Response to report #1 on amt-2022-311

Anonymous Referee #2

Suggestions for revision or reasons for rejection

The revised manuscript is improved, but some concerns still remain.

We appreciate anonymous referee #2 for their effort in reviewing our revised manuscript and providing constructive comments.

Below are the responses to the comments and concerns from Referee #2.

(All concerns have been addressed point-by-point with responses highlighted in blue, and the corresponding modifications in orange have been incorporated into the revised manuscript. The line numbers mentioned in this response letter correspond to the revised manuscript of clean version.)

1. Since the impact of Aeolus winds on forecast are not statistically significant over the tropical oceans and the SHX, the result may be removed from the manuscript, just briefly mention the results in the manuscript.

Response: Thank you very much for this suggestion. We have removed some plots and texts for tropical ocean and Southern Hemisphere (SH) high-latitude regions. For example, for Figure 4 in the revised manuscript, we only keep the results for the tropical Pacific Ocean to show examples of the impact of Aeolus data quality on near-surface wind forecasts.

2. The Aeolus impact on the longer range forecast lead times in the NHX are statistically marginal significant. To understand and justify the results, and to prove your speculation: "For the high-latitude region in the Northern Hemisphere, the noticeable impact is found mainly from T+192 h onward, which is possibly owing to the downward propagation of Aeolus increments to the surface", the authors need to show further analysis demonstrating how the downward propagation is done in detail.

Response: Thank you very much for this comment.

To understand and justify the results, we made comparisons with existing studies. We find that our results are partly comparable with the verifications at ECMWF (Rennie and Isaksen, 2022). The main difference is that in our study, this evident positive impact exists at more forecast steps from T+192 h to T+240 h, which is partly due to the different reference data we are based on and the different spatial coverage they have.

Regarding the downward propagation, it would be worth doing a further analysis to demonstrate the downward propagation in the model. However, it is slightly beyond the scope of this paper, which mainly focuses on evaluating near-surface wind forecasts. Instead of doing further analysis or eliminating the sentence entirely, we tried to rephrase the sentences and added relevant references to support this speculation. Please see below:

"For the NH high-latitude region, Aeolus makes more positive impacts as the forecast extends. This result is partly comparable with the analysis-based verifications at ECMWF, with a noticeable positive impact obtained at the T+216 h forecast step (Rennie and Isaksen, 2022). The main difference is that in our study, this evident positive impact exists at more forecast steps from T+192 h to T+240 h, which is in part due to the different reference data we are based on and the different spatial coverage they have. In addition, since there are a limited number of low-level Aeolus winds inland assimilated into the ECMWF model, we suspect that this positive impact is probably associated with the downward propagation of Aeolus increments to the surface as the changes in stratospheric initial conditions can affect tropospheric circulation on subsequent forecasts (Kodera et al., 1990; Christiansen, 2001; Charlton et al., 2004; Tripathi et al., 2015)."

(Lines 274-281)

3. The assumption of the independence of the errors of the two OSEs is questionable since the two OSEs are based on the same NWP system. You can show the actual correlations between the errors of the two OSEs to see if they are really small enough. Otherwise, the triple collocation results would be dropped.

Response: Thank you very much for this comment and suggestion.

We quantified the error correlations between the forecasts from two model runs and found the correlation coefficients are greater than 0.6 for most forecast steps. Thus, we have removed the results of triple collocation (TC) analyses. In addition, we added a paragraph in the Discussion section to explain the issues when implementing the TC analysis to assess two correlated data sets. Please see below:

"In terms of the evaluation method, apart from the conventional inter-comparison analysis like what we used in this study, triple collocation (TC) analysis is another beneficial method for environmental parameter evaluation when there are three independent data sets (Stoffelen, 1998; Vogelzang and Stoffelen, 2012). Different from the inter-comparison analysis that regards a reference data set free of errors, TC analysis assumes that each data set is linearly correlated with the truth. Following the equation derivation documented in Vogelzang and Stoffelen (2012), the primary output of TC is the error standard deviation (ESD) of each data set, which allows us to compare the quality of different data sets. We made an attempt to implement TC method to our cases (results are not shown). The results can generally reflect the impact of Aeolus on wind forecast, with the ESD from the forecast with Aeolus lower than the one without Aeolus implying the positive impact of Aeolus. But the ESD values are inaccurate since the errors of the two forecasts are not independent because they are from the same NWP model. Theoretically, without taking this dependence into account may lead to the ESDs of two forecasts under-estimated and the ESD of in situ measurements over-estimated since the error covariance of the two forecasts are greater than zero (Caires and Sterl, 2003). Therefore, to obtain accurate results when implementing the TC method to assess two correlated data sets, quantifying the non-zero covariance or making a further modification of the method is required."

(Lines 309-321)

Reference:

Caires, S. and Sterl, A.: Validation of ocean wind and wave data using triple collocation, J. Geophys. Res., 108, 3098, https://doi.org/10.1029/2002JC001491, 2003.

Charlton, A. J., Oneill, A., Lahoz, W. A., and Massacand, A. C.: Sensitivity of tropospheric forecasts to stratospheric initial conditions, Q. J. R. Meteorol. Soc., 130, 1771–1792, https://doi.org/10.1256/qj.03.167, 2004.

Christiansen, B.: Downward propagation of zonal mean zonal wind anomalies from the stratosphere to the troposphere: Model and reanalysis, J. Geophys. Res., 106, 27307–27322, https://doi.org/10.1029/2000JD000214, 2001.

