

Interactive comment on “A novel approach to climate reconstructions using Ensemble Kalman Filtering” by J. Bhend et al.

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Review of the manuscript cp-2011-97 "A novel approach to climate reconstructions using Ensemble Kalman Filtering" by J. Bhend, J. Franke, D. Folini, M. Wild, and S. Bronnimann submitted to Climate of the Past.

Pavel Sakov 30 October 2011

The study aims to demonstrate the possibility of applying the ensemble square root filter (ESRF) for assimilation of proxy observations into an atmospheric GCM. It conducts a twin experiment and compares the improvement of the analysis over the background. It is found that data assimilation (DA) improves the background in the vicinity of observations not only for the assimilated variables, but also for other variables. Also,

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importantly, DA improves some composite indices.

Major issues

1. The DA method used in the manuscript can not be characterised as a filter because assimilation of the past data does not affect the current state of the DA system. Perhaps, it could be characterised as an ensemble based data fitting method.
2. Because of the design of the method, it is impossible to use the standard methods of assessment of the skill of the system, such as comparing the forecast versus persistence. The authors use a "reduction of error" metric that characterises the relative reduction of the distance between the estimation and the truth. It is difficult to see the importance of this metric for assessing the system performance in the context of climate reconstruction. If, for example, one simply replaces the observed model state elements with observations, this metric will normally show a positive skill, while the overall quality of the analysis remains unknown.
3. In this context, a demonstrated improvement of composite indices observed in the manuscript could be considered, generally, as a good indicator of the skill of the method. Unfortunately, the design of the experiment has little to do with assimilating real observations. Namely, the true field is represented by one of the members of the unconstrained ensemble of model runs; consequentially, it uses the same model and the same forcing as the rest of the ensemble. These conditions of perfect model and perfect forcing can not be satisfied with real observations; therefore, the positive correlations between the analysis and the truth observed in the course of the study are unlikely to take place in practice.

Minor issues

1. P. 2839, l. 14: "In order to keep computations tractable, we thin out the initial model grid..." The computational complexity of the EnKF in regard to the state vector dimension is linear; modern EnKF based DA systems routinely function with the state

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vectors of 10^8 - 10^9 elements.

2. I can not see the relevance of section 2.3 "Ensemble Square Root Filtering" for the rest of the manuscript – see major issue 1. In particular, the discussion of filter divergence is completely irrelevant for the method involved.

It is a good idea to give credit to the authors when describing methods. Equation (4) represents (a parallel) square root filter solution by Andrews (1968). As such, it is not used in the EnSRF. The EnSRF uses the serial solution by Potter.

3. P. 2843, l. 21-22. "With localisation, skill is less confined to the regions where we assimilate data". But it is zero outside these regions?

4. P. 2844, l. 4-6. "The spread of the ensemble - here expressed as the intra-ensemble standard deviation - indicates hindcasting uncertainty." Once again – only for the twin experiment involved. It will not represent hindcasting uncertainty when assimilating real observations.

5. P. 2850, l. 20-22. "This approach extends previous suggestions for data assimilation in paleoclimatology to a high-resolution GCM with data assimilation as used in weather forecasting applications." Once again – the proposed approach has little in common with data assimilation methods used in weather forecasting applications.

Conclusion

Data assimilation into climate models represents a major challenge due to the sheer complexity of the physical system. Reconstruction of the past climate through data assimilation of paleo observations seems almost unthinkable to me, and any attempt in this direction must be admired. There is little (I tend to say "no") hope of constraining dynamic models to such a degree that the DA system could have a positive forecasting skill. It less obvious though whether the variational or ensemble methods used in atmospheric or ocean forecasting systems can be useful for extracting some (or any) information about the state of the system from paleo observations. The manuscript

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gives a positive answer; however in my view this conclusion is not substantiated due to fundamental difference in properties of the system used in the twin experiment (perfect model, perfect forcing) and practice.

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