

11 March, 2022

Title: *Analog Data Assimilation for the Selection of Suitable General Circulation Models*

Recommendation: Accept subject to **Minor Revision**

Dear Editor,

this is a very good and original work pushing forward a research line that was initiated only a few years ago. In particular this study investigates the use of a model-free data assimilation framework to perform model selection. The key novelty of this work stands on the use of the “analog” method to replace the very costly forward model computation.

I am very favourable about accepting the manuscript. I have however some minor points that I would ask the Authors to address before acceptance. Specifically about the lack of sufficient clarity on the details of the proposed approach, and on readability.

My specific minor points follow below:

1. Given that you defined the acronym DA, I would encourage the Authors to use it throughout the manuscript. In many instances the full wording is used instead.
2. Line 9–10. The sentence is not sufficiently clear to be in the Abstract.
3. Line 37. Maybe better “selection” in the place of “evaluation”.
4. Line 51. The citation should go in between parentheses.
5. Equation 1. The CME is given by the sum of the individual CMEs. You must recall that the system must be Markovian and the observations independent [Carrassi et al., 2017].
6. Equation 6. The model error term, η should be bold face. Is it a vector, isn't?
7. Line 104. Please specify which \mathbf{Q} did you use? Is this the same for both the EnKF and the AnEnKF? Is this the same for all value of λ ? Also, I think you should use the bold face notation.
8. Equation 13. I acknowledge the Authors use of inflation, but I wonder: are you also using localisation in the experiments with SPEEDY?
9. Line 147. The citations are in the text and should go without parentheses.
10. Line 148. “the the”.
11. Line 149. “An interesting feature of AnDA is that it can be applied locally, without the need to approximate the full model.” This sentence, in particular with regards to the locality, must be clarified.
12. Line 159. “Note that this regression is nonlinear since the linear approximation is applied locally in state space and corresponds to a first-order expansion of the dynamical model (see Platzer et al., 2021).
13. Equation 15. Are you saying that the N realisations of Eq. 6 are substituted with the single realisation in Eq. 15? How do you mimic/get ensemble spread then? Please clarify.
14. Line 182. “have” should be “has”.
15. Line 183. “Secondly, model errors associated with the local linear regression are considered and contribute to the forecast ensemble spread.” Very unclear, please explain better.
16. Line 204–205. What is the order of the Runge-Kutta? It is written “4-5”. Then, is the model time step, $dt = 0.1$, equals to the assimilation interval?
17. Line 215–216. “Figure 3 shows the mean CME for different values of λ ”. I think this sentence can be moved before when you started describing the figure.
18. Line 221. x and x^a should be bold.
19. Caption of Table 1. It should be “parentheses”.
20. Line 267. Do you mean “latter”?
21. Lines 275–276. “Note that data assimilation cycles performed for each grid point are completely independent of their neighbours”. This is very unclear. Please explain better, in particular about the concept of gridpoints independence that seems contradicting the multivariate nature of DA.

22. Lines 277–282. This part is also very unclear. You need to work it out better as it contains key details of your method. For instance, you need to construct your catalogue by running the full model anyhow, isn't? Then I understand you search for analog within the 3x3 domain.
23. Line 285. Please explain from where the number of 250 analogs comes from the other experiments details.
24. Line 286. What do you mean by “staggered”? What is the difference then between assimilation and observation frequency?
25. Line 287. Please explain how do you get 4,380 analysis cycles.
26. Line 312. I suggest that you include the equation as a formula in a generic way valid for RMSE and CME.
27. Lines 324–326. I overall agree of what is said right before and it seems to me that these conclusions are in line with those Metref et al, 2019 and Carrassi et al, 2017. However, I do not understand the lines here: what large errors are you talking about?
28. Line 397. Do you mean “weighting”?
29. Conclusion. I think the Authors results is also potentially very relevant for the so called “super-modelling” approach, whereby a dynamic combination of imperfect models is built. There the issue on how to “weight” the different models entering the combination is very important (see e.g. *Schevenhoven et al. (2019)*) and their approach may provide a ranking of model quality.

References

- Schevenhoven, F., F. Selten, A. Carrassi, and N. Keenlyside, Improving weather and climate predictions by training of supermodels, *Earth System Dynamics*, 10, 789–807, 2019.