

Interactive comment on “Further Insights on the Role of Accurate State Estimation in Coupled Model Parameter Estimation by a Simple Climate Model Study” by Xiaolin Yu et al.

Anonymous Referee #3

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This paper investigates how the model parameter estimation works in an EnKF for an atmosphere-ocean coupled system. This study performs a series of parameter estimation experiments using a low-order, toy system based on the famous Lorenz-63 three-variable model but with an extension of additional near-surface and deep ocean components. The results are somewhat interesting that the fast atmospheric component's state estimation plays a key role in the parameter estimation problem both for the ocean-atmosphere coupling coefficient c_2 and the internal dynamical parameter a_2 for the second atmospheric variable x_2 . I find the topic of parameter estimation stability jointly with state estimation stability is very interesting, and this paper is a useful contribution in the field, although could be done better. I find the value of publishing this

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article, but I found some issues that need to be addressed before final publication as below:

1. There are a number of grammatical errors, which need to be corrected.
2. “Signal-to-noise” of the ensemble-based error covariance between the states and parameters appears repeatedly, but there is no direct investigation about it. Since this study performs idealized toy-model experiments, I would assume that the authors may find a better way of investigating and presenting the signal-to-noise more explicitly.
3. P.7, L.7-9, “Here our results suggest that in a coupled system, to determine oceanic coefficients, it is more important to get more atmospheric measurements to constrain the atmospheric states than to get more oceanic measurements to directly apply to oceanic PE.” This is an interesting hypothesis inspired by the simple toy model results, but this statement seems to be an overgeneralization. The real coupled atmosphere-ocean system is much more complicated than the two-time-scale toy system with only 3 atmospheric and 2 oceanic variables. This statement should be a hypothesis or speculation at this point.
4. P.7, L.21-22, “reducing x_2 uncertainty is critical”, I do not find this statement well supported or proven by the experimental results. This statement seems to be a hypothesis or speculation.

Minor comments:

1. Eq. (2) does not contain observation error statistics, and I am curious how to interpret this equation intuitively. I understand that this equation gives analysis increments for the i th ensemble member. The analysis increments should balance between the observation error and background error. This equation has only the background error variance in the observation space as the denominator, but does not contain the observation error variance which usually appears in the data assimilation equations as an R matrix.

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2. P.6, L.30, eta-to-c6 PE suddenly appears here, without any description about observations for eta (deep ocean state variable). Section 2.2 described only x_2 and w observations, and the readers would assume the experiments use only x_2 and w observations.

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