Assimilating the SCATSAR-SWI with SURFEX for a high-resolution European soil moisture product

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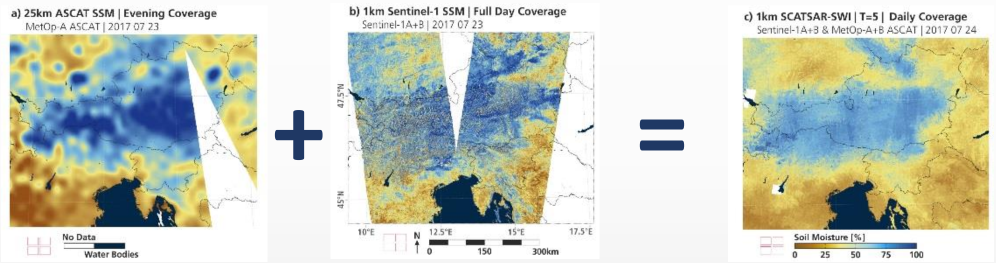
Due to manifold land-atmosphere interactions, soil moisture is an essential part of the energy water cycle and its knowledge is important for many applications, e.g., in meteorology, hydrology and agriculture.

With the goal to provide a high-resolution soil moisture product over Europe, we assimilate the multi-layer fused SCATSAR-SWI with the SURFEX Offline Data Assimilation (SODA). We probe the impact of the 1.25 km compared to the 2.5 km analysis onto the NWP forecast in Austria and verify the soil moisture analysis with a gridded water balance product.

Observations

The [SCATSAR-SWI] (Scatterometer Synthetic Aperture Radar Soil Water Index) is a fused data product exploiting the high-temporal resolution of MetOp/ASCAT (≈1 day) and the high-spatial resolution of Sentinel-1/CSAR (1 km) surface-soil moisture.



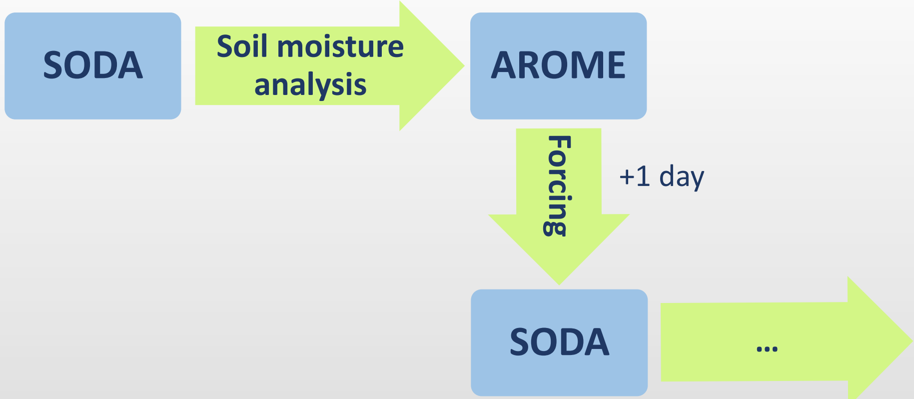
In addition, the surface soil-moisture signal is propagated into deeper layers using the exponential filter approach, which provides soil moisture information for several vertical layers.

Being available in almost NRT on the European domain, the SCATSAR-SWI is ideal observational input for the assimilation of soil moisture.

Assimilation system

We employ SODA with the simplified Extended Kalman Filter. The multi-layer diffusion scheme ISBA-DIF included in SURFEX allows to treat the different soil layers of the SCATSAR-SWI within the assimilation.

SODA is cycled by using forcing fields from the meso-scale NWP model AROME and by providing the initial soil moisture fields for six assimilated soil layers in return.



We run the assimilation system for June 2018 in the Austrian domain and evaluate the benefit of using a grid sampling of 1.25 km vs. 2.5 km.

Verification of the NWP forecast

The forecasted 2m temperature and 2m relative humidity were verified against Austrian semi-automated weather stations.

