Dear Dr. Ad Stoffelen,

Thanks very much for yours and other reviewers' work in improving the manuscript. We are truly grateful to yours and other reviewers' critical comments and thoughtful suggestions. Based on these comments and suggestions, we have made careful modifications on the original manuscript. We are now sending the revised manuscript. The comments and suggestions you and reviewers gave are marked in blue, our modifications are marked in black, the original texts are marked in italic black, and our reasons for the modifications are marked in red. Below you will find our point-by-point responses to your and the reviewers' comments/ questions:

AE's comment

Overall, the reviewers are pleased with your responses to their comments, representing clarification of the manuscript and its value for AMT. Nevertheless, the requirement for needs to be clearly expressed, as well as the degradation by not measuring in dawn-dusk. Please clarify the inconsistencies found by the reviewer. Finally and importantly, for work by your colleagues, the use of the English language needs improvement and corrections by a fluent colleague in English are highly recommended.

Response: In the modified manuscript, we described the requirements for the Aeolus operating on the other sun-synchronous orbits according to Referee 3's suggestions. The degradation in wind observation uncertainties by measuring in other orbits and the inconsistencies between our rebuttal and the referee's supplementary material were clarified in this document. The detail can be found in the response to Referee 3's comment. Moreover, our manuscript was modified by native English speaker. We hope the new manuscript will meet your magazine's standard.

Referee 2's comment

In my first review, I had addressed a couple of issues. The authors responded to all of them adequately in their present revised version. In particular, they have recomputed their results by using the recent satellite and instrument parameters reported in the ATBD issue 4.4, 20.04.2018, by O. Reitebuch et al. In this way, the usefulness of the investigations and results reported by the authors has been substantially increased. Thus it is proposed to publish the paper in AMT. Before doing so, some spelling errors should be corrected.

Response: Thanks again for your previous comments. They did much help in improving the manuscript. In this modification, the manuscript was modified by native English speaker, we think most spelling errors should have been corrected.

Additionally, I would like to comment on the author's reply to my former item (7):

Of course, the Mie channel is used to detect winds in the PBL. In their original paper however, the authors showed also the required laser pulse energy down to the PBL, based on their investigations in the Rayleigh channel. So it was interesting for me to get the author's opinion on the observed behaviour of the required laser pulse energy in the PBL. In their reply now, the authors do not want to speculate about this behaviour and mention that the accuracy of the Rayleigh channel winds in the PBL is not considered in the paper. I accept their point of view. To my opinion, backscattered signals of aerosols and clouds, present in the PBL, are also measured in the Rayleigh channel (cross talk from the Mie channel) due to an imperfect filtering. This leads to a larger signal level in the Rayleigh channel than it would be case without any clouds and aerosols. Thus the signal to noise ratio is also better, the wind uncertainties decrease, and the required laser pulse energy to meet a specified accuracy criterion decreases.

Response: Thank you for your further discussion with me on this questions. We understand your points, and will carry out related simulation research in the next step, and further communicate with you if any results are obtained.

Furthermore, the authors raised the question why the wind observation accuracy in the Mie channel is higher than that of the Rayleigh channel, in the PBL. In the PBL, the aerosol and cloud particles produce strong backscattered signals which can be seen as sharp peaks in the spectrum. The corresponding Doppler shifts can be determined more accurately than those of the broader molecular spectra. Consequently, the Mie channel wind uncertainties are smaller than those of the Rayleigh channel.

Response: Thanks very much for your answer about the question.

Referee 3's comment

The authors provide suggestions for future Aeolus-type follow-on missions, with different local overpass times compared to 6/18 UTC (dawn-dusk) for Aeolus and taking into account increased solar background radiation in measured Aeolus signals, hence reduced data quality, as a consequence of selecting different sun-synchronous orbits.

I thank the authors for considering my earlier review and corresponding comments to improve the manuscript.

