Comments from Reviewer #2

We thank the reviewer#2 for the valuable suggestions and constructing comments. This GMDD manuscript has been modified accordingly. Point-to-point response to the reviewer's comments is given below.

This is a well-written manuscript on the important topic of assimilation of aerosol-affected infrared radiances. The manuscript describes key model developments and highlights the ability of aerosol-aware radiance assimilation to improve forecast performance. I recommend minor revisions to improve some of the analysis and discussion points in the manuscript.

Science questions/issues

Line 112: "The optical tables from other aerosol models are not finalized yet"; It would benefit readers to know what other optical tables are in development. Can you mention at least one of them here?

The sentence is changed to "There are ongoing and planned CRTM development efforts to incorporate more aerosol optical tables (such as the Community Multiscale Air Quality model, CMAQ). With the expansion of the aerosol schemes, a new releasing and versioning system for optical tables is essential and currently under discussion. This article, however, discusses mainly the GOCART model, which is the default aerosol scheme in the CRTM version 2." (line 128-131)

Note that the statement regarding version number is to respond to the editor's comment.

Line 195-198: According to Gelaro et al. (2017), MERRA-2 includes infrared radiance assimilation of IASI in an aerosol-blind configuration. As a result, should we expect any significant differences in the meteorological fields (e.g., temperature) between MERRA-2 and the baseline GSI experiment? Can you provide information on the possible magnitude of systematic biases in dusty regions of the MERRA-2 reanalyses?

Presume the baseline GSI experiment, mentioned in the reviewer's comment, is the aerosol-blind, cycled experiment using GDAS. Both GEOS-ADAS and MERRA-2 by GSFC are aerosol-blind cycled runs (using GSI/CRTM for analysis and GOES-5 for forward model). GDAS, on the other hand, uses GSI/CRTM for analysis and GFS for forward model. We don't anticipate significant aerosol-induced differences between GDAS and MERRA-2 (or GEOS-ADAS).

We do anticipate that there could be some differences between aerosol-aware GDAS versus aerosol-blind MERRA-2. To quantify systematic errors associated with not constraining aerosol transmittance effects, cycled experiments with aerosol-blind versus aerosol-aware configuration over a longer time period will be needed.

Our previous study (Wei et al 2021) shows 0.3-0.5K warmer SST and 0.15K warmer lower atmosphere over the dust-laden region. While we hesitate to draw any conclusion on the anticipated differences, the manuscript is revised to provide more information on the temperature differences (see line 65-67).

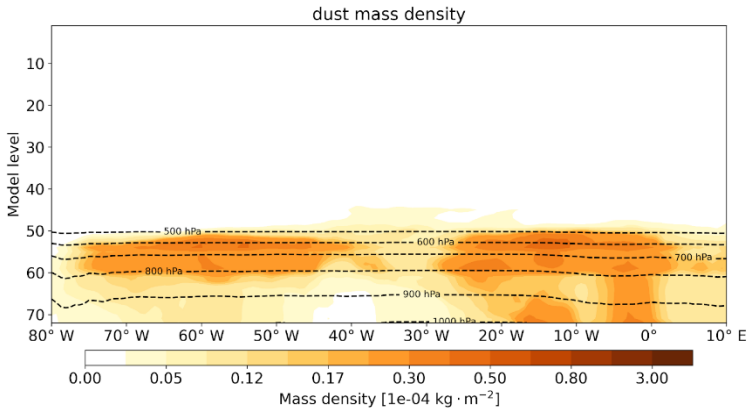
Lines 199 – 206: More explanation on Fig. 1b is recommended. This map shows dust dominating in almost all areas of IASI coverage. I understand this is the active dust season with long-range transport,

but could MERRA-2 be overestimating the global dust coverage, which would impact the results in Fig. 1a? For instance, there are some areas of carbon aerosols mostly over eastern Siberia, but I would expect a more extensive area of carbon dominated aerosols across Siberia.

