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An Extended Kalman Filter for soil analysis in SURFEX

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In the recent past an Extended Kalman Filter (EKF) has been developed within the externalised surface scheme SURFEX for the initialisation of soil water content and soil temperature, based on observations of screen-level temperature and relative humidity. The EKF aims to improve the Optimum Interpolation (OI) assimilation scheme by allowing for an easier integration of new observation types and by using dynamical gain coefficients based on the Jacobian of the model observation operator.

An externalised surface scheme like SURFEX provides a major advantage for surface assimilation techniques such as the EKF. It allows computationally cheap offline runs, that can be used for a cheaper numerical estimation of the observation operator Jacobian. Here we make a comparison between the Jacobian calculated with offline SURFEX runs and the Jacobian calculated with SURFEX runs fully coupled to the numerical weather prediction model ALARO. Comparisons are made with respect to spatial structure and average value of the Jacobian, gain values and increments. We determine the optimal perturbation size of the Jacobian for the offline and coupled approaches and compare the linearity of the Jacobian for these cases.

We document a new case of non-linearities that can hamper the linearity assumption of the EKF and can cause spurious $2\Delta t$ oscillations in small parts of the domain. While these oscillations do not have a detrimental effect on the model run, they can introduce noise in the Jacobian for the affected locations. We propose a filter to remove the oscillations and show that this filter works accordingly.

Finally, some preliminary results are presented concerning the combination of the EKF with a 3 dimensional variational upper-air assimilation (3DVAR) in an operational setup. A comparison is made between the EKF and OI, and their added value in combination with a 3DVAR upper-air assimilation.