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Geoscientific Model Development Discussions
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Interactive comment on "JRAero: the Japanese Reanalysis for Aerosol v1.0" *by* Keiya Yumimoto et al.

Anonymous Referee #3

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This study describes the production of an aerosol reanalysis for the period 2011-2015 through the assimilation of quality assured MODIS observations into the MASINGAR mk-2 global aerosol transport model. The data assimilation scheme used is a 2D-Var method. The paper is well written. Authors describe with clarity the different components of the system: the aerosol transport model, the assimilation method, the observations and the observation operator. The quality of assimilation system is evaluated through internal checks based on analysis and first guess departures from assimilated observations, while the quality of the reanalysis product is evaluated with independent observations, and compared to a control experiment which has been run without data assimilation. I think that the paper is suitable for publication after addressing the following comments.

Specific comments:

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1) I am concerned about your background error covariance (BEC) matrix, and it would be good if could add some more comments about them:

a) Can you please justify your choice of using in equation 26 a normalized temporal standard deviation in AOD? Other studies have estimated background error covariances using independent observations or difference of forecasts at different lead times.

b) Can you please justify your choice of expressing the flow-dependent component of the BECs by the forecast AOD (P12, L11-12), and comment on possible drawbacks?

c) Your background error covariances are quite large, in particular (by construction) for high simulated AOD values. Are you not this way over-fitting too much the assimilated observations?

d) Studies by Rubin and colleagues have shown the importance of flow-dependent BECs in aerosol data assimilation, and how ensemble methods can best estimate the temporal evolution of the background error covariances. As you say in the section on "Future directions", you plan to use better BECs in the future, and I think that you should mention this point also when you describe your assimilation method, in the conclusions, and in the abstract.

2) Could you show or comments on whether your analysis is smooth in space and time throughout the day?

a) Given that observations are really assimilated in a given location at most once a day, your reanalysis could have jumps from the one time step where observations are present to the others. If so, you could mention in your conclusions, and in the future outlook, that observations in a future reanalysis should actually have a good coverage. Regarding this issue, Lunch et al. (2016) showed the importance of model tuning in particular when there are areas not covered by assimilated observations, which are therefore highly impacted by the model first guess.

b) When using localization it is important that analyses in neighbour regions share

assimilated observations. How do you deal with this aspect when you divide the model space in local regions?

3) It might be good to stress a bit more that assimilated MODIS observations are not an independent set of observations to validate the reanalysis (e.g., in the abstract P1, L12-15, in the introduction P4, L14-15, ...), but they can be used to perform valuable sanity checks on the assimilation system.

4) P12, L27: Can you justify the use of a diagonal observation error covariance matrix?

5) P13, L18: Don't you think that it would be more correct to use in the validation AERONET AODs which are the closest in time to model results, without doing any averaging of them?

6) P14, L23-27: What about the accuracy of the analysis when decreasing the BECs? Rather than persistent overestimation of the observation error, could not be that your current BECs simply do not describe well the structures of your background model errors?

7) Could you also add in Figure 6 the analysis increments (analysis minus first guess) and comment on them? This would allow you to identify better local systematic corrections made by the observations and hence discuss model bias, while the differences of Figure 6c (analysis minus free run) are affected also by corrections that might happen somewhere else and are transported.

8) P15, L26 and P19, L24: I think that you can only verify with a certain degree of independence your 6h forecast, and not a forecast up to 24h. Don't you produce a 6h forecast from each analysis step?

9) As you show in P15, L34 and P16, L1, the mean bias and the MFB can have a different sign. Therefore in the discussions in section 3.3.3 should you not add the value of the mean bias, or use the wording "mean fractional bias" when commenting on the MFB values at the various stations?

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10) The first few months of simulations (clearly a spin up period for the data assimilation) could have been removed when estimating the statistics reported in the various tables...

Technical corrections:

1) P3, L33: The NASA aerosol reanalysis is called Modern Era Retrospective analysis for Research and Applications Aerosol Reanalysis (MERRAero)

2) P5, L7: Please change the position of the word “respectively” to avoid ambiguity

3) P7, L5: Please change “land-cover factors vegetation” with “land-cover factors for vegetation”

4) P7, L8-L13: Please change “grid(s)” with “grid cell(s)”

5) P7, L21: Please add the air density and the gravitational constant which are also present in equation 9

6) P7: Please use a consistent symbol for particle diameter d_s or D_s between equation 9 and 10

7) P11, L3: Please remove one of the K in equation 20

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