Some aspects are still not convincing enough in my view.

point 1

====

line 10: "For that the future spaceborne DWLs may not operate on sun-synchronous dawn-dusk orbits due to their observation purposes"

The "observation purposes" have not been mentioned in the text. The authors seem to suggest in lines 52-53 that being more flexible on orbit selection for an Aeolus follow-on (FO) mission, rather than fixed to dawn-dusk as in Marseille (2008), offers the possibility to sample the diurnal cycle with Aeolus.

The motivation or need for Aeolus-FO to sample the diurnal cycle is not given in the text. The authors could refer here to the WMO OSCAR database which provides a list of requirements for future observing systems to be beneficial for NWP, among others (http://www.wmo-sat.info/oscar/requirements, see Ids 311-313). Aeolus meets the observation cycle threshold requirement of 12 hours. The orbits suggested by the authors improve on this, approaching the "breakthrough" requirement.

Another motivation for flying other than dawn-dusk is experience from scatterometer use in global NWP. Scatterometers measure winds near the ocean surface. It has been demonstrated that scatterometers provide independent information to NWP for overpass times separated by only ~3 hours (Indian scatterometer OSCAT with ~12UTC local overpass time provides independent information relative to

ASCAT with ~9:30 local overpass time). Some details are found in figure 24 of the pdf at https://www.knmi.nl/kennis-en-datacentrum/publicatie/research-and-development-in-europe-on-global-application-of-the-oceansat-2-scatterometer-winds

Response: Thanks for your suggestions. In the modified manuscript, we added the motivations of Aeolus-FO flying on the other orbits in Section Introduction.

Original: Ln 37, Page 2

In addition, Marseille et al. (2008) demonstrated that larger observation coverage is more beneficial in the improvement of NWP results in global scale compared to the measurement of horizontal vector wind by proposing several multi-satellites joint observation scenarios with Aeolus-type instruments. However, the measurements of horizontal vector wind perform better for NWP results in the region close to the satellite tracks.

Modified: Ln 42, Page 2

In addition, Marseille et al. (2008) demonstrated that a larger observation coverage is more beneficial in the improvement of NWP results on global scale compared to the measurements of the horizontal vector wind by proposing several multi-satellite joint observation scenarios with Aeolus-type instruments. Regarding multi-satellite joint observation scenarios, according to the World Meteorological Organization's (WMO) Observing Systems Capability Analysis and Review Tool (OSCAR) (Eyre, 2009), an observation cycle of 12 h with Aeolus operating on a sun-synchronous dawn-dusk orbit would meet "the minimum" requirements that have to be met to ensure the observations are useful for global NWP. When another Aeolus-type satellite operates on a sun-synchronous noon-midnight orbit combined with Aeolus, the observation cycle may become 6 h, which would meet breakthrough requirement that, if achieved, would result in a significant improvement in global NWP compared with those based on a single Aeolus.

Original: Ln 43, Page 2

The future spaceborne DWLs may operate on different orbits which should be related to their observation purposes. For example, according to Marseille et al. (2008), larger coverage of wind observations would perform better in improving results of NWP. Furthermore, if the wind field at about 00:00/12:00 or

03:00/15:00 can be observed, we can reconstruct the wind speed diurnal cycle combing with the wind observations of Aeolus. If the future spaceborne DWLs would operate on the sun-synchronous orbits with different local time of ascending node (LTAN) crossing, the received SBR would become larger which would lead to higher uncertainties of wind observations.

Modified: Ln 55, Page 2

Future spaceborne DWLs may operate on different orbits according to their observation purposes. According to experience gained from scatterometers used in global NWP (Stoffelen et al., 2013), it has been demonstrated that the forecasting errors of tropical cyclone positions are much lower when the Indian Space Research Organisation's (ISRO) scatterometer, which has an ~12:00 UTC local overpass time, is assimilated in the NWP with the original METOP-A and METOP-B (~9:30 UTC local overpass time). Therefore, it is assumed that if the global wind field at about 00:00/12:00 or 03:00/15:00 can also be observed, the global forecast may also be significantly improved.

point 2

====

I am not convinced that the simulations of SBR are representative for Aeolus. Figure 2c of the rebuttal shows values up to 5e+5 ACCD counts, while Figure 2b (also winter period) shows values a factor of 10 higher. How can the authors conclude that "the number of ACCD counts is consistent"?

