The Multi Satellite precipitation Working Group (MSWG)

Chairs: **Ali Behrangi & Daniel Vila**

Members: ~ 40

Active Participants (20):

Malar Arulraj, Ali Behrangi, Yagmur Derin, Ardeshir Ebtehaj, Chris Funk, Andy Heymsfield, Chris Kummerow, Zhong Liu, Viviana Maggioni, Hiro Masuanga, Davide Melfi, Yoo-Jeong Noh, Ana Nunes, Giulia Panegrossi, Veljko Petkovic, Heikki Pohjola, Andrea portier, Jackson Tan, Pingping Xie, Yu Zhang,

Sorry if I missed your name

The multi satellite precipitation working group originally formed since IPWG 10 in Fort Collins to discuss 2 major questions:

1. **Users' needs from global product producers**

1. **Global product producers' needs from the research community.**

Consequently, a google-doc was constructed, and participants participated by replying to (and/or adding) a few questions.

A summary of the outcomes is reported as follows.

The multi satellite precipitation working group originally started to discuss 2 major questions:

1. Users' needs from global product producers

- Participants agreed that **latency** seems to be a priority and preferred to be less than one hour to be useful. For flash flood probably 30 minutes is needed. The group, however, recognize that this is application dependent.
- It was also suggested that there is a need for a **unified evaluation system** so the data set can be submitted to that and evaluated. There are already a few examples of such systems, but they tend to be local. They also need to be well-documented.
- Importance of **sub monthly bias adjustment** of satellite products were emphasized, however for near real time products that might be challenging.
- Participants emphasized the importance of **homogeneity of the datasets** For climate analysis, however they also recognized that with different microwave sensors in orbit this may not be an easy task. There might be a tradeoff between near real-time accuracy and consistency of the record.

The multi satellite precipitation working group originally started to discuss 2 major questions:

2. Global product producers' needs from the research community.

- The need for **long term record of IR** data containing at least window but also water vapor channel was emphasized.
- The group felt that there is a need for a core satellite (active and passive sensors, like GPM) and constellations of MW small satellites for more frequent sampling of the precipitation with no time-gaps larger than 3 hours.
- **W band seemed essential for high latitude precipitation/snowfall**, but the presence of surface clutter and attenuation remain the most relevant limitations. Finer range resolution and wider swath of W band were recommended.
- **Infusing lower PMW frequency channels**, together with improved spatial resolution, were suggested. It seems that the more recent satellites are moving away from the low frequency channels.

Heikki Pohjola of WMO suggested we should also pay attention to the OSCAR/Space information about current and future sensor capabilities to guide our discussion https://space.oscar.wmo.int/spacecapabilities

After 2 zoom meetings, the group felt that a common theme for both users and developers of the products is **uncertainty quantification and how to communicate uncertainty**. *IPWG co-chairs recommended to focus on the uncertainty discussion.*

Uncertainty focus group:

Ali Behrangi, Yagmur Derin, Pierre Kirstetter, Chris Kummerow, Andrea Portier, Daniel Wright,

- We recognized that there is no universal definition/need for uncertainty information. Therefore, we thought about **developing a survey** to share with the community and learn from their need and interest. We originally faced with some specific questions like:

➢ What is it that we should provide with our estimates? Uncertainty? Quality index?

➢ Assuming that we can find it for a location, how do we generalize it to locations without GV data?

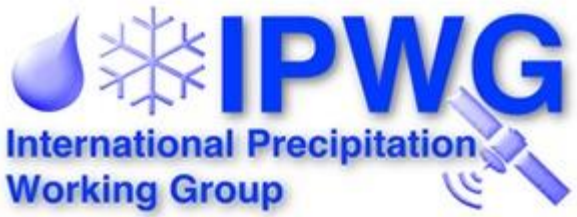
➢ Is it enough to say ±10%? Does that really mean that for example 0.1 mm/hr estimate is accurate to within 0.01 mm/hr?.

➢ Errors are really not gaussian, what exactly do we mean/want by uncertainties reported in the files?

- During the PMM STM 2023 we found that GPM application team is also interested in such discussions and surveys. This led to a **joint effort between the IPWG multi-satellite WG** and **the Global Precipitation Measurement (GPM) Mission applications team**, having a similar interest. The goal of the survey is to assess data requirements and uncertainty needs of stakeholder user communities across space and time scales to facilitate the development and improvement of precipitation data products and data formats that users need to enable their application.

