Reply on RC1:

This study extended the all-sky radiance DA capability in MPAS-JEDI to ATMS based on previously AMSU-A all-sky DA work. ATMS temperature-sounding channels, humidity-sounding, and window channels are assimilated using all-sky approach. Three month-long cycling hybrid-3DEnVar experiments were conducted to evaluate the impact for all-sky ATMS DA. The all-sky ATMS DA has been shown to improve the 6-h forecast background fits to radiosonde observations, satellite radiances, and GFS analyses. Forecast verification against GFS analyses and independent radiance observations also demonstrated statistically significant improvement. It's encouraging to see the positive impact from all-sky ATMS DA in JEDI-MPAS. Overall, this manuscript is well written and well structured. The manuscript also fits well with the special issue related with the application of JEDI.

Comments:

- ATMS has different field of view sizes and separations. Did you process the ATMS data with remapping and spatial averaging to a common FOV (if the original data are not remapped)? As the quality control procedures are based on the assumption that all channels have the same beamwidth.

Thanks for mentioning the remapping and spatial averaging issue for ATMS. In the present study, we did not process the ATMS data using remapping and spatial averaging to a common FOV. The IODA converter supports remapping of BUFR-format ATMS observations during the conversion from BUFR to IODA format (e.g., through the bufr2ioda.x utility and the ATMS remapping configuration file https://github.com/JCSDA-internal/ioda-converters/blob/develop/test/testinput/bufr_ncep_atms_remap.yaml). However, in our study period, most of the NOAA-20 ATMS BUFR data were missing. Therefore, we downloaded the HDF-format ATMS observations from GES DISC and converted it to IODA format.

We note that, so when BUFR-format ATMS observations are available, our standard workflow does use the remapped observation to data assimilation.

- I understand that the experiments are all-sky ATMS DA runs and most data screening related with cloud/precipitation are not necessary, but have you removed any observations affected by strong convective situations, observations having a very large CLW values, observations in the cold air outbreak area where/if the forecast model tends to produce too much ice cloud? Have you performed any data screening specially for channels 9/10 as the all-sky error model is not applicable to these two channels? If you have QC producers for the above situations, please provide more information. If not, please explain why? If possible, please also provide some information (e.g., how much etc.) about the data removed by your QC procedures.

Thank you for this comment. We do not apply removal procedure for strong convective conditions, given that we use a 30 km/60 km dual-resolution configuration. For observations having a very large CLW values, the observation error is inflated and will be rejected by the background check procedure.

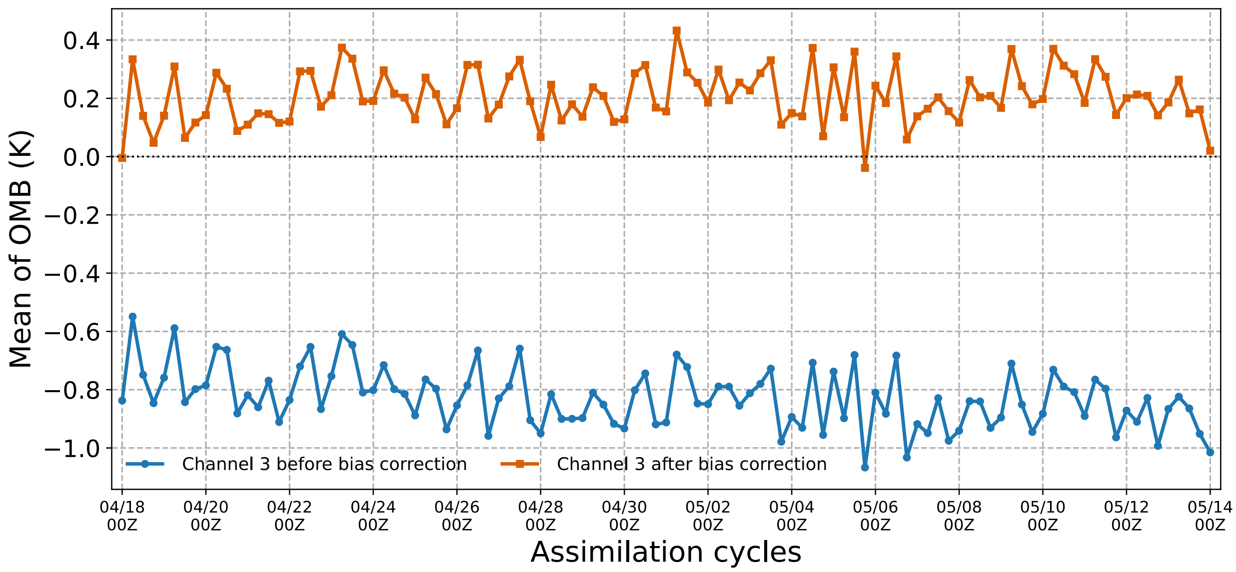
At present, we have not used the cold-air-outbreak, which was not available in JEDI-UFO when we conducted this study. We acknowledge that such a filter could be beneficial and will consider it in future work with more recent version of MPAS-JEDI.

