Aeolus L2B horizontal HLOS wind product monthly quality report

Period: For the month of May 2022 and up to 6 June 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

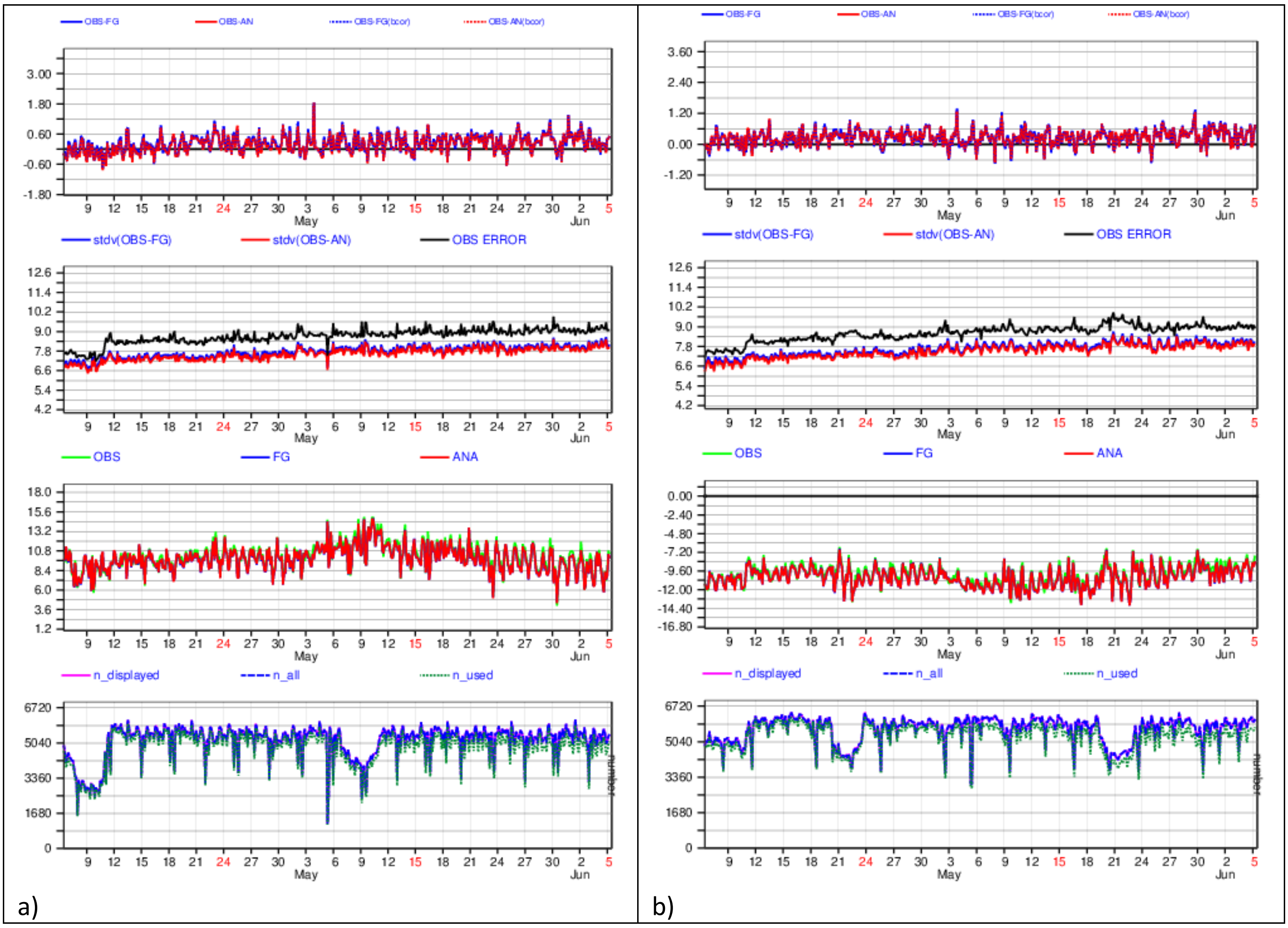

Figure 1. This figure shows changes with time in the O-B and O-A departure statistics of the L2B Rayleigh-clear winds with respect to the ECMWF model. The statistics are calculated every 3 hours for the 0-400 hPa pressure range. Panel a) is for ascending and panel b) is for descending orbit phase. The 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.

