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Interactive Comment

Interactive comment on "A variational data assimilation system for soil–atmosphere flux estimates for the Community Land Model (CLM3.5)" *by* C. M. Hoppe et al.

Anonymous Referee #2

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General Comments:

The manuscript presents the implementation of 4D-Var data assimilation to the Community Land Model. The authors developed the adjoint of the CLM using automatic differentiation tools and compilers. The main objective is to estiamte the flux rates of energy and moisture between the soil and atmosphere. A series of idealized data assimilation twin-experiments, where sinthetic observations are sampled from a reference run of the mode, are presented and discussed. Additionally, a real-data assimilation experiment is also presented. The results show a significant improvement of the CLM results when assimilating soil temperature and moisture observations. The paper is well explained and concise, although some minor clarification and corrections are

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needed for publication.

Specific Comments:

1. On line 26, page 6606, the authors mention that the fluxes of interest cannot be obtained by either model or measurements, could the authors expand on why is this the case? one or two senteces, or an appropriate citation, will sufice.

2. On line 20, page 6607, the authors make the following claim: "More precisely, initial values have a high impact on the forecast skill, while, at the same time, are insufficiently well known." I'm somewhat troubled by this sentece since it is known that the dependence of the forecast to the initial condition is severly degraded over the simulation time for a number of weather models. More precisely, the concept of chaos is brought to mind, which suggests that a meteorological model has a forecast limit of about two weeks. Afterwards, as chaos theory indicates, any miniscule perturbation in the initial condition provides a forecast that is almost completely dissasociated from the initial condition. I would recommend rephrasing this sentence to include the idea of a time-window for which the forecast is still highly dependent on the initial condition.

3. On line 20, page 6610, the authors say that the 4D-Var provides a physically consistent and continuous solution, which is not the case with Kalman filter approaches. Has there been any studies that apply a Kalman filter assimilation to the CLM or similare models? If so, do any of these studies suggest that the discontinuities causes a problem in the model solution?

4. In section 3.2.1 the authors talk about validation of the adjoint code, presenting the various approximations that can be used for validation, but no validation results are presented. I strongly suggest including some figures or discussion on any validation experiments the authors performed. Otherwise, it is hard to judge on the accuracy of the adjoint code, even if the 4D-Var experiments seem to be working.

5. In section 4, "Parameter Impact", the authors discuss the parameters of interest for

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the study, and metion the importance of sensitivity analysis to these parameters. But again, no results are shown and are only slightly discussed. I suggest including the sensitivity analysis results, since this will make this particular section more relevant for the paper.

6. On section 5.1, "Idealized Experiments" the authors choose the background and observation error covariance matrices to be similar, why were these matrices similar? What is the typical error of real observations (2-10%)? It would seem better to use an observation covariance matrix that reflex the observation error expected in real life. That way the idealized experiment would carry more credibility.

Technical Corrections:

1. On line 11, page 6607, the "Nevertheless" at the beginning of the sentece seems odd. The sentece seems to follow the same idea as the previous sentence, but it begings with "nevertheless".

2. On line 22, page 6610, there is a "has not discontinuities", should be "contains no discontinuities".

3. In Table 1, the authors present the layer depth and thickness. I'm somewhat confused since, following the table, there seems to be gaps between each layer. That is, layer 1 starts at 0.7 cm and has a thickness of 1.8 cm, wich means that it goes all the way down to 2.5 cm, but layer 2 starts at 2.8 cm. There is a gap of 0.3 cm between layers 1 and 2, what is that gap? what is it filled with?

4. In Figure 1, what are the dotted black lines? This is not explained in the caption or main body of the manuscript. Also, due to the very slim line thickness of the plot it is hard to discern colors. Please use slightly thicker lines.

5. Figures 4-8 are also hard to read, due to their size and line thickness. I strongly suggest modifying these plots to make them clearer.

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