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# Assimilation of SMOS Level 2 soil moisture retrievals for improved soil moisture estimates over northern latitudes

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Soil moisture information at northern latitudes could help improve hydrological, NWP and climate modelling efforts, and help monitor environmental threats such as droughts and floods, and effects of Climate Change. Providing reliable information on the land surface hydrological cycle over northern areas is problematic. Remote sensing observations are difficult owing to the presence of snow, ice, water bodies, strong orography and rocks. On the other hand, land surface models are often limited by parameterizations and poor initialization. In this work we utilize land surface data assimilation and SMOS level 2 soil moisture retrievals to constrain the ISBA land surface model over northern latitudes. The novelty of this work lies in the focus of soil moisture data assimilation over northern areas, a region which proves difficult to monitor with satellites observations alone.

The land surface data assimilation system (LDAS) is setup over continental Europe and northern parts of Europe (Scandinavia). By including southern parts of Europe where SMOS is shown to have positive skill when compared to in situ stations we are able to ensure that our LDAS is properly tuned.
We use MERRA-2 for atmospheric forcing, without any observation correction to precipitation, to ensure that forcing over high and middle latitudes are of the same quality. Soil moisture dynamics and land processes are modelled using the ISBA land surface model. Surface soil moisture observations from the SMOS level 2 product are quality controlled, bias corrected and gridded to a regular latitude longitude grid.
In the data assimilation scheme we use the Ensemble Kalman Filter (EnKF), which allows for flow dependent background errors. The model ensemble is created using multiplicative perturbations to the downward short-wave radiation and rainfall rate. Additive perturbations are applied to the downward long-wave radiation and the top 8 layers (1 m depth) of the land surface model. A first-order auto-regressive model is used to simulate the errors in the forcing and the prognostic variables, we impose cross-correlations between the perturbation fields to ensure physical consistency between the perturbations.
A 10 year spin-up is done to initialize the land surface model, then we start assimilating 5 years of SMOS data starting in 2010. We use 12 ensemble members, and an assimilation window of 6 hours.
For evaluation of the resulting surface and root zone soil moisture product we use stations in the International Soil Moisture Network (ISMN).

The results presented in this work suggest a positive impact of assimilating SMOS level 2 retrievals into the ISBA land surface model in areas "favourable" for satellite observations of soil moisture. The largest impact was seen in the root zone soil moisture, while less impact was seen in the surface zone. This is likely due to the surface layers sensitivity to the external forcing.