- An initial uncertainty survey was developed. In the survey we are asking for feedback from a range of user communities to provide their requested ***uncertainty information to precipitation data developers***. In addition, we have a section *for* ***Assessing Data Attribute Tradeoffs***. As such, **this survey is intended for users of precipitation data products and will help bridge the gap between data developers and the community.**
- Details are being finalized, but the group, encouraged by Chris Kummerow, felt that it is important to first provide a brief tutorial about the precipitation products strengths and limitations before users start to respond. This is to make sure we have a common baseline. An example of the survey that is being developed (incomplete) is here. https://docs.google.com/forms/d/e/1FAIpQLSfoVvuv5AQBb0dSx885jMGB7W56qKr8qNo1r7v_IyUiOq71PA/viewform
- The survey was shared with the broad Multi-satellite WG members and comments /suggestions were requested (2 broad-WG emails)

The survey


IPWG
International Precipitation
Working Group


全球降水観測計画
GPM
GLOBAL PRECIPITATION MEASUREMENT

Understanding Stakeholder Uncertainty Needs

Goal of Survey: The Global Precipitation Measurement (GPM) Mission Applications Working Group and the International Precipitation Working Group are assessing data requirements and data uncertainty needs of stakeholder user communities across space and time scales to help facilitate the development and improvement of precipitation data products and data formats that users need to enable their application.

Rationale: Precipitation uncertainty is critical for scientific analysis and applications. However, little efforts has been made to understand what user communities really need and what developers should provide with their products.

These two working groups are asking for feedback from a range of user communities to provide this needed information to precipitation data developers. **As such, this survey is intended for users of precipitation data products and will help bridge the gap between data developers and the community.**

**If you have any questions or comments about this survey, please do not hesitate to reach out to Andrea Portier (GPM Applications Lead) at andrea.m.portier@nasa.gov.*

* Indicates required question

1. What is your precipitation related application? *

- [ ] Weather Forecasting and Modeling
- [ ] Subseasonal to Seasonal Forecasting and Modeling
- [ ] Climate Forecasting and Modeling
- [ ] Extremes: Process Understanding
- [ ] Disasters Forecasting
- [ ] Disaster Modeling and Monitoring
- [ ] Weather Index Insurance
- [ ] Water Resources
- [ ] Agriculture and Food Security
- [ ] Transportation and Logistics
- [ ] Alternative Energy
- [ ] Public Health
- [ ] Ecosystem Management
- [ ] Rules, Policy, and Regulation
- [ ] Other:

2. Describe your primary use of and at what space and time scales that you use satellite precipitation data to facilitate applications and inform decisions? *

Your answer

3. What degree of user would you consider yourself with respect to using satellite precipitation data products? *

- ○ Novice
- ○ Intermediate
- ○ Expert

4a. What is the satellite precipitation product that you use most often for applications? *

**Think of the main satellite precipitation product that you are using or plan to use for your application. Please be specific and state only one (e.g., IMERG V07A Final Run half-hour, GSMaP_Gauge_NOW).*

Your answer

4b. Based on your answer from Q4a, what are needed baseline attributes of *this data product* to enable your application: *

- What is its spatial resolution? (e.g., 0.1 deg. Lat/Long)

- What is its temporal resolution? (e.g., 30 min)

- What is its current latency? (e.g., 4 hours)

- How far back in time it goes? (e.g., since year 2000)

-Do you feel/perceive that uncertainty information is critically missing for your application?

Your answer

4c. **Assessing Data Attribute Tradeoffs:** What attribute improvements do you want to see in the data product you mention in Q4a? *

Imagine you are invited to advise the data developers of the above product on how they should prioritize their efforts for your application. Rank and assign each aspect a value of 1, 2, 3, 4 or 5, with 1 being very little prioritization (i.e., you are happy with the current product) while 4 being all effort.* ***All attributes need to be assigned a unique number and you should not select a number twice.*

	1. Low	2. Minor	3. Moderate	4. Significant	5. Required
Improving accuracy	☐	☐	☐	☐	☐
Increasing resolution	☐	☐	☐	☐	☐
Reducing latency	☐	☐	☐	☐	☐
Extending the length of the record	☐	☐	☐	☐	☐
Improving uncertainty information	☐	☐	☐	☐	☐

4d. **Assessing Data Attribute Tradeoffs:** It would be helpful if you share your rationale from your selection in Q4c.

