

We would like to thank the reviewer for the valuable comments of our manuscript and constructive suggestions, which help us to improve the quality of the paper. Our responses to specific comments are below. The reviewer's comments are in black and our answers are in blue.

Significant issues:

1. In the paper, there is no discussion of the observational error assigned to the data within the data assimilation system. Without this information, it is difficult to interpret the results of the experiments.

*Reply:*

Thank you for reminder. We forget to mention this important information. We have added the description of observation errors. "The observation error was estimated using statistics of observed-minus-forecast radiance departures. Currently, fixed values of 0.3 K, 0.35 K, 0.35 K and 0.35 K are applied for MWTS channels 5-8 respectively." The observations of AMSU-A are also shown in a Table 4.

Please see the text (Page 13 Lines 12-14).

2. On page 2, the authors state that "the performance of atmospheric sounding instruments in particular meets or exceeds the specification." There is no reference or results to support this statement.

*Reply:*

Thank you for your attention to the details. We have added two references. In these two references. Please see the text (Page 2. Line 32; Pages 19. Lines 7-9, 13-15).

3. Page 3 lines 1-16. It should be noted that the MWTS-2 instrument differs from the ATMS instrument in that it contains only the 50Ghz frequencies and thus the other frequencies cannot be used for quality control.

*Reply:*

Thank you for reminder, we have added the statement in this paragraph "In addition, it should also be noticed that compared with ATMS, MWTS-2 contains only the 50 GHz frequencies and thus the other frequencies cannot be used for quality control."

Please see the text (Page 3. Lines 11-13).

4. Page 3 lines 17-24. This appears to be repetitious with the previous paragraphs.

*Reply:*

We have deleted the repetitious descriptions. Only one sentence is remained "It is anticipated that the MWTS-2 data could also be useful for NWP modeling systems"

Please see the text (Page 3. Lines 17-18).

5. Page 5 line 19. In general the B matrix is not ill-conditioned, just large. For example when it is defined in spectral space as a diagonal matrix, it is well conditioned and easy to invert.

*Reply:*

Thank you for reminder, we have deleted the “ill-conditioned”. Please see the text (Page 5. Line 15).

6. Page 6 Channel selection. The authors were very conservative in the choice of channels. With a model top at 3-4 hPa, it would seem that channels 9 and 10 could easily be considered for assimilation. Fig 1. demonstrates that most of the signal from these channels would be below the model top. Of course the vertical distribution of model levels may also enter into the choice of channels.

*Reply:*

Thank you for comments. When we are going to use a new satellite in GRAPES, we are always cautious at first. In some area, the model top can be as low as 7-8 hPa, so we decided not to use channel 9 and 10 in our initial experiments. We will try to use channels 9 and 10 in our next study.

7. Pages 6-7, Section 4.2.1. In this section, the authors use a different radiative transfer model (CRTM) and a different background field (post-processed GFS). While it is probably true that the radiative transfer models probably give similar results if trained with similar data, it is not clear why the authors choose to do this and it is not demonstrated that the results are similar. The non-terrain following aspects of the post-processed GFS fields, the low top for this data set and the different vertical distribution of layers can easily introduce biases and inconsistencies when compared to the GRAPES native model coordinate.

*Reply:*

I am sorry that the description in this part is not clear. Section 4.2.1 introduce an evaluation of MWTS-2 data. It is just an evaluation before the data assimilation. GFS field and CRTM were not used in the assimilation of MWTS-2 in the global GRAPES system. Section 4.2.2 extract the striping noise from the observations from MWTS-2, then the data are used in the data assimilation.

In section 4.2.1, global simulations of brightness temperature are used as a “reference” for examining the performance of the MWTS-2 instrument. The 6-hour forecasts of the vertical profiles of temperature, specific humidity and the surface pressure from the NCEP global forecast system (GFS) are used as input to CRTM. We also compare the brightness between observations and simulations (O-B) with those of ATMS. ATMS is used here to compare with the MWTS-2 observations. The NCEP GFS background fields and CRTM have been used by Guan et al., (2011), Zou et al. (2011) and Qin et al. (2013) to evaluate the data quality of MWTS-1, MWHS-1 (onboard FY-3A/B) and ATMS (onboard SNPP).

