An assessment of the expected quality of Aeolus Level-2B wind products

by Michael Rennie (aeolus@ecmwf.int)

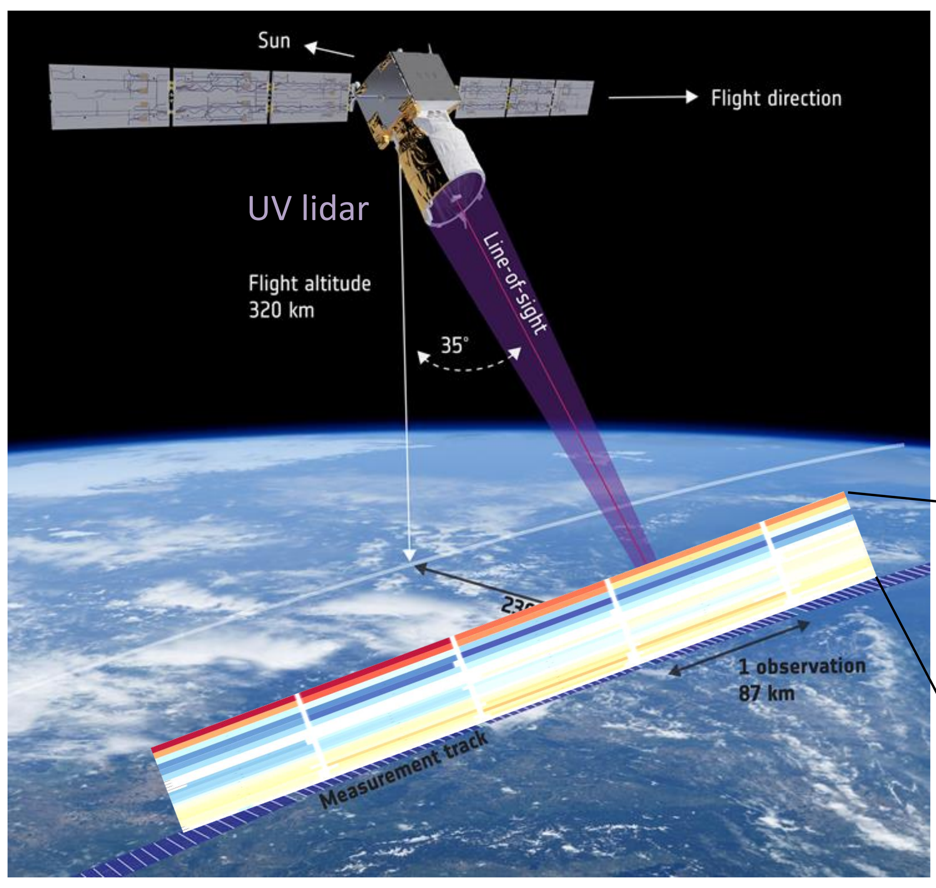
European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, United Kingdom