Your answer

5. **Product Uncertainty:** For locations without ground validation data, how should we generalize precipitation uncertainty? *

**Describe the information or data that would be useful to you and your application.*

Your answer

6. **Product Uncertainty:** Is it enough to say ±10% (e.g., that 0.1 mm/hr estimate is accurate to within 0.01 mm/hr)? Please provide a rationale to your response. *

Your answer

7. **Product Uncertainty and Wishlist:** If you could receive uncertainty information in a specific way (e.g., expressed quantitatively vs qualitatively, in a specific data format, or a variable such as distribution uncertainty information, etc) to trust the data and further enable your application, what is it then that data developers should provide with precipitation estimates? *

Your answer

8. **Understanding the User Perspective:** Errors are really not Gaussian, having complicated correlation scales, etc. What exactly do we mean by uncertainties that we report in the files? *

Your answer

9. Please enter your email if you give permission to contact you with potential follow-up questions or would like to participate in a potential stakeholder-driven uncertainty workshop.

Your answer

Submit Clear form

An example for a brief tutorial about the precipitation products strengths and limitations before users start to respond

Chris Kummerow:
Intro text

Weather it is a rain gauge, a radar or a satellite sensor, all products have uncertainties. The uncertainties, while having different magnitudes, tend to have very similar overarching properties – namely that some errors are random and average out over time, while some are systematic.

For rain gauges, random errors come about because rainfall consists because at these small scales, the impact of a single raindrop falling into the gauge or next to it causes noise. This averages out in minutes. At the same time, wind is known to cause gauges to under-catch precipitation. This is most severe when light drizzle is being blown sideways by a strong wind at the surface. Heavy rain is less affected. This create biases, but they are not consistent in time or location. They depend on the rain rates a given location experiences, and the wind speeds that are common at that location.

Satellite precipitation also has issues similar to gauges. Some errors are random and some depend on local conditions. Random errors easily occur, for instance, because satellites are looking at rain drops or ice particles well above the surface that take some time to fall and may fall some horizontal distance away from where they are observed. These average out as we consider larger areas and longer time periods. Satellites also have systematic errors that are due to the environment under which the precipitation formed. Over land, for instance, radiometers often used to detect rain require ice to form as it does in most thunderstorms. Over islands like Hawaii, however, one often gets very heavy rain without any ice in the clouds. Radiometers underestimate these events significantly and consistently, making even climatological products suspect. While this is an extreme example, all satellite products have difficulties reporting what they think are random vs systematic errors, and if applicable, space and time scales at which these errors should average out.

For XX (e.g. hydrology of medium size basins specifically, ……

We are therefore soliciting input from users to (a) help better report the key information we may already have, and (b) prioritize the research needed to improve our ability to provide essential information we do not yet have

Another example ....

Temporal sampling uncertainty:

The temporal distribution of precipitation at a given location could be very important. This can be obtained true rain gauges with recording system but if readings are performed every few hours then we will miss the temporal distribution of precipitation. Satellites enable to produce instantaneous maps of precipitation but this is not continuous in time. Some satellites orbit the earth so they can observe the earth at a given location once or twice a day. There are other satellites that can stay over a region (stationary with respect to the Earth; referred to as geostationary satellite), enabling us to estimate precipitation right every few minutes but with a lower accuracy than those that orbit the earth. Currently to improve the accuracy and reducing the temporal sampling of precipitation from satellites a combination of multiple satellites are being used through merging methods that may be different from one merged-product to the other. This is how we currently can provide precipitation estimates every 30 minutes, partly limited by the sampling frequency of geostationary satellites. This can produce uncertainties in capturing the exact timing of precipitation events peak and/or termination. More advanced satellites have enabled us to obtain a higher temporal sampling regionally, but not necessarily globally.

Surface type uncertainty:

Rain gauges measure the amount of participation falling inside their bucket. However, satellites retrieve precipitation rate based on the observed radiation that can be affected by surface and atmospheric conditions, for example the presence of clouds, hydrometeors, and humidity in the atmosphere and in some cases surface type. The presence of snow and ice on the surface can sometimes be confused by the presence of ice particles in clouds and could be a source of uncertainty in our precipitation retrievals….

We have received only a few comments so far, so **more comments or suggestions or modifications are appreciated.**

Hi Ali,

The survey looks pretty good to me! The only [minor] suggestion I have is to consider eliminating the requirement on providing an answer to any except the first three questions. I typically give up on surveys (those I am not required to do) as soon as I run into a question I don't care too much about or is not relevant to what I do but I am not allowed to skip it.

Veljko

An example of a feedback (from Giulia Panegrossi):

Dear Ali and Daniel,
thank you for your great work and for your email.
I have taken a look at the survey, I would suggest:

- adding "operational hydrology" or "hydrology" among the key applications, and maybe being more specific in "disaster modeling and monitoring" and "disaster forecasting" (maybe flood/drought forecasting or weather/precipitation related disaster?).