In this section, the initially assessment shows that there are striping noises in MWTS-2 data. Then the striping noises are extracted from the data using the method proposed by Qin et al. (2013). 2013, Qin et al. evaluate the quality of the brightness temperature measurements from ATMS and the NCEP GFS forecast fields and CRTM

are used in the simulations. To make our evaluation of MWTS-2 comparable to the results from Qin et al. (2013), we also choose GFS forecasts fields and CRTM in the simulation of satellite radiance.

To make it more clearly, we changed the title of 4.2.1 to “Evaluation of MWTS-2 data quality”. We also added a statement “The global observed brightness temperatures of MWTS-2 channels 5-8 are assessed before they are assimilated in GRAPES”. Please see the text (Page 6. Lines 18-19).

References:

Guan, L., Zou, X., Weng, F., and Li, G.: Assessments of FY-3A Microwave Humidity Sounder measurements using NOAA-18 Microwave Humidity Sounder, *J. Geophys. Res.*, 116, D10106, doi:10.1029/2010JD015412, 2011.

Qin, Z., Zou, X., and Weng, F.: Analysis of ATMS striping noise from its Earth scene observations, *J. Geophys. Res. Atmos.*, 118, 13214-13229, doi:10.1002/2013JD020399, 2013.

Zou, X., Wang, X., Weng, F., and Guan, L.: Assessments of Chinese FengYun Microwave Temperature Sounder (MWTS) measurements for weather and climate applications, *J. Atmos. Ocean. Technol.*, 28, 1206-1227, 2011.

8. Page 8 lines 16-17. The larger standard deviation of the MWTS-2 data than the ATMS data when compared to the same background indicates that either the data from the MWTS-2 has much more noise in it or the radiative transfer for this instrument is inaccurate. Referring to point 1, it would be interesting to know how much less weight was given this data than the ATMS data in the following experiments.

*Reply:*

The standard deviation of the MWTS-2 data are larger than ATMS. Currently, fixed values of 0.3 K, 0.35 K, 0.35 K and 0.35 K are applied for MWTS channels 5-8 respectively. They are a little larger than those of AMSU-A similar channels. Observations error are shown in Table 1. However, ATMS has not been assimilated in GRAPES. Thus, there is no weight given to ATMS in GRAPES.

9. Page 10 lines 11-12. Is the size and shape of the FOV taken into account when determining the land/sea/ice mask?

*Reply:*

I am sorry that there is a typo. The 0.25° database were used for MWTS-1 onboard FY-3A/B. The land/sea/ice masks of FY-3C instruments are based on a land mask database with about 0.1° longitudinal and latitudinal resolution (about the nadir size of the MWTS-2 FOV). We have corrected it. This work are done by National Satellite Meteorological Center of CMA. I have consulted them about some technical details. When determining the land/sea/ice mask, the sizes of FOV are considered, and

the shape change from the nadir to the scan edge is generally considered but it is not so precise.

10. Page 10 line 17. The "bi-weighting quality control procedure" should be described in more detail. It is not clear what is the basis of this procedure without going to the references.

*Reply:*

Thank you for reminder. We have added the description of the bi-weighting quality control procedure. The equations are added. Please see the text (Page 10. Line 24-Page 11 Line10).

11. Page 11 lines 12-13. It is not clear what the authors mean by the statement "However, only SAT1 is implemented in the operational GRAPES assimilation system." This may just be a matter of use of English, but it is confusing.

*Reply:*

It is confusing. We have deleted this sentence.

12. Page 11 Figure 6 and lines 20-22. I do not see the bi-weighting quality control in Fig. 6. Is this the same as O-B check?

*Reply:*

Thank you for your attention to the details. Yes, the O-B check is the bi-weighting quality control. We changed the statement to "As indicated in Fig. 6, the observations that are removed by the bi-weighting QC are typically located near cloudy FOVs". Please see the text (Page 12. Lines 9-10). The legend of Figure 7 is also modified. The "O-B check" is changed to "Biweighting QC".

13. Page 11 lines 23 and 24. It should be noted that some operational centers are currently using or developing the ability to use microwave all-sky data.

*Reply:*

Thank you for reminder. The statement on cloud and precipitation affected radiances is not appropriate. Assimilating cloud- and precipitation-affected radiances, though challenging, has being studied by some operational centers. We have deleted this sentence.