ECMWF

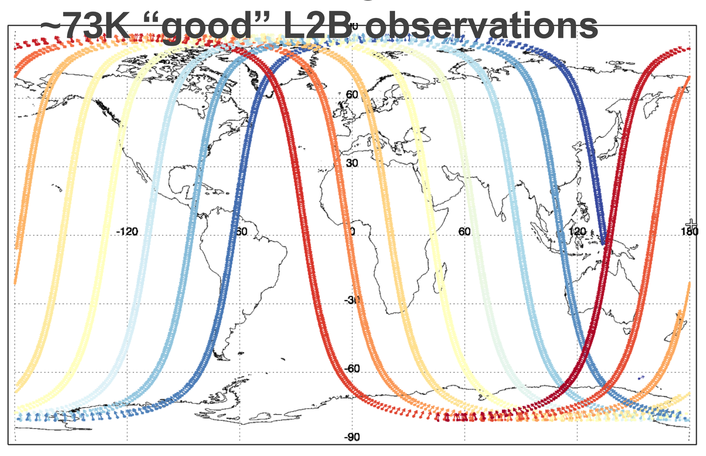
esa European Space Agency

Aeolus Level-2B winds

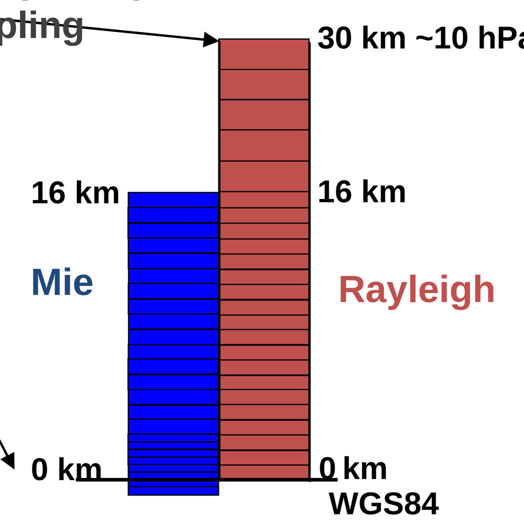
Aeolus is an ESA Earth Explorer mission that is part of the Living Planet Programme [1], which is scheduled for launch on August 21, 2018. Its main objective is to provide profiles of wind information from the surface to a maximum altitude of ~30 km. It does this via a Doppler wind lidar instrument ALADIN (Atmospheric LAser Doppler Instrument). It will occupy a near-polar sun-synchronous, dawn-dusk orbit. The wind information is the line-of-sight (LOS) component, observed from a 35° off-nadir direction and perpendicular to the satellite's velocity. ECMWF is closely involved in the mission: in running the operational Level-2B (L2B) processing as part of the mission's Ground Segment. ECMWF plan to operationally assimilate the L2B winds. L2B wind assimilation is expected to significantly improve NWP weather forecasts [4]; assuming the mission requirements [3] are met. ECMWF and KNMI (Royal Netherlands Meteorological Institute) have developed the L2B processing software over the past decade i.e. Horizontal LOS (HLOS) wind retrieval, to produce the winds suitable for use in NWP data assimilation. Here, we assess the L2B HLOS wind error statistics resulting from using realistic simulations and the operational processing chain.



Horizontal coverage in 12 hours; ~73K "good" L2B observations



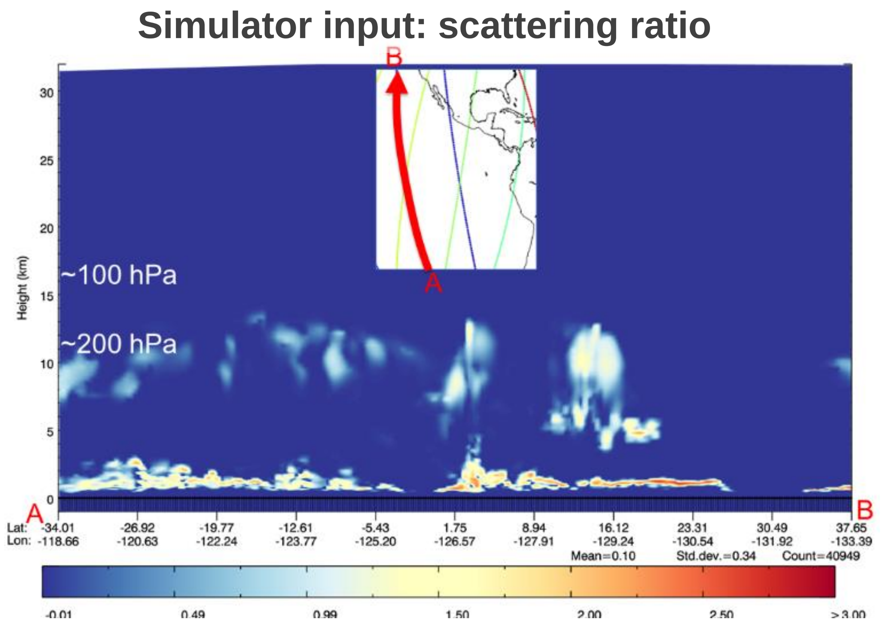
Example of possible Aeolus vertical sampling