Response: Although the solar background noise (SBN) shown in Figure 2b and Figure 2c of the rebuttal are both in winter period, Figure 2b shows the peak values of SBN in winter and Figure 2c shows the valley values in winter as Figure 1a and 1b of the rebuttal illustrate. And Figure 1b indicates that the peak value of SBN in winter is likely to be 10 times the valley values.

In the rebuttal, the sentence "As Fig. 2 illustrated, the amount of ACCD counts near summer and winter solstice are consistent with Fig. 1 of the supplement." is derived from the fact that:

1) The amount of global maximum and local maximum values of SBN near summer and winter solstices are about 1e7 and 0.5e5, and that are consistent with the values shown Figure 1b of rebuttal.
2) From Figure 2(a, b) of the rebuttal, the values of SBN show periodic variation, which are consistent with the periodic variation of Figure 2c.

Regarding Figure 4 of the rebuttal and figure 2 of the supplement. First the authors conclude: "The comparisons between Fig. 4 and Fig. 2 of the supplement show large difference." Can the authors explain this large difference?

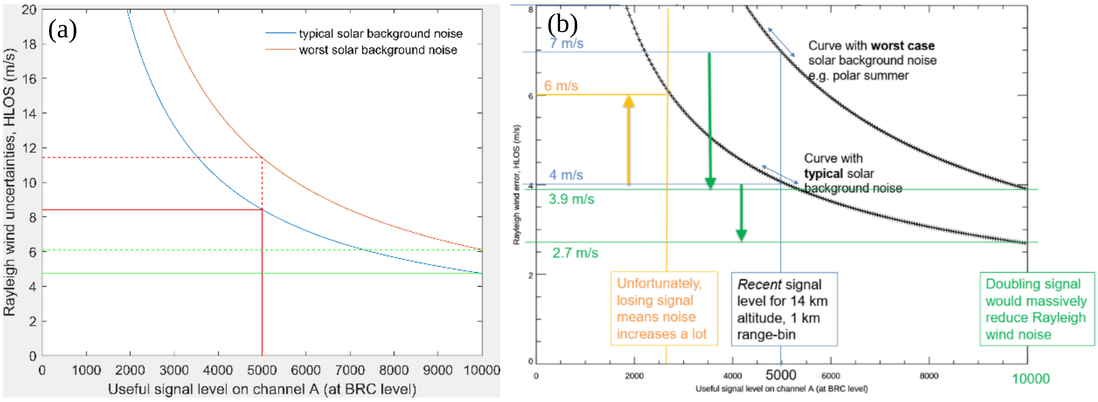

Fig. 1. The relationship between uncertainties of wind observations and useful signal of channel A on Rayleigh channel. (a) Figure 4 of the rebuttal; (b) Fig. 2 of the supplement.

Response: As is illustrated in Fig. 1(a), the same as Fig. 4 of the rebuttal, when useful signal on channel A reach 5000, the uncertainty on Rayleigh channel is about 8 m/s on typical solar background noise. However, the uncertainty is about 4 m/s when useful signal on channel A is 5000 on Fig. 1(b), the same as Fig. 2 of the supplement. The fact demonstrates that “the comparisons between Fig. 4 and Fig. 2 of the supplement show large difference”.

"However, the uncertainties of wind observation are about 2~3 m/s when the SBR is about 72.19 mW·m−2·sr−1·nm−1". The value of 72.19 corresponds to a "typical" SBR value, which is plotted as a red curve in Figure 4. I cannot see uncertainly values of 2-3 m/s in this plot. Can the authors please explain?

