Response to report 1

I am very happy with the authors response to the reviewers comments. They have addressed all the issues we raised in an fully acceptable way. Congratulations to the authors for providing an excellent paper on use of Aeolus data in a high-resolution limited area model assimilation system. I would though propose to update figure 5 to include an extra row with DFS values for the cycles where Aeolus is available. The authors have already prepared such a figure in the response to me. Only the top row with absolute DFS is required to be added, as the relative DFS values are very similar to the ones presented. This would provide a fairer picture of the absolute DFS of Aeolus data versus other observing systems for the cycles where Aeolus data is available.

Thank you for your comments. We have added the absolute DFS for the hours were Aeolus are available to figure 5 and updated the manuscript accordingly.
Kind regards,
the Authors

Report 2

Review of Hagelin et al.
The manuscript title Evaluating the use of Aeolus satellite observations in the regional NWP model Harmonie-Arome provides an investigation into the impact of Aeolus HLOS winds assimilation in the 3DVar Harmonie-Arome model over the MetCoOp domain. The paper describes well the datasets used from Aeolus, details about the implementation into the DA system, and impacts both the analysis and forecast. The result suggest that the Aeolus data has a positive impact on wind analysis, with Mie winds providing larger impact, but more neutral impact on the forecast. The reviewer recommends however, that more details be given on the forecast impact, by examining more metrics relevant for regional NWP, especially humidity and precipitation forecast skill which should be influenced by improve wind analysis. Therefore the reviewer recommends publication of the manuscript after major revisions.

Thank you for your comments. We have updated the manuscript to address the issues that have been raised by this review. Details are reported here below.
Kind regards,
the Authors

Minor Comments:
Page 1, Line 22: Atmospheric Motion Vectors is already defined- change “Atmospheric Motion Vectors (AMV)” to “AMVs”
Second definition removed.

Page 1, Line 22-23: AMVs can also be computed by water vapor image sequences as noted earlier in the text, so it is not correct to say wind speed is only measured at cloud top height, but also in layers of the atmosphere where satellite observations are sensitive to water vapor signal. I think the point still remains that vertical coverage with all AMVs is limited.
Sentence lightly modified to take this into account.

Page 2, Line 32: Suggest saying the wind measurement is usually near the zonal component of the wind vector rather than east-west since this changes depending on ascending/descending orbit.
Zonal added as suggested, but is east-west kept in parenthesis, as I feel this is easier to understand intuitively rather than zonal component (which I always need to look up to remember which direction is the zonal component and which is the meridional component).

Page 3, Paragraph 2: Could you please explicitly mention the horizontal spatial resolution of the Harmonie-Arome model and also the thinning grid resolution for Aeolus observations?
The resolution of the Harmonie-Arome grid is 2.5 km, as mentioned on line 66, and we don't thin the Aeolus observations. We calculated the horizontal correlations of the Aeolus data and concluded that there was no need to thin the data.

Page 4, Line 110: change "providing to sets of LBC" to "providing two sets of LBC"
Thank you for spotting this. A w is added in the appropriate place

Page 4, Line 114: change "All the experiment" to "All the experiments"
added

Page 4, Line 122: change "first satellite-based lidar mission" to first satellite-based wind lidar mission"
wind added.

Page 5, Line 141: Can you please define the MetCoOp domain? I do not see any description previously in the text.
Line 65 and onwards describe the MetCoOp domain briefly and the area covered can be seen in figure 1.

Page 5, Line 145: Can you describe the method used to conclude the inflation factor and the rationale for adjusting the observation error limits upward? Is this based on looking at O-A stats from the control, or some other method?
Following our previous experience of these observations, the results of the Desroziers diagnostics and the recommendations from ECMWF, we decided this would be an appropriate inflation factor.

Page 7, Figures 2/3: Is it possible to include plots of observation counts for the Mie and Rayleigh winds used to compute the statistics? And also mention average number of observations assimilated per 3 hour cycle.
We have added a black dotted line to each panel in figure 3 to show the number of Aeolus observations used in the data assimilation for the full period. The number of observations per 3 h cycle varies, in particular for the Mie observations, but on average for the laser B period we use ~200 observations for the Mie data and ~450 observations for the Rayleigh data. Since we only use one overpass for the laser A experiments, the figures are lower here, ~180 Rayleigh observations and ~60 Mie observation per cycle.

We did not add the observation count to figure 2, as that would create a very messy plot with too many lines. The information is the same as what is now shown by the black dotted lines in figure 3.

Major Comments:
Page 7, Figures 2/3 and text: Is there an additional bias correction used to remove the residual bias of the HLOS O-B illustrated for the Rayleigh winds for the laser A data? If not, can you please add text to highlight this point and any impact it might have on the analysis?
Just the regular observation error check. This bias will be removed in future reprocessed Aeolus datasets. At the time we did these experiment, such bias correction was not available. We have added a sentence on variation bias correction to the manuscript, to outline what can be done in case the reprocessed Aeolus data doesn't completely remove this bias over our domain.