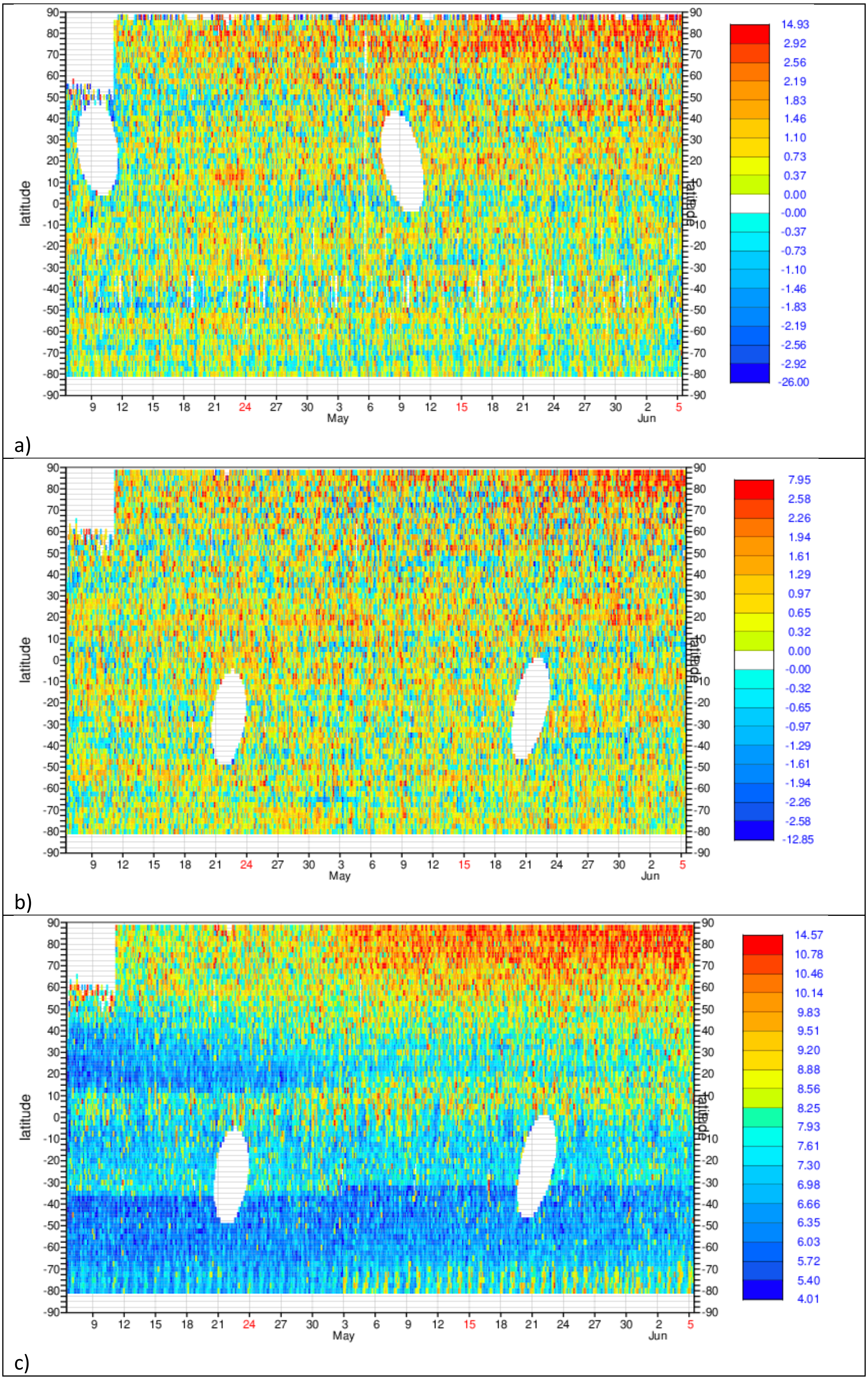
latitude
9 12 15 18 21 24 27 30 3 6 9 12 15 18 21 24 27 30 2 5
May
Jun
14.93
2.92
2.56
2.19
1.83
1.46
1.10
0.73
0.37
0.00
-0.00
-0.37
-0.73
-1.10
-1.46
-1.83
-2.19
-2.56
-2.92
-26.00
a)
latitude
9 12 15 18 21 24 27 30 3 6 9 12 15 18 21 24 27 30 2 5
May
Jun
7.95
2.58
2.26
1.94
1.61
1.29
0.97
0.65
0.32
0.00
-0.00
-0.32
-0.65
-0.97
-1.29
-1.61
-1.94
-2.26
-2.58
-12.85
b)
latitude
9 12 15 18 21 24 27 30 3 6 9 12 15 18 21 24 27 30 2 5
May
Jun
14.57
10.78
10.46
10.14
9.83
9.51
9.20
8.88
8.56
8.25
7.93
7.61
7.30
6.98
6.66
6.35
6.03
5.72
5.40
4.01
c)

