biases among the products in precipitation climatology including the multi-decadal changes as well as the long-term mean.

Precipitation products often contain systematic regional biases. The largest among all is the contrast between land and oceans, since most retrieval algorithms take essentially different strategies between oceanic and continental rains. Other sources of regional biases arise when algorithm assumptions (DSD, freezing level height, etc.) are not properly tuned to accommodate the regional variability in the climatological characteristics of precipitation. Regional biases potentially contain useful information for tracking down the algorithmic issues that are responsible for the biases specific to each product.

The datasets with a sufficiently long temporal record are qualified for this assessment focus. For example, GPCP and CMAP are well qualified, and the 17-year long data of TRMM are marginally useful from climatological perspectives, while GPM is obviously not ready yet under this criterion. This main focus of this section would be to assess the agreement of global precipitation trends, regional differences, and connection between these two among these products.

(b) Time series analysis in the context of different modes of climate variability
The natural variability of precipitation over time exists over a wide spectral range. The most notable are the diurnal and annual cycles, intra-seasonal oscillations (MJO etc.), and inter-annual variations (ENSO, Arctic Oscillation, etc.). Some products may be found to have a greater temporal variability than others, and understanding such biases would be beneficial for identifying algorithmic issues.

(c) Extremes
A standard measure to quantify the detectability of extreme events is precipitation rate at, say, the 99 % percentile of PDF. Such estimates would be sensitive to the spatial and temporal scales, so the resolutions should be carefully matched before different products are compared.

In contrast to the climatological assessment, the capability to detect localized heavy rainfall is more important than the length of record. Spaceborne radars (TRMM, CloudSat, and GPM) are most useful to this end among satellite instruments.

(d) Frozen precipitation
The reliability of snowfall estimates is confronted by a number of technical challenges. Snow retrieval requires additional assumptions with significantly larger uncertainties than rain retrieval. Some datasets may store the liquid and solid phases of precipitation separately, while others do not. Despite its practical importance for some hydrological applications, it would be unrealistic to include in-depth discussions on frozen precipitation in the assessment report within a short timeframe.

(e) Structural Errors
As mentioned above, uncertainties in algorithm assumptions yield spatially and temporally inhomogeneous biases in precipitation estimates. Such systematic errors, or structural errors, do not readily average out and can be confused with real climate signals when analyzed without care. They are also very difficult to quantify based upon observations alone. We envision instead, a qualitative examination of these errors based upon result of (a) - (d) along input from the algorithm developers who are in the best possible position to anticipate such errors.

Summary

For a timely release of precipitation assessment reports, it is feasible to deliver interim reports targeted on a limited number of prioritized foci while a full assessment report is being prepared on a mid- or long-term basis. The prioritized assessment foci include:

- Global and regional climatology including the long-term trend.
- Time series analyzed in light of different modes of climate variability
- Extreme weather events focusing on PDFs of precipitation
- Frozen precipitation assessment
- Qualitative structural error analysis