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Scaling Applications in hydrology

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Besides downscaling applications, scaling properties of hydrological fields can be used to address a variety of research questions. In this presentation, we will use scaling properties to address questions related to satellite evapotranspiration algorithms, precipitation-streamflow relationships, and hydrological model calibration.

Most of the existing satellite-based evapotranspiration (ET) algorithms have been developed using fine-resolution Landsat TM and ASTER data. However, these algorithms are often applied to coarse-resolution MODIS data. Our results show that applying the satellite-based algorithms, which are developed at ASTER resolution, to MODIS resolution leads to ET estimates that (1) preserve the overall spatial pattern (spatial correlation in excess of 0.90), (2) increase the spatial standard deviation and maximum value, (3) have modest conditional bias: underestimate low ET rates ($<$ 1 mm/day) and overestimate high ET rates; the overestimation is within 20%. The results emphasize the need for exploring alternatives for estimation of ET from MODIS.

Understanding the relationship between the scaling properties of precipitation and streamflow is important in a number of applications. We present the results of a detailed river flow fluctuation analysis on daily records from 14 stations in the Flint River basin in Georgia in the United States with focus on effect of watershed area on long memory of river flow fluctuations. The areas of the watersheds draining to the stations range from 22 km2 to 19,606 km2. Results show that large watersheds have more persistent flow fluctuations and stronger long-term (time greater than scale break point) memory than small watersheds while precipitation time series shows weak long-term correlation. We conclude that a watershed acts as a "filter" for a "white noise" precipitation with more significant filtering in case of large watersheds.

Finally, we compare the scaling properties of simulated and observed spatial soil moisture fields in the Little Washita watershed in the United States. Results show that the simulated soil moisture patterns are more fragmented, being more reluctant to organization, than observed soil fields. This is an indication that model simulations, while reproducing correctly the total streamflow at the outlet of the watershed, may not accurately reproduce the runoff production mechanisms. Consideration of the scaling characteristics of spatial soil moisture fields can therefore serve as a more intensive means for validating distributed hydrologic models, compared to the traditional approach of only comparing the streamflow hydrographs.