(The line numbers refer to the line number showed on the revised manuscript with track changes.)

1. To address to Reviewer 3's concern that there were limited coincident measurements between Aeolus and Ka-band radar and ground-based Doppler lidar (comment Q1), the following passages have been revised:
   - Revisions to the abstract: At line 17, we state: "**In particular, Aeolus data is compared to a limited sample of coincident ground-based Ka-band radar measurements at Iqaluit, Nunavut**". At line 23, we state: "**except for lower values for the comparison with the Ka-band radar, reflecting limited sampling opportunities with the radar data**". At line 30, we add: "**Our work shows that the high quality of the Aeolus dataset that has been demonstrated globally applies to the sparsely sampled Arctic region. It also demonstrates the lack of available independent wind measurements in the Canadian North, lending urgency to the need to augment the observing capacity in this region to ensure suitable calibration and validation of future space-borne DWL missions.**"
   - In the methods, at line 223, the material the described the Doppler lidar at Iqaluit has been shortened and moved to the results section. In particular, at line 223
     "Lastly, the Doppler lidar measures the LOS component of wind and, similarly to the radar, can retrieve horizontal winds via the VAD method. However, it is used only for visual comparison in this study (in the example profiles of Fig. 2) because it has very few coincident measurements with Aeolus due to its small vertical range, about 3 km a.g.l. or the cloud base height. Nevertheless, the Doppler lidar wind-profile observations were found to have measurements consistent with high-resolution radiosondes (Mariani et al., 2020), which should be borne in mind when considering our validation of Aeolus against radiosondes."

     has been revised to

     "**We will also briefly mention ground-based Doppler lidar measurements in Sect. 3.1.**" in line 193

     and "There are three" in line 191 has been revised to "**We focus on two**"

     and the corresponding passage has been added to the results in line 262:

     "**The Iqaluit site also hosts a ground-based Doppler lidar whose LOS wind measurements yields horizontal vector winds via VAD up to about 3 km a.g.l. or the cloud base height. This instrument provides very limited coincident measurement opportunities with Aeolus due to its limited vertical range. Observations from this instrument, which have been extensively validated against high-resolution radiosondes (Mariani et al., 2020) and are useful for boundary-layer focused work, are also shown in Fig. 1 for visual comparison only for 22 and 24 September and will not be considered further.**"
   - In the results section, at line 260: The passage

     "The Ka-band radar's vertical range extends to less than 5 km in both profiles, around where there are Mie wind measurements from Aeolus, because its vertical range depends on hydrometeor concentration; the lidar's vertical range only extends to around 2 to 3 km. Due to the limited region of comparison, the agreement between Aeolus and radar is less good as we will discuss later, and we will not consider the lidar measurements further in this study."

is revised to

"**The Ka-band radar's vertical range extends to less than 5 km in both profiles, around where there are Mie wind measurements from Aeolus, because its vertical range depends on hydrometeor concentration, and its sampling of coincident timing is limited for the Aeolus measurement period.**"

- In the results section, at line 285: The passage and Fig.3 that compares between radiosonde and radar is added:
  "**Although the Ka band radar offers limited sampling, it is retained in this analysis because it offers an entirely independent and unique set of observations in the Canadian North that are not assimilated in any NWP model. Furthermore, it provides consistent measurements with the radiosondes, as shown in Fig. 3. For the same period of analysis and when the radar observations are within 30 minutes of radiosonde launch, the bias of the wind speed between the radar and radiosonde is less than 1 ms^{-1} for measurements above 200 m a.g.l., and the standard deviation of the differences are within 3 ms^{-1}**"
- In the conclusion, at Line 536:

"The comparison with the Ka-band radar at Iqaluit has been limited to the early phase of Aeolus lifetime due to some technical issues from the ground-based radar. The agreement between Aeolus wind product and the Ka-band radar is systematically worse than with the forecasts and reanalysis products. We acknowledge the little overlap data with Aeolus due to the radar's limited sampling, but the comparison between Aeolus and radar, which are totally independent, is still at 99% confidence level using F-test. This provides encouragement for programs like CAWS to enhance independent radar measurements over Canadian Arctic sites."

