Aeolus L2B horizontal HLOS wind product monthly quality report

Period: For the month of March 2022 and up to 12 April 2022

By Michael Rennie (ECWMF); a member of the Aeolus DISC team

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

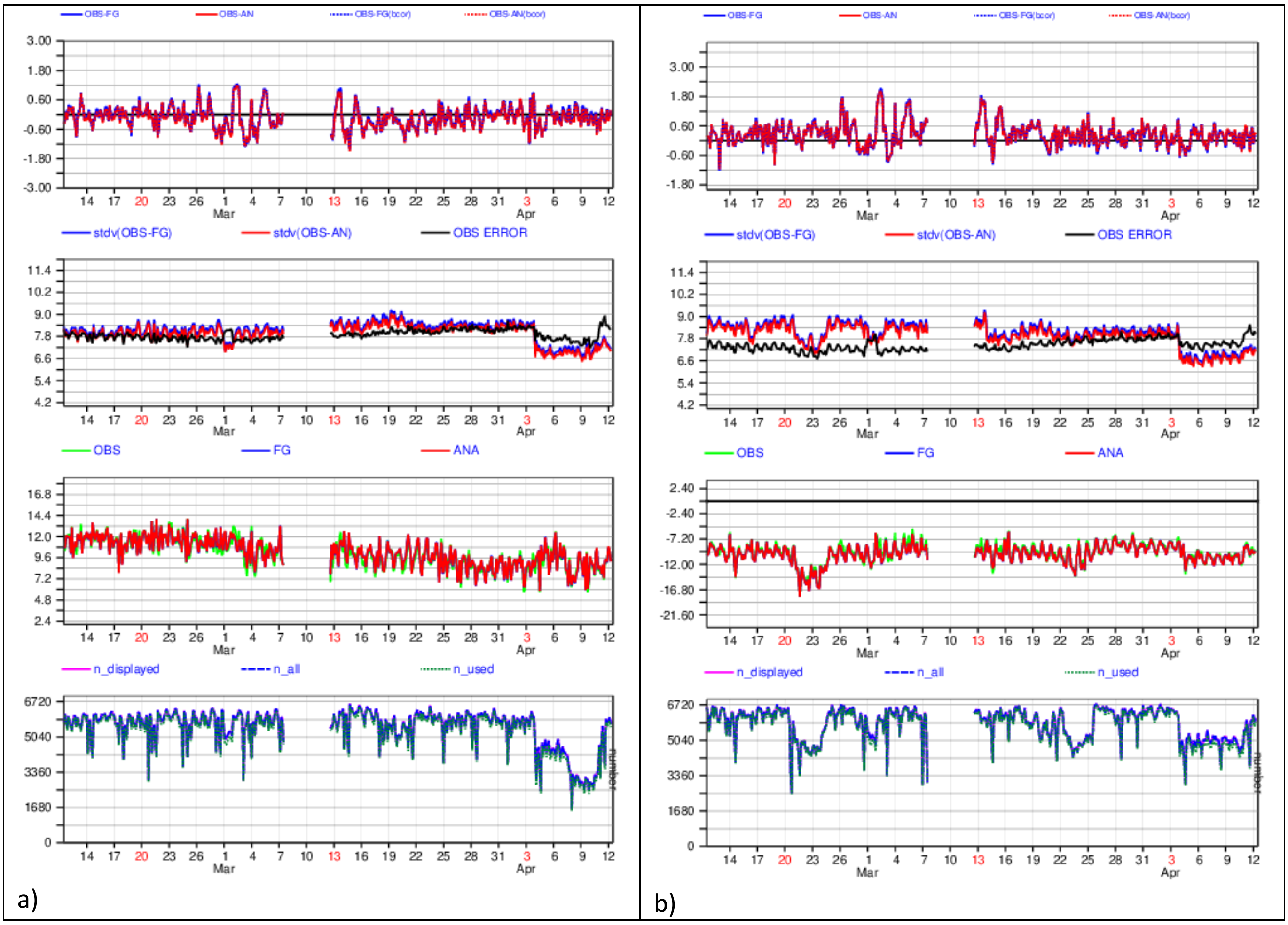


Figure 1. This figure shows changes with time in the O-B and O-A departure statistics of the L2B Rayleigh-clear winds with respect to the ECMWF model. The statistics are calculated every 3 hours for the 0-400 hPa pressure range. Panel a) is for ascending and panel b) is for descending orbit phase. The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