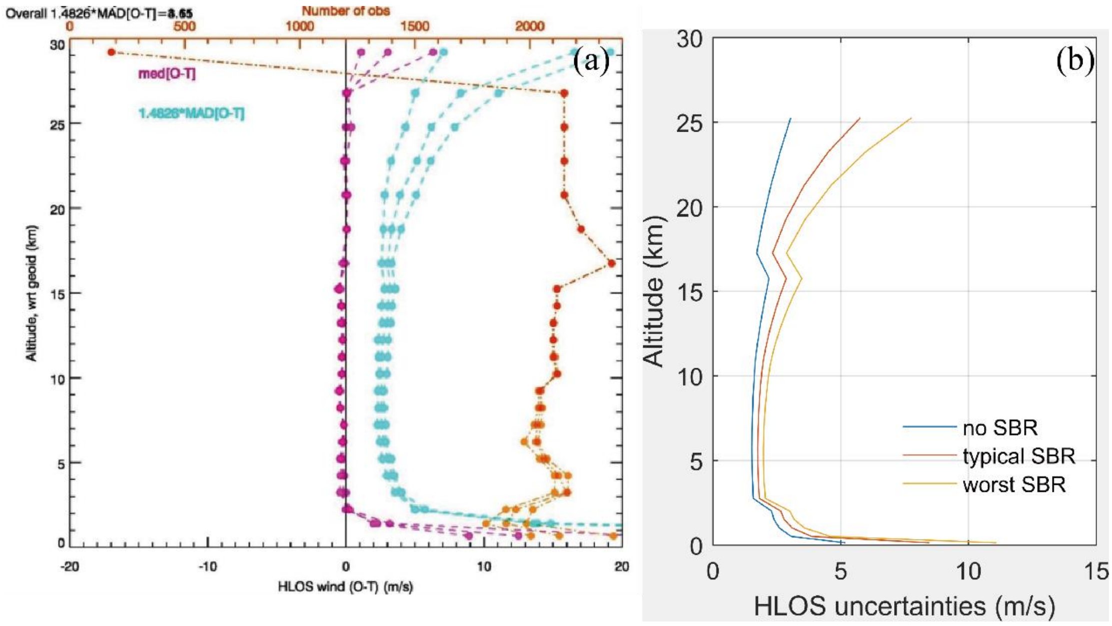

Fig. 2. HLOS wind uncertainties of Rayleigh channel for three level of solar background noise under clear skies. (a) Results of TN17.4 (Figure 4) (Rennie, 2017), the blue lines show the median absolute deviation of the error, and the three lines show uncertainties under no solar background radiation (SBR), typical SBR, and worst SBR, respectively; (b)The simulation results of our model.

Response: (Rennie, 2017) have tested the wind uncertainties of Rayleigh channel for three level of solar background radiation (SBR): no SBR, typical SBR (72.19 mW·m^{-2}·sr^{-1}·nm^{-1}), and worst SBR (154 mW·m^{-2}·sr^{-1}·nm^{-1}, polar summer) as the blue lines of Fig. 2(a) shown. Fig. 2(a) illustrates that the wind uncertainties of Rayleigh channel is relatively small in the free troposphere, and large in planet Boundary Layer (PBL) and stratosphere; the differences of wind observation uncertainties in the free troposphere are not large under the three level of SBR, all of them are about 2~3 m/s. Fig. 2(b) which was simulated by our model shows the similar characteristics. The sentence "he uncertainties of wind observation are about 2~3 m/s when the SBR is about 72.19 mW·m^{-2}·sr^{-1}·nm^{-1}" refers to the uncertainties in the free troposphere. The comparisons between the results of Rennie (2017) and our simulations verify the rationality of our model.

In the rebuttal the authors state: "In the manuscript, Aeolus was assumed to be operated on best case scenario." Please add this to the abstract explicitly, to ensure that the context of the manuscript is very clear for all readers already at the beginning, also for those readers who are used to work with real Aeolus data, whose random error is substantially worse than the best case scenario presented in the manuscript.