The bias correction used in our studies is the same as that used by ECMWF where they estimated the bias after running experiments for long periods, but we used a shorter period both for laser A

and laser B. We would have implemented additional bias correction if we had the opportunity to experiment with longer periods.

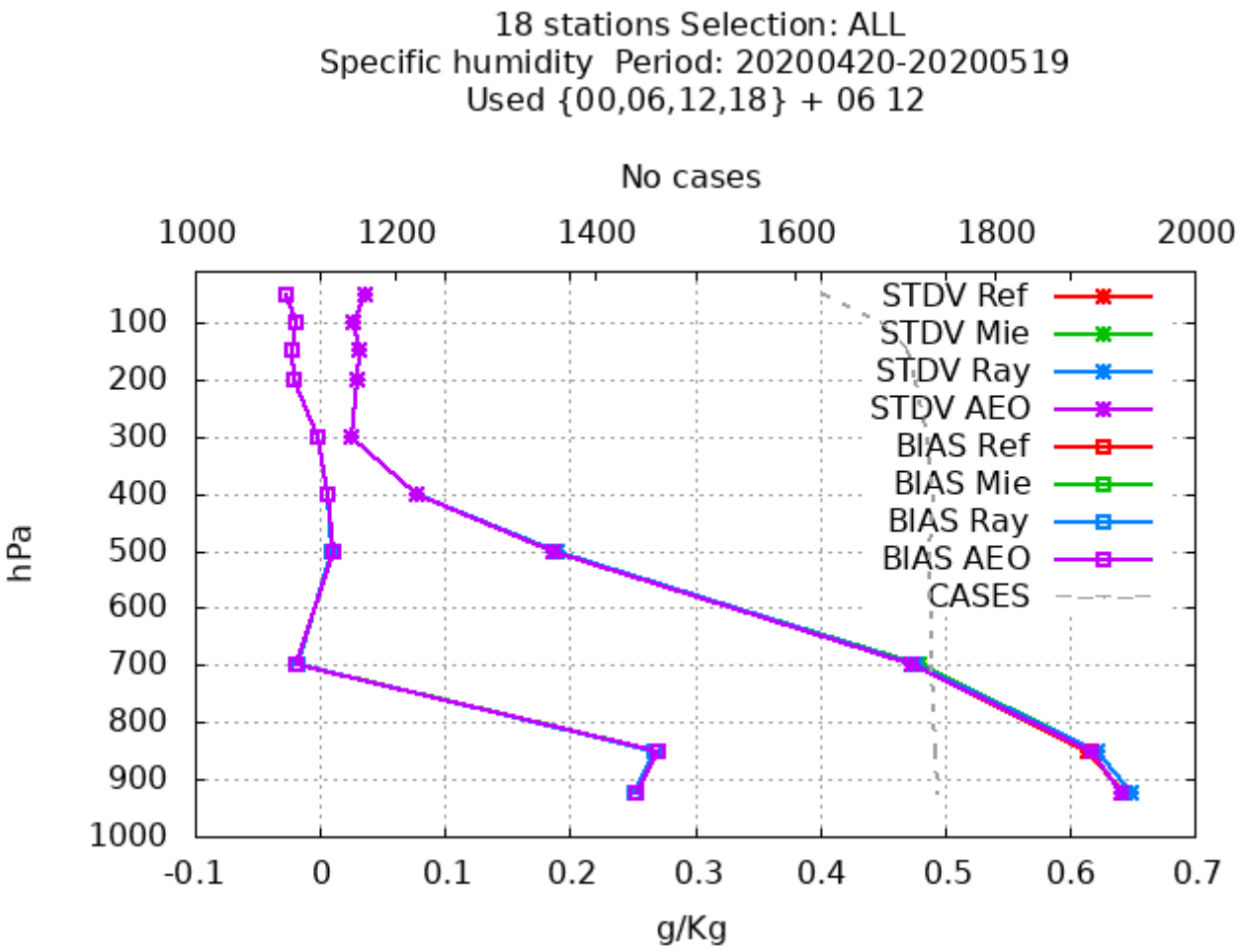
Section 4.2: The section on forecast impacts should be expanded to include other metrics, particularly with the application in regional NWP. Realizing that the impacts on the wind forecast are relatively small in terms of speed and wind vector. It may be worth looking at the impact of the u and v wind components (perhaps more wind impact on the u component), and then assess other forecast metrics, especially precipitation or specific humidity as the transport of moisture variables should be impacted by Aeolus information added to forecast initialization.