Especially at night, the differences between 2.5 km and 1.25 km run in the forecast verification can be partially attributed to different model dynamics (D0 vs. D1), which were required for the NWP model.

Compared to the 2.5 km experiment, the performance of the 1.25 km run improves at day time but degrades at night.

The bias (model minus station measurement) indicates that the cold and wet forecast bias is on average reduced by the 1.25 km assimilation. In addition, both 2m temperature and 2m relative humidity show an average improvement for the RMSE.

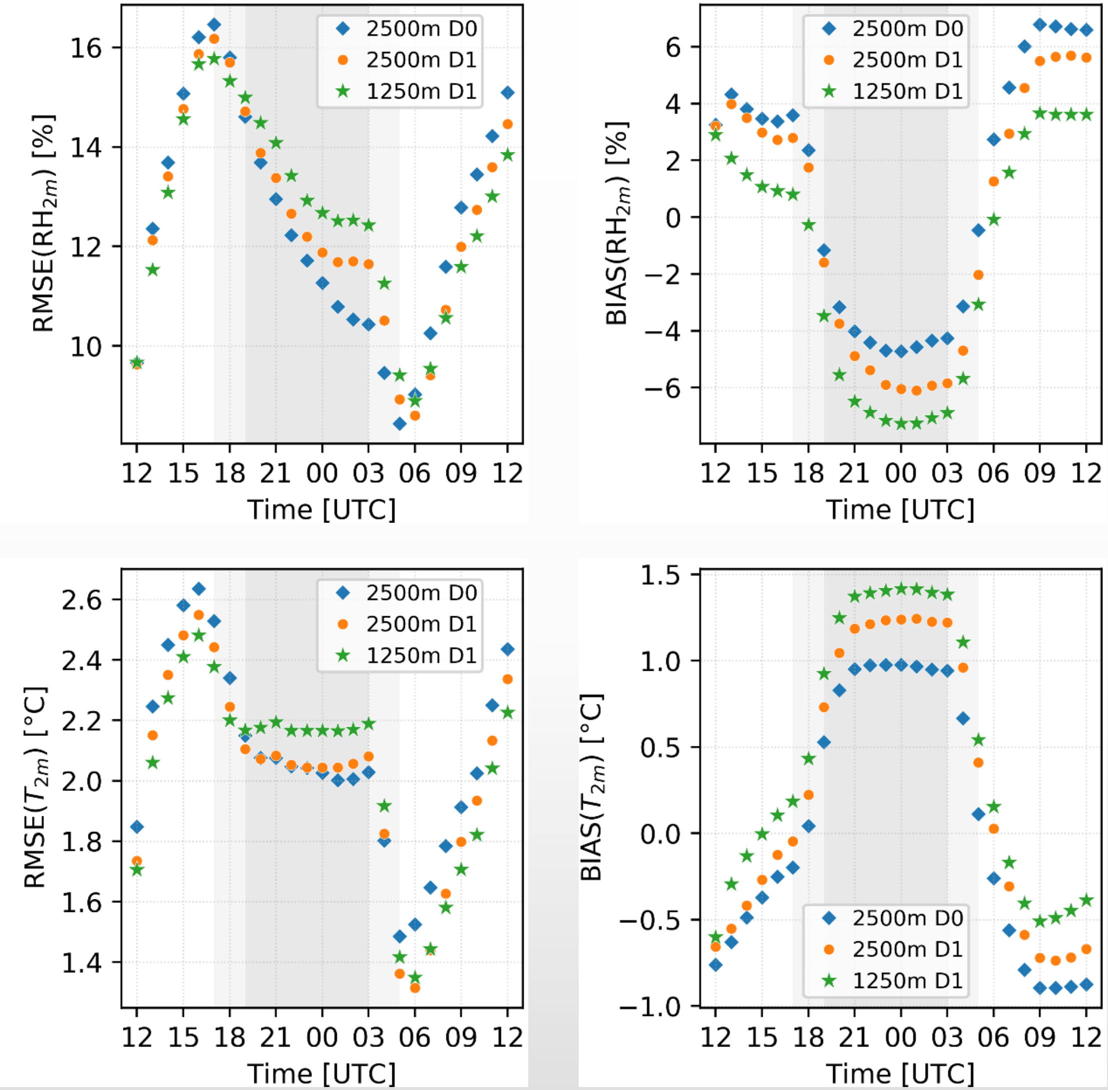


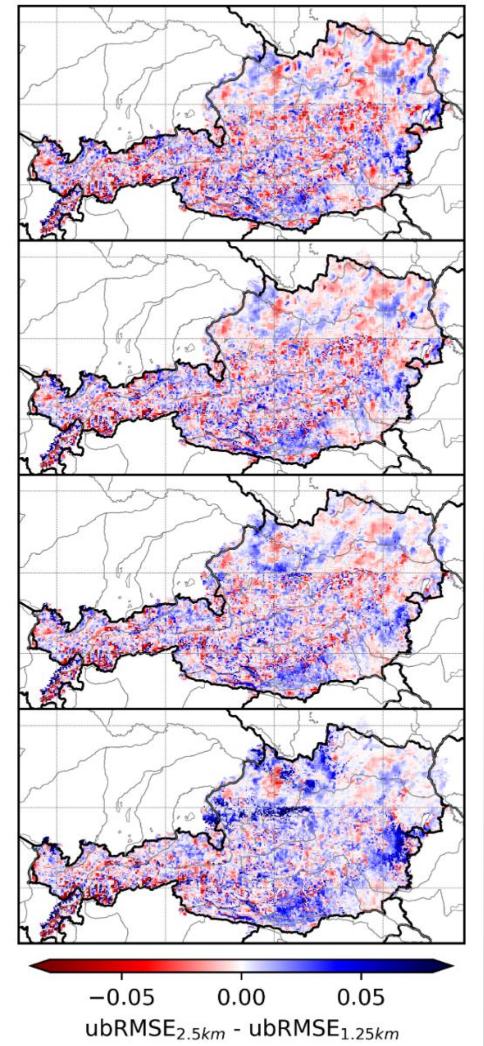
Figure: Bias and RMSE for 2m temperature and 2m relative humidity for a 24h forecast for the assimilation experiments at 2.5 km and 1.25 km using model dynamics D0 and D1, respectively. The values represent an average over low-elevation (<600 m) stations in Austria.

Verification of the soil moisture analysis

The water content of soil can be assessed by considering the water balance. Neglecting runoff processes, we use SPARTACUS gridded temperature (T) and precipitation (RR) fields (with 1 km spatial resolution) to compute the evapotranspiration ET and eventually a water balance reference measure for the soil moisture analysis: $WB \sim RR - ET(T)$.

Having computed ubRMSE and correlation coefficient r_P between soil moisture analysis and WB, we compare the changes of those measures between the 2.5 km and the 1.25 km assimilation experiment.

The average ubRMSE/r_P differences of the assimilated regions are slightly in favour of the 1.25 km run.



