Reply on RC2:

This manuscript demonstrates the extension of the all-sky assimilation to ATMS radiances in the MPAS-JEDI system. A couple of month-long data assimilation experiments were conducted to evaluate the impact of assimilation of additional ATMS radiances starting from temperature sounding channels and then addition of window and humidity sounding channels. The background forecast and extended forecast up to 5 days are verified against other observations and GFS analysis. The results are encouraging. The manuscript is generally well written. However, some clarifications about the all-sky approach, the choices of the data sources and the verifications are needed to help readers to better understand this work and what can be learned from it.

Section 2.1 and 2.2: The assimilated observations are from different sources. Could you provide the rationale behind the choice of data sources. The ATMS data in BUFR format should also be available. Why did you choose to use the ATMS observations from GES DISC? How did you do quality control and bias correction GMI and ABI radiances used for verification?

Thanks for mentioning the issue. For the study period, most of the NOAA-20 ATMS BUFR data were missing from NCAR's RDA archive. That is why we used the HDF-format ATMS observations from GES DISC. We did not do bias correction for GMI and ABI when do radiance-space verification, which is all-sky CRTM hofx. GMI-space verification is performed over water between 55°S – 55°N degrees. The raw ABI infrared channel data at 2 km resolution are preprocessed into super-observations averaged over 15 by 15 pixels to match the model resolution. ABI-space verification is performed over both land and water for the water vapor channels, but only over water for window channels.

Section 3.4: In Zhu et al. (2019) and Tong et al. (2020), radiances affected by strong scattering are excluded. In this study, although precipitation hydrometeors are included, the lookup table based on Mie scattering theory would introduce large biases for radiances affected by strong scattering. Did you also do QC based on scattering index as in Zhu et al. (2019)?

We thank the reviewer for highlighting this critical aspect of all-sky assimilation. In this study, we performed a scattering index quality control check as part of the situation-dependent screening procedure, however, it was based on Zhu et al. (2016) rather than Zhu et al. (2019). Implementing scattering index as in Zhu et al. (2019) is a good suggestion and we will explore it in our follow-up work. We added the following to the manuscript: Scattering index quality control was included as part of the situation-dependent check. The scattering index was calculated from the observed brightness temperatures of channels 1, 2, and 16 using the retrieval formula of Grody et al. (1999), following the approach adopted in Zhu et al. (2016).

Section 4: Please explain the considerations of assimilating some channels over both ocean and land, and some channels over ocean only for ATMS experiments.

Thank you for the suggestions. The selection of ATMS channels for assimilation over ocean only or over both ocean and land are based on surface emissivity considerations. For channels whose weighting functions peak close to the surface, the observations are assimilated only over ocean. For channels with weighting functions peaking higher in the atmosphere are less sensitive to surface emissivity effects and are assimilated over both ocean and land.

Table 3: The description of ATMS_THSch is a bit confusing. It reads like there are two subset of experiments for ATMS_THSch as indicated by (1) and (2).

Accepted. Rewrote the sentence:

Based on ATMS_Tch, the experiment additionally assimilated ATMS water vapor channels 18–22 over both land and ocean surfaces, except for channel 18, which was assimilated only over water. In addition, ATMS channels 1–5 were assimilated over oceans between 60°S and 60°N.

Figure 2: The statistical significance level or confidence interval is missing in the caption.

Accepted. Added the 95% confidence level in the caption.

Line 270-275: How about the fit to other AMSU-A channels?

Thank you for raising this point. This figure shows the fit to other channels such as 1/2/3. The improvement from ATMS_THSch is primarily observed in the extratropical regions.

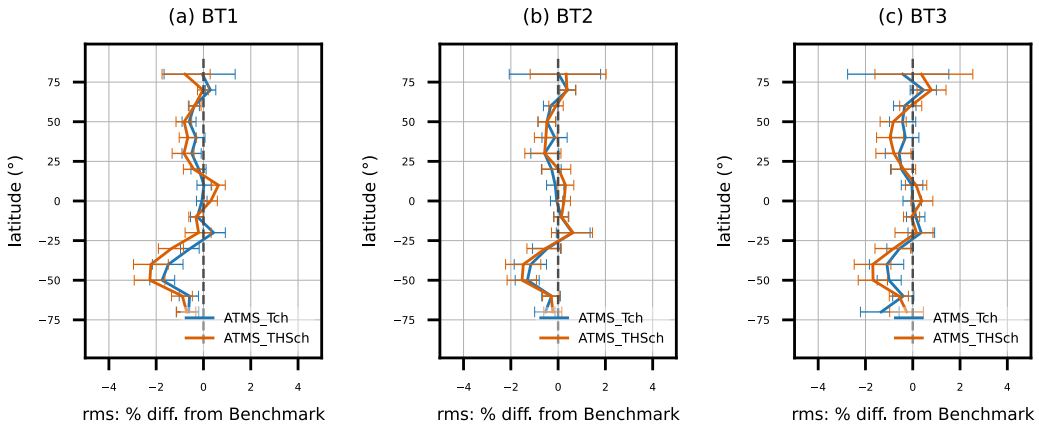

Figure 5: Please add 'with respect to GFS analysis' after 'RMSE'

Accepted. Added 'with respect to GFS analysis' after 'RMSE'

Line 330-335: To help readers to better understand the impact, please add why you choose GMI channel 5 for verification.

We thank the reviewer for this helpful suggestion. We added the following to the manuscript: GMI Channel 5 (23.8 GHz) was selected for verification because of its strong sensitivity to low-level atmospheric moisture and total column water vapor. This characteristic makes it affected the largest by all-sky ATMS DA.

Line 354-355: You need to be careful when making this comment. It's not a fair comparison between operational GFS and this under development MPAS-JEDI system. First, more observations are assimilated in operational GFS than this study. So the impact from adding ATMS radiances could be different. Second, Tong et al. 2020 assimilate precipitation affected radiances and marginal improvement was found in the vector wind forecast over the Southern Hemisphere. The all-sky approach used in this study is similar to early studies. So, here it's too quick to jump to the conclusion.

Accepted. Rewrote the sentences (354-356):

In Zhu et al. (2019), RMSE reduction for vector wind in the all-sky ATMS experiment over the Southern Hemisphere was also investigated, but the improvements were small and typically not statistically significant. Note that the operational GFS assimilates more observations than the system used in this study and thus it is harder to obtain a larger impact by adding more observations.

Line 378: ‘In Liu et al. (2022), AMSU-A temperature sounding channels were assimilated under clear-sky conditions.’ Since AMSU-A all-sky assimilation has already been implemented in the MPAS-JEDI system, this sentence doesn’t seem to be necessary.

Accepted. Remove this sentence.