1.3. Monitoring of satellite precipitation estimates through the IPWG validation studies

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1.3.1. Status

The International Precipitation Working Group (IPWG) builds upon the expertise of scientists to provide a focus for the precipitation community to develop and improve precipitation measurements and their utilization, to improve scientific understanding of precipitation, and to further develop international partnerships (Turk and Bauer, 2006; Kidd et al., 2010; Levizzani et al., 2018). A major activity of the IPWG is the verification, validation and intercomparison of precipitation products to enable product developers and users to continually monitor and assess the performance of the available products. This activity has developed an ongoing validation program, comparing surface reference datasets and satellite precipitation products to better inform product developers and the user community.

Several key precipitation intercomparison projects have been organized to assess satellite-based products against surface data. These have included regional and global assessments of the Global Precipitation Climatology Project (GPCP) Algorithm Intercomparison Programme (AIP) series (see Arkin and Xie, 1994; Barrett and Bellerby, 1992; Allam et al., 1993; Ebert, 1996; Ebert et al., 1996), and of the NASA WetNet Precipitation Intercomparison Projects (PIP) series (see Barrett et al., 1994; Smith et al., 1998; Adler et al., 2001). Since 2002, a number of validation sites have been organized by IPWG members, based primarily upon the availability of their regional surface reference datasets (see Kidd et al., 2020). Comparisons of the satellite/model precipitation products against surface data are typically analyzed at the 0.25°x0.25°, daily scale in near real time, although intercomparisons at the full, instantaneous resolution of the products have also be developed (see Kidd et al., 2018.)

The validation work of the IPWG should be seen as complementary to the targeted ground validation (GV) campaigns of mission-specific programs (Skofronick-Jackson et al., 2015; Petersen et al., 2016; Petersen et al., 2020). Key differences relate to the end goal of the validation: the IPWG validation aims to improve satellite precipitation products, focusing upon statistical analysis over regions with existing reference data at moderate temporal/spatial resolutions. Mission-specific validation tends to relate more to the microphysical scale, aimed at improving our fundamental understanding of precipitation-observation capabilities using a multi-tier (satellite, airborne, surface) approach at fine, instantaneous resolutions.

Figure 1.3.1 shows the global distribution of the IPWG validation regions together with the source of their validation data. Note that these are largely operated on a best-effort basis with only a few regions receiving funding, and consequently not all regions operate continuously (also due to cyber-security issues). The development of a validation region over the Indian subcontinent through collaboration with the Indian Meteorological Department is ongoing.

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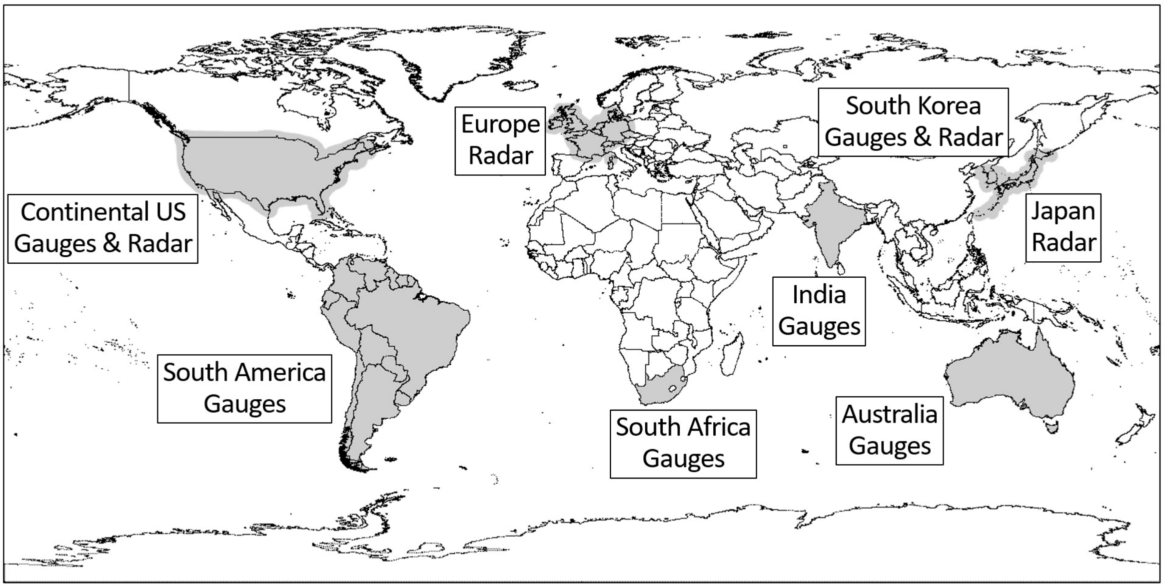

Figure 1.3.1. Distribution of past and current IPWG validation regions and their surface reference datasets.

The surface reference data for the IPWG sites encompasses surface radar and/or gauge datasets. Radar data are in many ways most useful since they provide frequent, regular spatial measures of instantaneous precipitation, which can be easily matched to the satellite data. Aggregating these data into daily totals to match the satellite/model precipitation products is relatively easy. However, care is needed to address artefacts in such data (for example, missing low-level precipitation beam blockage, anomalous propagation errors, etc). Gauge data, at least for these studies, are usually already gridded and reported at (local time) daily scales: as such, the gauge data may not be co-temporal with the satellite products, which usually accumulate midnight–midnight UTC. Some regional variations between the sites is therefore inevitable to ensure that the most is made of the available surface datasets.

