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Interactive comment on "An ensemble Kalman filter data assimilation system for the whole neutral atmosphere" *by* Dai Koshin et al.

Anonymous Referee #2

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Comments for the Author:

Described in this paper is the setup and execution of an LETKF data assimilation system for a global general circulation model with T42 horizontal resolution and 124 levels in the vertical covering from surface to about ∼150km altitude. The observations assimilated included the conventional PREBUFR data set from NCAR and the Aura Microwave Limb Sounder observations for the stratosphere and mesosphere. The setup was verified using meteor radar wind observations from 80 to 92km, that were not assimilated by the LETKF, as well as comparison with the MERRA-2 reanalysis data set covering up to 0.1 hPa (or about 60km).

Overall Comments:

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Discussion paper

#1 The paper spends a lot of time tuning and setting up the parameters for the LETKF, as makes sense for a paper like this, and you do look into the sensitivity to model diffusion as well as model gravity wave drag parameterization; however, it would be nice to see some discussion, if not some results, of the sensitivity of the MLT model parameters to the verification data sets. I'm referring to section 2.1 where you mention radiative transfer processes, ion-drag, chemical heating, dissipation heating and molecular diffusion. Several places you mention how immature the modeling of the MLT region is, it would be good to at least give the reader a since of the order of magnitude these other model parameters have on your relative to your results.

#2 For the tuning of the model parameters of horizontal diffusion and gravity wave source intensity (figures 2 and 4) it seems you use the PANSY radar at the Syowa Station in the Antarctic and MLS observations. First, is the MLS observations used in both figures is not discussed in the text, please include statements on how the MLS observations used to make the figures, i.e. are these only MLS found at 69 degrees south and then averaged over the what period? Second, is tuning of the model parameters only using observation from around a single latitude (it seems) indicative of the best tuning of for the rest of the atmosphere? If you looked at Longyearbyen or Kotoabang meteor radar results would you come to the same conclusion? Or if you used MLS globally averaged observations would you come to the same conclusion? Third, how is the model data from the A, B and C curves averaged in latitude? Are these the values only for 69 degrees south or is it over a range of latitudes? Fourth, if you were to pull off the model data at the lat-lon of PANSY (or the lat-lon of the MLS for that particular model state) and then average those results over the time period would you get the same result as the zonal means you show in the figure? If not, how do you justify the zonal mean method comparison that you are usingâĂŤor am I not understanding your figure/method.

#3 The results in Figure 8, 9, 10, 12, 13 and 15 show OmF results. Is the "forecast" here the background forecast of 6-hours? Have you done any analysis on the results

for forecasts longer than 6-hours? Maybe this is outside of the scope of the study, but can you comment on how far out your model forecast may have skill in the MLT region?

#4 The results in Figure 9, 10, 12, 13 and 15 all show bias error with respect to observations. Is there a reason you only looked at bias? Did you look at the standard deviation error for any of these results?

Major Comments:

Lines 221-222: Here you mention thinning the observations to $\frac{1}{4}$ of the available amount, could you give more information on this, i.e. what method did you use for thinning, did you check on the sensitivity of your results to thinning more/less or can you site someone else who used this thinning procedure?

Lines 236-237: You state that you horizontally averaged the Aura MLS observations but then on line 510 you mention the sparseness of data in the upper stratosphere. If the data is so sparse region don't you want to maximize the amount of data there? If it's a computational issue then couldn't you further reduce the observations in the troposphere so that you could have more in the MLT? Did you do any sensitivity studies on including more Aura MLS observations?

Lines 383-389: How did you arrive at the B and C profiles? Did you try others and they didn't work as well?

Line 444: "Most previous studies of data assimilation did not make this bias correction." Which studies didn't, or if it's easier which studies did. Or take out the statement.

Line 499: Why only comparing at 0.1 hPa? Did you get the same results at other levels?

Lines 547-553: For Figure 11 you are showing an average of ensemble spread over the time period of 12 Jan to 20 Feb. Can you show some sort of figure that shows the ensemble spread as it is changing through the window from cycle to cycle. What I'm getting at is that often with inflation coefficients you are trying to tune them so that the

ensemble spread is too low that it is collapsing or too high that it is endlessly expanding. Could you show a figure that captures this, or is it that none of these values caused collapse or endless expansion? If this is the case then please state so.

Line 605-606: This is definitely true for the tuning of the localization since localization and ensemble size needs to be considered at the same time. I wonder if you would be able to at least do one sensitivity study looking at the optimal localization with 200 ensemble members?

Minor Comments:

Line 307: Not sure what you mean here by “at each other grid”.

Line 308: What is “a setting” parameter.

Line 333-335: You have a 6-month free run from June 1st and then you pull your initial conditions over 10 days centered on January 1st. Was this same method used for the initial conditions for 30, 90 and 200 members?

Line 406: Don’t you mean Figure 2d?

Line 426: Shouldn’t it be: “20 February 2016”?

Line 494: Which previous studies?

Lines 527-532: You are comparing with RMS shown in Table 2. For the other parameters you compare to bias. Can you state why you switched your statistical parameter?

Line 707: Table 1?

Table 1: First “Ctrl” line “B” is boldâĂŤshouldn’t it not be bold?

Table 2: Seems it would be better to plot this up and show more levels. Why in table form?

Table 3: Seems this would be better presented as a plot or series of plots. Why in table form?

Figure 3 you use “DB”, figure 4 your use P0.7, figure 8 you use “G20”. . .these acronyms are not defined in Table 1 or anywhere else in the manuscript. I’m not sure how to improve this for future readers but it seems that you might be able to do something like listing the acronyms in the “Ctrl” line of Table 1.

Figure 16 and 17: Why only 40N? Where the other latitudes similar?

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