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TRMM- and GPM-based precipitation analysis and modelling in the Tropical Andes

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Despite wide-spread applications of satellite-based precipitation products (SPPs) throughout the TRMM-era, the scarcity of ground-based in-situ data (high density gauge networks, rainfall radar) in many hydro-meteorologically important regions, such as tropical mountain environments, has limited our ability to evaluate both SPPs and individual satellite-based sensors as well as accurately model or merge rainfall at high spatial resolutions, particularly with respect to extremes. This has restricted both the understanding of sensor behaviour and performance controls in such regions as well as the accuracy of precipitation estimates and respective hydrological applications ranging from water resources management to early warning systems.

Here we report on our recent research into precipitation analysis and modelling using various TRMM and GPM products (2A25, 3B42 and IMERG) in the tropical Andes. In an initial study, 78 high-frequency (10-min) recording gauges in Colombia and Ecuador are used to generate a ground-based validation dataset for evaluation of instantaneous TRMM Precipitation Radar (TPR) overpasses from the 2A25 product. Detection ability, precipitation time-series, empirical distributions and statistical moments are evaluated with respect to regional climatological differences, seasonal behaviour, rainfall types and detection thresholds. Results confirmed previous findings from extra-tropical regions of over-estimation of low rainfall intensities and under-estimation of the highest 10% of rainfall intensities by the TPR. However, in spite of evident regionalised performance differences as a function of local climatological regimes, the TPR provides an accurate estimate of climatological annual and seasonal rainfall means. On this basis, high-resolution (5 km) climatological maps are derived for the entire tropical Andes.

The second objective of this work is to improve the local precipitation estimation accuracy and representation of spatial patterns of extreme rainfall probabilities over the region. For this purpose, an ensemble of high-resolution rainfall fields is generated by stochastic simulation using space-time averaged, coarse-scale (daily, 0.25°) satellite-based rainfall inputs (TRMM 3B42/ -RT) and the high-resolution climatological information derived from the TPR as spatial disaggregation proxies. For evaluation and merging, gridded ground-based rainfall fields are generated from gauge data using sequential simulation. Satellite and ground-based ensembles are subsequently merged using an inverse error weighting scheme. The model was tested over a case study in the Colombian Andes with optional coarse-scale bias correction prior to disaggregation and merging. The resulting outputs were assessed in the context of Generalized Extreme Value theory and showed improved estimation of extreme rainfall probabilities compared to the original TMPA inputs. Initial findings using GPM-IMERG inputs are also presented.