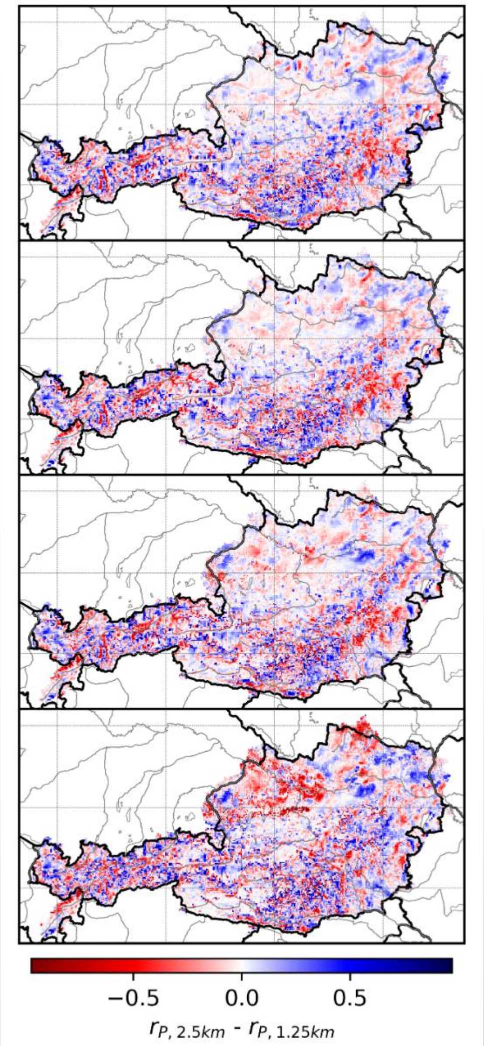
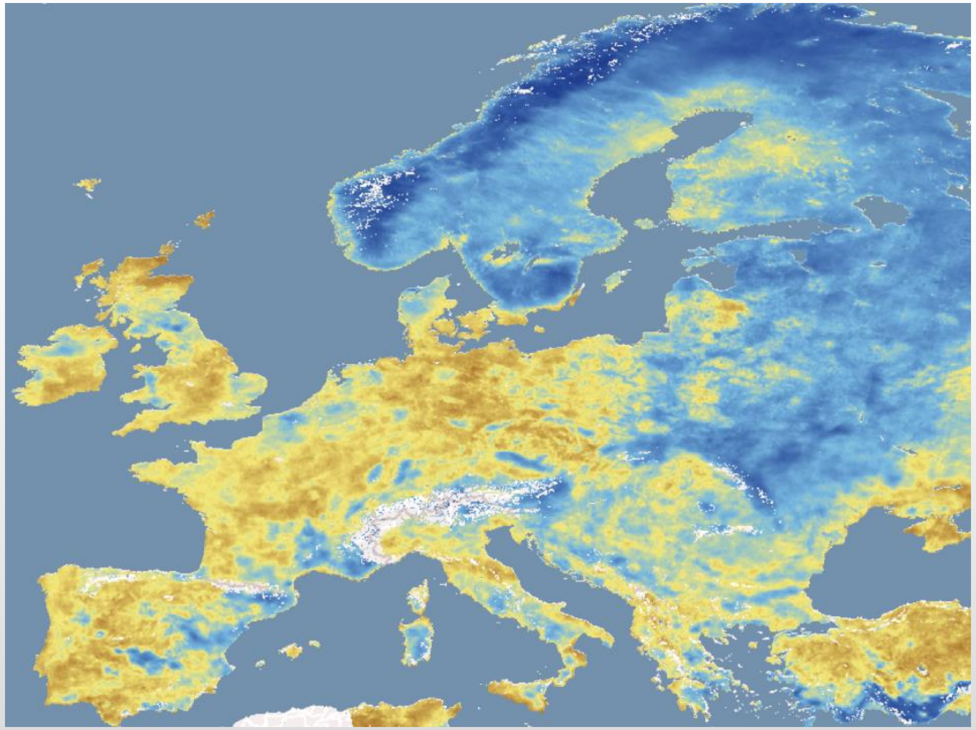


Figure: Spatial distribution of ubRMSE/ r_P differences between the 2.5 km and 1.25 km runs for 4 different soil layers .

Outlook

In addition to expanding the computations to the European domain, tests with larger grid sampling are planned to fully exploit the high resolution of the SCATSAR-SWI.



Conclusion

Compared to the 2.5 km resolution experiment, the results of the 1.25 km assimilation system showed on average a positive impact on the atmospheric forecast, especially during day time.

The comparison of the soil moisture analysis with a simplistic approximation of the water balance confirmed the benefit of assimilating at 1.25 km.

The impact of moving to even higher resolution assimilation systems will have to be evaluated against the larger demand of computing ressources.