Review of "Assimilation of surface observsations in a transient marine ice sheet model using an ensemble Kalman filter", Fabian Gillet-Chaulet

This paper presents a methodology for improving the initialisation of basal conditions from observed surface data for ice sheet models using a time-dependent initialisation. The author uses an established method – ensemble Kalman filter – to assimilate transient observations of surface elevation and velocities into a marine ice sheet model with a moving grounding line. The method is tested on an idealised marine ice sheet that is in the early stages of an unstable retreat using a twin experiment. Previous use of this method was for a flowline shallow ice method (Bonan et al., 2014).

I can see that the paper has been through a thorough technical review in the previous round, and that the author dealt with the comments thoroughly and in detail. New figures have been added that aid the understanding of the method and to further explore the results. I particularly like Figure 1, which gives a clear outline of how the method works and provides a comparison with the maybe more well-known 4D time-dependent variational methods. This figure really adds to the manuscript and makes it more accessible. I do agree with the author that the paper now constitutes a clear introduction to the use of these methods in glaciology. The technical aspect of the paper is well explained and clear as a result of the review process already undertaken.

The results from the idealised twin experiment look promising, with good agreement between a reference forecast and data-assimilated forecast when the assimilation period is sufficiently long (20-35 years). The results are well presented and well explained. The paper is detailed, well written and gives a thorough discussion of the strengths and limitations of the method, in particular detailing the main challenges that need to be overcome before generalising this method for use in large-scale ice-sheet modelling, which will be of interest to many other scientists.

Overall, I find it to be an interesting and worthwhile addition to the literature in this area, and I expect it will be of use to a range of other scientists working towards using such algorithms in realistic simulations. In view of this, and the other reviews and subsequent response from the author, I recommend publishing this article with only a few minor revisions.

Minor points:

1. From looking at the results for 20 years versus 35 years, it seems that we need quite a long observation record in order to use this method successfully -i.e. in Figure 12 and page 16, second paragraph – 20 years doesn't seem like long enough to get the benefits from using this method. Can you comment on that? Would we expect to have such data sets available soon?
2. Page 11, Line 30: So volume isn't conserved, but you say that estimation of ice sheet volume should improve as more data are assimilated. So you should converge on the true volume using this method? Can you directly compare the reference volume with results at the end of the DA process? Actually, Figure 12 shows convergence of VAF change at t=100 – should this figure be referenced here?
3. Page 11, Line 33 – clarify this sentence please: "as smoother might be more appropriate and the smoother extension of the ESTKF can be found in…". Do you mean "a smoother", and what about a 4D-var method?
4. Page 17, L5: I think this is the first time grid size is stated? If so, I think it'd be helpful to state it earlier.

5. Page 17: I'm confused about the "effective observation dimension" – can you explain why it is 56?
6. Figure 5: green dots are not clearly visible in the top panel.
7. Table A1: Zs is listed as both top surface elevation and bottom surface elevation
8. "informations" appears a few times in the text rather than "information"