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Nonlinear Processes in Geophysics Discussions
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# *Interactive comment on* "Data assimilation using adaptive, non-conservative, moving mesh models" *by* Ali Aydoğdu et al.

**Anonymous Referee #3**

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## 1 OVERVIEW

The paper aims to adapt a stochastic Ensemble Kalman Filter to numerical models involving moving meshes with possible remeshing. The difficulty of ensemble DA in this context lies in the varying number of meshes for each member of the ensemble. To overcome this difficulty, the authors proposes to perform the analysis on a defined fixed grid adding a mapping from each ensemble member to the fixed grid (forward mapping) before the analysis and a backward mapping after the analysis. The approach is validated using 1D toy models: Burgers and Kuramoto-Sivashinsky equations considering Eulerian and Lagrangian synthetic observations for twin experiments.



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Discussion paper

## 2 GENERAL COMMENTS

This paper is a sound attempt to adapt ensemble DA techniques to numerical models that uses remeshing (i.e. the main source of issues) and is complementary of the work of Du et al. (2016) and Bonan et al. (2017). This paper can also be seen as a preliminary work for an ensemble data assimilation system applied for the 2D sea ice models simulating discontinuities neXtSIM. The manuscript is well written and well organised. The methodology and experiments are thoroughly detailed. As a consequence, I consider this work deserves to be published after minor revision.

I now detail my main comments and questions below:

- Your approach heavily relies on the quality of your forward and backward mappings. If they introduce too much interpolation errors, it may lead to severe inaccuracies. It seems not to be the case in your experiment. Nevertheless, I still have some questions on the forward and backward mapping:
  - Why do you use such crude interpolation for HR and LR cases for the forward mapping? Why not using for example a classical linear interpolation instead?
  - The forward mapping adds errors to forecast estimates. Then you perform a linear interpolation in the observation operator to obtain observation equivalents meaning that you add an additional interpolation error from estimates that already contain interpolation error. Could you assess the effect of each interpolation (forward mapping and observation operator) on results (if possible)? Also would it not be possible to have a reference grid that contains points located to observation locations in order to avoid the double interpolation?
  - Is the backward mapping necessary in your approach? You may transfer new analysed states on old grids that are not necessary fit for the new

physics of the analysis (at least you are adding another error due to interpolation). Why not restarting the model using the analysed states directly on the reference grid after process $S_2$ (in Fig. 3) and let the model do the potentially needed remeshing from the reference grid for each ensemble member?

- Your introduction emphasises on neXtSIM but they are many differences between neXtSIM and the study cases. Among others, both study cases work on a fixed domain while neXtSIM works on a moving domain (where there is sea ice). While I consider this work being useful for the sea ice application, I think that a discussion on how this work could be adapted to neXtSIM is missing. I suggest you include one in your revised manuscript or either you downplay the importance of the sea ice application in your paper.
- I think you should emphasize more the novelty of your work compared to Du et al. (2016). Many readers do not know that paper and it is worth pointing out that what you do is different from their work.

## 3 MINOR COMMENTS AND TYPOS

- p. 4, l. 25: "*Our paper goes beyond extant work* . . .", I think you mean EXISTENT rather than extant here.
- p. 5, l. 26: ". . . *as the number of mesh points will change*S *in time*"
- p. 6, Eq. (5): Can you replace $u$ by $v$ in the equation? You already use $u$ for scalar quantities in Eq. (1) and (2).
- p. 7, l. 2: Could you reformulate the sentence involving $t + 2\Delta t$? I thought your approach was the following:

- you calculate the new position of mesh points at time $t + \Delta t$ using the mesh and the physical solution at time $t$
- then, you calculate the physical solution knowing the new mesh using some conservation principle at time $t + \Delta t$
- you iterate the approach for each time step

Could you confirm or disprove my claim?

- p. 22, l. 13: "*Interestingly, the EnKF does exhibit great sensitivity* . . .". I think you rather mean the EnKF does not exhibit a great sensitivity to $N_0$.

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