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Downscaling soil moisture over East Asia through multi-sensor data fusion and optimization of regression trees

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Soil moisture is one of the most important keys for understanding regional and global climate systems. Soil moisture is directly related to agricultural processes as well as hydrological processes because soil moisture highly influences vegetation growth and determines water supply in the agroecosystem. Accurate monitoring of the spatiotemporal pattern of soil moisture is important. Soil moisture has been generally provided through in situ measurements at stations. Although field survey from in situ measurements provides accurate soil moisture with high temporal resolution, it requires high cost and does not provide the spatial distribution of soil moisture over large areas. Microwave satellite (e.g., advanced Microwave Scanning Radiometer on the Earth Observing System (AMSR2), the Advanced Scatterometer (ASCAT), and Soil Moisture Active Passive (SMAP)) -based approaches and numerical models such as Global Land Data Assimilation System (GLDAS) and Modern- Era Retrospective Analysis for Research and Applications (MERRA) provide spatial-temporalspatiotemporally continuous soil moisture products at global scale. However, since those global soil moisture products have coarse spatial resolution (~ 25-40 km), their applications for agriculture and water resources at local and regional scales are very limited. Thus, soil moisture downscaling is needed to overcome the limitation of the spatial resolution of soil moisture products. In this study, GLDAS soil moisture data were downscaled up to 1 km spatial resolution through the integration of AMSR2 and ASCAT soil moisture data, Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM), and Moderate Resolution Imaging Spectroradiometer (MODIS) data—Land Surface Temperature, Normalized Difference Vegetation Index, and Land cover—using modified regression trees over East Asia from 2013 to 2015. Modified regression trees were implemented using Cubist, a commercial software tool based on machine learning. An optimization based on pruning of rules derived from the modified regression trees was conducted. Root Mean Square Error (RMSE) and Correlation coef[U+FB01]cients (r) were used to optimize the rules, and finally 59 rules from modified regression trees were produced. The results show high validation r (0.79) and low validation RMSE (0.0556m3/m3). The 1 km downscaled soil moisture was evaluated using ground soil moisture data at 14 stations, and both soil moisture data showed similar temporal patterns (average r=0.51 and average RMSE=0.041). The spatial distribution of the 1 km downscaled soil moisture well corresponded with GLDAS soil moisture that caught both extremely dry and wet regions. Correlation between GLDAS and the 1 km downscaled soil moisture during growing season was positive (mean r=0.35) in most regions.