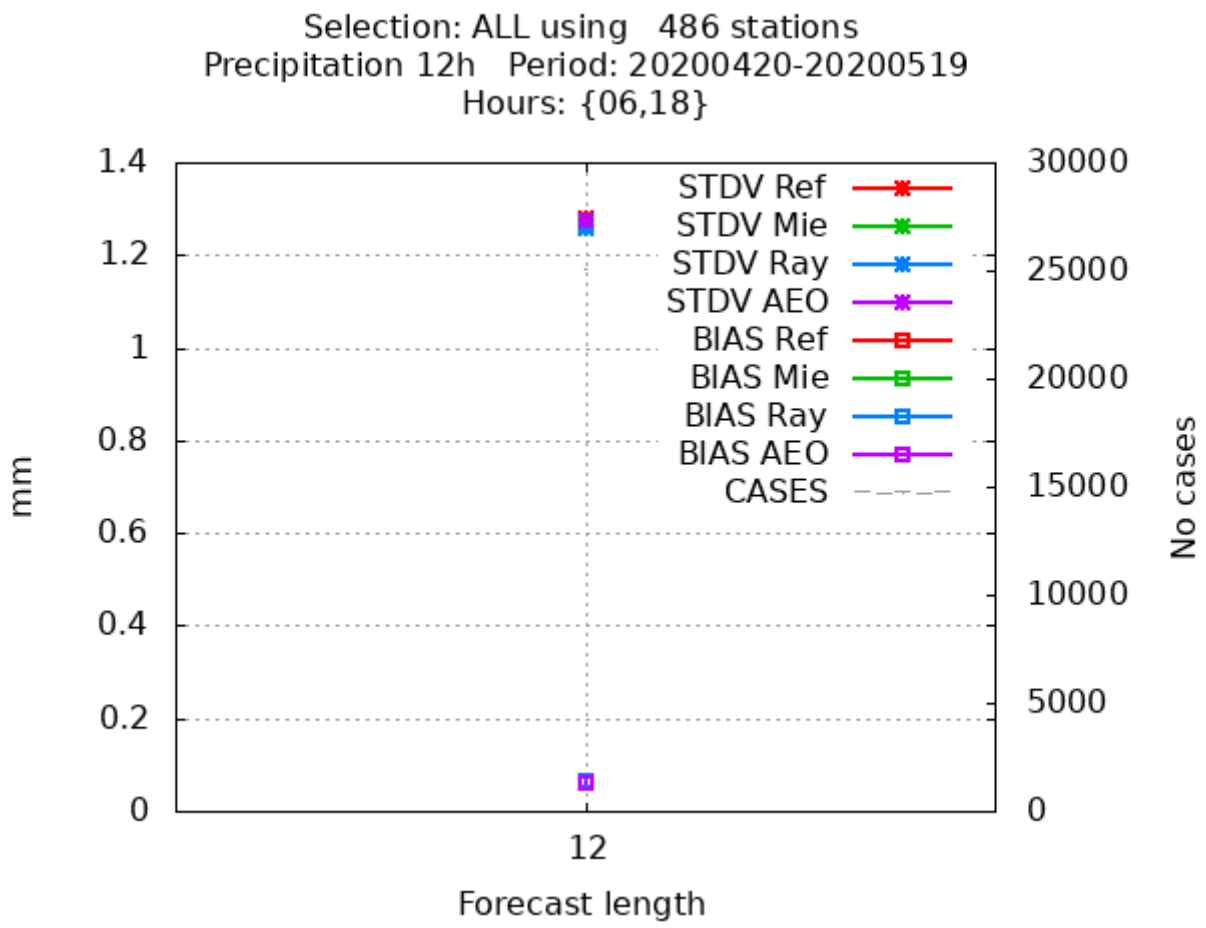
Our current verification system only allows us to verify wind speed and direction, not the wind speed components themselves. Presumably we would see the same impact (possibly marginally larger) in the u component and no impact for the v component.

The radiosonde network over the MetCoOp region is rather sparse and it is difficult to properly verify small-scale parameters like humidity with this network. We do have verification of specific humidity and other parameters, but we decided not to include them as the impact of Aeolus data is negligible. We have added a sentence concerning this to the end of the section about the impact on forecasts.

The image below show the result for specific humidity when comparing against radiosonde data for the laser B period. The only visible result is a small degradation of the standard deviation when using the Rayleigh data at the lowest levels. The vertical profiles of specific humidity for the laser A period are even more neutral than for the laser B period.

For the precipitation, (shown on the next page) perhaps there is a small improvement in using the Rayleigh data, but it’s not large enough to draw any conclusion other than that the Aeolus data have a neutral impact on the forecast scores. Looking at the same score for laser A, there is a corresponding tiny improvement in precipitation from using all Aeolus data and Rayleigh only is the worst performing.


18 stations Selection: ALL
Specific humidity Period: 20200420-20200519
Used {00,06,12,18} + 06 12
No cases
1000
1200
1400
1600
1800
2000
hPa
100
200
300
400
500
600
700
800
900
1000
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
g/Kg
STDV Ref
STDV Mie
STDV Ray
STDV AEO
BIAS Ref
BIAS Mie
BIAS Ray
BIAS AEO
CASES


Selection: ALL using 486 stations
Precipitation 12h Period: 20200420-20200519
Hours: {06,18}
mm
No cases
Forecast length
12
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
5000
10000
15000
20000
25000
30000
STDV Ref
STDV Mie
STDV Ray
STDV AEO
BIAS Ref
BIAS Mie
BIAS Ray
BIAS AEO
CASES