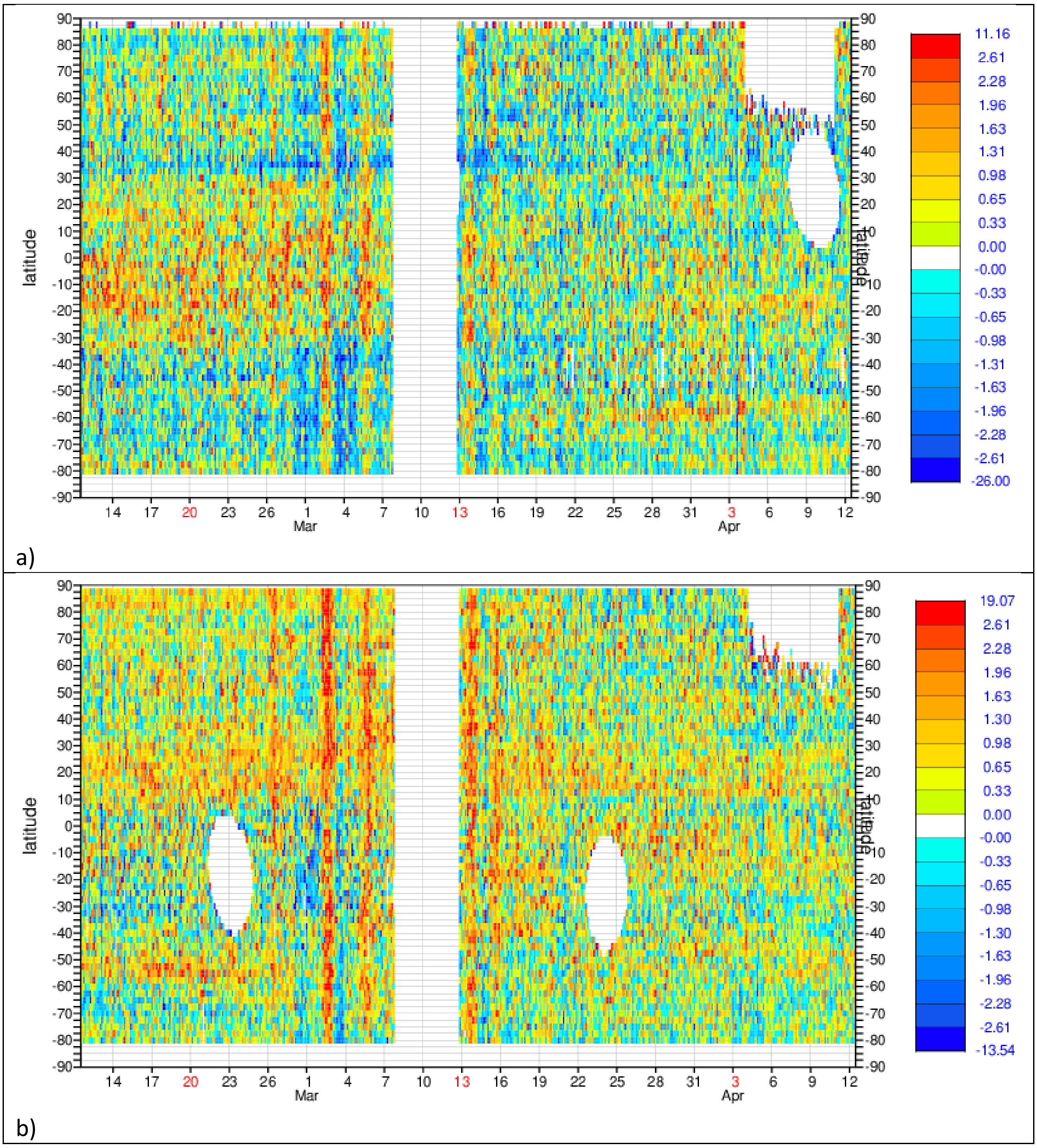


Figure 2. Latitude-time dependence of the mean(O-B) for L2B Rayleigh-clear HLOS winds for the 0-400 hPa pressure range for a) ascending and b) descending orbit phase. Unit: m/s.