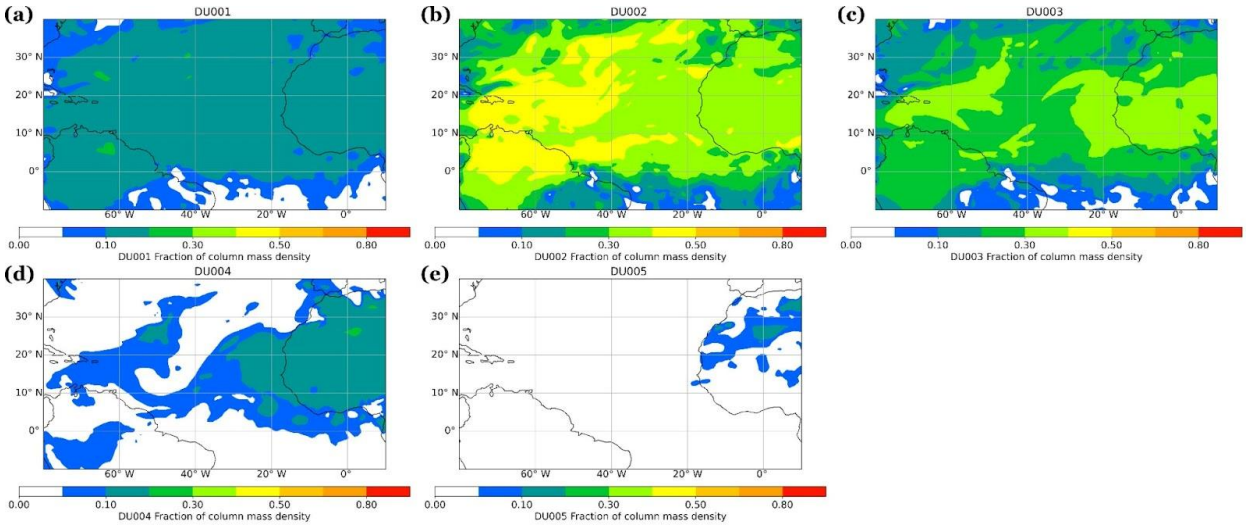
We add a new figure (Figure 1) showing dust, sea salt, carbonaceous, and sulfate loading. A new paragraph is added (line 220-231) to describe Figure 1 and address MERRA-2 high biased on dust at high-latitude region.

Lines 228 – 232: A more detailed explanation of Fig. 3 is strongly recommended. Additional panels showing dust column mass density (in addition to total aerosol column density) and dust effective radius would be helpful to the analysis and readers. How are dust sizes varying in the dust contaminated areas and influencing the AER-CTL TEMP differences? Dust size should be analyzed and discussed here, as it is an important factor when accounting for aerosol-affected satellite radiances. Also, why are the much cooler BTs in the AER experiment over western Africa (Fig. 2a) leading to only a minimal warming signal at 900 hPa? I was expecting to see significant warmer temperatures in AER compared to CTL at 900 hPa in this area. Less important, what is causing the significant AER-CTL temperature differences over the Southern Ocean and Antarctica?

After adding two figures (Figure 1 and 4), the Figure 3 mentioned here is now Figure 5. The discussions on Figure 5 are extended (line 285-300) to address the reviewer's comments. Dust off of west Africa is carried by the SAL and the aloft air mass (see top panel below) is changed toward more fine particles (see bottom panel below). The present study, however, is focused on documenting the CRTM aerosol option. The GSI experiments conducted in the present study demonstrate the aerosol impact, but further study will be needed to characterize and quantify the response of the GSI analysis to aerosol-affected BT calculations.



Meridional mean of dust aerosol mass density over region (10S-40N and 80W-10E) on 12Z June 22, 2020.



Fraction of total column mass density for bin 1 to 5 dust aerosols from MERRA-2 on 12Z June 22, 2020.

Line 242: What are the specifics of this fully cycled experiment (e.g., cycling frequency and assimilation window)?

The specifics of this fully cycled experiments, including model version, resolution, initialization, cycling frequency and assimilation window) are described in line 307-311.

Line 243: "aerosol-affected satellite radiances are taken into account"; Were infrared radiances from all satellites in GDAS considered? A short list of some key satellites considered in these experiments would be helpful.

A list of satellite IT sensors is given in section 2.1 (line 92-97).

Line 263: Can you explain the poorer results over the Southern Hemisphere? Simply due to less aerosol loading?

We suspect the cloud contamination and mixture of sea salt and aged sulfate/smoke aerosols (line 334-335). However, further study will be needed to understand the poorer results.

Lines 263 – 265: A map of mean total aerosol column mass (or for the different aerosol species) for the period of interest or perhaps a table of aerosol column masses for the different regions would be helpful here.

We add a new figure (Figure 1) showing column mass density for dust and other aerosols.

Technical corrections

Line 232: missing "K" after "0.5° to 1°"

Corrected. See Line 290.

Line 262 – 263: “The RMSE scorecards … while neutral or degradation over the Southern Hemisphere (20° S – 80° S)”, sentence structure needs improvement

Revised to “The RMSE scorecards show the forecast improvements in the wind, temperature and height fields throughout the troposphere over the Tropics (20° S – 20°N) and at upper level over the Northern Hemisphere (20° N – 80° N). For the Southern hemisphere (20º S – 80º S), however, there is neutral or degradation in the forecasts, which is likely due to cloud contamination and mixture of sea salt and aged smoke/sulfate aerosols“ (line 332-334).

Line 270, Figure 5 caption: replace “means” with “mean”

Corrected. (Line 341-342)