Downscaling of AMSR2 soil moisture content using multi-satellite land surface variables with regression kriging

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Soil moisture is a primary state variable of hydrology and the water cycle over land. Recent remote sensing technologies have enabled microwave satellite sensors to monitor soil moisture for wide area irrespective of weather conditions. AMSR-E (Advanced Microwave Scanning Radiometer - Earth Observing System) instrument on board the Aqua satellite which was launched in 2002 provided global daily 25-km soil moisture data, and MIRAS (Microwave Imaging Radiometer with Aperture Synthesis) instrument on board the SMOS (Soil Moisture and Ocean Salinity) satellite which was launched in 2009 produces global daily 25-km soil moisture data. Also, AMSR2 (Advanced Microwave Scanning Radiometer 2) instrument on board the GCOM-W1 (Global Change Observation Mission-Water 1) satellite which was launched in 2012 succeeds the role of AMSR-E and provides global daily 25-km and 10-km data. NASA (National Aeronautics and Space Administration) has launched SMAP (Soil Moisture Active Passive) satellite in 2015. It has an active radar and a passive radiometer for producing global daily 3-km and 36-km soil moisture data, respectively, but owing to the failure of the radar, only 36-km data is available now. The spatial resolution of 10 to 36 km is not sufficient for regional-scale applications for hydrology and meteorology although the temporal resolution is quite appropriate. To solve the problem of limited spatial resolution of soil moisture data retrieved from microwave satellite sensors, this study presents the downscaling by spatial statistical methods combined with various land surface variables. To date, statistical methods such as multiple regression and machine learning have been employed for downscaling of soil moisture. However, the inevitable residuals (that is, the part which cannot be explained by the statistical models) bring about differences between the original and the downscaled data, so the consistencies between them may not be maintained. To overcome the drawback, a novel method named regression kriging has been proposed by combining multiple regression and kriging interpolation. Downscaling by the regression kriging can produce a high-resolution data which is spatially consistent with the original data through the correction of residuals. Several studies conducted the downscaling by regression kriging for rainfall datasets such as TRMM (Tropical Rainfall Measuring Mission), but the application of this novel method to soil moisture dataset has not been reported yet. In this study, we carried out the downscaling of AMSR2 soil moisture data using multi-satellite land surface variables with the regression kriging. The database for LST (land surface temperature), RR (rising rate of LST in daytime), NDVI (normalized difference vegetation index), NDWI (normalized difference water index), TVDI (temperature vegetation dryness index), and SA (surface albedo) was built using the satellite images from MODIS (Moderate Resolution Imaging Spectroradiometer) and COMS (Communication, Ocean and Meteorological Satellite). The low-resolution soil moisture data from AMSR2 on the 10-km grid was downscaled on the 1-km grid using the land surface variables. The spatial consistency before and after downscaling was be measured by comparing the pixel values of the low-resolution grid with the upscaled block means of the high-resolution grid. Our results of the spatial consistency showed a correlation coefficient greater than 0.95. The downscaled soil moisture data can be used in various regional-scale applications for hydrology and meteorology.

Keywords: Satellite remote sensing , Soil moisture, Statistical downscaling, Regression kring