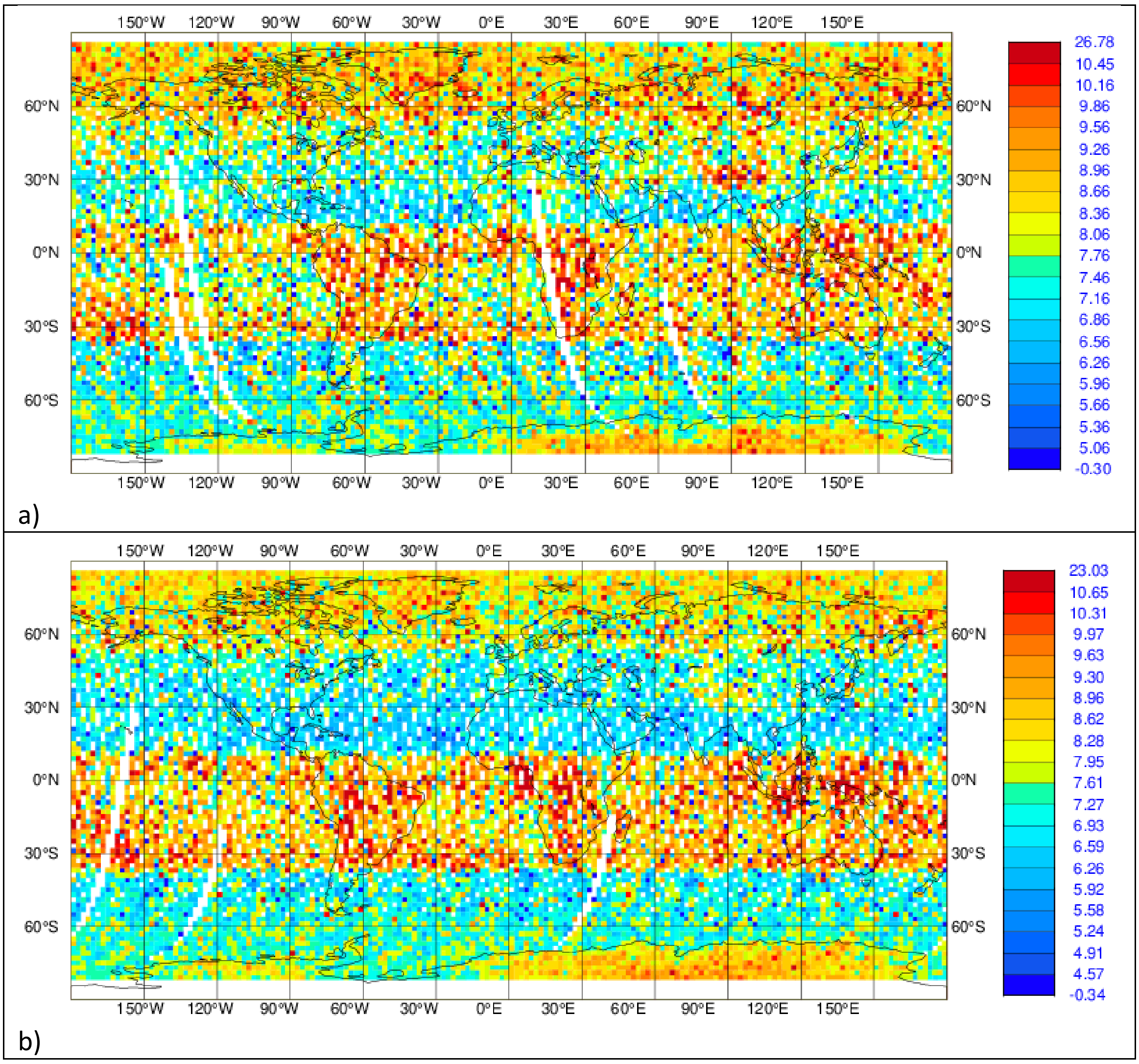


Figure 3. Maps of L2B Rayleigh-clear stdev(O-B) for the 0-400 hPa pressure range for a) ascending and b) descending orbit phases. Unit: m/s. For the period: 28 February 2022 to 9 April 2022. These plots are only updated once per week.

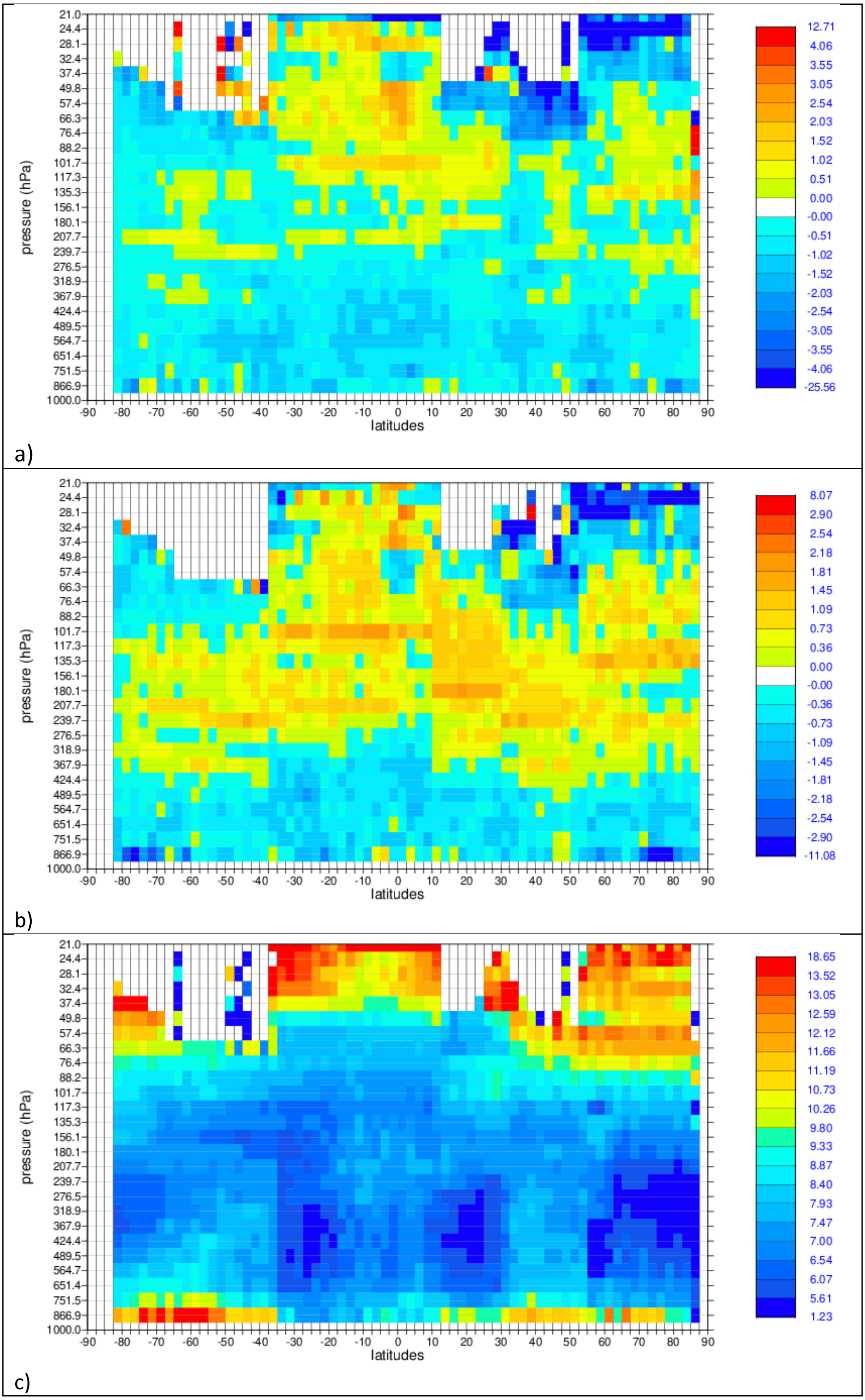


Figure 4. Pressure versus latitude dependence of the L2B Rayleigh-clear mean(O-B) for a) ascending and b) descending orbits. Panel c) is the standard deviation of (O-B) for ascending orbits. Unit: m/s. For the period: 28 February to 9 April 2022.