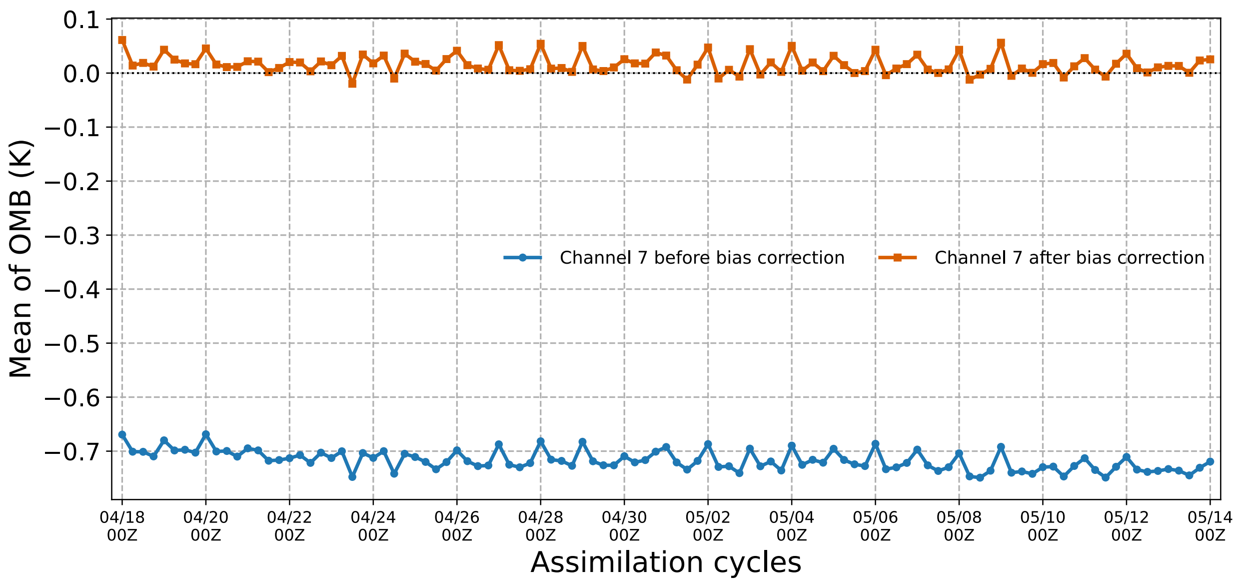
Weighting functions peak for Channels 9 and 10 sit in the upper troposphere and lower stratosphere. Background check is performed to identify and reject observations with large departures.

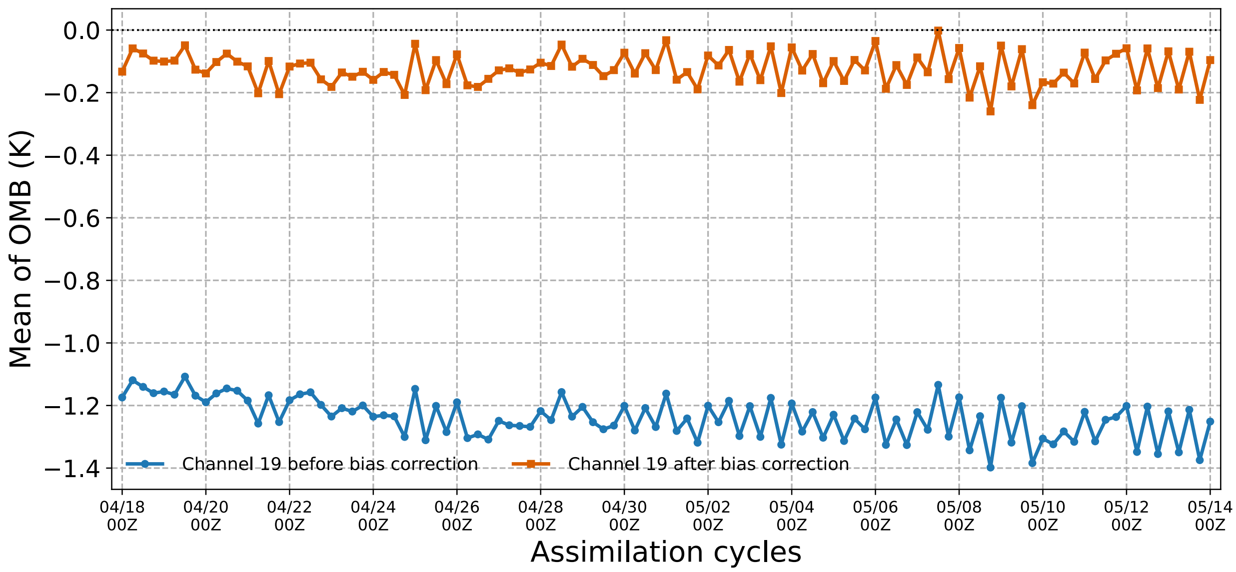
Take channel 3 (50.3 GHz) for example and excluding observations discarded by the 145-km thinning procedure, approximately 2.28% of the observations were rejected by the background check, 40.42% were excluded by the latitude-band screening (60°S–60°N), and 0.57% were identified as out-of-bounds observations. These statistics are calculated over the entire cycling period.