Kodera, K., Yamazaki, K., Chiba, M., and Shibata, K.: Downward propagation of upper stratospheric mean zonal wind perturbation to the troposphere, Geophys. Res. Lett., 17, 1263–1266, https://doi.org/10.1029/GL017i009p01263, 1990.

Rennie, M. and Isaksen, L.: The NWP impact of Aeolus Level-2B winds at ECMWF, ECMWF, 227 pp., https://confluence.ecmwf.int/display/AEOL/L2B+team+technical+reports+and+relevant+papers?preview=/46596815/288355970/AED-TN-ECMWF-NWP-025--20220810_v5.0.pdf (last access: 20 October 2022), 2022.

Stoffelen, A.: Toward the true near-surface wind speed: Error modeling and calibration using triple collocation, J. Geophys. Res., 103, 7755–7766, https://doi.org/10.1029/97JC03180, 1998.

Tripathi, O. P., Baldwin, M., Charlton‐Perez, A., Charron, M., Eckermann, S. D., Gerber, E., Harrison, R. G., Jackson, D. R., Kim, B., Kuroda, Y., Lang, A., Mahmood, S., Mizuta, R., Roff, G., Sigmond, M., and Son, S.: The predictability of the extratropical stratosphere on monthly time‐scales and its impact on the skill of tropospheric forecasts, Q.J.R. Meteorol. Soc., 141, 987 – 1003, https://doi.org/10.1002/qj.2432, 2015.

Vogelzang, J. and Stoffelen, A.: Triple collocation, Royal Netherlands Meteorological Institute, 22 pp., https://cdn.knmi.nl/system/data_center_publications/files/000/068/914/original/triplecollocation_nwpsaf_tr_kn_021_v1.0.pdf?1495621500 (last access: 27 January 2022), 2012.

Response to report #2 on amt-2022-311

Anonymous Referee #1

Suggestions for revision or reasons for rejection

The authors have addressed my comments and improved the manuscript significantly. They also removed all ambigous interpretations of the results by clearly stating where the assimilation improvements are not significant.

I very much support the inclusion of the new Figure 1, but would suggest to change the longitudinal sampling from 5° to a multiple of the Aeolus orbit distance (~3.2°) to avoid the strange looking checkerboard pattern. Once this change is applied, I think the article is ready for publishing.

We are grateful for the positive feedback and suggestion from anonymous Referee #1 on our revised manuscript.

The map in Figure 1 has been re-generated with a grid size of 3.2°x3.2°.

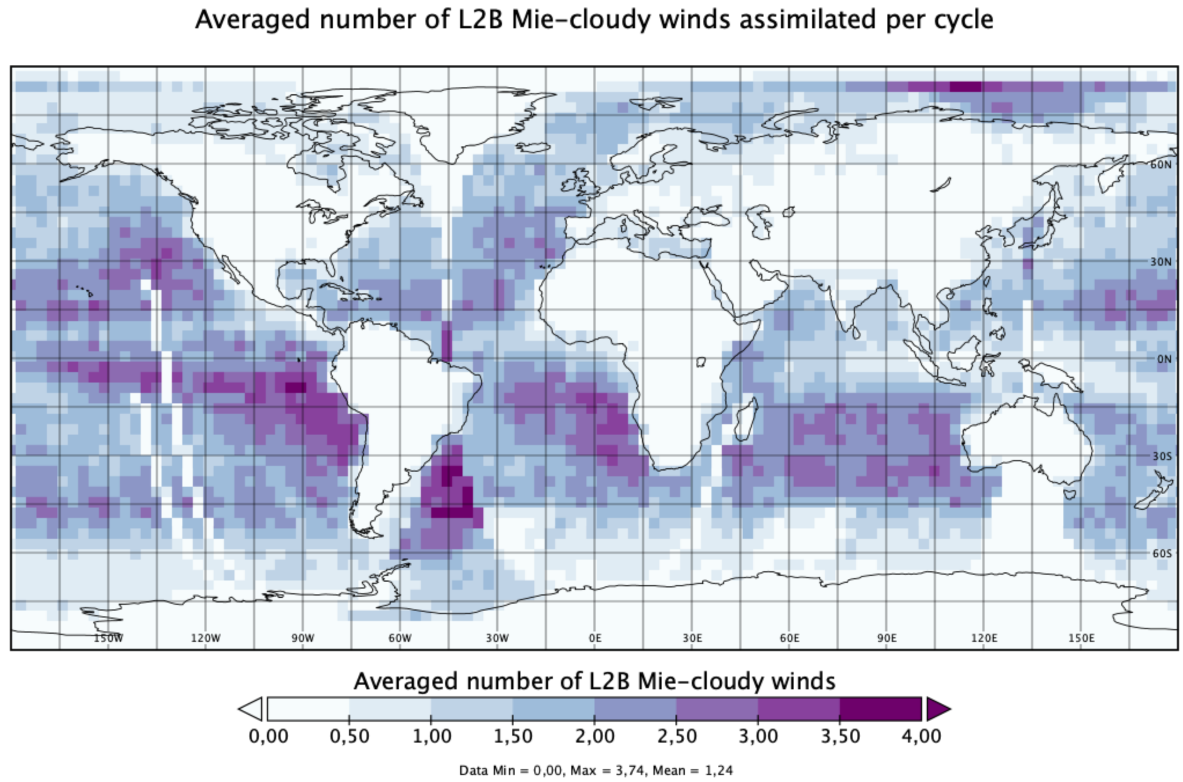

Figure 1. The averaged number of L2B Mie-cloudy winds at pressure > 850 hPa assimilated into the model