Aeolus L2B horizontal HLOS wind product monthly quality report

Period: For the month up to 3 March 2022

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Introduction

Information on the derivation of ECMWF Aeolus Level-2B (L2B) HLOS (horizontal line-of-sight) wind monitoring statistics is available on the ESA CAL/VAL webpage (under L2B Data Quality Handbook); for those people that have access. Section 2.3 of the Technical Memorandum also explains how ECMWF's Aeolus observation minus background (O-B) departure statistics are calculated. ECMWF's daily updated, automatically produced statistics of L2B HLOS wind observation minus background (O-B) and observation minus analysis (O-A) are available here.

The statistics are produced for Rayleigh-clear and Mie-cloudy winds and not for the unassimilated Rayleigh-cloudy and Mie-clear. An expert interpretation of these statistics for the past month is provided in this report, including insights into any relevant data events.

Quality Control (QC) is applied when calculating the ECMWF "all data" statistics:

- Rejection of observations with Level-2B processor estimated instrument error (1-σ) exceeding a threshold: σ_O > 12 m/s for the Rayleigh-clear and σ_O > 5 m/s for the Mie-cloudy to remove outliers which were found to help the non-robust metrics (like mean and standard deviation).
- Rejection of observations if the Level-2B HLOS wind result overall confidence flag is invalid.
- Rejection of observations which fail the ECMWF model "first-guess check" i.e. reject if $O - B > 5\sqrt{\sigma_O^2 + \sigma_B^2}$ (a 5-sigma check). This is effectively a gross-error QC.

The website also has available the "used" or actively assimilated observation statistics.

Daily ECMWF data coverage plots for Aeolus are available here.

Other NWP monitoring websites for Aeolus L2B winds:

- Météo-France
- Met Office:
  - O-B statistics
  - Data timeliness

1. L2B Rayleigh-clear O-B and O-A departure statistics

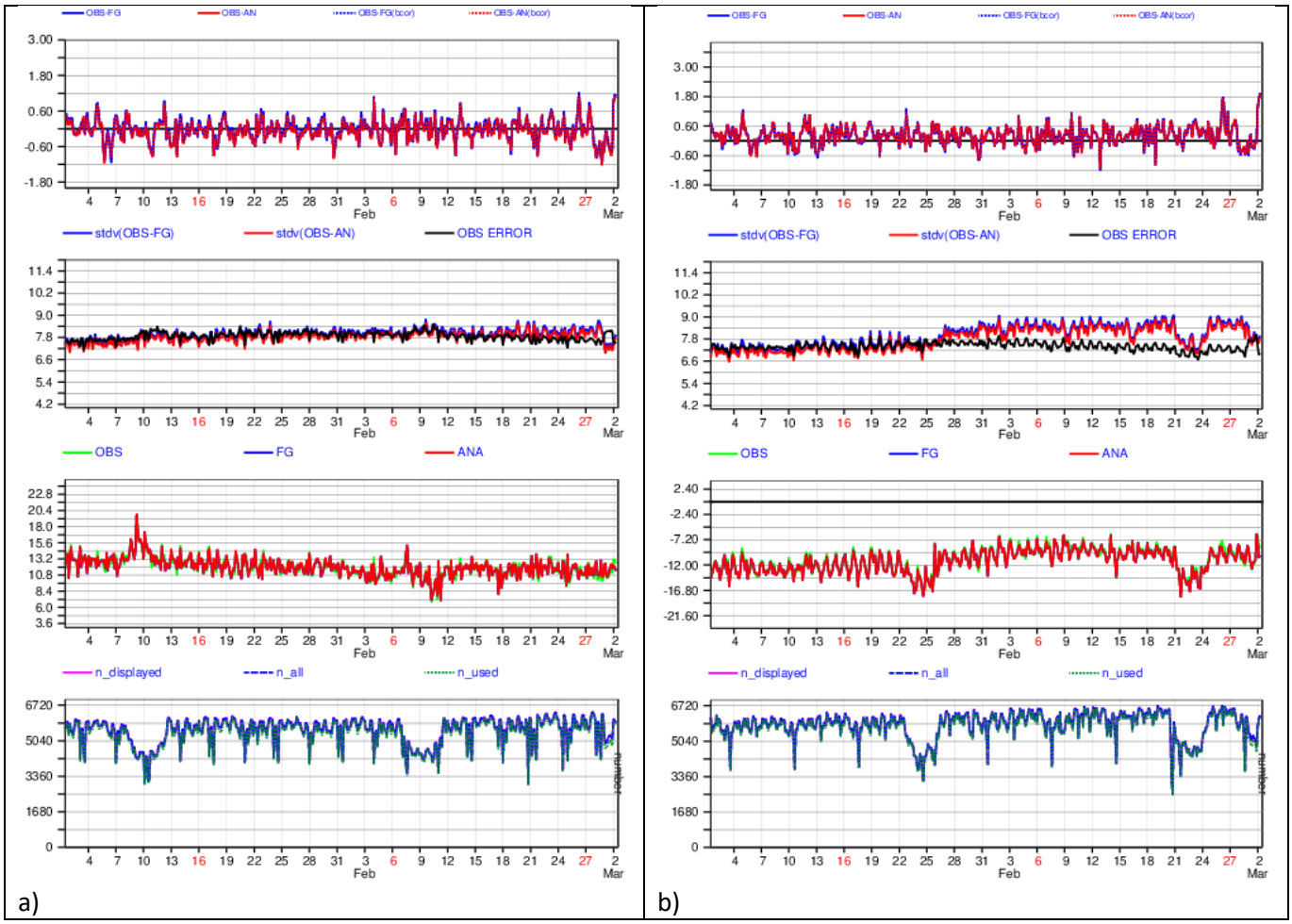


Figure 1. This figure shows changes with time in the O-B and O-A departure statistics of the L2B Rayleigh-clear winds with respect to the ECMWF model. The statistics are calculated every 3 hours for the 0-400 hPa pressure range. Panel a) is for ascending and panel b) is for descending orbit phase. The top plot is the mean of departures i.e. bias; the second plot down is the standard deviation of departures and the assigned observation error in data assimilation (OBS ERROR) i.e. information on random error; the third plot down is the mean observation value and mean model equivalent and the bottom plot is the number of observations per sample.