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

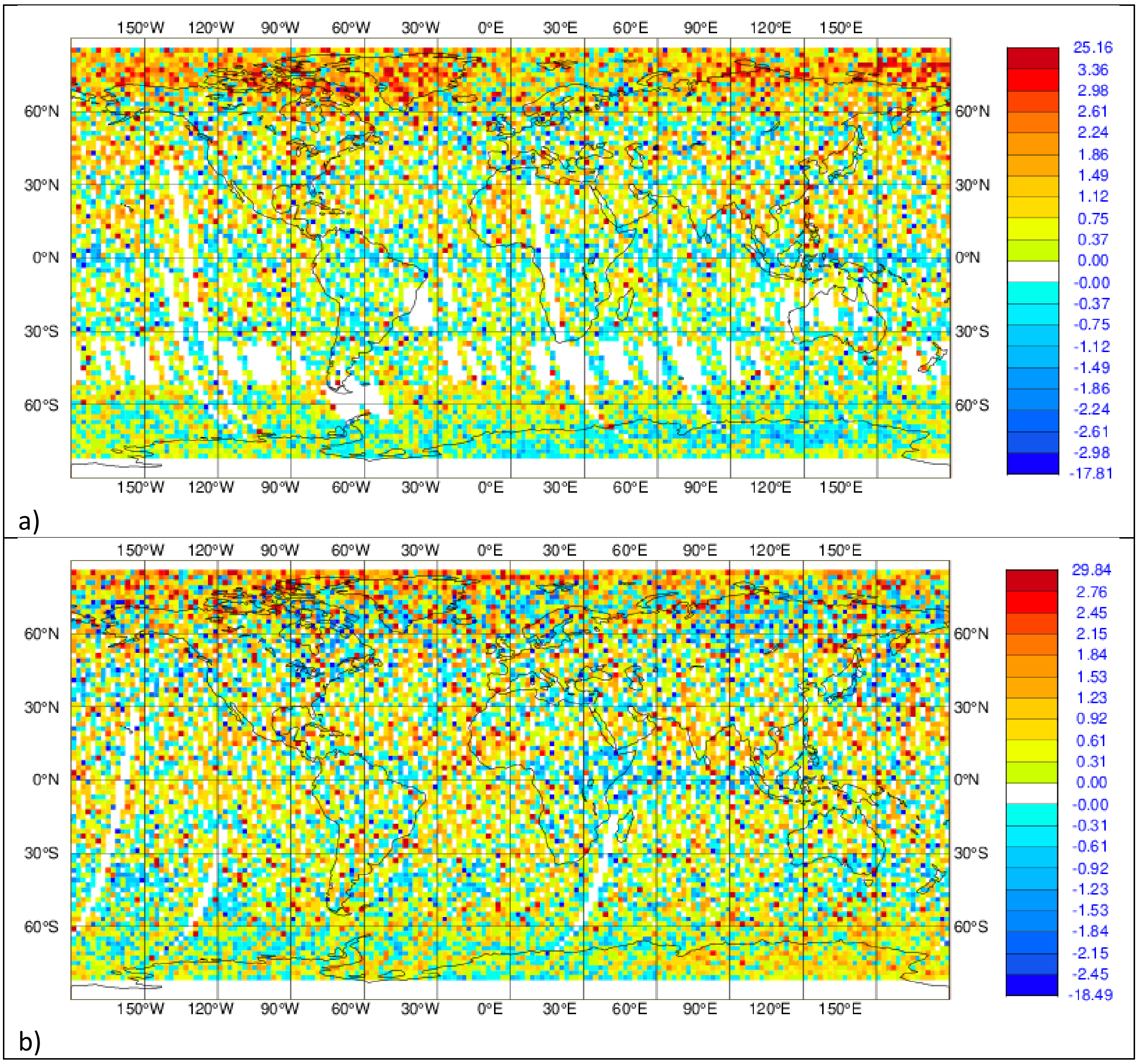

Figure 3. Maps of L2B Rayleigh-clear mean(O-B) for the 0-400 hPa pressure range for a) ascending and b) descending orbit phases. Unit: m/s. For the period: 30 April 2022 to 4 June 2022. These plots are only updated once per week.

