Towards an ensemble-based assimilation of boundary-layer observations for soil moisture

Tobias Sebastian Finn\textsuperscript{1,2,3}, Gernot Geppert\textsuperscript{4}, and Felix Ament\textsuperscript{1,5}

\textsuperscript{1}Universität Hamburg, Meteorological Institute, Hamburg, Germany (tobias.sebastian.finn@uni-hamburg.de)
\textsuperscript{2}University of Bonn, Meteorological Institute, Bonn, Germany
\textsuperscript{3}International Max Planck Research School on Earth System Modelling (IMPRS-ESM), Hamburg, Germany
\textsuperscript{4}Deutscher Wetterdienst, Offenbach, Germany
\textsuperscript{5}Max Planck Institute for Meteorology, Hamburg, Germany

The temporal and spatial development of the atmospheric boundary layer is coupled to soil conditions via latent and sensible heat flux. Information about soil conditions is following encoded in atmospheric screen-level observations. To infer the soil moisture, these observations are usually assimilated with a Simplified Extended Kalman Filter (SEKF). This data assimilation technique is simplified in comparison to Ensemble Kalman Filters (EnKF), which are often used for data assimilation in the atmosphere. To make full use of the interface between atmosphere and land, we want to use strongly-coupled data assimilation with a unified system. We will present which problems have to be solved within an EnKF framework to use it as unified data assimilation system. We initialized an observing system simulation experiment with the TerrSysMP system, where a limited area model for the atmosphere is coupled with the Community Land Model. Here, we assimilate the two-metre temperature with an EnKF to update the soil moisture for a dry time period. We use initial soil moisture and soil temperature perturbations as only method to create an ensemble.

We show a positive observation impact during daytime. The analysis and forecast are further improved compared to assimilation with a SEKF. During daytime, the atmosphere and soil are strongly coupled, while they are almost uncoupled during night-time. Following, we have a slightly negative observation impact during night-time. This negative impact is induced by sampling errors of the ensemble. The negative impact is further amplified in the transition time between night and day. We can attribute this amplification to horizontal heterogeneities and multiplicative ensemble inflation in soil. We can therefore say that the inflation is wrongly tuned for the soil during night-time, while it works for the atmosphere and during daytime. We hypothesize that these problems during night-time can be avoided by using additional models, like a time-dependent localization radius and inflation factor.