has been revised as follows:

"**The comparison with the Ka-band radar at Iqaluit has been limited to the early phase of Aeolus lifetime due to a technical failure of the ground-based radar requiring extensive repair. The agreement between Aeolus wind product and the Ka-band radar is systematically worse than with the forecasts and reanalysis products. Nevertheless, for the limited sampling available, we have verified that the Ka-band radar provides consistent vector winds above 200 m a.g.l. with a bias less than 1 ms-1 and a RMSD less than 3 ms-1, and that the radiosonde measurements are consistent with Aeolus winds with an adjusted r-squared greater than 0.8. While the Ka-band radar data availability was limited, its analysis is retained in this paper because this independently generated ground-based data, which is unique in the large geographical region of the Canadian North, is not assimilated in any NWP system and is critical to validate Aeolus in this part of the Arctic. This highlights that radar observations are rare and challenging to obtain because of costs and**

logistics and the sparsity of independently generated ground-based data in the Arctic. Because this critically limits validation capacity for this region, these results encourage programs like CAWS to enhance independent radar measurements over the Canadian Arctic and to continue investment in such infrastructure."

2. To address to Reviewer 3's comment Q3 and Q4, the description of the ECCC-B interpolation has been revised
   Line 168: "The data used to compare with Aeolus winds in this paper is the assimilated data that is linearly interpolated to Aeolus measurement locations and times." has been revised to "**For the comparison between ECCC-B and Aeolus winds, the closest short-range forecast field, available every 15 minutes, is selected. Then, this field is linearly interpolated in space to Aeolus measurement locations, first horizontally and then vertically**"
3. To address to Reviewer 3's comment Q6, Fig. 1 has been revised:
   - The circles have now equal radius and "(some circles appear differently sized because of map-projection distortion)" in line 208 has been deleted.
   - The lon/lat limits have been changed.
   - The color for Iqaluit and Whitehorse sites is now green instead of magenta.
4. To address Reviewer 3's comments Q10 to Q12, the passage on description of coincident criterion has been revised.
   Line 243: "For example, if Aeolus overpasses selected as a target for validation at the Iqaluit site at 11:15 UTC, 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, the Aeolus HLOS profile would be compared to the reanalysis data and radiosonde measurements at 12 UTC and to the nearest scan by the radar. On the other hand, if the overpass time is 02:25 UTC, the profile would be compared to the ERA5 data at 02 UTC, the radiosonde measurements at 00 UTC, and, again, the nearest scan by the radar."
   has been revised to
   "**For example, if Aeolus overpasses selected as a target for validation at the Iqaluit site occur at 11:15 UTC, the Aeolus HLOS profile would be compared to the reanalysis data at 11 UTC, to radiosonde measurements at 12 UTC, and to the nearest scan by the radar. On the other hand, if the overpass time is 02:25 UTC, the profile would be compared to the ERA5 data at 02 UTC, the radiosonde measurements at 00 UTC, and, again, the nearest scan by the radar.**"
5. To address Reviewer 3's comment Q15,
   "When the measured HLOS winds are positive westward, i.e., when Aeolus is in its ascending orbit phase, we plot the profile of negative HLOS winds to ease the interpretation."
   is revised to
   "**When the measured winds are positive, it means the HLOS winds are directed away from the instrument (eastward for the ascending orbit phase and westward for the descending orbit phase). To ease the interpretation, we plot the negative HLOS winds when Aeolus is in its descending orbit phase (panel b).**"
6. To address Reviewer 3's comment Q18, "during fall 2018" in line 297 has been deleted.
7. To address Reviewer 3's comment Q23, "**All adjusted r-squared values in this comparison are above 0.95 for both sites and the slopes of the fitted line are all $\mathbf{1 \pm 0.1}$.**" is added in line 310.
8. To address Reviewer 3's comment Q30, line 372: "This decrease in the consistency is almost insignificant" is revised to "**The cloud cover, number of observations, and estimated error**

from Aeolus do not seem to control this decrease. Its cause, which could be due to the Aeolus measurement or the wind retrieval, remains unclear."