Response: In the modified manuscript, the related descriptions are added in the abstract.

Original: Ln 13, Page 1

On the two new orbits, the increments of averaged SBR received by the new spaceborne DWLs range from 39 to 56 mW·m^{-2}·sr^{-1}·nm^{-1} under cloud-free skies near summer and winter solstices, which will lead to the increment of averaged Rayleigh channel wind observation uncertainties of 0.19 m/s for 15:00 orbit and 0.27 m/s for 12:00 orbit using the instrument parameters of Aeolus with 30 measurements per observation with 20 laser pulses per measurement.

Modified: Ln 13, Page 1

On these two new orbits, the increments of the averaged SBR received by the new spaceborne DWLs range from 39 to 56 mW·m^{-2}·sr^{-1}·nm^{-1} under cloud-free skies near the summer and winter solstices, which will lead to uncertainties of 0.19 m/s and 0.27 m/s in the increment of the averaged Rayleigh channel wind observations for 15:00 and 12:00 orbits using the instrument parameters of Aeolus with 30 measurements per observation and 20 laser pulses per measurement. This demonstrates that Aeolus operating on the sun-synchronous dawn-dusk orbit is the optimal observation scenario, and the random error caused by the SBR will is larger on other sun-synchronous orbits.

Line 316: "The comparison illustrates that SBR caused the maximum increase in the averaged wind observation uncertainty of about 3.04-2.61=0.43 m/s for Aeolustype DWLs operating on the sun-synchronous orbits."

That is actually a marginal degradation, so that could be an argument to fly other than dawn dusk, in case of flying more than a single Aeolus type instrument at the same time. These random error values correspond to the right hand side of the last figure in the supplementary material, which shows an increase of 1.2 m/s random error between typical and worst case SBR scenario, so a factor of 3 larger increase than simulated by the authors. It seems that the simulated results of the authors are much more positive than what can be infered from real Aeolus data. Can the authors please comment?

Response: The wind observation uncertainties caused by SBR are influenced by not only the amount of SBR, but also the photon number backscattered by atmospheric molecules. When the photon number excited by the atmospheric molecules is large enough, the wind observation uncertainties will be small even if the SBR is large enough. And when the photon number excited by the atmospheric molecules is small, little SBR would cause large wind observation uncertainties.

When the useful signal on channel A is up to 10000, the difference of wind observation uncertainties between typical and worst SBR is 1.37 m/s in our simulation, as is shown in Fig. 1(a). The result is close to the result in the supplementary material.

The average SBR received by the three orbits are 20.09, 60.68, and 76.36 $mW \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$ respectively. The SBR are not large compared to worst case (154 $mW{\cdot}m^{-2}{\cdot}sr^{-1}{\cdot}nm^{-1}$). Furthermore, the useful signals of Rayleigh channel are 2.65e+4 each bin in the free troposphere and stratosphere for the three orbits. The useful signals are 2.5 times the useful signals of the supplementary material. The two facts can account for the little differences of averaged uncertainties among the three orbits. According to Fig. 2(a) derived from the TN 17.4, the differences among the three SBR conditions are not large, especially in the free troposphere.

References:

RENNIE, M. (2017) TN17.4 CCN6 results: further Chain-of-Processors testing of L2B results and testing of CCN6 L2B processor algorithm updates., ECMWF.

STOFFELEN, A., VERHOEF, A., VERSPEEK, J., VOGELZANG, J., MARSEILLE, G., DRIESENAAR, T., RISHENG, Y., De CHIARA, G., PAYAN, C., COTTON, J., BENTAMY, A. & PORTABELLA, M. (2013) Research and Development in Europe on Global Application of the OceanSat-2 Research and Development in Europe on Global Application of the OceanSat-2 Scatterometer Winds: Final Report of OceanSat-2 Cal/Val AO project., KNMI, Royal Netherlands Meteorological Institute, de Bilt, the Netherlands.