- About uncertainty, this is really crucial and complex, since the error is regime dependent (to define a unique % for all regimes might not be enough), and it also depends on precipitation processes (we have larger uncertainties in some conditions, e.g., orographic precip., shallow precip., warm rain etc.).

- Moreover, **depending on the application it might be important to define the error on precipitation *amount* or precipitation *intensity* which are very different quantities and have different dependencies**.

- Moreover, **the error on precipitation detection (and not only quantification) is also quite relevant for several applications.**

At the moment, I don't have specific suggestions on how we could represent such complexity in the survey.

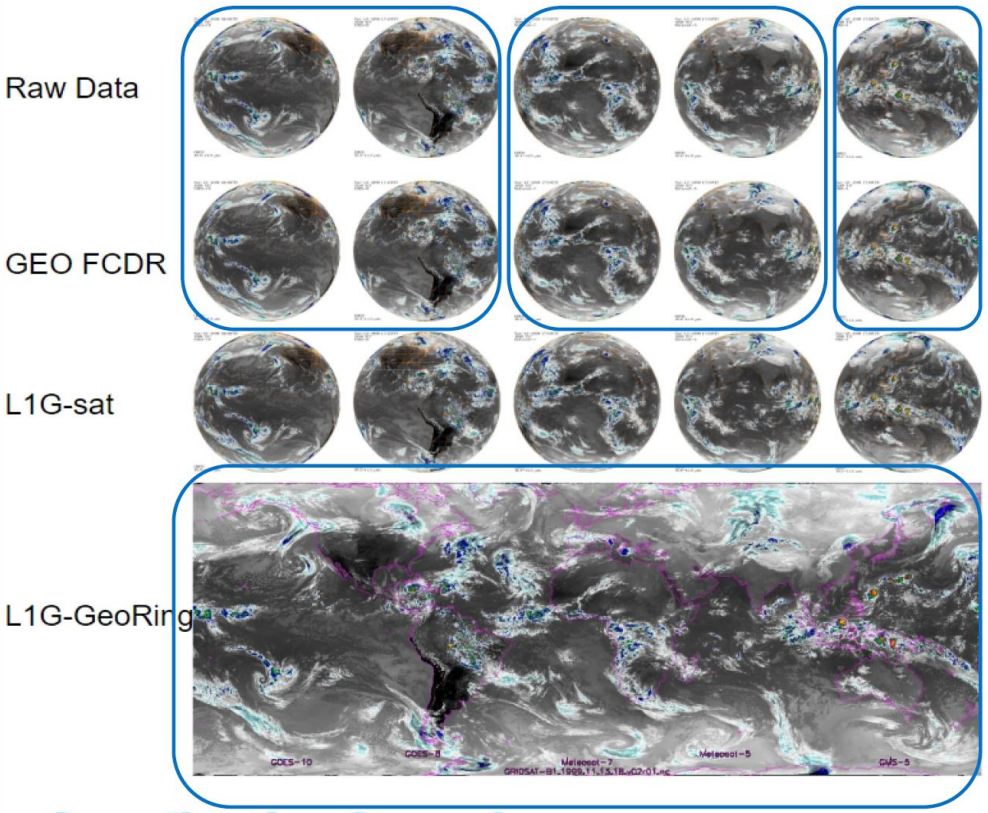
GEO-Ring:

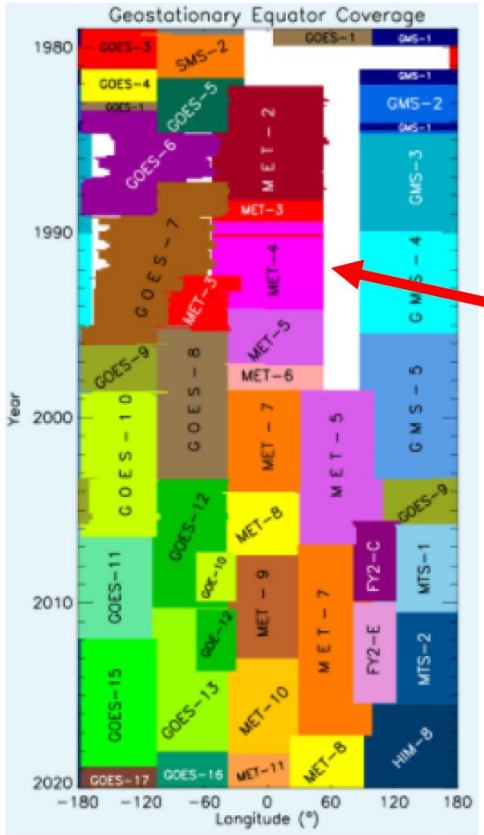
- IPWG leadership recommended that we include a discussion about GEO-Ring at IPWG-11. Viju John can help us on this discussion and convey our message/recommendations to Jörg
- IPWG needs to be aware of the data policy for L1 data, redistribution, etc.
- There is an interest in using multi-spectral data to enhance IR based products