9. To address Reviewer 3's comment Q32, we added this sentence in line 385: "**This decrease in this period also shows how the contribution to the error due to the solar background radiation is decreasing with the transition from summer to fall conditions**".
10. To address Reviewer 3's comment Q40, the sentence in line 409:
    "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)"
    has been revised to
    "**Figure 8a and c show examples of stacked distributions of the Rayleigh and Mie winds for winter 2020 over the Arctic. Rayleigh winds at pressure greater than 850 hPa are ignored as recommended by Rennie and Isaksen (2020), because they show some indications of degradation in forecasts.**"
11. To address Reviewer 3's comment Q41, line 413
    "The Mie channel measures winds under cloudy condition and thus has more measurements in the PBL than in the stratosphere (e.g., Fig. 7c)."
    has been revised to
    "**The Mie channel measures winds under cloudy conditions and thus has more measurements in the PBL and in the free troposphere than at higher altitudes (e.g., Fig. 8c).**"
12. To address Reviewer 3's comment Q42, line 415
    "Furthermore, some ascending and descending HLOS wind measurements cancel in the average owing to simply to the change of the angle of the LOS."
    has been revised to
    "**Furthermore, the ascending and descending Rayleigh distributions (Fig. 8b) 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.**"
13. To address Reviewer 3's comment Q44, line 422
    "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)."
    has been revised to
    "**We also notice that the projected zonal component of the HLOS winds can provide some information about the vertical variation of the zonal wind.**"
14. To address Reviewer 3's comment Q45, line 424
    "For example, for Aeolus the projection of HLOS into the zonal direction for the stratosphere, UTLS, and troposphere are +11.00 ms^{-1}, +4.00 ms^{-1} and +1.00 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)."
    has bee revised to
    "**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. 8e and g), agree well with ECCC-B (and ERA5 – not shown).**"
15. To address Reviewer 3's comment Q46, line 427,
    "The distributions have mean values that are positive because the winds are mainly westerly over the Arctic in the winter."

has been revised to

"**Aeolus-measured positive values of the zonal wind component from the stratosphere into the troposphere is consistent with the known climatological presence of westerlies in this region in polar winter. Analyzing the zonal projection of the HLOS winds highlights this feature**".

16. To address Reviewer 3's comments Q47 to Q56, Fig. 9's vertical scale has been reduced by dividing the standard deviations by a factor of 10. And the paragraph about it has also been revised.

    Line 438: "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. The measurements are decomposed into Rayleigh (red) and Mie winds (black). They are further decomposed into ascending (indicated with upright triangles) and descending (inverted triangles) measurements. The results, with the bias (the mean values of these differences for the different sampling used) being smaller than 0.7 ms-1, are consistent with our bias correction method. The distributions of the differences in the ascending and descending measurements do not show a significant difference. 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."

    has been revised to

    "**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. 9, which shows the bias and standard deviations of the differences for the HLOS winds and for their zonal and meridional projections. To highlight the variations of the means, the standard deviations were divided by a factor of 10. The measurements are separated into Rayleigh (red dots) and Mie winds (black dots). They are further separated into ascending (indicated with upright triangles) and descending (inverted triangles) measurements. The results, with the biases being smaller than 0.7 ms-1, are consistent with ECCC bias correction method. The means and standard deviations of the differences in the ascending and descending measurements do not show a significant difference. 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**".
17. To address Reviewer 3's comment Q58 and 59, line 500
    "The RMSD are systematically greater in the lower-atmosphere than in the upper-atmosphere as shown in Figs. 10 and 11"
    has been revised to
    "**The RMSD are systematically greater in the upper-atmosphere than in the lower-atmosphere as shown in Figs. 11 and 12, and the differences could be anticipated from the Aeolus estimated errors from L2B product (as shown in Figs. S1 and S2)**".
18. To address Reviewer 3's comment Q61, **", possibly because the reprocessed product had improved the precision (error characterization) of the measurements while not leading to a change in the overall agreement between the products, suggesting that accuracy is not changed**" has been added in line 522 after "Arctic region".
19. To address Reviewer 3's comment Q65, line 564,