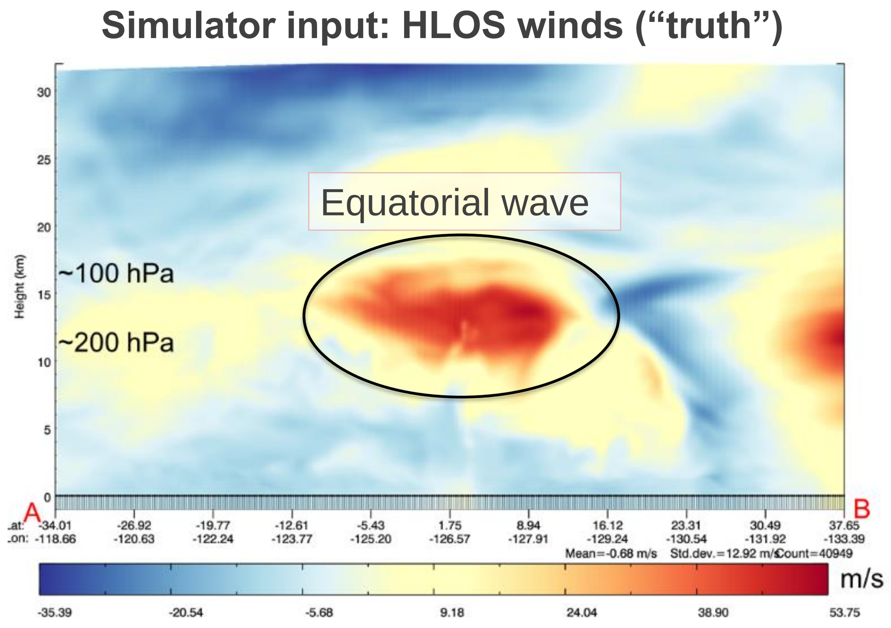
What would Aeolus observe for an equatorial wave?

Evidence suggests that errors in ECMWF's analysis for an upper troposphere equatorial wave in the East Pacific in March 2014 led to a forecast bust over Europe six days later. It is interesting to consider what Aeolus could observe in such regions.