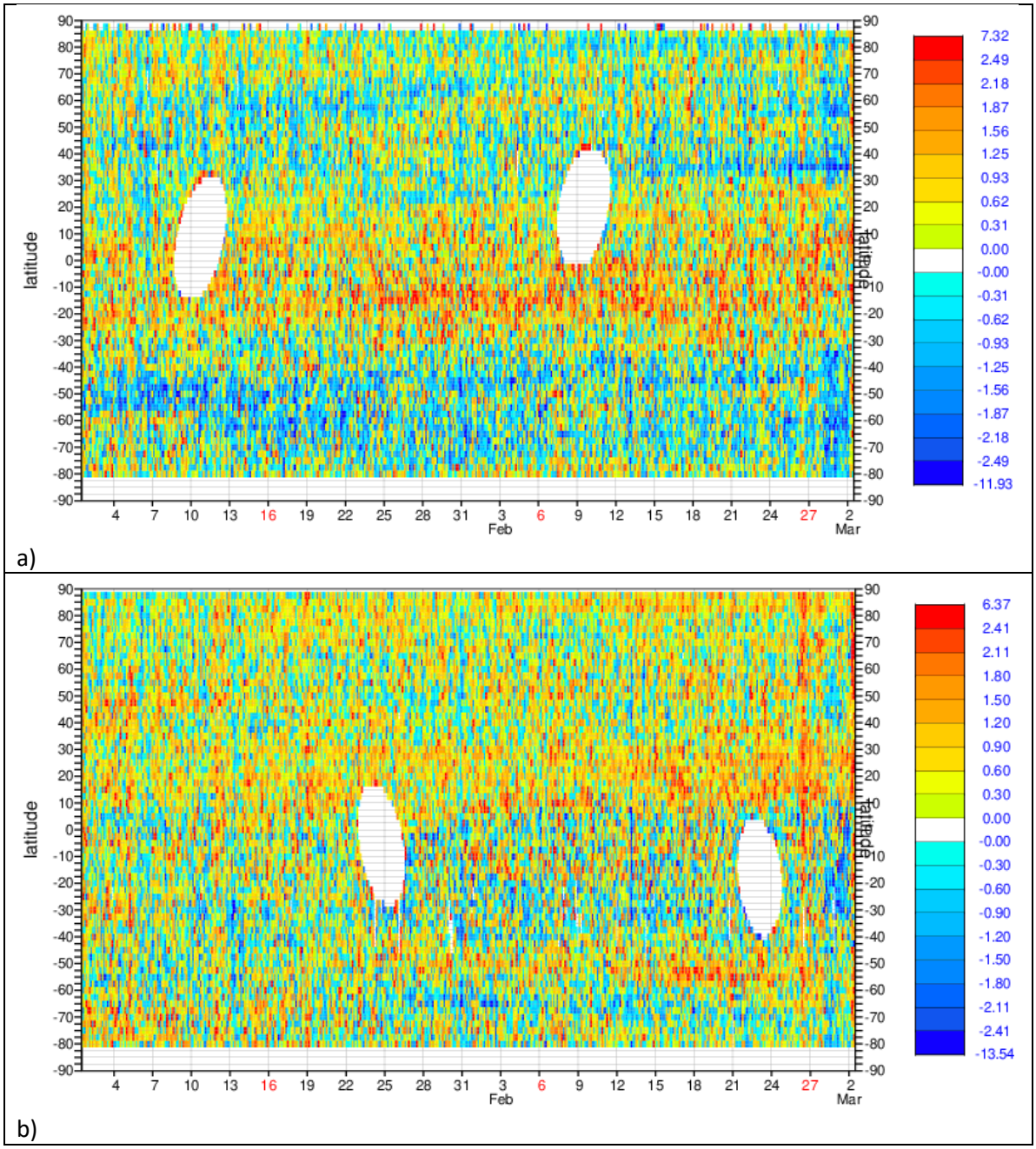


Figure 2. Latitude-time dependence of the mean(O-B) for L2B Rayleigh-clear HLOS winds for the 0-400 hPa pressure range for a) ascending and b) descending orbit phase. Unit: m/s.