"the standard deviations of Aeolus winds are 5 to 40% greater than ECCCB in every layer" has been revised to
"**the standard deviations of Aeolus winds are 5 to 40% greater than ECCC-B in every layer with abundant Aeolus measurements, i.e., above the troposphere for Rayleigh winds and below the lower stratosphere for Mie winds, with an exception for the stratospheric Rayleigh winds in summer.**".

20. To address Reviewer 3's comment Q65, line 568
"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."
has been revised to
"**In any case, this analysis reveals consistent Rayleigh HLOS winds above the troposphere and Mie HLOS winds below the lower stratosphere with correlations higher than 0.8 except during summer in the stratosphere due to the solar background noise and normalized standard errors within one standard deviation of ECCC-B.**"
21. Some minor changes have been made on the wording:
    - Line 16: "progressing" has been inserted.
    - Line 16: "measurement stations" has been revised to "specific locations".
    - Line 40: "surfaced-based" has been revised to "surface-based".
    - Lines 66, 81, 82, and 206: "northern Canada" has been revised to "the Canadian North".
    - Line 201: "UTLS" has been revised to "upper troposphere/lower stratosphere (UTLS)".
    - Line 212: "cloud" has been deleted.
    - Line 215: "0.27" has been rounded up to "0.3".
    - Line 217: "In other words, it is scanning" has been revised to "whereby the radar scans".
    - Line 218: "and is known function of time" has been deleted.
    - Line 221: "(u, v, and w)" has been added after "these three unknown parameters".
    - Line 254: "2018" has been added after "22 September".
    - Lines 274 and 275: "component" has been revised to "projection"
    - Line 276: "In Fig. 2, we see that" has been added.
    - Line 282: "from the other datasets around 8 km a.g.l.," has been added after "50%".
    - Line 290: Figure 3 has been added. In text, the figure number has been revised thereafter.
    - Line 296: "(ECCC-B, ERA5, radiosonde, and the limited number of coincident Ka-band radar profiles)" has been added.
    - Line 301: "the" is added before "consistency".
    - Line 305: "y" has been revised to "y_i".
    - Line 320: "Mie" has been deleted before "winds" and "in general" has been added before "less consistent".
    - Line 321: "and for the Rayleigh winds" has been removed and "Moreover, at Iqaluit, Rayleigh winds show a higher consistency than Mie winds, while the opposite is true for Whitehorse." has been added.
    - Line 327: "Whitehouse" has been revised to "Whitehorse".
    - Line 338: "distinctive" has been revised to "distinct".
    - Figures 4 and 5: Data at Whitehorse has been changed from blue to red.
    - Figure 6: background horizontal grid lines have been added.
    - Line 384: "indicated by the vertical red dashed line" has been added after "9 September".

- Line 387: “During this period” has been revised to “From 9 September to 6 October 2019”.
- Line 389: “averaging” has been revised to “averaged”.
- Line 390: “on” has been revised to “along”.
- Line 392: “as a trade off of having higher vertical resolution, the Aeolus estimated errors are larger” has been revised to “the price for having a higher vertical resolution is larger errors”.
- Line 419: “stacked” has been added in front of “distribution”.
- Line 420: “Rayleigh” has been added after “Aeolus”.
- Line 421: “decomposition” has been revised to “projection”.
- Line 450: “Although” has been added in front of “Fig. 9” and “but” has been added in front of “more analysis”.
- Line 455: “the distance” has been added in front of to the star.
- Line 459: “or greater” has been added after “1.05 to 1.40”
- Line 462: “for Rayleigh winds above the troposphere and for Mie winds below the lower stratosphere, with an exception for stratospheric consistency for Rayleigh winds during the summer.” has been added after “greater than 0.8”.
- Line 552: “2019” has been added after “1 December”.