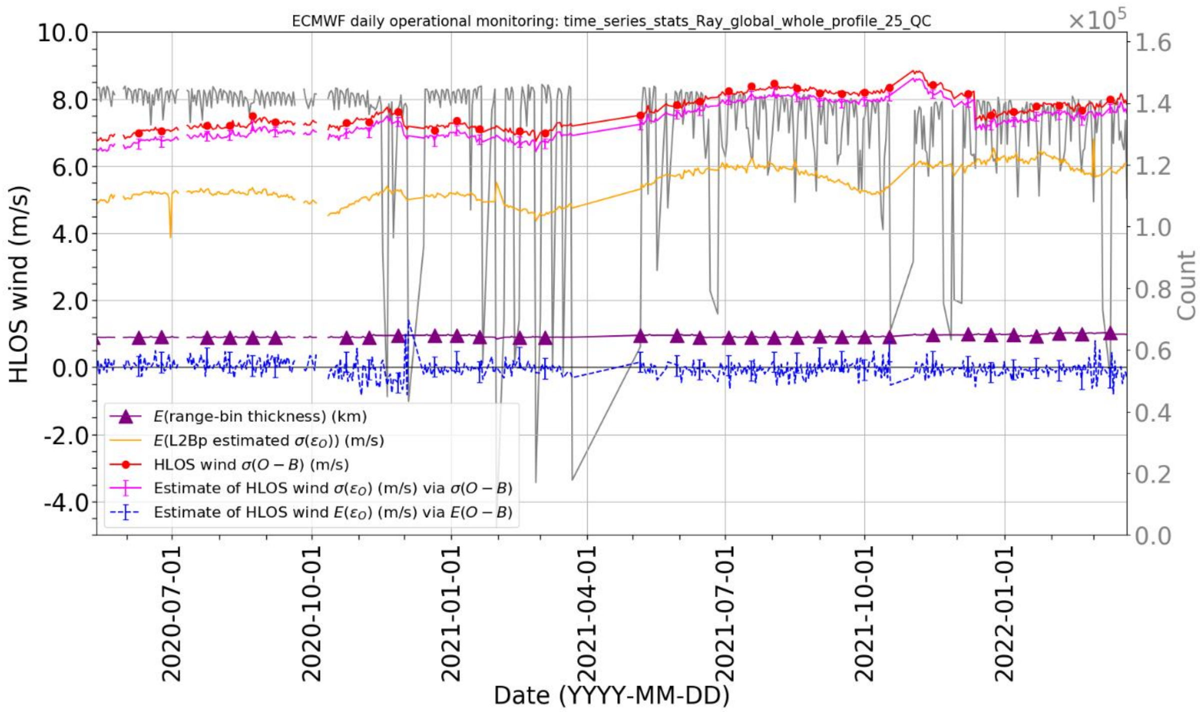


Figure 5. Times-series of daily, global, whole profile L2B Rayleigh-clear HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject winds if abs(O-B) > 25 m/s. Data up to 23 March 2022.

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

- The higher top altitude range-bin settings (RBS) for the latitude band 10 to -35 degrees to capture the plume from the Hunga Tonga-Hunga Ha'apai volcano eruption (on 15 January) is still present and is evident in the standard deviation of O-B maps. But the top altitude was adjusted to 26 km more recently rather than 30 km as the plume has descended. There are still Mie-cloudy winds at 23-25 km altitude in the tropics. CALIPSO shows the plume to range from -30 to +20 degrees in early April, so our RBS coverage is a bit limited on the northern extent: [https://www-calipso.larc.nasa.gov/products/lidar/browse_images/std_v341_showdate.php?browse_date=2022-04-03.](https://www-calipso.larc.nasa.gov/products/lidar/browse_images/std_v341_showdate.php?browse_date=2022-04-03)
- There were some large bias fluctuations from late February to mid-March due to issues with the DUDE measurements (for hot pixel correction) being invalid due to contamination by solar background. This was resolved by the DUDEs being moved to the S. Hemisphere.
- A new processor baseline (14) was implemented on 29 March 2022. This did not lead to any noticeable change in the O-B statistics.
- The random error was increasing until 4 April. A decent improvement in random error is evident since 4 April. This was because of a new N/P setting (N=5, P=114) going operational improved the instrument noise (reducing the estimated observation error by 17% in testing). Initially this change led to a lack of data north of 50-60 degrees latitude, because the larger accumulation of signal per measurement led to the solar background range-bin becoming saturated (didn’t happen when the new N/P was tested on 1 March). This issue was fixed on 11 April by reducing the solar background range-gate time. The improvement in noise by reducing the number of measurements per BRC (N) is now known to be due to a reduction in read-out noise. which dominates when we have low atmospheric path signals. The L2Bp

estimated error does not account for read-out noise (since pre-launch simulations used large atmospheric path signals), hence any scaling of the L2Bp estimated error for assimilation purposes may need retuning after the change to N=5.