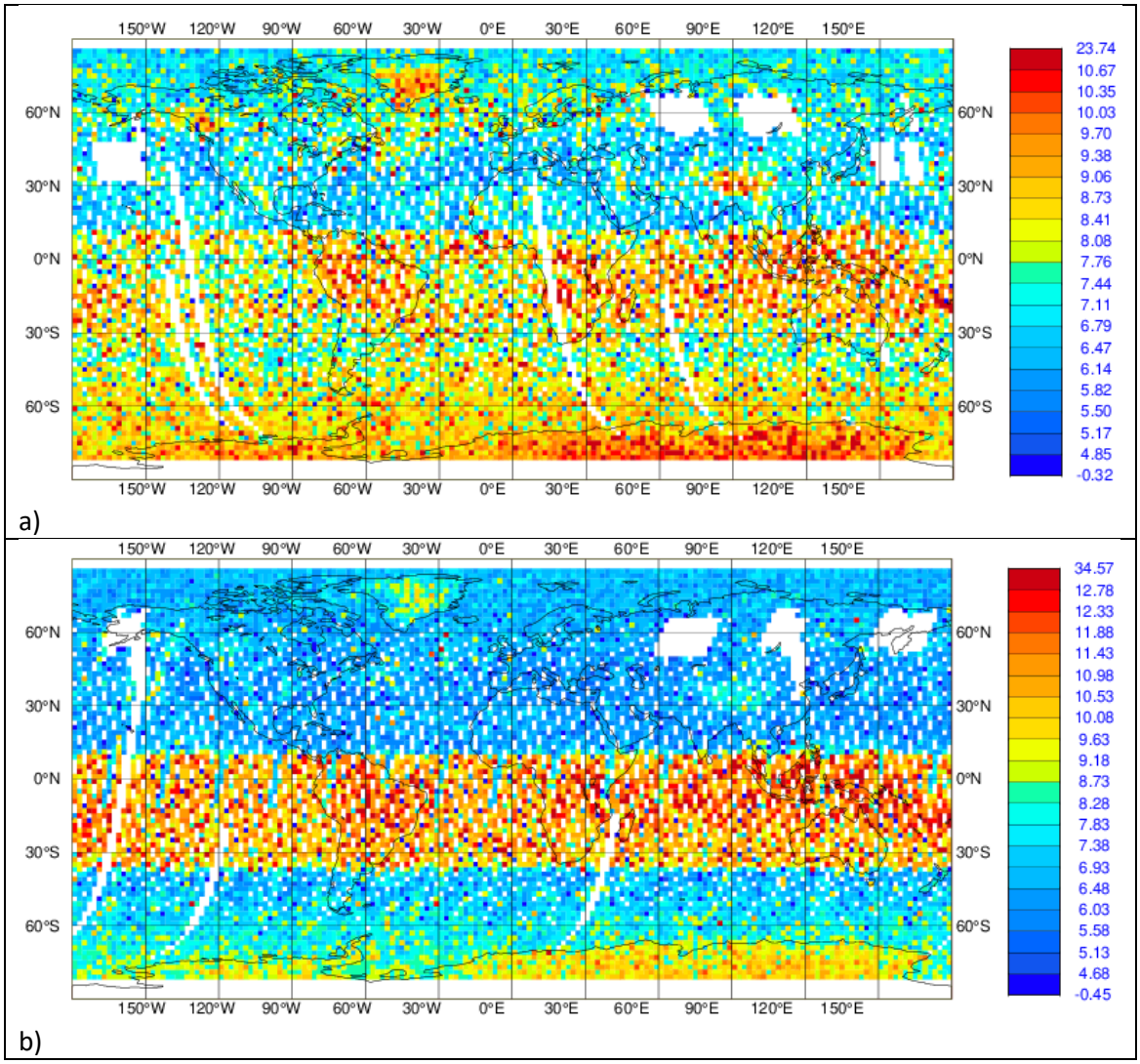


Figure 3. Maps of L2B Rayleigh-clear mean(O-B) for the 0-400 hPa pressure range for a) ascending and b) descending orbit phases. Unit: m/s. For the period: 31 January 2022 to 25 February 2022. These plots are only updated once per week.

