IMERG V06 Ground Validation Wishlist

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Introduction

To precipitation algorithm developers, ground validation results are useful feedback for assessing product quality, benchmarking performance against existing datasets and previous versions, and identifying surprising or unexpected results. This is particularly pertinent to multi-satellite datasets such as IMERG, whose inputs can have considerably different characteristics. The huge range of diverse studies on ground validation of IMERG has provided valuable feedback to the IMERG algorithm development team. To further enhance the value of ground validation studies to the IMERG team, we have compiled a list of items for which insights from ground validation will be especially useful to the improvement of the algorithm. Some of these ground validation aspects have already been done—either in published studies or by the GPM Ground Validation Office—but more results, particularly over different regions or using different reference datasets, are always useful.

This list applies primarily to IMERG V06B. Details about the algorithm can be found in the Algorithm Theoretical Basis Document (Huffman et al. 2019a) and the Release Notes (Huffman et al. 2019b). We do not expect a major upgrade of IMERG (i.e. to IMERG V07) before the end of 2021, so this presents users with the opportunity to assess a "stable" version of IMERG.

If you have any results or studies on such ground validation, please contact us at george.j.huffman@nasa.gov.

Ground Validation Wishlist

1) Biases of different sensors within IMERG

Due to differences in instrument channels, footprint size, and scan strategy, sensors in the GPM constellations have different performances (Tan et al. 2018; Kidd et al. 2018). The intercalibration of all passive microwave (PMW) estimates aims to mitigate the mean bias of each sensor. Knowledge of biases in the calibrated PMW estimates can help the IMERG team refine the intercalibration process. The data fields `HQprecipitation` and `HQprecipSource` can facilitate such validation activities.

2) Performance of morphing near orography

In IMERG V06, motion vectors for morphing are computed from total precipitable water vapor (or total column water vapor), TQV, which is a vertically integrated quantity from MERRA-2 (IMERG Final) and GEOS FP (IMERG Early and Late). However, TQV is affected by orography due to a reduction in the vertical column, and it is not clear what effect this has on the accuracy of motion vectors (Tan et al. 2019). Therefore, evaluations of morphed estimates, which can be identified through the data fields `HQprecipSource` and `IRkalmanFilterWeight` (Tan et al. 2016), can aid the IMERG team in assessing the impact of orography on the motion vectors and evaluating the merits of variables besides TQV.

3) Performance of PMW precipitation and IR precipitation over frozen surfaces

Due to the challenges in accurately retrieving passive microwave (PMW) estimates over snow- and ice-covered surfaces, IMERG falls back to infrared (IR) precipitation estimates over frozen surfaces as indicated by the NOAA AutoSnow product. Recent progress in the PMW retrieval algorithm, the Goddard Profiling (GPROF) algorithm (Kummerow et al. 2015), may have brought PMW retrievals to a level competitive with IR estimates over frozen surfaces. Therefore, assessments comparing PMW estimates (`HQprecipitation`) and IR estimates (`IRprecipitation`) over frozen surfaces—both for rainfall and for snowfall, and also as a function of surface temperature—can assist the IMERG team in deciding whether the preference for the IR precipitation over frozen surfaces is justified.

4) Accuracy of precipitation phase and/or snowfall rates

Snowfall is a focus in the GPM mission. Estimates of precipitation phase are currently provided in IMERG (data field `probabilityLiquidPrecipitation`) through a diagnostic scheme (Sims and Liu 2015) using wet-bulb temperature computed from model and reanalysis data. This estimation of precipitation phase is independent of the retrieval of precipitation rates in GPROF. However, evaluation of this phase probability and the rate of frozen precipitation against ground stations capable of measuring snowfall has thus far been limited (e.g., Wen et al. 2016). Note that this is different from a broad evaluation of wintertime precipitation, which does not necessarily translate to frozen precipitation. More information on the accuracy of such quantities can help the IMERG team adjust the parameters of the scheme.

