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Investigating the Multi-dimensional Error Structure of Satellite Rainfall at Hydrologically Relevant Scales

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Advancing the development of hydrologically relevant satellite rainfall algorithms over land requires the use of error metrics that are mutually interpretable by hydrologists and data producers. Recent work has reported a multi-dimensional structure of satellite precipitation uncertainty with important implications for modeling the dynamic hydrologic state over land. At a minimum, the major dimensions of this error structure are known to be: (1) the joint probability of successful delineation of rainy and non-rainy areas accounting for a spatial structure; (2) the temporal dynamics of the conditional rainfall estimation bias; and (3) the spatial structure of the random deviation of conditional retrieval. While recognition of the detailed error structure is important for optimal integration of satellite precipitation data in hydrologic models, a comprehensive analysis as a function of scale against quality-controlled ground validation datasets is currently absent in literature. In this study, we systematically investigate the behavior of the multi-dimensional error structure parameters across scales ranging from 4 km to 96 km for a geo-stationary infrared based algorithm. We observe that a reduction in space-time scales for satellite rainfall estimation triggers a progression from a deterministic to a highly probabilistic state of error structure that is more complicated than the conventional first and second order moments (mean and standard deviation of error). The coefficient of correlation is found to be modestly sensitive to scales at resolutions smaller than 24 km. The probability of detection of rain and its functional relationship to ground validation rainfall are found to be most sensitive to scale followed by the correlation length for detection of rain. These types of specific error metrics that account for an algorithm's ability to capture rainfall intermittency therefore appear more informative for identifying the optimal spatial scales for data integration overland for the hydrologist. In addition, we hypothesize that, such error metrics, being computable by the data producing community, can lay a foundation

for better feedback to and from hydrologists towards development of the next generation of satellite rainfall algorithm in anticipation of the proposed Global Precipitation Measurement (GPM) mission.