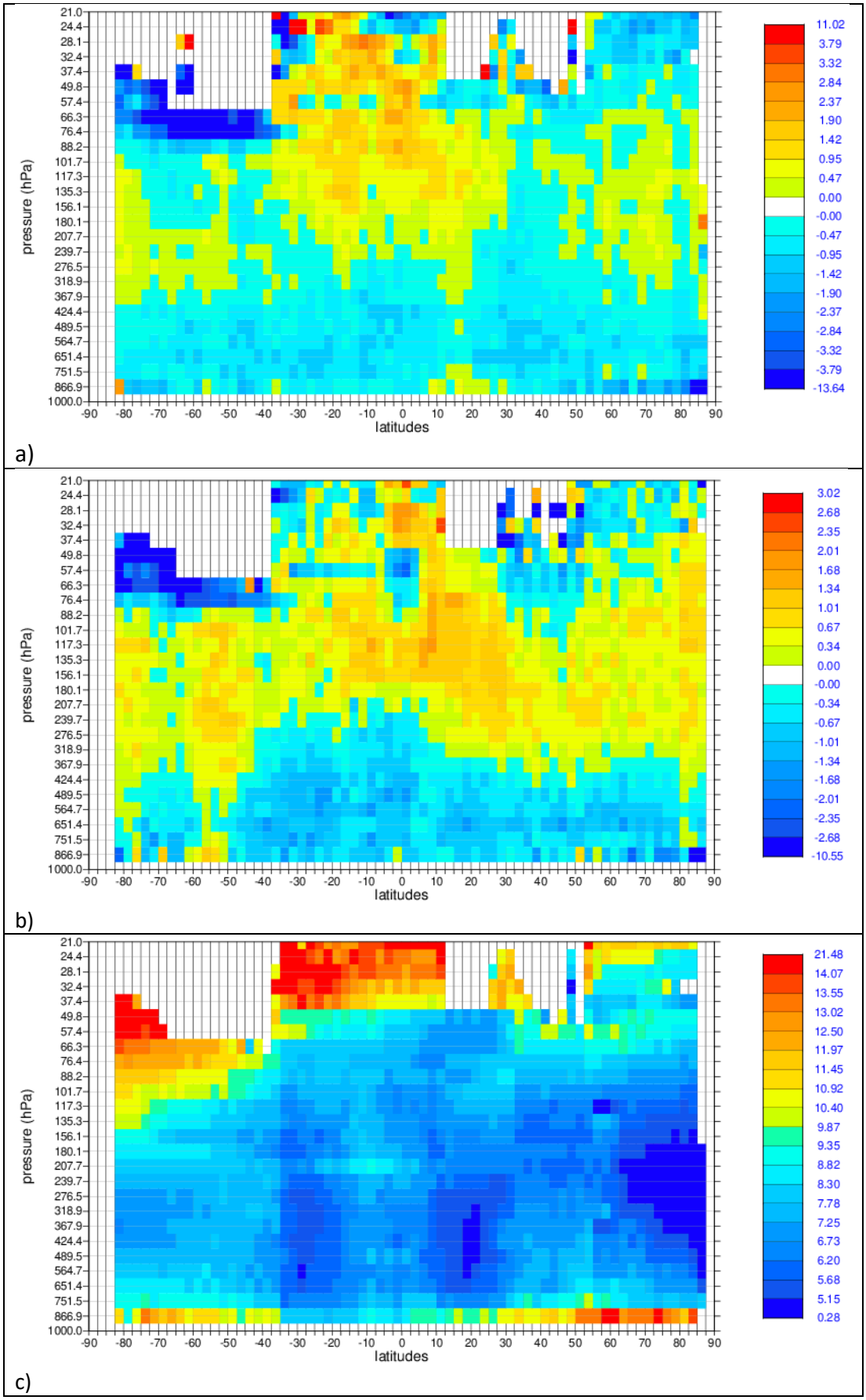


Figure 4. Pressure versus latitude dependence of the L2B Rayleigh-clear mean(O-B) for a) ascending and b) descending orbits. Panel c) is the standard deviation of (O-B) for ascending orbits. Unit: m/s. For the period: 17 January to 26 February 2022.

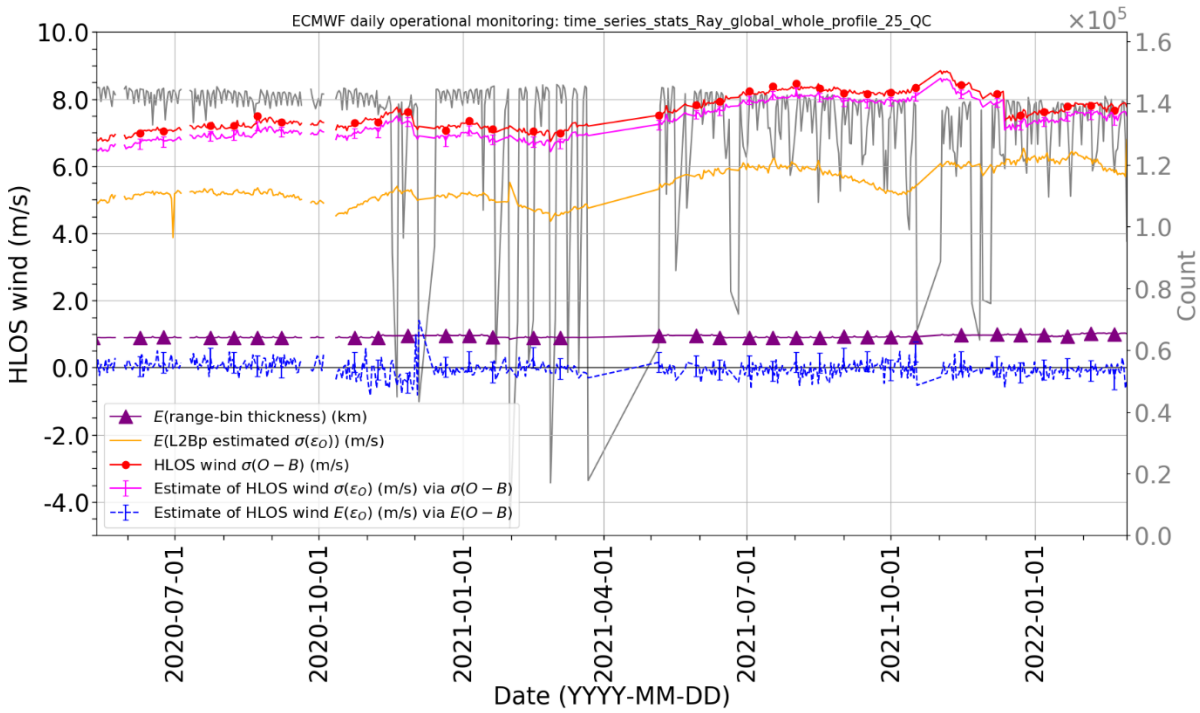


Figure 5. Times-series of daily, global, whole profile L2B Rayleigh-clear HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject winds if abs(O-B) > 25 m/s.

Comments and assessment of L2B Rayleigh-clear winds for this period:

- There was a significant change in range-bin settings (RBS) for the latitude band 0 to -35 degrees since 24 January and then 10 to -35 degrees since 31 January. The top range-bin was raised to 30 km to capture the plume from the Hunga Tonga-Hunga Ha'apai volcano eruption (on 15 January).
- Noise levels have been reasonably stable in the past month in the global-whole-profile average.
- There was a hint of noise improvement on 1 March in Figure 1. This was because of a test of new N/P (N=5, P=114) settings which improved the noise - but due to inappropriate AUX_PAR_2B QC settings on the L1B measurement-scale Ray SNR (max set to 38), a lot of troposphere L1B data was not processed to L2B winds. Offline testing with appropriate AUX_PAR_2B settings shows that the new N/P settings improves the noise by about 17% (profile average). We expect the new N/P settings can be implemented permanently once the next baseline (14) is operational (hopefully in March).
- In more depth: there are some complicated changes in the random errors as a function of altitude due to the RBS change. Thicker range-bins in the Tonga RBS latitude band in the troposphere (required to allow the 30 km top) resulted in lower stdev(O-B), however this is compensated by increased noise for the higher altitude range-bins 20-30 km. The 0-400 hPa stdev(O-B) map clearly shows the increased noise at higher altitudes due to the new RBS. The increased noise leads to a strong interaction with the QC choices for the ECMWF operational monitoring i.e. the 12 m/s L2Bp estimated error threshold (this should perhaps be increased). The QC causes apparent noise differences for ascending and descending orbits (dependent on the level of solar background noise).
- There appears to have been some hot-pixel related biases affecting the system on 26-27 February, for descending orbits at least.