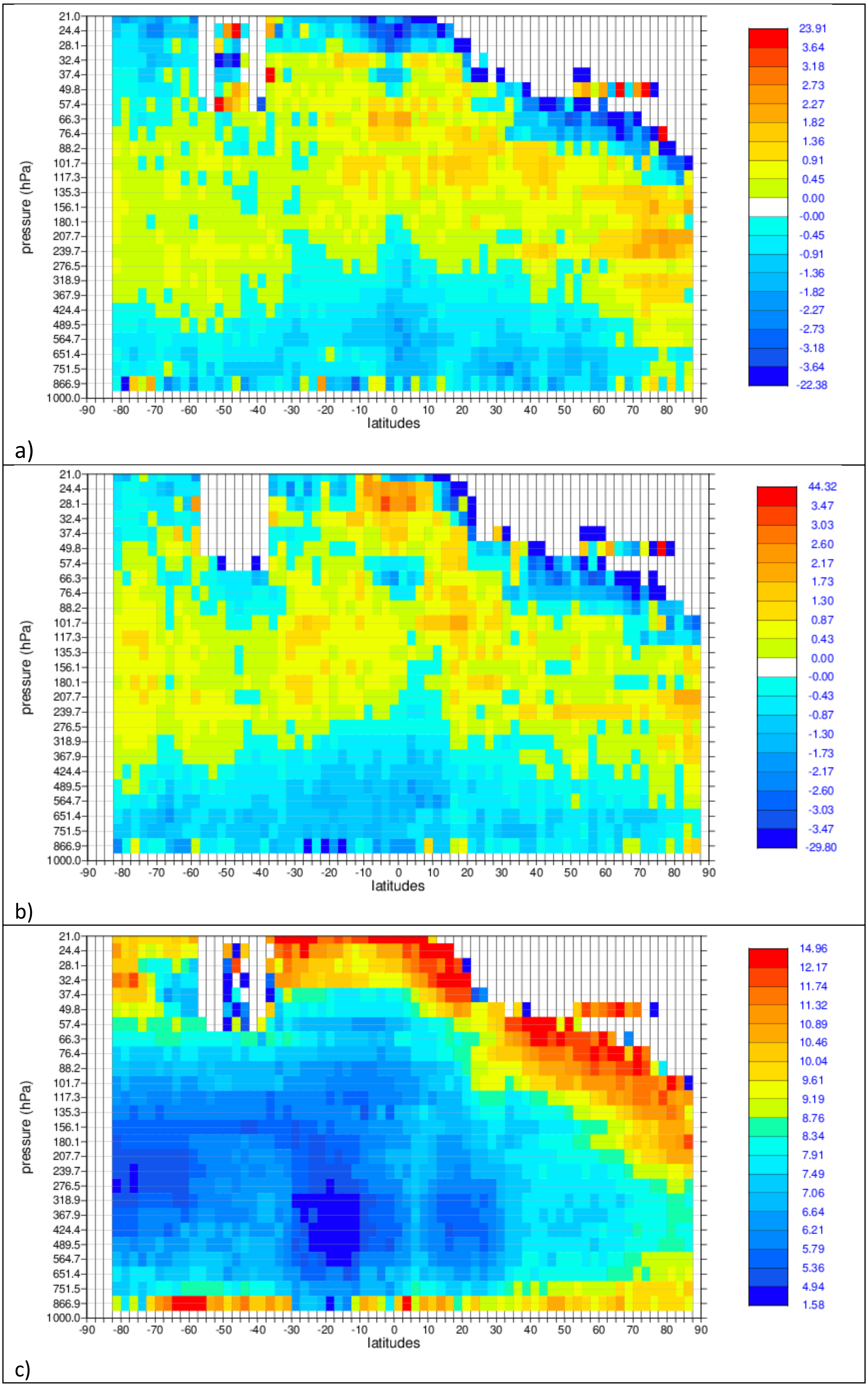

Figure 4. Pressure versus latitude dependence of the L2B Rayleigh-clear mean(O-B) for a) ascending and b) descending orbits. Panel c) is the standard deviation of (O-B) for ascending orbits. Unit: m/s. For the period: 25 April to 4 June 2022.

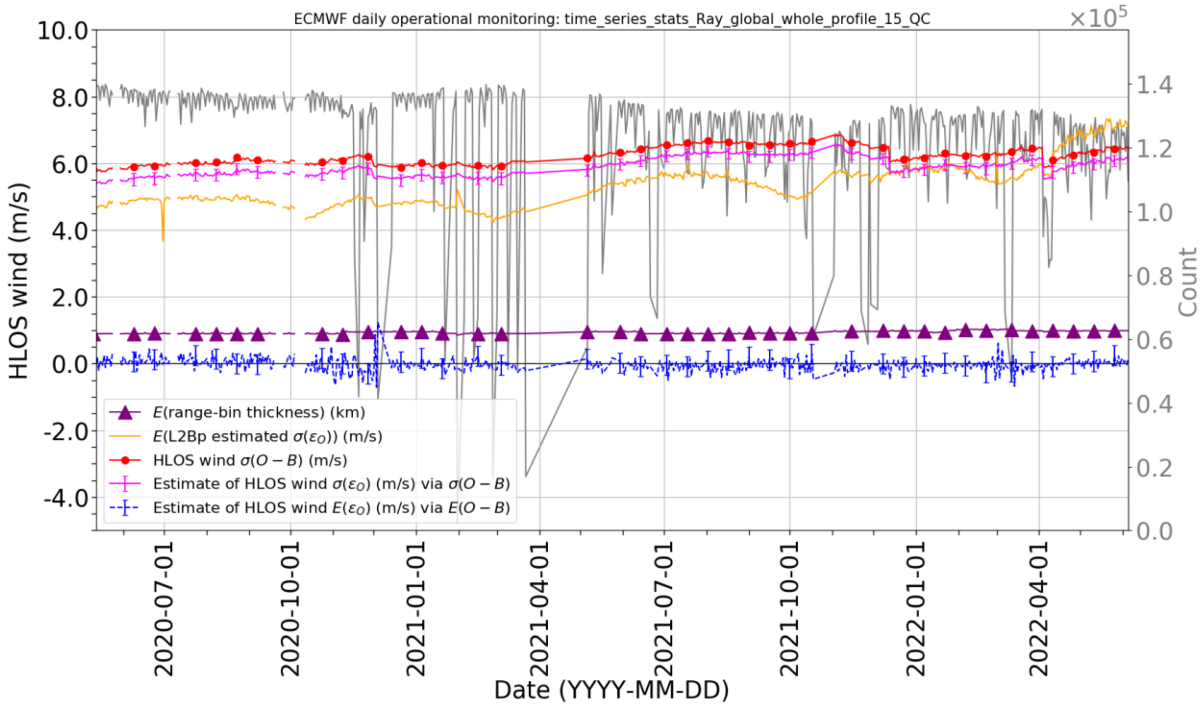

Figure 5. Times-series of daily, global, whole profile L2B Rayleigh-clear HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject winds if abs(O-B) > 15 m/s. Data up to 5 June 2022.

