Answer to anonymous referee #1's commnets

Fallah et al.

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We wish to thank the reviewer for his/her critics which definitely helped us a lot to make our point clearer. We will answer the comments(*italic*) point by point (**Bold**) in the following :

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.

We agree with you and will add a discussion on stationary KG in the new manuscript . However, for time-slice simulations using RCMs which are conducted at high resolutions, it is very expensive to go over several decades. Our main focus in this study is contributed to time-slices of 30 years. This period length is chosen as representative time span for a typical climate. If there exists a regional RCM simulation longer than this period, the methodology can be applied more frequent than 30 years, eg. every decade or every 5 years.

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.

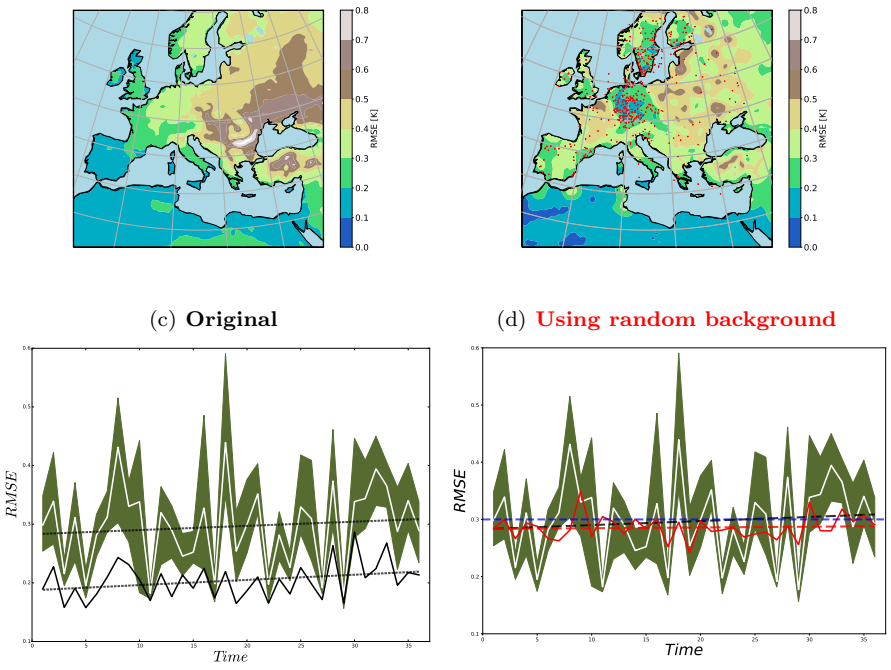
We implemented your comment. We took 40 random states from the climate pool of 4 members $\times$ 36 years of RCM simulations for each time-step and repeated the experiment instead of using the state of 4 members at the exact assimilation time. The results for winter(DJF) are shown in figure (1). Using random states as the background removed the uprising trend in the RMSE (red line in Fig.1.d) and the spread of the error is also reduced. However, the RMSE mean is in the range of the background state and there is no sign of error reduction in the analysis. This is more clear in the maps of analysis' RMSEs (Fig.1.b). Compared to the original background (Fig.1.a), using random states destroys the skill of the background itself (for example over west of the domain,i.e., Spain, Portugal, France, Morocco, ...) and reduction of RMSE elsewhere is leveled off. Therefore, usage of random states would be beneficial if the model had no significant skills at any region. However, the significant skill of the model background might be a characteristic of this particular RCM. We plan to add this experiment to the supplementary part of the new manuscript.

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.

It is true. According to reviewer 2 and 3's comments who were interested to see a real application of our methodology in paleoclimate, we decided to change this chapter. We will show results of assim-

(a) **Forecast of original ensemble background**

(b) **Analysis using random background**



(c) **Original**

(d) **Using random background**

Figure 1: **(a)**: 36 years average of ensemble RMSE of the original simulations (without assimilation), **(b)**: 36 years averaged of RMSE of analysis using 40 random states as background, **(c)**: fieldmean of RMSE from ensemble (shading shows the ensemble spread, the white line the mean) and from analysis (black line), dashed lines are the linear fits. **(d)**: fieldmean of RMSE from ensemble (shading shows the ensemble spread, the white line the mean) and from analysis using random background states (red line), dashed lines are the linear fits and the blue line shows the 0.3 K RMSE value (is plotted only for comparison of the trends).

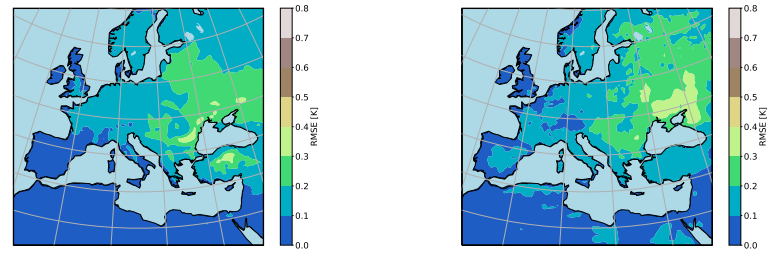
ilation of pollen-based reconstruction within the RCM runs during the Holocene and remove the tests with E-OBS data. In the new experiments we assimilate 78% **of the data and hold** 22% **for the validation. For more information please refer to our answer to question 5 of reviewer 2.**

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.

We set up 4 new runs of 20 years each with 1 month lag starting time. Figure 2 shows the time average of ensemble spread for winter and summer. The ensemble spread patterns for both summer and winter are very similar to the domain-shifting experiments (Fig.2.c,d). However, the spread values are smaller, which might be due to the fact that the spread is larger in 36 years (domain-shifting experiments) than 20 years (time-lagged experiments).

(a) **Winter with time-lagging** (b) **Summer with time-lagging**



(c) **Winter with domain-shifting** (d) **Summer with domain-shifting**

Figure 2: 20-year ensemble spread for winter(DJF) **(a)** and summer(JJA) **(b)** with lagging of initial time along with the 36-year ensemble spread for domain-shifting experiment winter(DJF) **(c)** and summer(JJA) **(d)**

minor comments:

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

Done.

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

We clarified in new version.

3- Page 1 line 14-16: too complicated. do you mean the radius within which we assume the observations are correlated? **Done.** *5- Page 2 line 31: unclear to me, please explain uncertainty in what?* **We clarify this in the new version of the paper.**