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A Multi-scale Coherence Study between Microwave Satellite Soil Moisture Observations and Land Surface Model Simulations

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Soil moisture has been heavily investigated in numerous modeling and observational studies for its important role in terrestial hydrology. Nevertheless, soil moisture stays among the most difficult hydrologic variables to study for its enormous variability across different spatial and temporal scales. Recent advancements in modeling systems enable us to simulate the soil moisture changes at very high temporal and spatial resolution and over a large region using a land surface model (LSM) forced with observed or modeled meteorologies. North-America Land Data Assimilation System (NLDAS) is a good example of such implementations, where the soil moisture state can be estimated at 0.125 degree and hourly scale all over the contiguous US region. At the same time, microwave band satellite observations start to prove its great potential in retrieving soil moisture, and show its advantages over traditional approaches for its large coverage and relatively low cost. Successful efforts have been made in deriving soil moisture products from 10.7 GHz brightness temperature images obtained by TRMM Microwave Imager (TMI) and Advanced Microwave Scanning Radiometer for EOS (AMSR-E). Both these advancements in modeling system and remote sensing provide us a large amount of soil moisture data, but how they relate to each other at different scales, where/what the consistencies/gaps are, and how to transfer knowledge from one to another remain open questions. And these are difficult questions due to not only the difference between the two estimation approaches, complicated radiative transfer processes involved in remote sensing, and also the complicated behaviors of soil moisture itself. In this study, we compare the soil moisture retrieval based on TMI and simulated by VIC/NLDAS, and obtain their coherence levels at different temporal and spatial scales, using an approach similar to quantifying the predicative skills of a

climate model at different scales. To handle complicated behavior of soil moisture data here, the traditional measure of coherence between samples of two random variables, the r^2, which fits best Gaussian models, will be replaced by a Gaussian copula model with Beta marginal distributions. Soil moisture samples will be fit to a more reasonable Beta, instead of Gaussian, distribution, then the dependency structure is modeled by a Gaussian copula, and the coherence is measured by the r in this Gaussian copula. In other words, samples are "Gassianized" before the r is calculated. Additionally, the distribution-independent measure, Kendall's τ, is also tested in quantifying the coherence between the two. This study is intended not only to explore the relationship between two data sets, but also serves to illustrate a general method to study any other variables with non-standard behaviors.