- Could the authors show a few plots about the performance (e.g., BT difference for different channels before and after bias correction) of the bias correction from all-sky ATMS DA?

Thanks for mentioning the bias correction for all-sky ATMS DA: the following figures show time series of the mean OMB before and after bias correction for channel 3 (50.3 GHz), 7 (54.4 GHz), and 19 (183.31±4.5 GHz):


Mean of OMB (K)
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
Channel 3 before bias correction
Channel 3 after bias correction
04/18 00Z
04/20 00Z
04/22 00Z
04/24 00Z
04/26 00Z
04/28 00Z
04/30 00Z
05/02 00Z
05/04 00Z
05/06 00Z
05/08 00Z
05/10 00Z
05/12 00Z
05/14 00Z
Assimilation cycles


Mean of OMB (K)
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
Channel 7 before bias correction
Channel 7 after bias correction
04/18 00Z
04/20 00Z
04/22 00Z
04/24 00Z
04/26 00Z
04/28 00Z
04/30 00Z
05/02 00Z
05/04 00Z
05/06 00Z
05/08 00Z
05/10 00Z
05/12 00Z
05/14 00Z
Assimilation cycles



- Have you removed observations when/if some window channels are missing (e.g., channels 1, 2, 5-7, 16? Any inter-channel QC is applied?

Thank you for the question. Yes. Inter-channel QC is applied to ATMS observations. Specifically, the quality control is performed on predefined channel groups (1–7 and 16–18) for ATMS. We have added the explanation to the revised manuscript.

- Can the authors give more details on how to obtain the values on table 2?

Thanks for your suggestion. We have added the following explanation to the revised manuscript: All-sky observation error statistics were computed using the observations minus the CRTM-simulated brightness temperatures from the 6 h forecast background of the benchmark experiment (see section 4). The statistics covers the period from 0000 UTC 18 April to 1800 UTC 14 May 2018 with a 6-h interval. Following equations (6) and (10), the values used for the observation-error model are summarized in Table 2.

- Do you have any numbers for the used channels on how much more observations are being assimilated for the all-sky ATMS DA compared with clear-sky ATMS DA? Have you conducted any comparison between clear-sky and all-sky ATMS DA experiments?

We thank the reviewer for this question. We did not conduct a clear-sky ATMS DA experiment in this study; therefore, we do not have quantitative statistics on the increase in the number of assimilated observations in the all-sky ATMS DA relative to a clear-sky ATMS DA configuration.

At present, our quality control procedures have been developed and tuned specifically for all-sky ATMS assimilation. Clear-sky ATMS quality control framework has not yet been fully implemented in our system. We agree that such a comparison would be valuable for quantifying the benefits of all-sky assimilation and identifying the impact of cloud- and precipitation-affected observations. We plan to pursue this work in future studies.

- Do the authors have plots similar to Fig. 2 but in the averaged vertical profile (similar to Fig. 3 in Liu et al. 2022)? Also, do you have any forecast verification against radiosonde data?

We thank the reviewer for this question. The Fig. 2a shows simular to Fig. 2 but in the averaged vertical profile (like Fig. 3 in Liu et al. 2022). Fig. 2b shows 24-h forecast verification against radiosonde.

