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Discussions

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Interactive comment on "Towards High Resolution Climate Reconstruction Using an Off-line Data Assimilation and COSMO-CLM 5.00 Model" by Bijan Fallah et al.

Anonymous Referee #1

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The paper uses the Ensemble Optimal Interpolation (EOI) method with time-averaged observation values to reconstruct the climate states by means of high resolution CCLM simulations, which are driven by the ERAInterim. The authors set up 3 different test runs to go through different aspects of the EOI. They show that the analysis has significant skill compared to the free ensemble simulations. The authors apply an offline method which is widely used in the paleo-DA community and have been shown successful for at least Climate Field Reconstruction (CFR). They show that the error reduction of the EOI is linearly related to the observation error. The word "towards" in the title confirms that the paleo-DA is still in its infancy and has to be discovered deeper.

Overall, it is a nice study that can impact the climate field reconstruction efforts and the results are scientifically sound. The techniques might be used by further studies for the high resolution paleo-climate reconstructions. This paper contributes to very few studies, which use the nested RCMs simulations for paleo climate studies and is suitable for publication in "Climate of the Past" . The authors should, however, consider my few points prior to final publication.

Main comments:

1- The usage of the stationary Kalman Gain shall be discussed in more details in the paper. It might be usable for time-slice simulations of several decades like this paper but for longer simulation windows which contain abrupt climatic shifts the static Kalman Gain can not capture the climate evolution. For centennial simulations, one shall use dynamic calculation of the background covariances. Such problems of static Kalman Gain must be discussed in the last section and the authors must mention what was the reason to go for static Kalman Gain.

2- I suggest to set up an extra test in which you explore the methodology, which you suggested in Page 11, lines 9-12. You might also split the 36 years of simulation and produce larger ensemble with more members, ie, transform any single simulation in a large background ensemble similar to the study of Hakim et al., 2016 . The reader is left with her/his curiosity to see if this might remove the trends in the RMSE. This might not be difficult, the DA is in offline mode and the results might be highly interesting for the community.

3- Instead of comparison of analysis with the gridded E-OBS data (Figures 11-12), I suggest to compare the analysis values with not assimilated observations. The gridded E-OBS already contains the assimilated observations and it makes the comparison very difficult.

4- The authors use the shifting of domain to create the ensemble members based on the reason that they do not touch the model configuration. However, different starting

times would also be a similar strategy. They can conduct a short test (with less than 10 years of simulation and with 2 or 3 members) to show if lag simulations also create comparable spread with the shifting of domains.

Minor comments:

1- Page 1 line 2: which kind of DA is expensive? Or calculation of covariance matrix in EnKF is expensive? Please revise.

2- Page 1 line 3: assimilation period or the time step of observations?

3- Page 1 line 14-16: too complicated. do you mean the radius within which we assume the observations are correlated?

4- Page 2 line 6-7 do you mean : "One of the main challenges is the lack of information for longer time-periods than the recent observed century" ? please modify!

5- Page 2 line 31: unclear to me, please explain uncertainty in what?

6- Page 3 lines 9 – 14. It should be mentioned that the offline DA is producing only the analysis state and the forecast skill which is the goal of usual DA (for example in weather predictions) is not considered. It is a kind of post-processing . From the text it seems the offline and online do the same job.

7- Page4 lines 1-5 : It should be made clear in the text that the state X is multivariable or just one variable and H is a linear function here.

8- Page 6 lines 13: "observationally constrained run"? I would call it "analysis". It is not a model run! It is manipulation of a model output.

9- Page 7 line 16: What do you mean by "optimal different boundaries"?

10- Page 7 line 21 the RMSE formula: change the superscripts Nature and Free and make it general. You also use this formula to calculate RMSE of analysis, etc...

11- Page 8 lines 20-29: could this minimum of RMSE be a local one? How is it set in

other studies?

12- Page 8 line 30: what do you mean "by the shape of the white noise added to create the pseudo-observation data" ? They are all White Noise. Clarify this!

13- Page 9 lines 28-30 As I mentioned in the main comments, the E-OBS uses kriging method for bringing observation on grids and comparison of analysis vs gridded E-OBS might not show the real skill. I suggest comparison of analysis against not assimilated observations.

14- Page 11 lines 16-20: Here a discussion on the culprits of stationary Kalman Gain is missing.

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