Title: Integrated Multi-Satellite Evaluation: Impact of Precipitation Characteristics on Spaceborne Precipitation Estimation

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Gridded precipitation rates retrieved from space sensors with quasi-global coverage feed numerous applications ranging from water budget studies to forecasting extreme events and natural hazards. Characterizing the error structure of satellite precipitation products is recognized as a major issue for the usefulness of these estimates. Despite numerous and extensive validation efforts, gaps in error characterization still hinder the improvement of satellite precipitation estimates. An integrated multi-product perspective is proposed to advance satellite precipitation validation, that accounts for the propagation of QPE uncertainty from low-earth orbiting (LEO) active/passive microwave precipitation estimates (Level-2) to gridded QPE (Level-3). It aims at providing users and algorithm developers with an assessment adequately coping with the varying performances of merged satellite precipitation estimates. This approach explicitly diagnoses the impact of precipitation characteristics that significantly drive errors, especially when these characteristics are not accounted for in the Level-2 retrievals. Examples focus on precipitation typology and precipitation small-scale variability. This approach is illustrated with the Global Precipitation Measurement mission that aims at unifying precipitation measurements from a constellation of LEO sensors with various capabilities to detect and quantify precipitation, in combination with geostationary observations to provide gridded precipitation accumulations. The GPM Core Observatory satellite serves as a calibration reference for consistent precipitation retrieval algorithms across the constellation. The impact of precipitation typology and variability on QPE from the Level-2 GPM Core Observatory Dual-frequency Precipitation Radar (DPR) to the Microwave Imager (GMI) to Level-3 IMERG precipitation will be discussed. We show that systematic biases related to precipitation characteristics display consistent features across Level-2 and Level-3 products. It highlights the need to better resolve key precipitation characteristics from space and the room for improvement in global-scale precipitation estimates.