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

- Random errors tended to increase in the global average in May 2022. This is mostly due to approaching the maximum amount of solar background noise over the Northern Hemisphere summer, which is a very dominant error term with our current low atmospheric path useful signal levels. The random errors remained fairly steady over the dark part of the orbit (SH extratropics).
- The trends were affected by a significant shift in range-bin settings on 2 May; particularly the shift of range-bins suited for polar vortex monitoring from the north pole to south pole and the extension of the Tongan eruption RBS further north.
- There is still a bias dipole near the equator for ascending and descending orbits at around 50 hPa, with the opposite sign. This is consistent with the ECMWF model not having enough vertical wind shear during the descending phase of the QBO easterlies - something seen with other observation types in the past. A hint of the pattern is also seen in the Mie-cloudy winds from the Tongan plume.

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

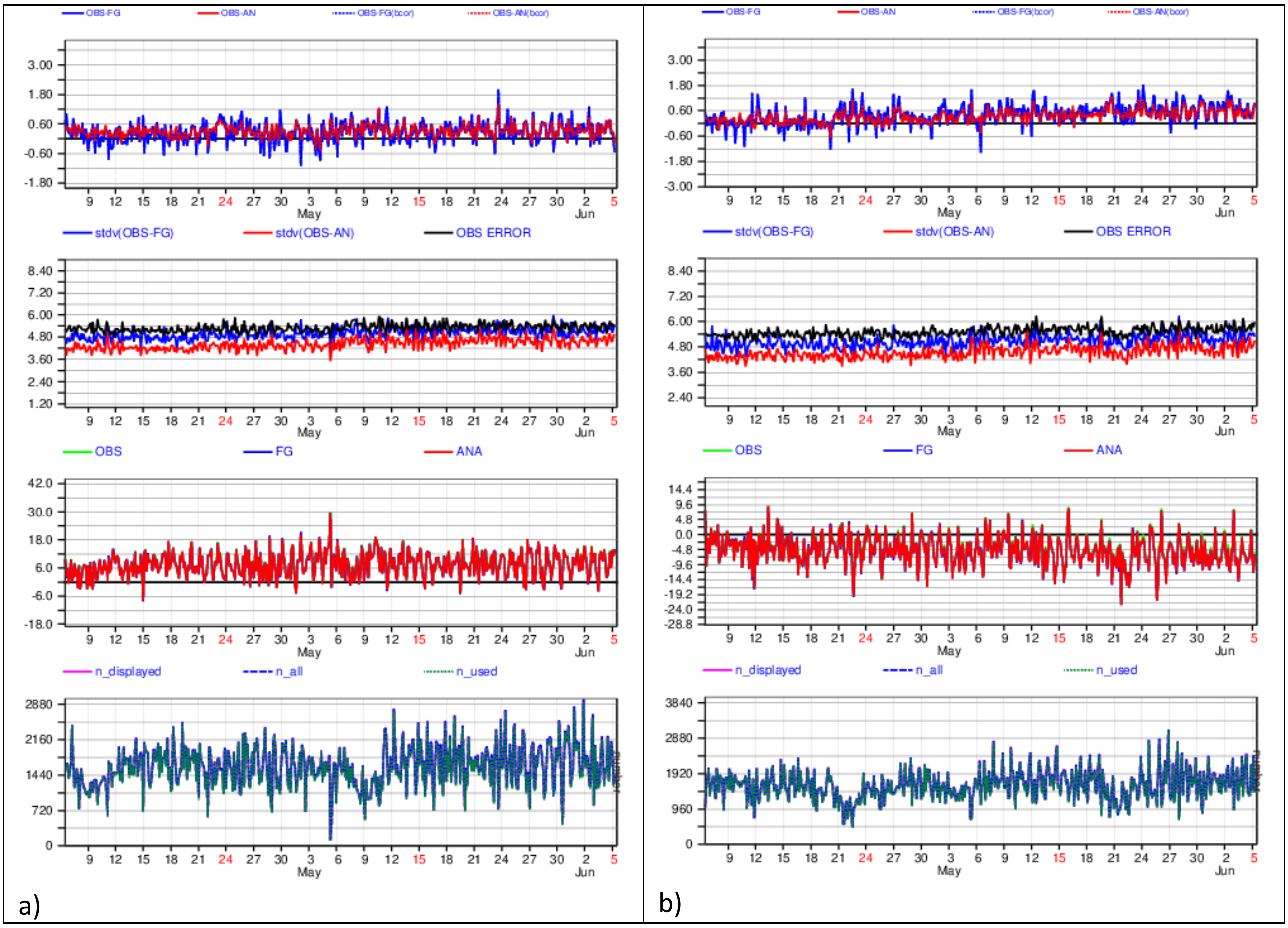

Figure 6. Same type of plots as in Figure 1, but for L2B Mie-cloudy HLOS winds.