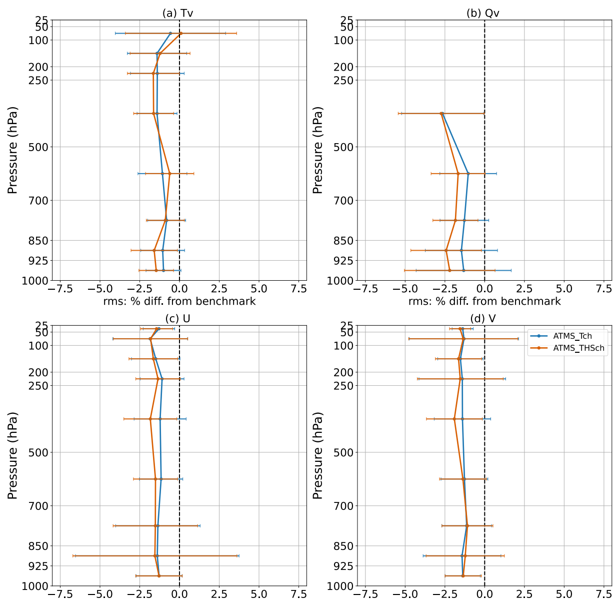


Figure 2a. Relative RMSE difference of ATMS_Tch and ATMS_THSch with respect to RMSE of benchmark for radiosondes' (a) Tv, (b) qv, (c) U, and (d) V. Statistics are computed over the period from 0000 UTC 18 April to 1800 UTC 14 May 2018. Error bars indicate 95% confidence intervals determined via bootstrap resampling. A negative percentage indicates improved fits relative to the benchmark.

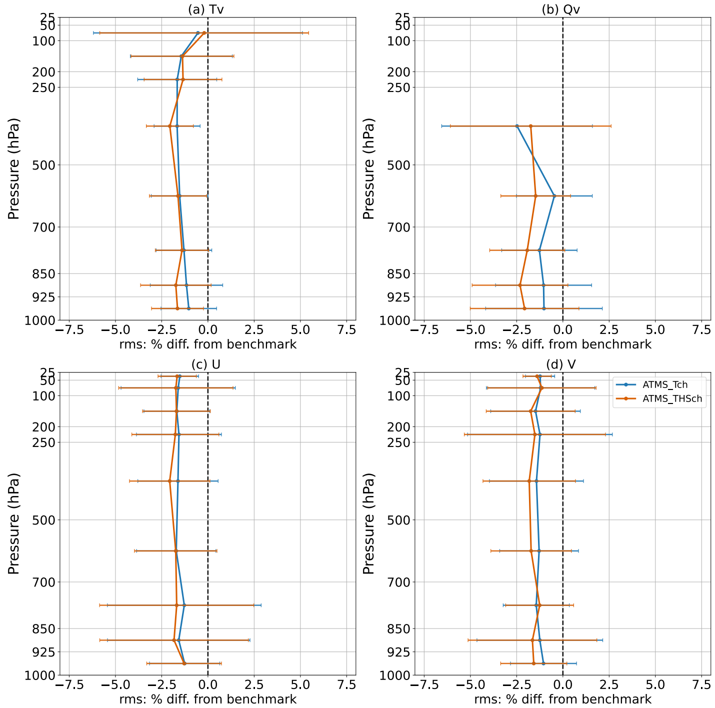


Figure 2b. Same as Figure 2a, but for 24-h forecast verification. Error statistics are aggregated over 27 forecasts initialized at 0000 UTC from 18 April to 14 May 2018. Error bars indicate 95% confidence intervals determined via bootstrap resampling.

- Are there any reasons that you did not assimilate temperature sounding channels from AMSU-A in your benchmark experiment? Are they related to lines 36-40, where the authors listed some challenges about the all-sky DA for AMSU-A temperate sounding channels? In your ATMS all-sky DA experiments, you included some temperature channels (e.g., channels 6-10) using the all-sky approach. Are there any additional procedures (in addition to humidity-sounding/surface channels) to address the challenges listed in lines 36-40 for all-sky DA for the temperature channels in this study ? Can you assimilate temperature channels (e.g., channels 5-9, understanding that the channels may vary for different satellites) from AMSU-A using the same/similar all-sky approach for ATMS temperature channels?

Thanks for mentioning this issue. We assimilated AMSU-A temperature-sounding channels using the clear-sky approach in the benchmark experiment simply following Liu et al. (2022), given this study focuses on ATMS. This decision is unrelated to the discussion in Lines 36–40. There are no additional procedures to address the challenges in lines 36-40 for all-sky DA for temperature channels in this study. In future work, we plan to investigate the assimilation of AMSU-A temperature-sounding channels (e.g., channels 5–9) using an all-sky approach like that employed for the ATMS temperature channels.

- Line 59 “clear-sky ATMS DA” suggested change to “clear-sky ATMS data”

Accepted. “Clear-sky ATMS DA” is changed to “clear-sky ATMS data”

- Lines 318-319, “undergo cloud detection at each pixel”, do you remove cloudy pixels and only using clear pixels for verification or what does that mean? Any QC procedure has been conducted for the ABI radiance data used for verification?

We do not remove cloudy pixels when doing verification against ABI. Doing cloud detection at raw pixels is to derive cloud fraction for super-observations so that we can obtain forecast errors as a function of observed cloud fraction, See section 5.2.2 and Figure 12 of Liu et al., (2022). This sentence is indeed confusing in this paper’s context and revised as “…, 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.”