- There is a dipole bias 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

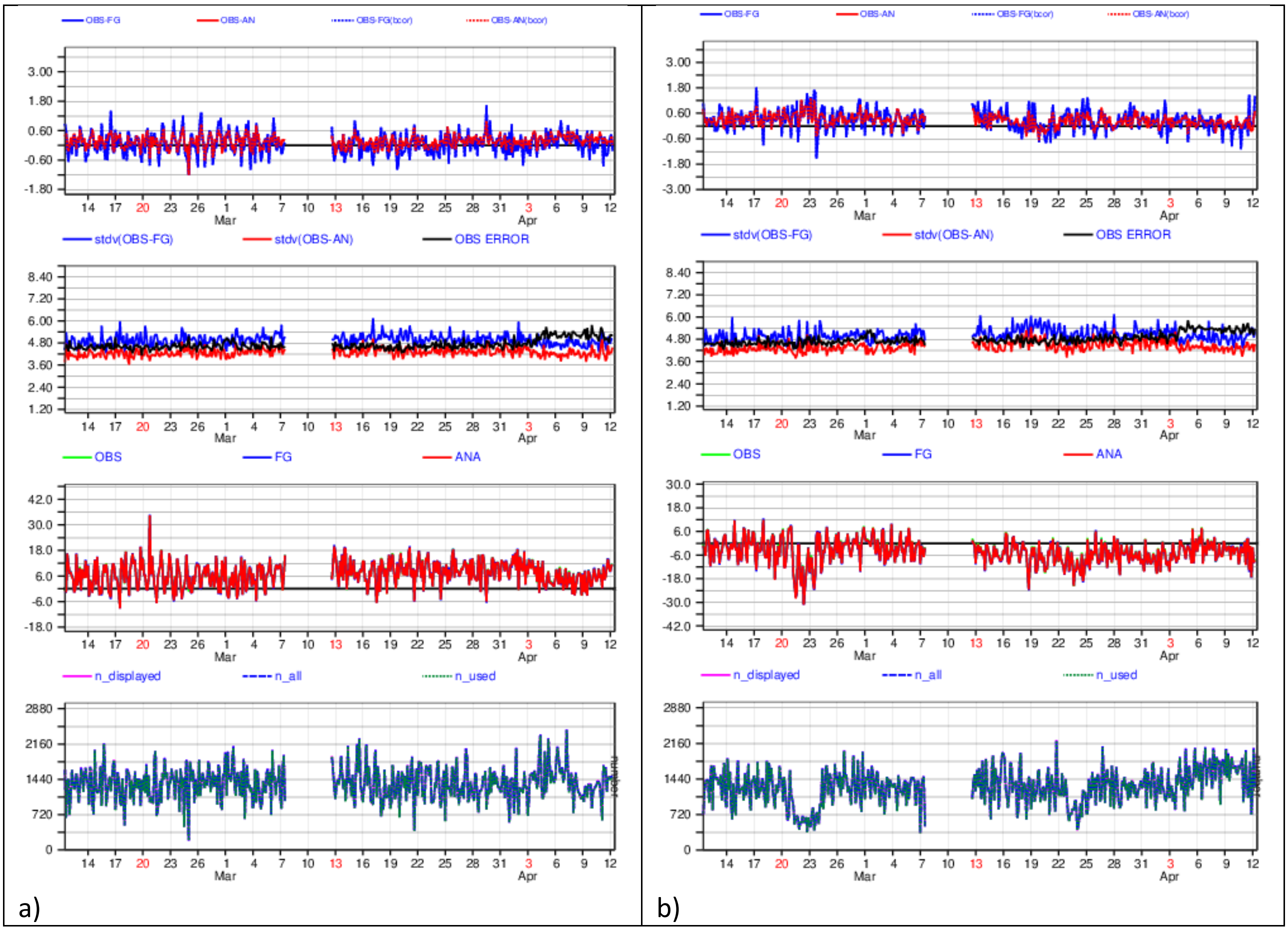


Figure 6. Same type of plots as in Figure 1, but for L2B Mie-cloudy HLOS winds.