5) Diminished performance during cold season

Related to the previous two items, ground validation studies often show that satellite retrievals are inferior to numerical model outputs during the winter season in the mid-latitudes. However, it is not established whether this poorer performance is primarily driven by snowfall, frozen surfaces, surface temperature, or winter precipitation systems in general (or a mix of factors). These results also apply only to the previous generations of products (e.g., TMPA); it remains to be seen if IMERG can outperform numerical models in mid-latitude winters. If IMERG remains inferior, an examination into the possible causes of the diminished performance of IMERG during winter will allow the IMERG team to begin resolving the issue.

6) Accuracy of quality index

Quality index (QI) is a quantity introduced in IMERG V05 and improved in IMERG V06. [Note that there are two definitions of the QI: one for the half-hourly products and one for the monthly products.] This quantity is designed to provide users with a simplified characterization of the expected accuracy of the estimates. As it is a recently released variable, validation of the QI has been limited. Questions remain as to whether the QI reflects the performance of the estimates and, if so, the precision of the relationship between the QI and performance. Therefore, evaluation of the QI (data field `precipitationQualityIndex`) can inform the IMERG team of its accuracy and assist in its further refinement. In addition, such results can provide guidance on the use of the QI in various applications.

7) Performance over "nontraditional" regions

While the extensive IMERG validations over many areas around the globe have been highly useful, there are regions which suffer from a paucity of validation. These includes high latitudes (above 60°N/S), over the oceans, and over sparsely-gauged areas such as Africa. However limited, some validation results over such regions can provide valuable indications of the reliability of IMERG where ground observations are limited.

8) Performance for extreme events

Due to their impact, extreme events such as intense rainstorms, tropical cyclones, and blizzards often receive significant attention. Hence, it is important for IMERG to be able to adequately represent such events. However, the rare occurrence of such events poses challenges both to the intercalibration and a robust evaluation of the estimates. Thus, evaluation of IMERG for extreme events, especially when broken down into its component estimates (i.e., PMW precipitation, IR precipitation) can give the IMERG team an understanding of its performance and feedback on whether adjustments to the intercalibration are necessary.

9) Metric of satellite/morphing-based "flickering"

Animations of IMERG data (e.g., https://svs.gsfc.nasa.gov/4285) show an east-to-west "flicker" that arises from satellite/sensor calibration differences, subtle details in the morphing, or perhaps something else. While this behavior is apparent in animations, its persistence through multiple versions of IMERG is partly due to the difficulty in quantifying it. It would be useful to develop a metric that separates this flickering from genuine variations, allowing us to (i) track how the flickering evolves with algorithm and sensor changes, and (ii) possibly indicate how the flickering can be addressed.

Considerations when performing ground validation

When performing ground validation for IMERG, there are several pieces of information that should be stated so the scope of the results is clear to the audience. These include basic information such as the IMERG version, Run, and variable that is being evaluated. Note that "IMERG" is not equivalent to "GPM"; the latter is a mission—involving a core satellite (the GPM Core Observatory) and a constellation of partner satellites—that produces different products that are based on DPR, GMI, and the passive microwave constellation, including IMERG. [So, for example, "IMERG validation" is not "GPM validation".] Furthermore, information on the reliability of the reference products is always essential. For example, how well are the ground instruments maintained? What are the quality control measures on the reference? What strategies are adopted to distinguish between reliable measurements and low quality estimates (e.g., that of snowfall)?

Several notes are in order for gauge-based validation of the Final Run. When gauges are used as the reference data, any overlap between those gauges and the GPCC gauges should be identified. While an overlap of the reference data with the GPCC gauges does not necessarily invalidate the results of the ground validation, it does mean that the results should be interpreted in context. For example, bias values, especially at the monthly scale, are expected to be small due to the overlap. However, statistics for sub-monthly precipitation characteristics are mostly not affected by the use of the monthly gauge analysis.

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