Geosci. Model Dev. Discuss., 7, C2911–C2913, 2015
www.geosci-model-dev-discuss.net/7/C2911/2015/

Geoscientific Model Development Discussions
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Interactive comment on "Study of the Jacobian of an Extended Kalman Filter for soil analysis in SURFEXv5" *by* A. Duerinckx et al.

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Received and published: 12 January 2015

The paper describes the application of the Extended Kalman Filter (EKF) to the ALARO Numerical Weather Prediction (NWP) model running over a Belgium centered domain and with a resolution of 4 km. Two methodologies are considered to calculate the finite difference estimates of the Jacobians based on a linearity assumption. Soil moisture and temperature analyses are performed using offline and coupled-mode derived Jacobians. These terms relate the observations of near surface atmospheric quantity, such as temperature and relative humidity, that can be routinely observed, to land surface quantity that are not easily measured in real time. The offline calculated Jacobians have a great numerical advantage in the fact that they are computationally inexpensive, which is a pre-requirement for NWP methods to be applied in critical time constraint.

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Interactive Discussion
Discussion Paper

The study is of relevance for operational modeling applications of the EKF as it documents the viability of the method and proposes a solution for numerical noise that can occur in presence of non-linearity. I find the paper excellently written and easy to follow. The methods are well adapted to an operational implementation and consider an issue of practical interest previously documented in other studies. Noisy or oscillatory estimates of the Jacobians can in fact reduce the accuracy of the analysis and lead to spurious land surface adjustments. One such a behavior is found in the Richardson's number when changing from an unstable to a stable boundary layer, with adverse effects in both coupled-mode and offline (although to nearly half the extent spatially) runs used for estimating the Jacobians of the 2m temperatures and relative humidity. A temporal filter has been proposed a shown to be effective in curing the oscillation in a case study. The availability of a remedy for oscillatory and noisy estimates allowed deepening the study on linearity of the observation operator and the choice of optimal size for the perturbations. The offline estimated Jacobian showed a much better behavior with respect to linearity, which allowed for a smaller perturbation size. The evaluation of the method on a single location demonstrates clearly the benefit of the filtering, which are mirrored on conventional scores for temperature and relative humidity. The score gain is sizeable and equally evident in coupled and offline experiments.

The paper is definitely of interest for operational applications of the EKF (and EnKF, due to similarities of the issues), it is well written and it has an adequate number of figures with a good analysis of results. I am supporting a fast publication in GMD after consideration of few remarks, that I estimate to be overall minor.

Main comments: 1) In "5.4 Evaluation for a single point" at page 7173 there is no mention to the fact that the filtered-Jacobian experiment exhibit larger soil moisture increments in several occasions. Why is that? Was the noisy behaviour simply dampening the Jacobian value in the reference offline runs? Please explain this result. 2) The scores comparison between coupled and offline estimated Jacobian is not made. Are those scores exactly the same? By visual comparison of Figure 15 and 16 this seems

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the case. If so this is a remarkable result and also a worthwhile comment to be added in 5.4 and the conclusions. 3) Given the number of stations present is manageable if possible I would suggest adding a table with results for temperature and relative humidity scores supporting the statement at P7173L13-15. I believe this could strengthen the conclusions. 4) In the perspective there is no mention to the possibility of using a different and more realistic vertical discretization for the soil layers (e.g. ISBA-DIF). Is this not envisaged in the future? For instance the irrelevance of wg Jacobians and the dominant weight of the w2 Jacobians in the presented study are also a reflection of the choice of land surface scheme version so maybe adding a comment on those lines would be worthwhile. 5) While the method is applied to the operationa ALARO domain it is not clear if the method is expected to be used operationally (or is already) and if yes which of the studied configuration is likely to be considered. A sentence in the introduction (in case already in operations) and conclusion would be a worthwhile clarification.

Detail comments: 7164 L25: processses –> processes 7167L4: jacobian –> Jacobian 7169L6: alinged –> aligned 7174L12:disapear –> disappear 7190Lend-3: finitie –> finite 7194 Fig 14; why not plotting figure a with the same x-axis as b,c?

Interactive comment on Geosci. Model Dev. Discuss., 7, 7151, 2014.