GEO-Ring:

Coordination Group for Meteorological Satellites - CGMS

EUMETSAT-NOAA GEO-Ring project with contributions from JMA and IMD





- GEO-Ring radiance data 1974-today and beyond
- Includes rescued data from SMS-1/2, GOES 1-7 and ~10 years INSAT data
- Nominal resolution is 30 min, 0.05° and all spectral channels
- Project runs 2023-2027 and aims at best and longest radiance climatology ever
- First data 2025/2026

Coordination Group for Meteorological Satellites

EUMETSAT CGMS

Reference: Jörg Schulz/CGMS talk at EUMETSAT, 2024

GEO-Ring:

- CGMS agencies EUMETSAT and NOAA started a bilateral activity to reconstruct radiance measurements into a Fundamental Climate Data Record (FCDR) from all historical measurements from imagers in geostationary orbit, forming the Geostationary Ring or GEO-Ring.
- The envisioned resulting climatology will come with **30-minute temporal and approximately 0.05°** spatial sampling. **It would start with data in the mid-1970s and extend to today's much more advanced measurements spanning 50 years'** worth of data.
- The steps that need to be undertaken to generate the FCDR include **data rescue, quality control, sensor recalibration and cross-calibration, production, and validation**. It may need codeveloping and distributing the data record using **cloud environments** and consideration of applicable data policies of participating agencies to make this most beneficial for the users.
- CGMS agencies are invited to contribute to this activity and to **its possible extensions such as addition of imager data from polar orbiting satellites and atmospheric sounding instruments** in the future.
- GEO-Ring imaging data records **could be produced at low latency (~5 days)** if initial project on past data is successful

Reference: Jörg Schulz/CGMS talk at EUMETSAT, 2024

Key issues of relevance to CGMS:

Data Policy Awareness

- ☐ Data processing and distribution via cloud systems is a relatively new way of addressing data production together.
- ☐ We need to be aware about the data policy for L1 data and rights required for redistributing L1 data of another agency
- ☐ May need to consider harmonization of data policies for the specific GEO-FCDR, L1g-sat, and L1G-GeoRing data looking at different user groups, e.g., public sector services, research, and commercial users

To be considered by CGMS:

Coordination of GEO-Ring work

- ☐ EUMETSAT/NESDIS have partnered together in a Bilateral Activity
- ☐ JMA has contributed data to both the GEO-Ring FCDR and ISCCP-NG
- ☐ IMD has started to contribute data to the GEO-Ring FCDR
- ☐ KMA and CMA have expressed interest in GEO-Ring/ISCCP-NG L1g activities
- ☐ PoC: Jörg Schulz, EUMETSAT and Andrew Heidinger, NOAA

Potential Extension of GEO-Ring activities

- ☐ GEO-Ring imaging data records could be produced at low latency (~5 days) if initial project on past data is successful
- ☐ GEO-Ring imaging data records could be enhanced with imager data from polar orbit to become truly global
- ☐ GEO-Ring data sets can be envisaged also for atmospheric sounding instrument data

Reference: Jörg Schulz/CGMS talk at EUMETSAT, 2024

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- ❑ IPWG needs to be aware of the data policy for L1 data, redistribution, etc.

- ❑ Joe? Chris? George? Any other points you want to make?

Summary:

Based on this in our upcoming Multi-satellite WG discussion we will:

- Continue discussing what really "Developers need to know from users"
- What can we do to help the users?
- Refine the survey: focus on *uncertainty but* can include other important questions. For example, "*Assessing Data Attribute Tradeoffs*"
- Discuss what we can do in the era of new data sets : GEO-Ring, small sats, EarthCARE, etc. **What are our needs and concerns?**
- **Other topics to discuss? Any suggestions ? Let us know….**

e.g., planning for the next IPWG high res. precipitation assessment:

- Objectives, methods, features/metrics, period, region, etc. (this should go beyond the multi-satellite WG).