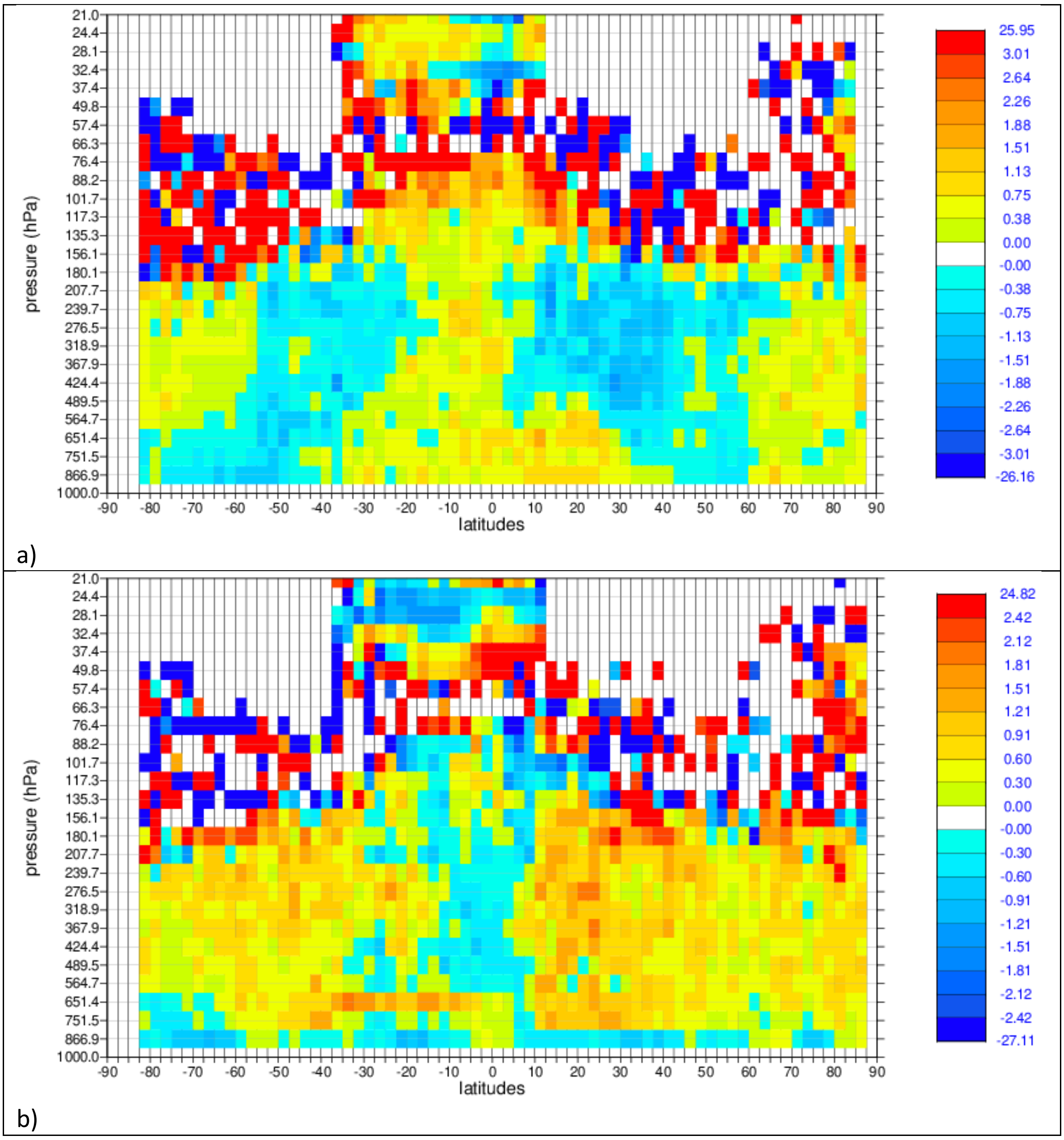
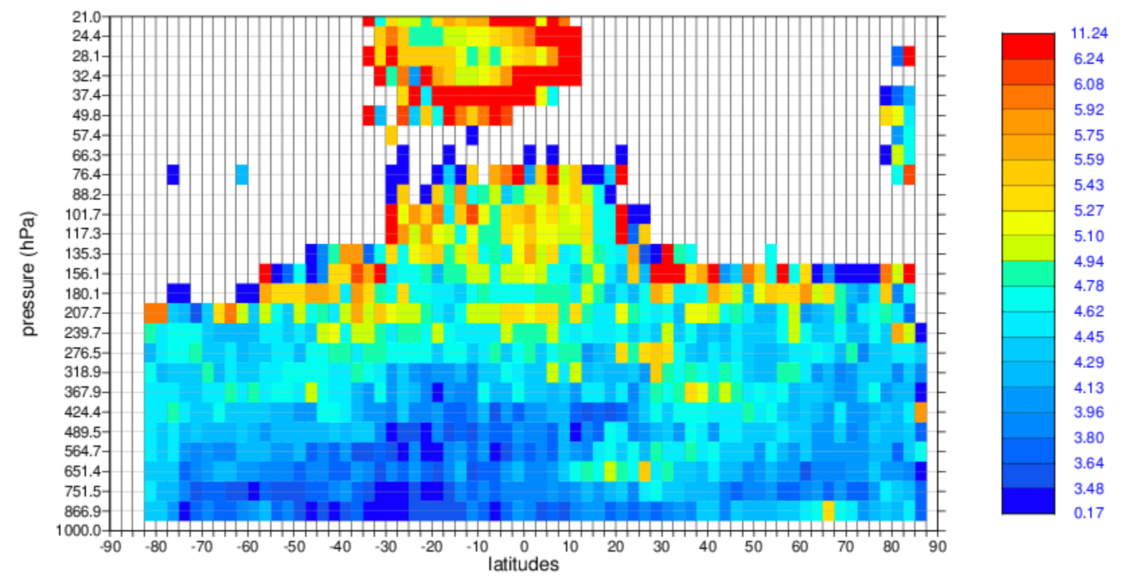
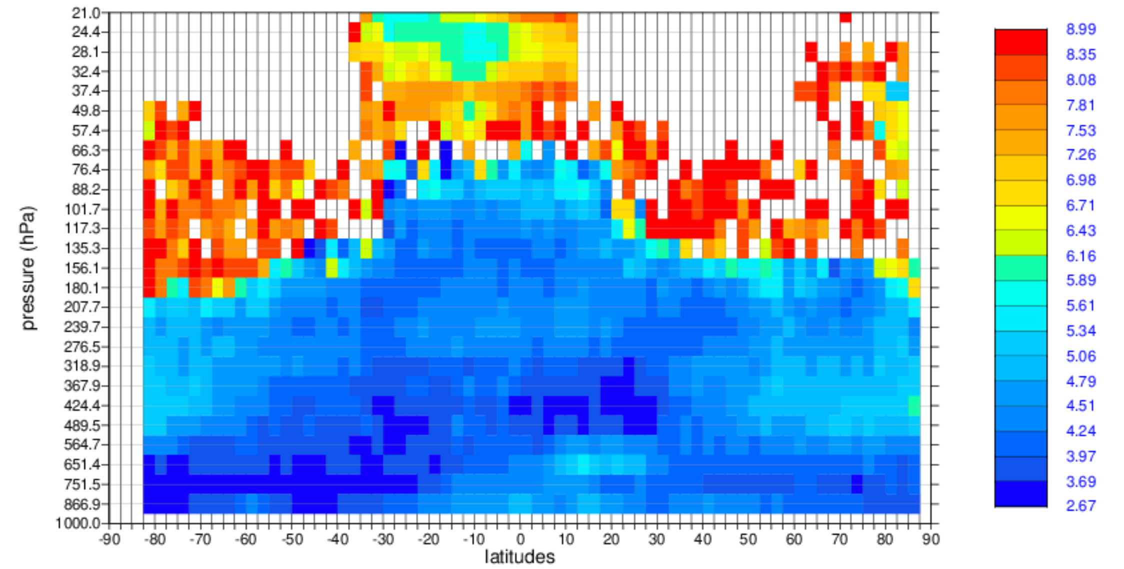