2. L2B Mie-cloudy O-B and O-A departure statistics

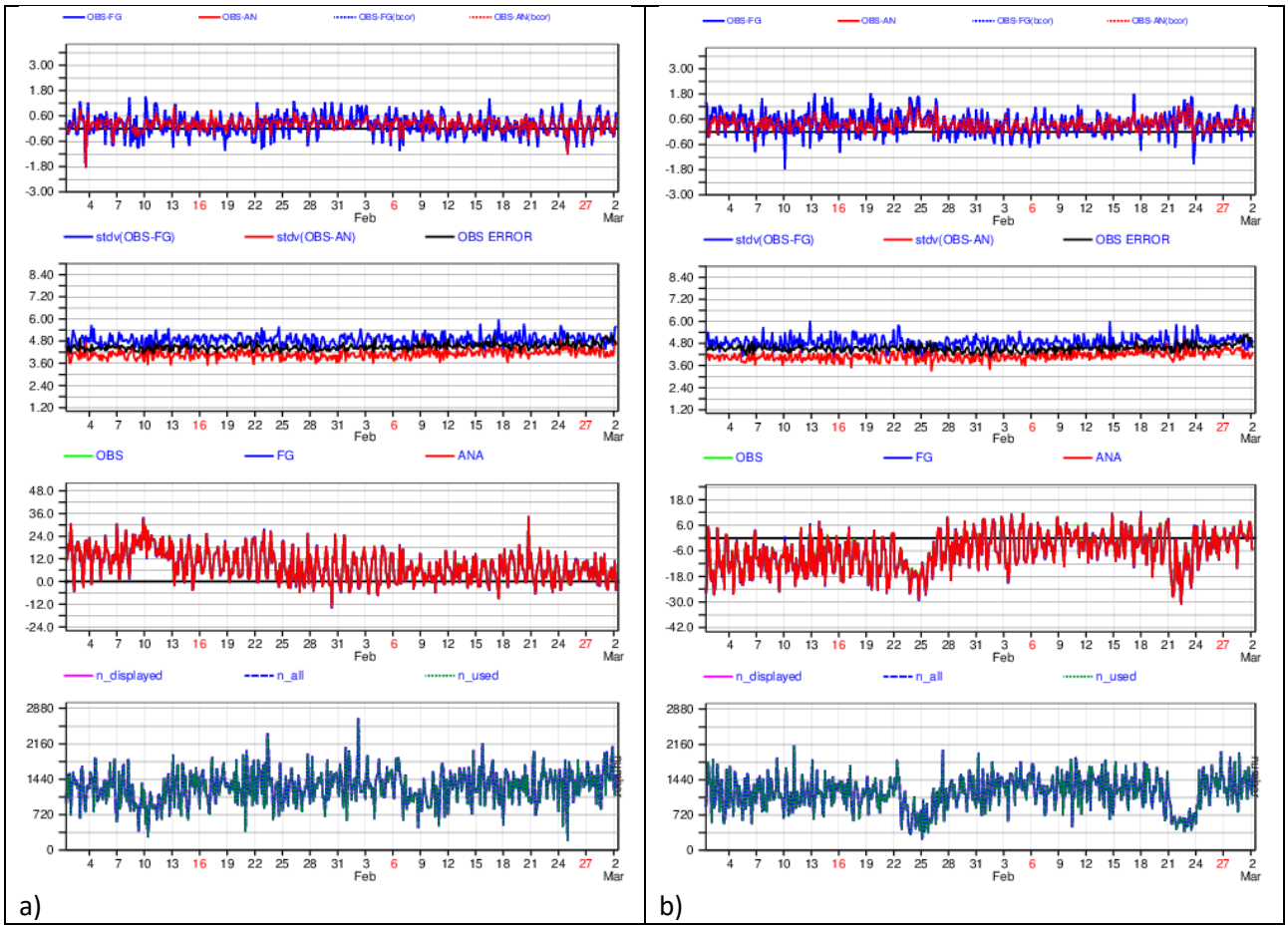


Figure 6. Same type of plots as in Figure 1, but for L2B Mie-cloudy HLOS winds.

