Application of Multiplicative Random Cascades to Spatially Downscale Observed Terrestrial Water Storage Anomalies

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Abstract. Gravity Recovery and Climate Experiments (GRACE) satellite mission has been observing terrestrial water storage anomalies (TWSA) at a monthly scale since 2002. Given its coarse spatial resolution (*i.e.* ≥160,000 km^2), TWSAs have been used in numerous hydrological studies at a regional scale. However, TWSA spatial footprint limits its use in understanding small-scale spatial variability of terrestrial water storage in connection with hydrologic, atmospheric, ecological and socio-economic processes. Therefore, spatial downscaling of observed TWSA is of great interest to hydrological community. In this study we explored the possibility of using the well-known, random cascade models to perform downscaling of GRACE TWSA. Using 0.5 degree GRACE MASCONS dataset for the southwest United States, we first analyzed the TWSA for spatial self-similarity. Near mono-fractal behavior (*i.e.,* simple scaling) of TWSA was observed in the process of spatially upscaling the GRACE TWSA observations from 0.5 degree to 4 degree. Given this behavior of TWSA, random cascades can be used to spatially model TWSA at scales ranging from 0.5 to 4 degrees. However, assuming that a similar scaling structure is present for scales below 0.5 degree, we used multiplicative random cascades to downscale TWSA from the large-scale (4 degree) to the small-scale (1/16th degree). Downscaling was performed using two variants of random cascade generators *i.e.*, i) uniformly distributed cascade and ii) beta log-normally distributed cascade. For each variant of cascade, 1000 realizations were performed to downscale TWSA. By comparing the best realization (realization for which Euclidean distance between modeled and observed TWSA images is minimum at 0.5 degree) for each variant of cascade, we found that random cascade based on uniform distribution better models the TWSA at small-scales. In this paper we present the method to downscale TWSA based on its scaling behavior and results of the described methodology.