Each of the IPWG sites is hosted by local institutions, although all provide similar information on the assessment of the precipitation products and surface data at a common scale (see http://www.isac.cnr.it/~ipwg/calval.html). These assessments follow a strategy of keeping any analysis clear and simple to ensure that they are understandable and pertinent to the user community. An example of a daily validation display for South Korea is shown in Figure 1.3.2. The information contained generally includes images of co-registered satellite/model and surface products for visual analysis and placing the statistics with the context of particular meteorological events. Satellite/model–surface scatterplots, cumulative distribution plots and bar plots provide further visual information on the product performance. Statistical information is provided through categorical statistics of probability of detection (POD), false alarm ratio (FAR) and Heidke Skill Scores (HSS), descriptive statistics for both the estimates and observed precipitation, and statistical scores, that is, bias, ratio (product/validation), RMSE, correlation coefficient and number of samples. Together, this information can be used by both the algorithm/product developer and the user to assess the performance of different algorithms, over different regions, for different meteorological situations.

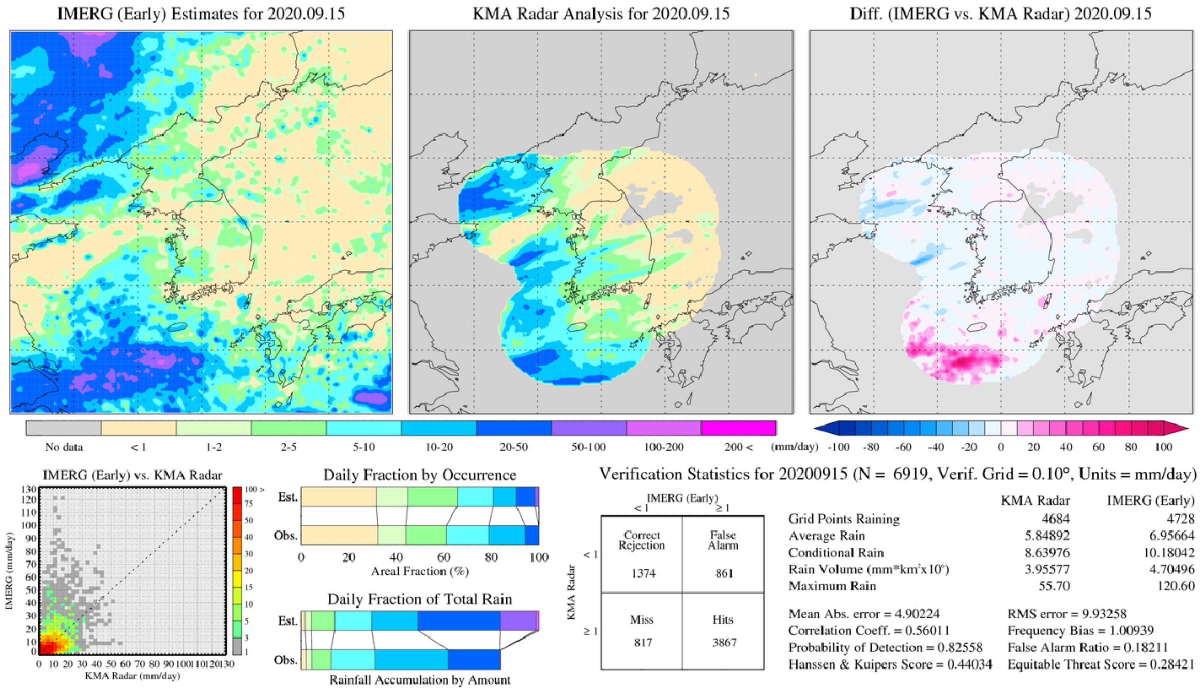

Figure 1.3.2. Example of IPWG validation over South Korea for the IMERG product versus the Korea Meteorological Administration radar analysis on 15 September 2020.

In addition to the near real time "monitoring" assessments, more detailed studies have been done to evaluate the precipitation products over a longer record and with a greater degree of accuracy. For example, the IPWG validation site over Japan, started in 2003, uses radar data from the Automated Meteorological Data Acquisition System (AMeDAS) network (Makihara et al., 1996; Makihara, 2007). Studies have included the assessment of precipitation products (Kubota et al., 2009) together with the evaluation of their Global Satellite Mapping of Precipitation (GSMaP) product over mountainous regions (Shige et al., 2013, 2014; Taniguchi et al., 2013; Yamamoto and Shige 2015; Yamamoto et al., 2017). They note, however, that validation of heavy, but shallow snowfall (see Murakami et al., 1994) is beyond the scope of this study (and many others). Studies over South America using daily rain gauge data have shown varying biases in satellite estimates on seasonal scales (see Kidd et al., 2020). Other IPWG-related studies have investigated smaller temporal/spatial scale comparisons, such as Kidd et al. (2012) together with the representation of the diurnal cycle at the global scale (Kidd et al., 2013). Maggioni et al. (2016) reviewed satellite precipitation validation efforts during the TRMM era, identifying mountains and semiarid areas as problematic geographic regions, seasonal problems associated with winter, and problems associated with light rainfall, snowfall and mixed-phase precipitation.

1.3.2. Recommendations

Key areas that have been identified for further development within the IPWG validation program are:

i. inclusion errors and uncertainties in the validation process,
ii. validation of snowfall,
iii. validation of precipitation, where possible, over open-ocean regions, and
iv. large scale validation against existing precipitation climatologies [such as from the Global Precipitation Climatology Centre (GPCC)].

Crucial to the validation activities of the IPWG is the need for practical funding since most of this work continues unfunded at present.

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