14. Page 12 lines 15-16. Please note that it is not good to remove the "the error in the first-guess model profile" with the bias correction. Otherwise, the analysis cannot correct these signals.

*Reply:*

Thank you for reminder. We will pay more attention to it in our future work.

15. Page 14 line 9. If the impact of the MWTS-2 data is negligible when other data is used, why use this data?

*Reply:*

MWTS-2 data are now seen as a backup observations. Although the impact of the

MWTS-2 data negligible, it can be supplement when we cannot receive other satellite radiance data (NOAA series, MetOp series, SNPP) and maintain the stability of the NWP system. In addition, we will try to use more data and further tap the potential of the application of MWTS-2 data in our future work.

16. Figure 7. It is unclear what color are observations that pass all of the quality control steps. Are these points included in this figure?

*Reply:*

Figure 7 only shows the outliers. The observations that have passed all of the quality control are shown in Figure 8.

Minor Issues:

1. Throughout the paper, the English can be improved. It is certainly not the worst I have seen, but there are places where it could be made more readable. Below I will point out some of the specific issues, but that does not mean there are not other additional English improvements that could be made.

*Reply:*

We are grateful for your valuable comments and suggestions. We will try our best to improve our English writing ability and check the spelling. We have read through the manuscript again to correct the English errors. Please see the text.

2. Page 1. Lines 22-25. The QC steps. Quality control steps does not imply removal of data. In the 5 steps, the consequence of the check needs to be stated. i.e., instead of "eight outmost FOVs" should be "eight outermost FOVs are not used" or "coastal FOVs" should be "coastal FOVs are removed"

*Reply:*

According to the suggest, we have modified the sentence to “Other QC steps are conducted in the follow order: (i) coastal FOVs are removed, (ii) eight outmost FOVs are not used, (iii) channel 5 over sea ice and land are not used, (iv) channel 6 observations are not used if the terrain altitude is greater than 500 m, and (v) outliers with large differences between observations and model simulations are removed”.

Please see the text (Page 1. Lines 22-26)

3. Page 2. Lines 1 and 2. "The quality control scheme of extracting the striping noise may contribute to the analysis and forecast <accuracy>". Add accuracy.

*Reply:*

We have added “accuracy” in this sentence. Please see the text (Page 2. Line 3)

4. Page 2. Kozo et al., should be Okamoto et al. References also needs to be make correct and reordered.

*Reply:*

Very sorry for that, we reverse the first and last names of the authors. We have corrected it in the reference and the corresponding citation. Please see the text (Page 2. Line 12; Page 19. Line 14)

The corrected reference is:

Okamoto, K., Kazumori, M. and Owada, H.: The assimilation of ATOVS radiances in the JMA global analysis system, J. Meteor. Soc. Japan, 83(2), 201-217, 2005

5. Page 2. Line 30. "Thesis" is probably not the best word here.

*Reply:*

We have changed "Thesis" to "article". Please see the text (Page 3. Line 1)

6. Page 2. Line 30 "assimilation" spelling error

*Reply:*

We have corrected it. Please see the text (Page 3. Line 1)

7. Page 4. Line 24 "discretization" spelling

*Reply:*

We have corrected the spelling error. Please see the text (Page 4. Line 19)

8. Page 4. Line 25 "package" spelling

*Reply:*

We have corrected it. Please see the text (Page 4. Line 20)

9. Page 4. Line 25 "Chen" capitalization.

*Reply:*

We have changed "chen" to "Chen". Please see the text (Page 4. Line 20)

10. Page 5 Line 26 "could" -> "can"

*Reply:*

We have changed "could" to "can". Please see the text (Page 5. Line 22)

11. Page 8 Line 10 "corresponding" spelling

*Reply:*

We have corrected it. Please see the text (Page 8. Line 11)

12. Page 10 Line 19 "than2" -> "than 2"

*Reply:*

We have corrected it. Please see the text (Page 11. Line 6)

13. Page 19 Line 13 "Courtier" spelling

*Reply:*

We have corrected the spelling mistake. Please see the text (Page 18. Line 13)

14. Fig. 1. It would be nice if the lines could be made a little thicker. When printed, some of the lines disappear.

*Reply:*

We have modified the figure and the lines are thicker now. Please see the text (Figure 1)