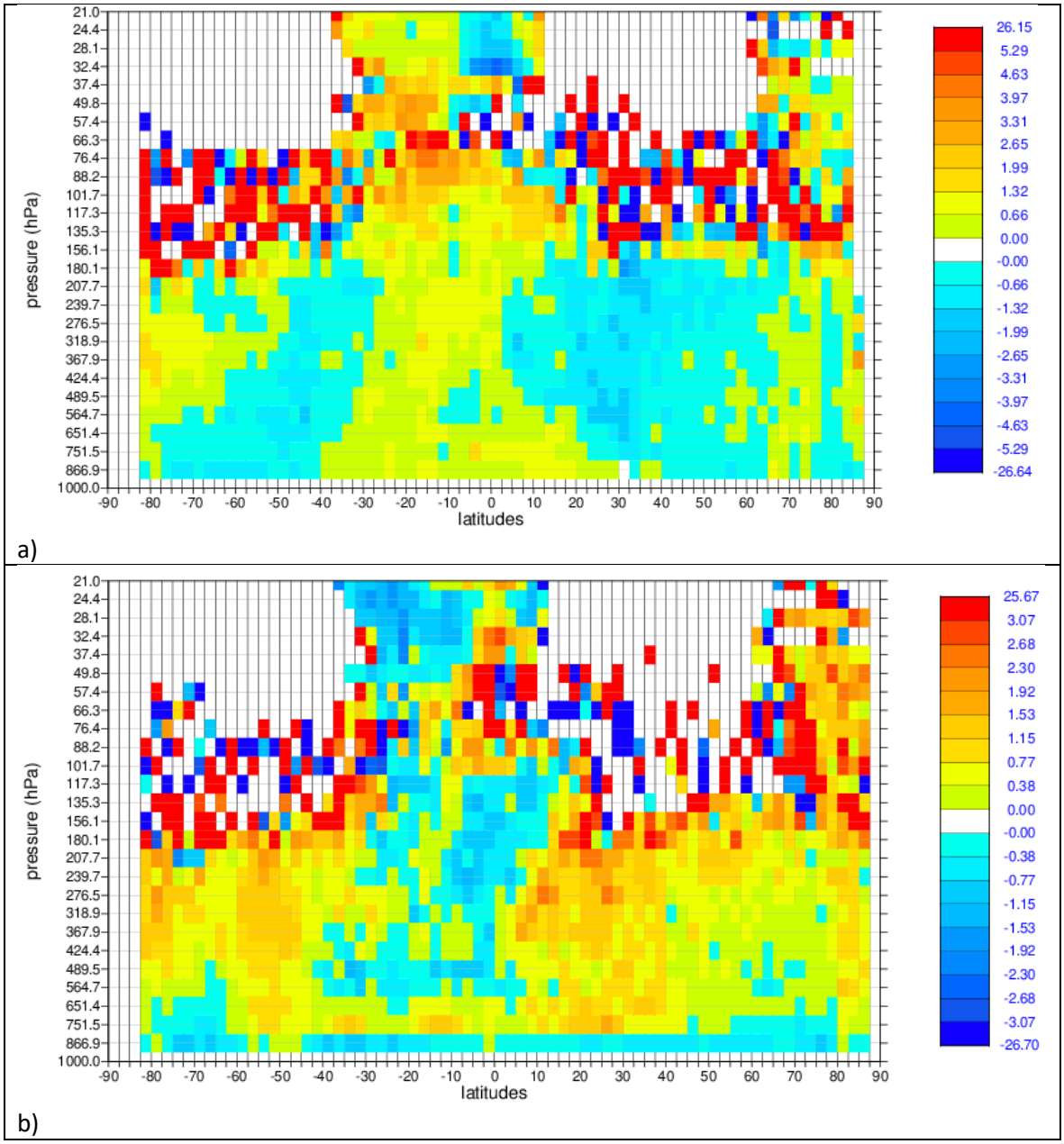
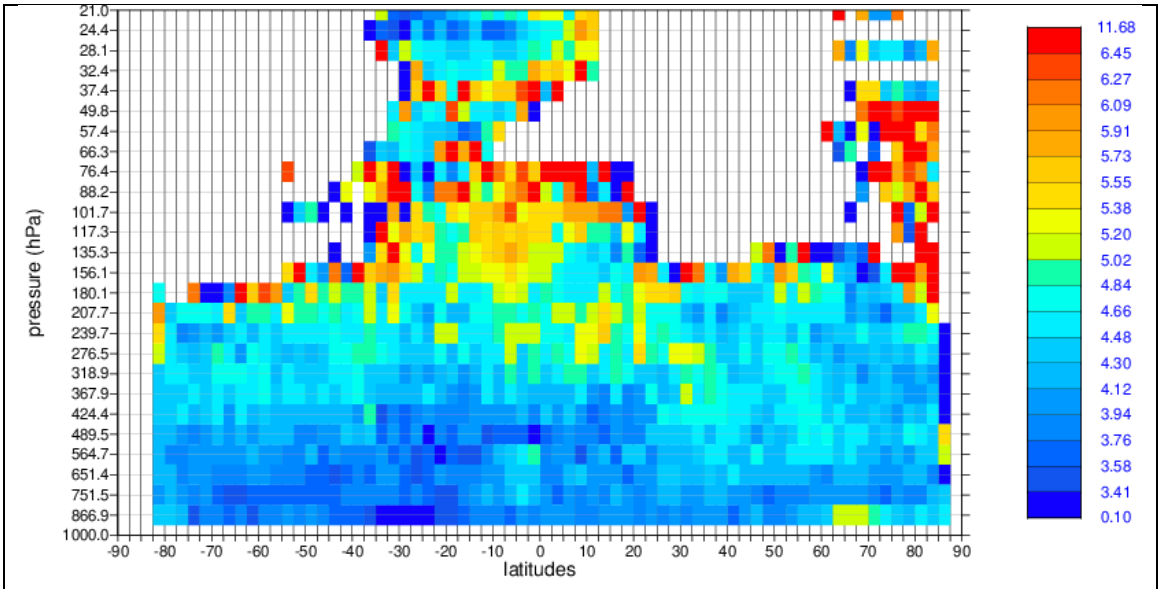


Figure 7. Pressure versus latitude dependence of the L2B Mie-cloudy mean(O-B) for a) ascending and b) descending orbits. Unit: m/s. For the period: 17 January to 26 February 2022.