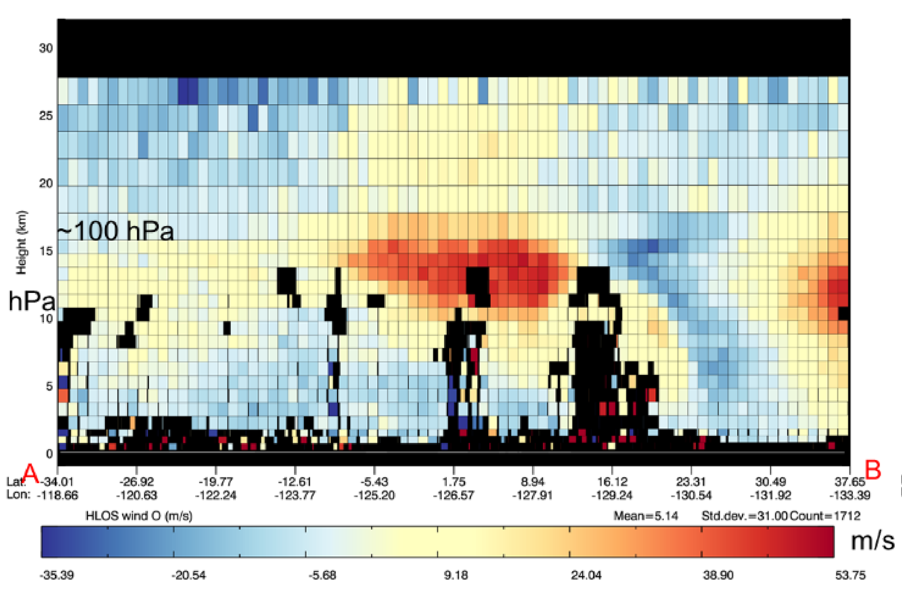
Simulator input: scattering ratio



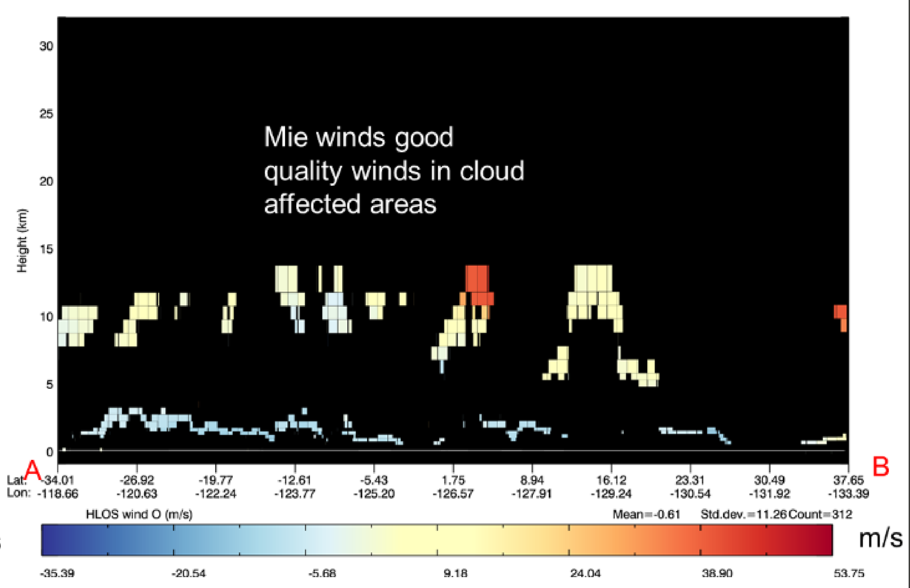
Simulator input: HLOS winds ("truth")



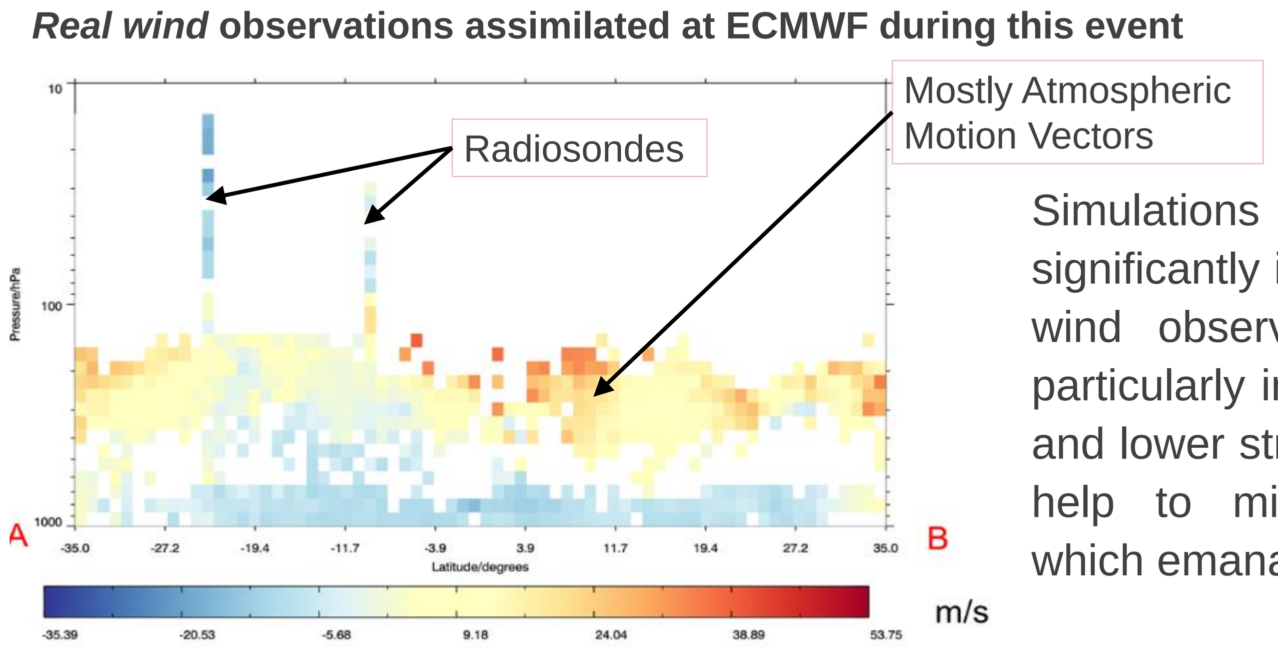
L2B product: Rayleigh-clear HLOS winds



L2B product: Mie-cloudy HLOS winds



***Real wind* observations assimilated at ECMWF during this event**



Simulations suggest that Aeolus will significantly improve the coverage of wind observations in the tropics; particularly in the upper troposphere and lower stratosphere. This should help to mitigate forecasts busts which emanate from the tropics.

