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Triple collocation-based validation of SMAP soil moisture product with sparse networks in China

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The Soil Moisture Active Passive (SMAP) L-band satellite was launched on 31 January 2015 by NASA, with the primary goal to obtain high precision soil moisture at a global scale for every 2-3 days. A prerequisite for utilizing soil moisture products derived from SMAP for scientific research is knowing their accuracy and robustness. In this study, in situ soil moisture from 1682 stations in China were collected to evaluate the performance of level 3 radiometer-only soil moisture product (L3_SM_P_v4) between 31 March 2015 and 3 June 2018. The comparison between SMOS soil moisture product and in situ soil moisture was also conducted to compare the performance of different satellites. Triple Collocation (TC) approach was used here to eliminate the spatial representativeness error between grid-scale satellite soil moisture and point-scale in situ soil moisture. Variable Infiltration Model (VIC) soil moisture outputs were used as the third component of TC. The results based on TC indicate that the correlation coefficient (R), bias, Root Mean Square error (RMSE) of SMAP L3_SM_P_v4 are 0.61 ($p<0.001$), 0.107 m3m-3, -0.032 m3m-3 (i.e. SMAP is drier), respectively. The overall unbiased Root Mean Square error (ubRMSE) of SMAP L3_SM_P_v4 is 0.047 m3m-3, which is slightly worse than the expected mission performance of 0.04 m3m-3, but it is better than SMOS product (with ubRMSE of 0.052 m3m-3). The best and worst performance are over open shrub and broad leaf forest land cover types, respectively. The Ratio Frequency Interference (RFI) detection and mitigation algorithm in the SMAP product effectively improves the performance of the soil moisture retrieval in high RFI regions (e.g., Sichuan province and Jilin province) compared with the SMOS product. The large error in the Northeast Plain may be associated with the irrigation during crop growing seasons and needs to be investigated in a future study. In general, the SMAP L3_SM_P_v4 is a reliable product that captures the main spatiotemporal characteristics of soil moisture. This study helps to provide a guideline for SMAP data application in scientific research and some references for improving the data quality (e.g., algorithm improvement).