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Assimilation of Sentinel-1 and SMAP observations to improve GEOS-5 soil moisture

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The SMAP (Soil Moisture Active and Passive) mission carries an L-band radiometer that provides brightness temperature observations at a nominal resolution of ∼40 km. These radiance observations are routinely assimilated into GEOS-5 (Goddard Earth Observing System version 5) to generate the SMAP Level 4 Soil Moisture product.

The use of C-band radar backscatter observations from Sentinel-1 has the potential to add value to the radiance assimilation by increasing the level of spatial detail. The specifications of Sentinel-1 are appealing, particularly its high spatial resolution (5 by 20 m in interferometric wide swath mode) and frequent revisit time (potentially every 3 days for the Sentinel-1A and Sentinel-1B constellation). However, the shorter wavelength of Sentinel-1 observations implies less sensitivity to soil moisture.

This study investigates the value of Sentinel-1 data for hydrologic simulations by assimilating the radar observations into GEOS-5, either separately from or simultaneously with SMAP radiometer observations. The assimilation can be performed if either or both Sentinel-1 or SMAP observations are available, and is thus not restricted to synchronised overpasses. To facilitate the assimilation of the radar observations, GEOS-5 is coupled to the water cloud model, simulating the radar backscatter as observed by Sentinel-1. The innovations, i.e. differences between observations and simulations, are converted into increments to the model soil moisture state through an Ensemble Kalman Filter. The model runs are performed at 9-km spatial and 3-hourly temporal resolution, over the period from May 2015 to October 2016. The impact of the assimilation on surface and root-zone soil moisture simulations is assessed using in situ measurements from SMAP core validation sites and sparse networks.

The assimilation of Sentinel-1 backscatter is found to consistently improve surface and root-zone soil moisture, relative to the open loop (no assimilation). However, the improvements are less pronounced than those with the assimilation of SMAP observations, likely because of less frequent observations. The best performance was obtained with the simultaneous assimilation of Sentinel-1 and SMAP data, indicating the complementary value of both types of observations for improving hydrologic simulations.