pressure (hPa)
21.0
24.4
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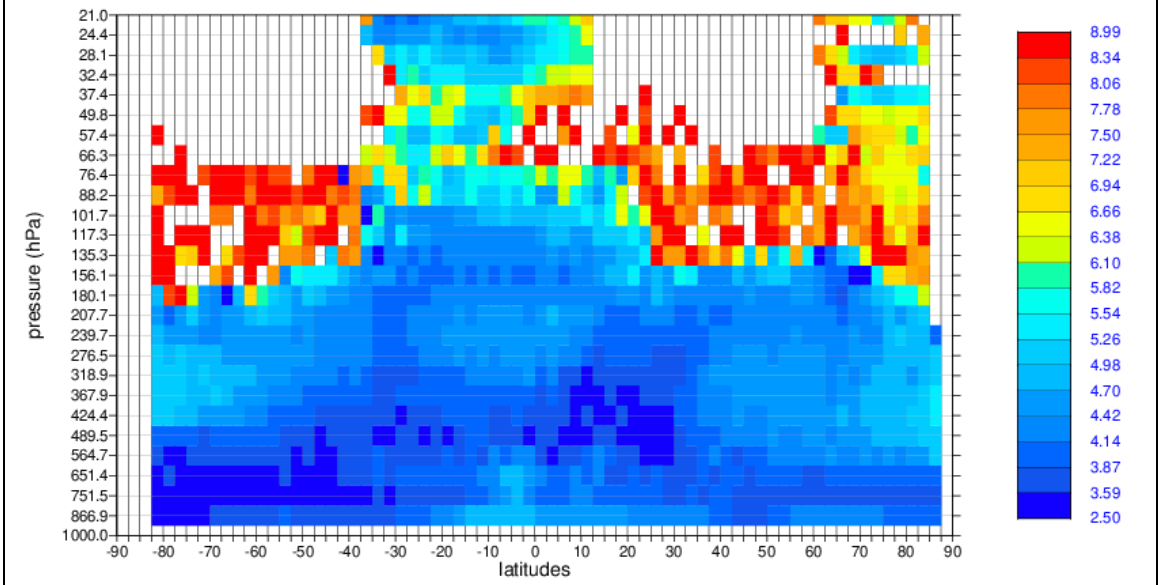
32.4
37.4
49.8
57.4
66.3
76.4
88.2
101.7
117.3
135.3
156.1
180.1
207.7
239.7
276.5
318.9
367.9
424.4
489.5
564.7
651.4
751.5
866.9
1000.0
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
latitudes
11.68
6.45
6.27
6.09
5.91
5.73
5.55
5.38
5.20
5.02
4.84
4.66
4.48
4.30
4.12
3.94
3.76
3.58
3.41
0.10

a)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latitudes
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8.34
8.06
7.78
7.50
7.22
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6.66
6.38
6.10
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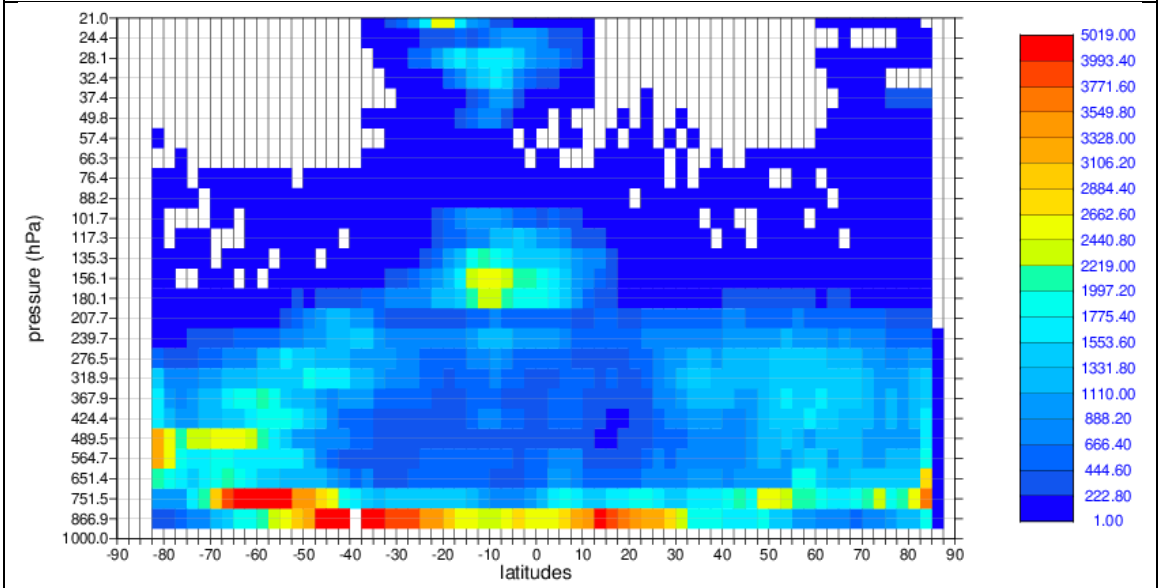
5.54
5.26
4.98
4.70
4.42
4.14
3.87
3.59
2.50

b)


pressure (hPa)
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3771.60
3549.80
3328.00
3106.20
2884.40
2662.60
2440.80
2219.00
1997.20
1775.40
1553.60
1331.80
1110.00
888.20
666.40
444.60
222.80
1.00

c)

Figure 8. Pressure versus latitude dependence of the ascending L2B Mie-cloudy a) stdev(O-B) m/s, b) assigned observation error in DA (via scaled L2Bp error estimates) and c) number of observations. For the period: 17 January to 26 February 2022.

