

Comment on the paper:

“Towards Strongly-coupled Ensemble Data Assimilation with Additional Improvements from Machine Learning”

General comments:

This paper compiles and comprehensively shows developments towards strongly coupled data assimilation. The studies included in this paper are organized according to the coupled model complexity, exploring the benefit of strongly coupled data assimilation over other approaches. They also include some studies in which one of the caveats of strongly coupled data assimilation is addressed by exploring low-order and intermediate-complexity coupled models. The last one is explored with the aid of neural networks. The paper is well-written and clear in general. However, it only focuses on the authors' research group developments and understanding of the field.

Although the title and the abstract are pertinent, the Authors should clearly state that the paper reviews their previous work. In its present form, the title indicates a novel contribution. At the same time, in being a review, the manuscript should also mention other key contributions to the field of coupled data assimilation.

Besides the above point, the paper is acceptable, with some technical corrections listed below.

The corrections are listed, in order of importance:

- The title and abstract should state clearly that this paper is a review (see general comment).
- In some of the experiments listed the details of how the DA is performed the variables assimilated are missing.
 1. Section 2: The SC ETKF and SC 4D-Var do not specify which variables are assimilated, and the components towards they are assimilated.
 2. Section 4: experiments do not explain the variables assimilated.
 3. Section 5: Missing which atmospheric variables are assimilated to atmosphere and ocean in both WCDA and SCDA.
- **Figure 1:** has a very poor quality and labels do not correspond to the experiments described in the manuscript, also the caption is confusing.
- In some results there is a confusion between high/low “accuracy” and low/large “error”. This, in lines:
 1. **In 255 - 256:** “... the SC 40-member ETKF and 4D-Var have similar accuracies for the atmosphere and ocean analyses, lower than SC 3D-Var.” Change “lower” for “higher”.
 2. **In 262:** “...ETKF SC 4D-Var and CERA present similar analysis accuracies smaller than SC 3D-Var.” This statement is wrong: the accuracy of 3D-Var is lower than for the other experiments.
 3. **In 471:** “... EnKF and 4D-Var reach similar analysis accuracy smaller than 3D-Var.” This statement is wrong: 3D-Var accuracy is smaller than EnKF and 4D-Var.
- **Figure 9:** The caption mentions lines that are not included in the figure. This is: the dashed lines for WCDA experiments, for the left panel. Besides, there is no indication on the meaning of the colors. Red=reduction, Blue=increase?
- **In 215:** There is not an explanation on what or which are the “quasi-SCDA” methods.

- **ln 222 - 224:** They talk about an experiment that uses 6-hour forcing in Figure 4 (a)-(b), but these subfigures do not present such experiment.
- **Figure 7:** The labels of the subfigures are wrong. Panels (c)-(d) do not exist.
- **ln 338:** It is mentioned the result for WCDA experiment, but the figure does not show it, or it is not clear.

Technical corrections:

- Make sure all the captions have the same style for the citations.
- **ln 63:** Citation for the 3D-FGAT method is needed.
- **ln 104:** "... Kalnay [2004], of which equations are written as." Replace the period with a colon.
- **ln 123:** "...standard deviation of $\sqrt{2}$. Besides, Assimilation experiments..." Change capital to low-case in word 'Assimilation'.
- **ln 124:** "... experiments with the Ensemble Transform Kalman Filter (ETKF) in this section uses 9 members." Mismatch between subject and verb. Change "uses" to "use".
- **ln 177:** "... , and constant surface fluxes $[f_{X,i}, f_{Y,i}, f_{Z,i}]$ that forces ..." Change "forces" to "force",
- **ln 178:** "... x_0^b represents the initial background states, ..." Change "states" for "state".
- **ln 183:** NMC is an acronym not defined.
- **ln 225:** "... update is still one order greater than..." Change to "... update is still one order of magnitude greater than..."
- **ln 287:** Acronym OSSE is not defined.
- **ln 313:** missing indent at beginning of paragraph.