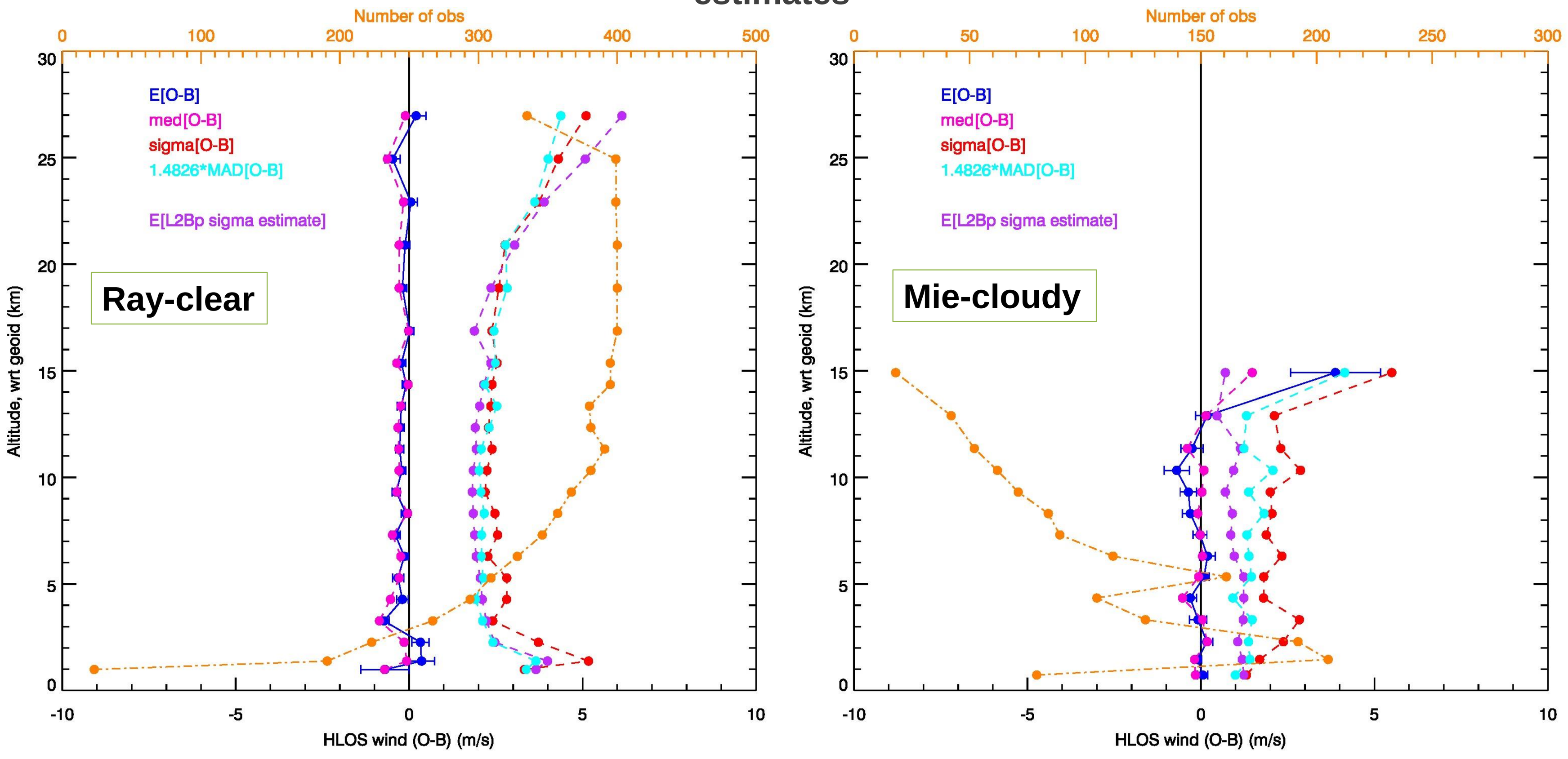
Features of the Level-2B (HLOS wind) processor

- The inputs to the L2B processor are the Level-1B "wind mode" product and various auxiliary files
- Main output: HLOS wind components geolocated by geometric height, latitude, longitude, azimuth angle and time;
- Uses a flexible "measurement grouping algorithm" to control the horizontal length-scale;
- Each observation type (either Mie or Rayleigh) is retrieved from the summation of "measurement-level" spectrometer counts after classification into "clear" or "cloudy" conditions using L1B scattering ratio;
- Rayleigh winds are corrected for a temperature and pressure sensitivity using a priori information (from NWP model forecasts) and also corrected for Mie cross-talk;
- