

Comment on amt-2021-247

General comments

The manuscript presents a comparison between Aeolus observations in the Arctic and corresponding ground-based remote observations (using a Ka-band radar and a Doppler lidar), in-situ observations from radiosondes and model output from ECCC-B and ERA5.

The scope of the comparison is to assess the consistency between Aeolus and the other wind sources and to validate its L2B error product in a region where direct wind observations are especially sparse.

The analysis of the authors shows that there is good agreement between Aeolus observations and radiosonde measurements and between Aeolus observations and model output from ECCC-B and ERA5. The differences between Aeolus and ECCC-B also correspond for the most part to the errors found in the Aeolus L2B product. The authors also confirm the issue, already shown in previous studies, of Aeolus Rayleigh faulty observations in summertime conditions due to contamination from solar background radiation.

Despite being the second time this manuscript has been submitted for revision, after taking into account the comments of the anonymous reviewers in the first round, it still presents deficiencies that do not make it ready for publication.

For what concerns the ground-based measurements (Ka-band radar and Doppler lidar), their amount is too limited in order to make a comparison with a good statistical significance. I therefore suggest to either increase the amount of observations or to completely remove them from the analysis of this manuscript and leave the focus on the comparison with radiosondes and model output.

Moreover, there are many issues throughout the manuscript that need to be corrected and clarified, as specified by the following comments.

Specific comments

- Line 34: correct "surfaced-based" with "surface-based".
- Line 163: I guess that for the comparison with Aeolus you used the analysis data (output of 4D-EnVar) rather than the assimilated data (input of 4D-EnVar, i.e. the observations).
- Lines 164-167: what is the interpolation sequence? First horizontal, then vertical, then temporal?
- Line 195: define the acronym UTLS.
- Figure 1: choose a different aspect ratio to make the figure more squared, change the combination of colors (magenta over red doesn't have a good contrast) and increase the image resolution (the red dots are blurred) to improve readability.
The circles, rather than being circles of different size, should resemble ellipses of different elongation. If you are not able to plot ellipses (I realize that it's not an easy task), it's better to just plot them as equal-sized dots to show the location of the different sites.
- Lines 213-214: specify the three unknown parameters.
- Line 215: the ftp site is not accessible because a password is required.
- Lines 216-221: why bothering including the Doppler lidar instrument in this study if its data will not be used eventually? The visual comparison of Figure 2 brings little information as the vertical range is limited to 3 km.

- Line 236: *"if Aeolus overpasses selected as a target for validation at the Iqaluit site at 11:15 UTC"*: I am missing the verb in this sentence. Perhaps you forgot to add something like *"occur at 11:15 UTC"*?
- Lines 236-238: *"since the reanalysis data is sampled hourly, the radiosondes are launched at 00 and 12 UTC, and the Ka-band radar at Iqaluit scans every 15 minutes"*: there is no need to repeat this information, it is already provided in the lines above (lines 234-236).
- Line 238: why Aeolus at 11:15 UTC is compared to reanalysis data at 12 UTC and not to reanalysis data at 11 UTC, which is the closest in time?
- Lines 239-240: when do the scans by the radar exactly occur? At HH:00, HH:15, HH:30, HH:45 (where HH is the hour)? If it is so, you can also specify the exact time of the radar, for example 11:15 UTC for the first example and 02:30 UTC for the second example.
- Line 246: add 2018 to 22 September.
- Line 249: it is the opposite, HLOS winds are negative westward during the ascending phase. HLOS wind is defined to be positive when blowing away from the instrument and the instrument is pointing eastward during the ascending phase.
- Line 250: *"we plot the profile of negative HLOS winds to ease the interpretation"*: this sentence is unclear. Do you mean that you invert the sign of the whole (ascending phase) profile to match the sign of the descending phase profile (or better the other way around, since in the caption of Figure 2 you say that the zonal projection is positive eastwards, which corresponds to an ascending profile)?
- Figure 2: it would help to have a background grid corresponding to the tick marks of the x and y axis. In the caption the "zonal component" should be called "zonal projection". The radar profile extends to less than 5 km, however there are Aeolus Mie measurements around 8 km (left panel), meaning that at that altitude there could be clouds and therefore hydrometeors detectable by the radar. How do you explain this lack of observation by the radar? Did you find a similar behavior in the other profiles too?
- Line 271: remove "during fall 2018" because this condition (more Rayleigh measurements than Mie) is valid for all the periods, not only fall 2018.
- Figures 3 and 4: increase the image resolution.
Choose another color combination because blue and black dots do not have a good contrast next to each other.
What is the utility of plotting the frequency distributions?
What do the colored bands around the best fit lines represent?
In the caption replace "(a) background" with "(a) ECCC-B".
I guess that the radar measurements come from Iqaluit only, as you state in the text.
Looking at the number of measurements reported in Table S1, there are 60 measurements matched with Aeolus Rayleigh at Iqaluit, but in Figure 3(d) there are only about 11-12 points. Similarly, Table S2 reports only 12 measurements matched with Aeolus Mie but in Figure 4(d) there are much more than 12 points.
Furthermore, as the radar measurements are associated with more cloudy conditions, I would expect to have more profiles from the Mie channel matched with radar profiles compared to Rayleigh, as the Mie channel is associated with cloudy conditions as well. However in Table S1 it is the opposite.
- Line 274: add "the" before "consistency".
- Lines 275-276: center the equations.
- Line 278: replace " \bar{y} is the mean of y " with " \bar{y} is the mean of y_i ".

- Line 280: in the following lines, only the values of the adjusted r-squared of Table 1 are discussed, but there is no comment about the values of the slope of the fitted line.
- Lines 291-294: *"It can be seen that Aeolus Mie winds are less consistent with ECCC-B, ERA5, and radiosondes at Iqaluit than the corresponding observations at Whitehorse and for the Rayleigh winds."*: I would rewrite this sentence like this: "It can be seen that Aeolus winds are in general less consistent with ECCC-B, ERA5, and radiosondes at Iqaluit than the corresponding observations at Whitehorse. Moreover, at Iqaluit, Rayleigh winds show a higher consistency than Mie winds, while the opposite is true for Whitehorse."
- Line 298: replace "Whitehouse" with "Whitehorse".
- Lines 297-299: the denominator of the second term of Eq. 5 doesn't have anything to do with the wind range. N is the number of measurements and p the number of profiles.
- Table S1: how come there are Ka-band radar measurements at Whitehorse if you stated in the main text that such radar is installed only at Iqaluit?
- Line 310: replace "distinctive" with "distinct" or "different".
- Figure 5: add background horizontal grid lines.
- Line 340: the decrease in the consistency for Mie in winter 2020 doesn't look that insignificant. Can you try to explain what could be the cause of that decrease?
- Line 350: after "9 September" add "indicated by the vertical red dashed line".
- Line 350: perhaps it is worth adding that the decrease in estimated errors in this particular period shows how the contribution to the error due to the solar background radiation is decreasing with the transition from summer to fall conditions.
- Line 352: "During this period": which period are you exactly referring to? 2 August to 30 September 2019, only September 2019 or the day of the jump (9 September)?
- Line 353: replace "averaging" with "averaged".
- Line 354: replace "on" with "along".
- Lines 355-356: *"Thus, as a trade-off of having high vertical resolution, the Aeolus estimated errors are larger for this specific range bin setting."*: I would rewrite this sentence like: "Thus, the price for having a higher vertical resolution is larger errors for this specific range bin setting."
- Line 371: replace "2km" with "2 km".
- Line 375: replace "cloudy condition" with "cloudy conditions".
- Figure 7: the distributions on the left appear to be "stacked" distributions. If this is the case, it must be declared both in the caption and in the main text, otherwise they might be confused with overlapping distributions and interpreted differently.
Increase the image resolution.
How come you show the HLOS u-projection for Rayleigh only? What about the HLOS u-projection for Mie?
- Lines 372-374: *"Rayleigh winds are more frequently sampled in the UTLS and the stratosphere since often cloud layers are too optically thick for the laser to penetrate (an example distribution for winter 2020 over the Arctic is shown in Fig. 7a)."*: this sentence is not entirely correct because besides the effect of clouds on limiting the view of the Rayleigh channel beyond cloud layers you also have to consider that the UTLS and the stratosphere layers simply span a larger vertical range (8 to 30 km) compared to the PBL and the free troposphere (0 to 8 km), hence there are more observations for those layers. In order to estimate the number of observations for each atmospheric layer it would be better to compute the height distribution of the observations instead of the HLOS wind distribution.

Furthermore, I find it a bit strange that for Rayleigh there are no observations at all in the PBL: can you please check your data again?

- Lines 374-375: "*The Mie channel measures winds under cloudy condition and thus has more measurements in the PBL than in the stratosphere (e.g., Fig. 7c).*": don't forget the free troposphere. I would change the sentence like this: "The Mie channel measures winds under cloudy condition and thus has more measurements in the PBL and in the free troposphere than in the upper layers (e.g., Fig. 7c)."
- Line 376: "to simply" remove "to".
- Lines 375-377: "*Furthermore, some ascending and descending HLOS wind measurements cancel in the average owing to simply to the change of the angle of the LOS.*": I would replace this sentence with: "Furthermore, the ascending and descending Rayleigh distributions (Fig. 7b) are symmetric about zero due to the symmetric azimuth angle of the instrument with respect to the north when switching from the ascending to the descending phase."
- Line 379: replace "for Aeolus" with "for Aeolus Rayleigh" and add "Rayleigh" also in the corresponding part of the figure caption.
- Lines 380-382: "*We also notice that the HLOS winds can provide some information about the vertical variation of the HLOS winds that are projected onto the zonal direction (Figs. 7e and g).*" I would rewrite this sentence as follows: "We also notice that the projected zonal component of the HLOS winds can provide some information about the vertical variation of the zonal wind."
- Lines 382-385: "*For example, for Aeolus the projection of HLOS into the zonal direction for the stratosphere, UTLS, and troposphere are $+11.00\text{ ms}^{-1}$, $+4.00\text{ ms}^{-1}$ and $+1.00\text{ ms}^{-1}$ respectively for this measurement period and these values (and the standard deviations of their distributions, see the figure legend for values) agree very well with ECCC-B (and ERA5 – not shown).*" I would rewrite this sentence as follows: "For example, for Aeolus Rayleigh the mean values of the zonal projection of the HLOS wind for the stratosphere, UTLS and troposphere are 11.00 ms^{-1} , 4.00 ms^{-1} and 1.00 ms^{-1} respectively. These mean values, as well as their standard deviations (see legend of Figs. 7e and g), agree well with ECCC-B (and ERA5 – not shown)."
- Lines 385-386: "*The distributions have mean values that are positive because the winds are mainly westerly over the Arctic in the winter.*" Please cite a reference about the statistics of winds in the Arctic.
- Lines 394-397: "*We compare the distributions of the differences between the Aeolus wind measurement data and the ECCC-B and ERA5 data during fall 2018, summer 2019, and winter 2020 over the Arctic, as summarized in Fig. 8, which shows the bias and standard deviations of the differences between Aeolus HLOS winds and the ECCC-B HLOS winds, and ERA5 HLOS winds, and their zonal and meridional projections.*" This sentence is too repetitive, modify the second part like this: "We compare the distributions of the differences between the Aeolus wind measurement data and the ECCC-B and ERA5 data during fall 2018, summer 2019, and winter 2020 over the Arctic, as summarized in Fig. 8, which shows the bias and standard deviations of the differences for the HLOS winds and for their zonal and meridional projections."
- Line 397: replace "are decomposed" with "are separated".
- Line 397: replace "red" with "red dots".
- Line 398: replace "black" with "black dots".
- Line 399: replace "bias" with "biases".

- Line 399: remove "the mean values of these differences for the different sampling used", there is no need to explain what the bias is.
- Line 400: replace "are consistent with our bias correction method" with "are consistent with ECCC bias correction method".
- Lines 400-401: *"The distributions of the differences in the ascending and descending measurements do not show a significant difference."* To be correct, here you are not showing the distributions but the means and standard deviations of the distributions. You can have different distributions (in shape) with equal mean and standard deviation.
- Lines 401-402: *"The discrepancies in the meridional projections of the HLOS winds are smaller because Aeolus picks up mostly the zonal component of the winds due to the direction of the LOS."* The vertical range of Figure 8 (-7 to +7 m/s) doesn't allow to grasp the subtle differences of the biases around zero. We can only see the differences between standard deviations. By "discrepancies" do you mean the standard deviations?
- Figure 8: increase image resolution.
Perhaps, to highlight the variations of the means near zero, you could reduce the vertical scale to [-1 1] or [-2 2] and divide the standard deviations by a factor 10 (specifying this change in the text and in the caption).
- Line 409: replace "to the star" with "the distance to the star".
- Lines 452-453: *"The RMSD are systematically greater in the lower-atmosphere than in the upper-atmosphere as shown in Figs. 10 and 11"*: it seems the opposite, the RMSD is smaller in the lower atmosphere (Fig. 10) than in the upper atmosphere (Fig. 11).
- Line 453: what is the estimated error product? The errors contained in the Aeolus L2B product?
Figures S1 and S2 have no caption so you should better explain what they represent in the text.
- Figure 10: how do you explain the increase in the error in (d) for longitudes between 60° W and 120° E?
- Lines 472-473: *"However, we do not see the same improvement in the O-B statistics between 2B06 and 2B10 products over the Arctic region."* Could you provide a reason why the improvement is not seen?
- Figure 11: how do you explain the large anisotropy in (e)?
You explained that the large errors in Summer for Rayleigh are due to contamination of solar background radiation. How do you explain that the errors are still high in Winter for Rayleigh (d)? Such errors are in fact lower in the L2B error product (Fig. S2d).
- Line 477: replace "the Aeolus data product are bias corrected" with "the Aeolus data products are bias-corrected".
- Line 490: add "2019" after "1 December".
- Lines 501-502: *"the standard deviations of Aeolus winds are 5 to 40% greater than ECCC-B in every layer."*: a standard deviation 40% greater than the reference means a normalized standard deviation of 1.4, but in Figure 9 there are values above that.
- Lines 504-505: *"In any case, this analysis reveals consistent HLOS winds with correlations higher than 0.8 except during summer in the stratosphere and normalized standard errors within one standard deviation of ECCC-B."*: there are other layers and periods with correlation coefficients below 0.8: PBL in (a), (b) and (c) and S in (d). Also, there are normalized standard errors above one standard deviation in in (a), (b), (c), (d) and (e).