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Characterization and Modeling of Satellite-Based Precipitation Uncertainty over Complex Terrain

Abstract:

The availability and quality of precipitation estimates is essential to the accuracy and reliability of hydrological modeling studies. Difficulties in the representation of high rainfall variability over mountainous areas using ground-based sensors make satellite-based precipitation products (SPPs) attractive for hydrological studies over such regions, since these products are quasi-global and available at high spatial resolution. Evaluation of several SPPs using rain gauge networks over ten mountainous regions across the globe has shown their performance is highly dependent on advancing the quality of primary data sources, one of which is passive microwave (PMW) retrievals.
The evaluation of PMW retrievals is challenging, since it requires reference datasets with high temporal and spatial resolution. This difficulty can be overcome through the use of experimental ground radar (GR) X-band polarimetric radar observations. The Self-Consistent Optimal Parameterization-Microphysics Estimation (SCOP-ME), an algorithm that uses best-fitted functions of specific attenuation coefficients and backscattering differential phase shifts used to retrieve rainfall rates and microphysical characteristics from GR. GR deployments over mountainous regions are used to evaluate the error characteristics of SCOP-ME retrieval and provide high-resolution estimates of the 4D rainfall variability. These estimates represented the benchmark precipitation dataset, which are then used in the error characterization and modeling of the PMW retrievals. To understand the source of uncertainties, a sampling volume-matching methodology is implemented between PMW and GR. The PMW retrievals showed weaker covariation than GR, with magnitude-dependent systematic error going from overestimation of light precipitation to, mainly, underestimation of heavier precipitation.

Overall, these investigations indicated that PMW retrievals have uncertainties that necessitate the use of error characterization and correction procedures, especially over complex terrain. This called for error modeling of the PMW retrievals, which is conducted with quantile regression forests (QRF), a nonparametric tree-based model. The ensembles generated through the QRF model are validated by independent matchups of PMW and GR data from four complex terrains. Validation of the error model is conducted in two ways, the k-fold and leave-one region out cross validation techniques. The study showed that the error model significantly reduces both mean relative error and the random component of the error compared to the original PMW products. Moreover, it demonstrated transferability of this error model among complex terrain regions around the globe, which will allow algorithm developers to integrate it to produce Level 3 products.