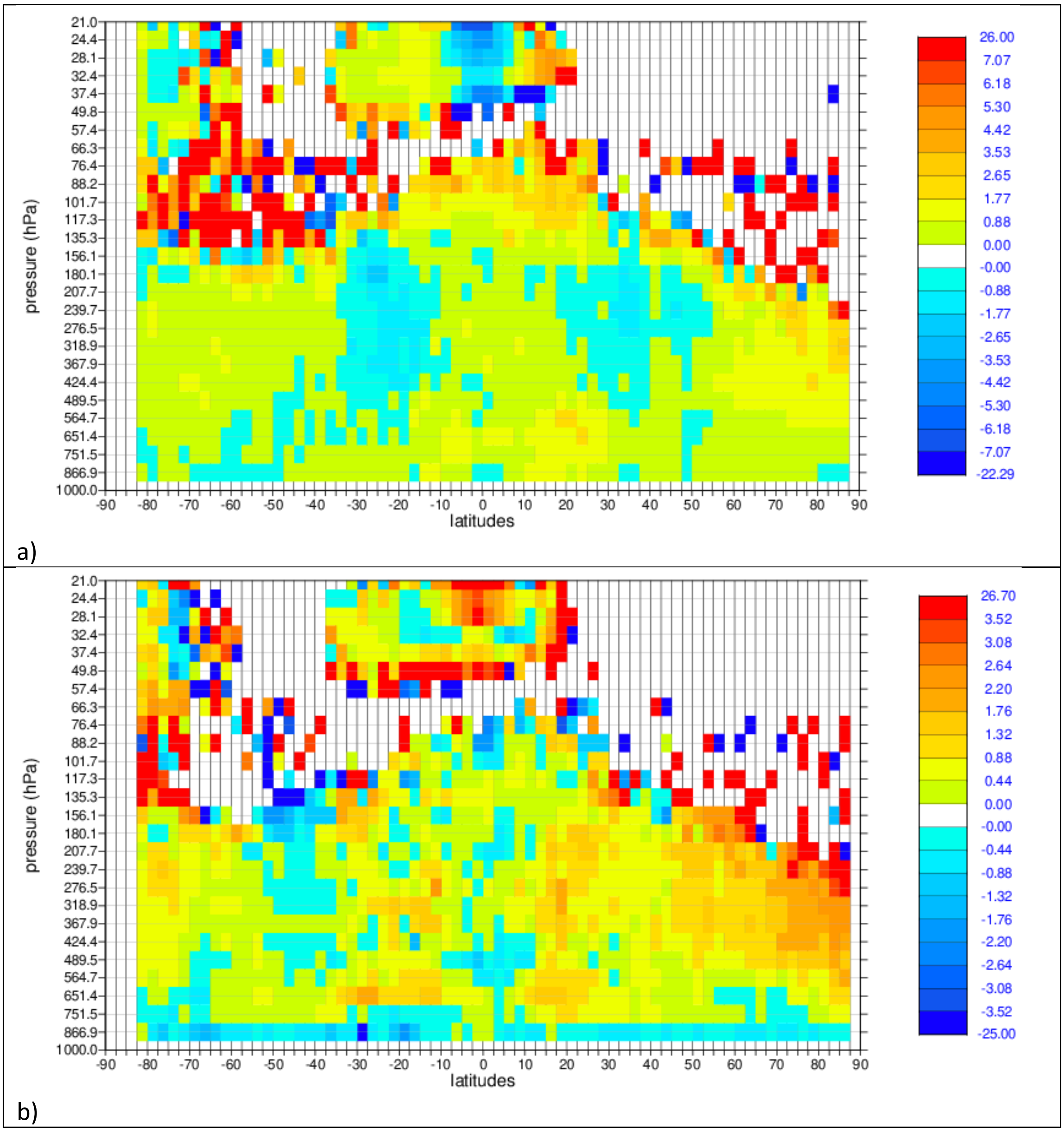

Figure 7. Pressure versus latitude dependence of the L2B Mie-cloudy mean(O-B) for a) ascending and b) descending orbits. Unit: m/s. For the period: 25 April to 4 June 2022.