Figure 7. Pressure versus latitude dependence of the L2B Mie-cloudy mean(O-B) for a) ascending and b) descending orbits. Unit: m/s. For the period: 28 February to 9 April 2022.


pressure (hPa)
latitudes
21.0 24.4 28.1 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
11.24 6.24 6.08 5.92 5.75 5.59 5.43 5.27 5.10 4.94 4.78 4.62 4.45 4.29 4.13 3.96 3.80 3.64 3.48 0.17

a)


pressure (hPa)
latitudes
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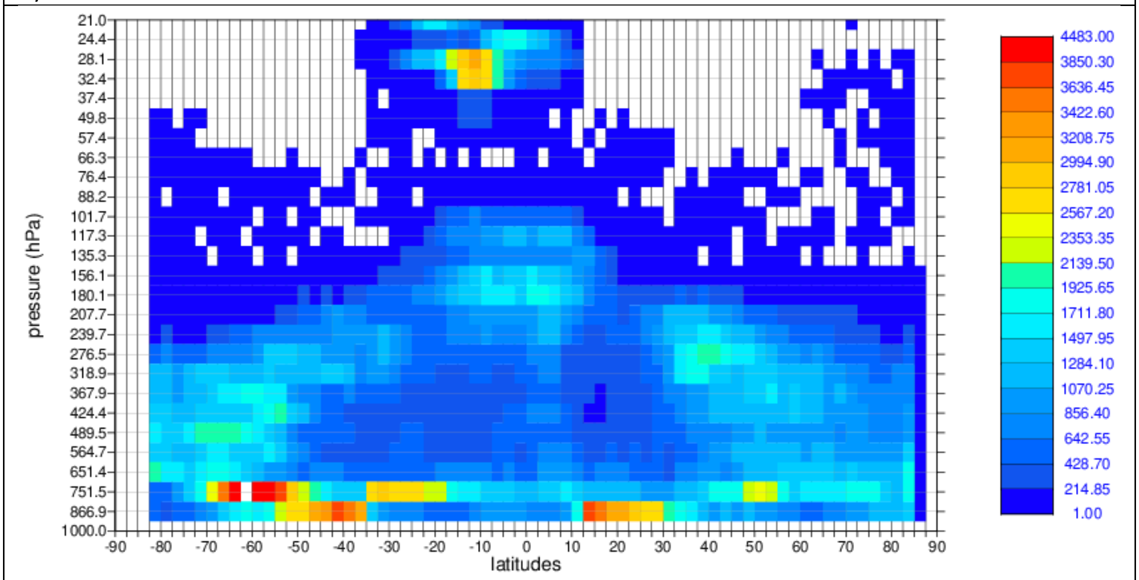
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
8.99 8.35 8.08 7.81 7.53 7.26 6.98 6.71 6.43 6.16 5.89 5.61 5.34 5.06 4.79 4.51 4.24 3.97 3.69 2.67

b)


pressure (hPa)
latitudes
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4483.00 3850.30 3636.45 3422.60 3208.75 2994.90 2781.05 2567.20 2353.35 2139.50 1925.65 1711.80 1497.95 1284.10 1070.25 856.40 642.55 428.70 214.85 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: 28 February to 9 April 2022.

