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A framework for studying optimal satellite rain retrievals in hydrologic applications

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Understanding the interactions and feedbacks between precipitation and land surface processes is key to advancing the predictability of water cycle at scales varying from meso to regional and climate. A critical aspect in the investigation of land-atmospheric interactions is the need to resolve the precipitation variability over large regions with high temporal (of the order of 1-3 hours) and spatial (0.05-0.25 deg2) resolution. In the first part of the talk we will present an experimental framework aimed at evaluating optimality criteria of satellite rain retrieval error for use in land data assimilation systems. The framework includes a physically based land surface model implemented in a data-rich region, and uses rain retrievals from combination of passive microwave (MW) and Infrared (IR) satellite observations and cloud-to-ground lightning data. The selected region for this experiment is an area covered by the Oklahoma hydro-meteorological station network (MESONET). The area is under the coverage of the WSR-88D network, and of an array of MW satellites (TRMM, SSM/I), GOES-IR, and the National Lightning Detection Network. The Community Land surface Model (CLM) is used in this study. The model is forced with radiation and meteorological (winds, temperature, relative humidity) field data measured by the Oklahoma MESONET. High-resolution (hourly at 4x4-sqkm) rain gauge-calibrated WSR-88D rainfall fields are used as ground reference of precipitation. This experimental framework constitutes the basis for assessing a number of satellite rain retrieval schemes and evaluating their error structure in the prediction of hydrological and other land surface parameters. We will argue that limiting the evaluation of rain retrievals at the level of rain rate estimation error is not sufficient to identify retrieval techniques that are optimal in terms of other hydrological variables (e.g., runoff, soil moisture). We will demonstrate that a rain retrieval algorithm that optimally combines MW rain estimates with ¡-hourly

MW-calibrated IR/lightning rain rate fields would give significantly improved hydrologic variable error characteristics compared to current MW-calibrated IR techniques. The second part of this talk will address the issue of studying error propagation from rain estimation to hydrologic prediction. For this purpose a two-dimensional Satellite Rainfall Error Model (SREM-2D) that characterizes the spatio-temporal variability of satellite rainfall error structure is formulated and evaluated. A new paradigm of error structure formulation is embraced which models the necessary recognition that as the space-time scales become smaller the error structure of satellite rainfall becomes more complex and random. The most definitive TRMM PR estimates are used to calibrate SREM-2D parameters for algorithms operating on MW and MW-calibrated IR retrievals. A Monte Carlo simulation framework involving SREM-2D is devised to evaluate the impact of satellite rain estimation error on the simulation of several hydrological variables simulated by CLM. The statistical summary of uncertainty propagation in CLM via SREM-2D is compared with CLM simulations obtained from reference radar rainfall data. It is found that the algorithmic formulation of SREM-2D is a valuable tool for understanding the implications of satellite rainfall estimation error on surface hydrological applications.