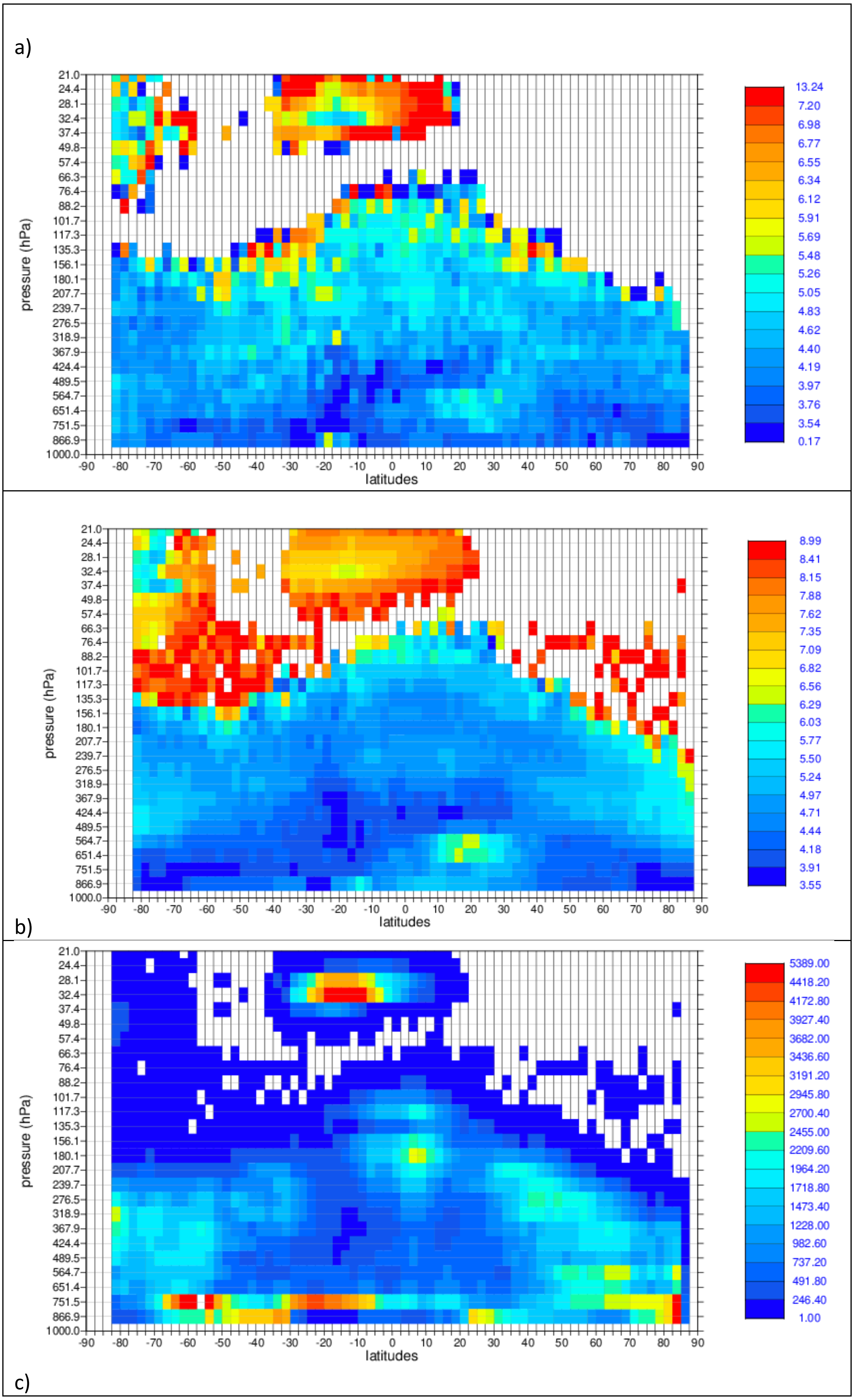

Figure 8. Pressure versus latitude dependence of the ascending L2B Mie-cloudy a) stdev(O-B) m/s, b) assigned observation error in DA (via scaled L2Bp error estimates) and c) number of observations. For the period: 25 April to 4 June 2022.