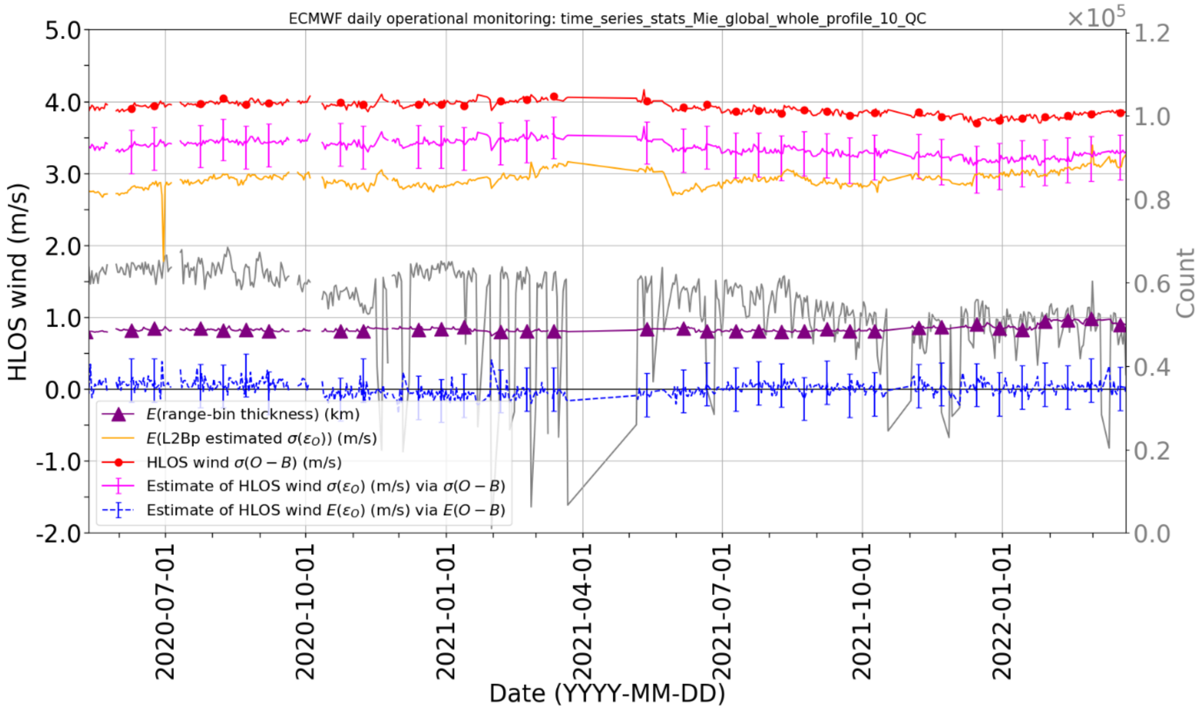

Figure 9. Times-series of daily, global, whole profile L2B Mie-cloudy HLOS wind related statistics since 12 May 2020 (when L2B data was made available for public release). QC for this type of plot is to reject if abs(O-B) > 10 m/s. Data up to 23 March 2022.

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

- A new processor baseline (14) was implemented on 29 March 2022. This did not lead to any noticeable change in the O-B statistics.
- Random error was gradually increasing, but improved a little with the N=5, P=114 setting since 4 April. The Mie-cloudy winds did not suffer a loss of data at high northern latitudes like the Rayleigh-clear, because the Mie channel range-bin 25 (solar background) did not reach saturation. Interestingly the stdev(O-B) and stdev(O-A) seemed to reduce, whilst the L2Bp estimated error increased. It is unclear why the L2Bp estimated error should increase, unless perhaps the larger observation-scale (17 km vs 14 km) led to more tenuous backscatter Mie-winds e.g. aerosol.
- Thanks to the Hunga Tonga-Hunga Ha'apai volcano eruption plume (eruption on 15 January) and range-bin settings up to 30 km since 24 January 2022, there is still a large and unique sample of Mie-cloudy winds of reasonable quality (estimated errors ~5-6 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.

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

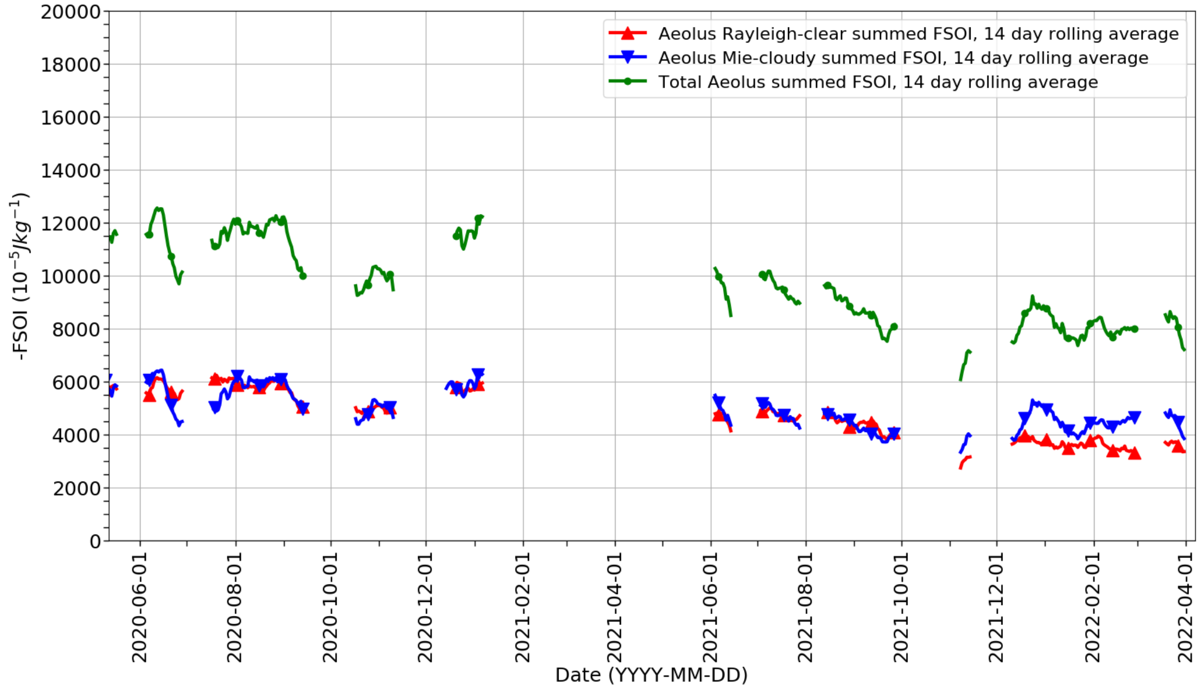

Figure 10. Time-series of the negative of the FSOI of Aeolus L2B HLOS winds in ECMWF operations since the L2B data public release (12 May 2020). Therefore, positive values of -FSOI indicate short-range forecast improvement due to assimilating Aeolus. Partitioned into Mie-cloudy (blue), Rayleigh-clear (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 March 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 March 2022 impact of ~8000 units is ~49% of the maximum impact.