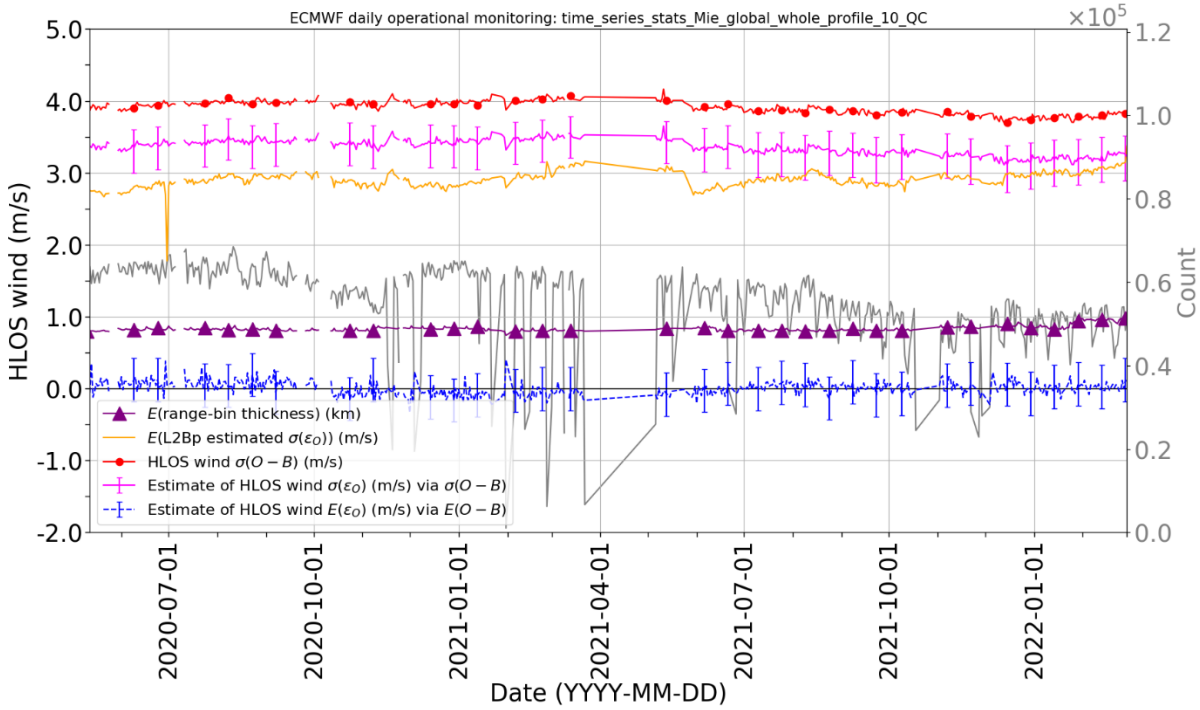

Figure 9. Times-series of daily, global, whole profile L2B Mie-cloudy HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject if abs(O-B) > 10 m/s.

Comments and assessment on L2B Mie-cloudy winds for this period:

- Random errors have increased by a small amount during February 2022.
- Thanks to the Hunga Tonga-Hunga Ha'apai volcano eruption plume and range-bin settings up to 30 km since 24 January, there is a large and unique sample of Mie-cloudy winds of high quality (estimated errors ~3-6 m/s) in the 22-28 km altitude range, centred around -15 degrees latitude. Also, there are some PSC Mie-winds over North Pole recently (but quite noisy).

3. L2B HLOS wind Forecast Sensitivity Observation Impact (FSOI) statistics from ECMWF's operational data assimilation

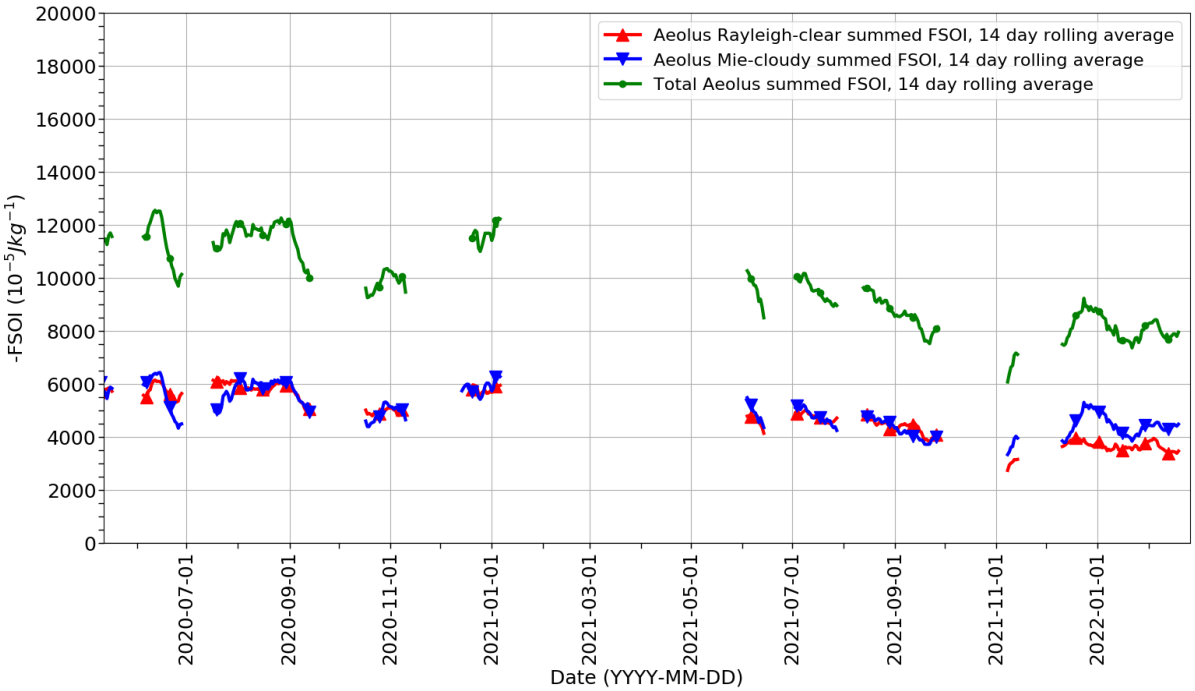

Figure 10. Time-series of the negative of the FSOI of Aeolus L2B HLOS winds in ECMWF operations since the L2B data public release (12 May 2020). Therefore, positive values of -FSOI indicate short-range forecast improvement due to assimilating Aeolus. Partitioned into Mie-cloudy (blue), Rayleigh-clear (red) and combined (green). This metric is based on a global dry energy norm. A 2 week rolling average was applied, and periods with reduced data counts, due to special operations were removed.

The short-range forecast impact of Aeolus HLOS winds remains positive in February 2022 according to the ECMWF FSOI metric. Note that the maximum impact of Aeolus with this FSOI metric was found to be roughly 16250 units in the early FM-B laser period with the largest signal levels of the mission (offline, reprocessed dataset testing). The February 2022 impact of ~8000 units is ~49% of the maximum impact. There is perhaps a downward trend over the past few months, which is not surprising given the ongoing atmospheric path signal decrease.