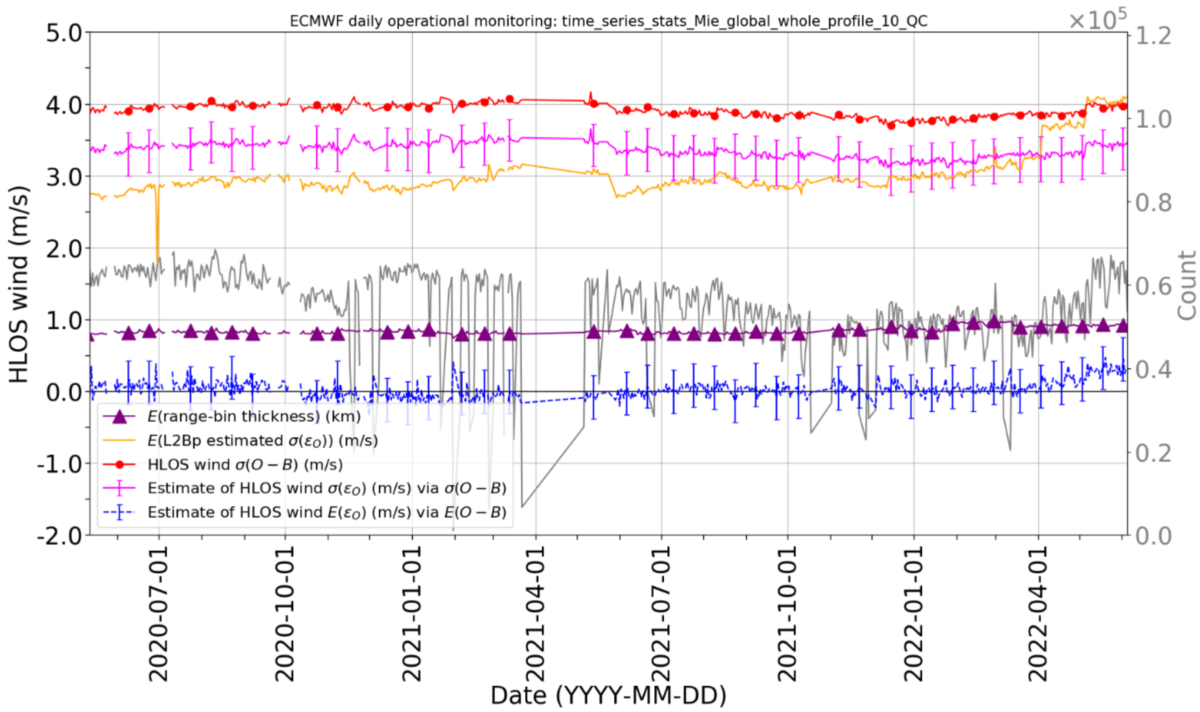

Figure 9. Times-series of daily, global, whole profile L2B Mie-cloudy HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject if abs(O-B) > 10 m/s. Data up to 5 June 2022.

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

- A slight increase in random errors occurred on 6 May 2022 with an update of the L2Bp settings files (AUX_PAR_2B) for the Mie core algorithm QC thresholds. Testing before the change went operational showed 7.4% more valid L2B Mie-cloudy winds (that pass the 5 m/s estimated error criteria) and only leads to a 1.1% increase in the scaled MAD(O-B).
- Thanks to the Hunga Tonga-Hunga Ha'apai volcano eruption plume (eruption on 15 January 2022) and range-bin settings up to 30 km since 24 January 2022, there remains a large and unique sample of Mie-cloudy winds of reasonable quality (estimated errors ~6 m/s) in the 23-25 km altitude range, centred around -15 degrees latitude. The smallest random errors are in the S. Hemisphere. The plume appears to be trapped in the lower stratospheric easterly part of the QBO. However, the winds are getting gradually noisier with time (as the plume disperses).
- A small sample of Mie-cloudy winds has recently appeared over the south pole which must be due to Polar Stratospheric Clouds which exist in the winter months.

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

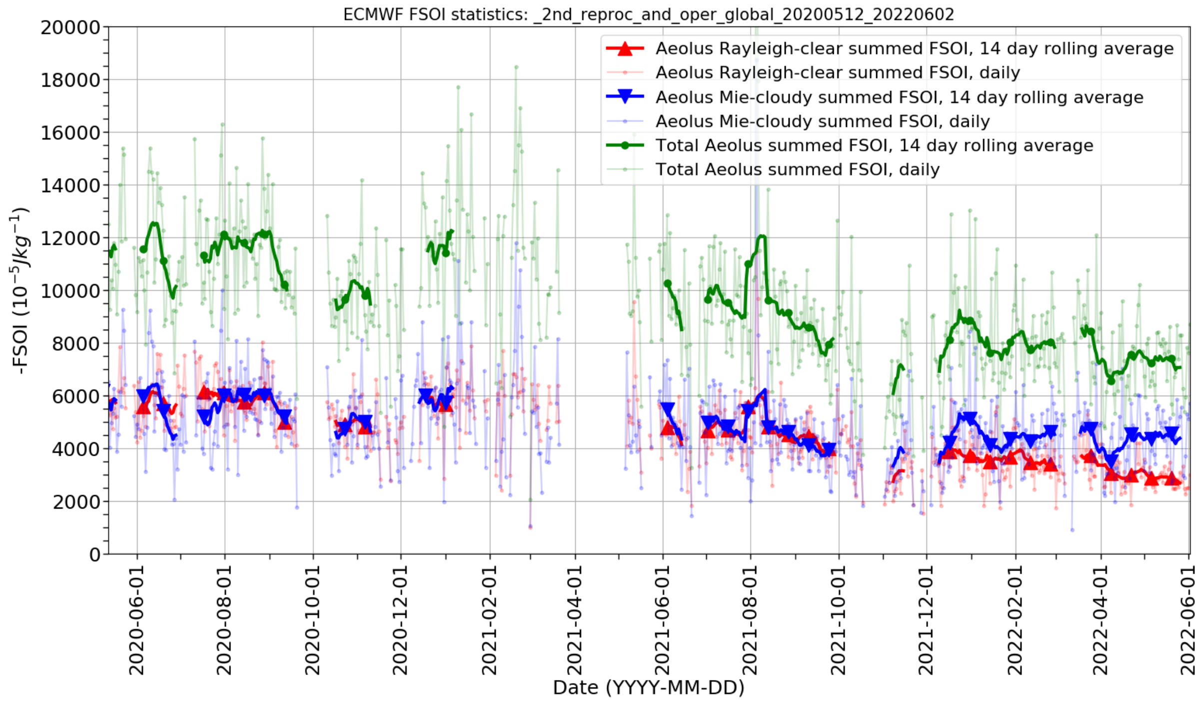

Figure 10. Time-series of the negative of the FSOI of Aeolus L2B HLOS winds in ECMWF operations since the L2B data public release (12 May 2020). Therefore, positive values of -FSOI indicate short-range forecast improvement due to assimilating Aeolus. Partitioned into Mie-cloudy (blue), Rayleigh-clear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

The short-range forecast impact of Aeolus HLOS winds remains positive in May 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 May 2022 impact of ~7500 units is ~46% of the maximum impact.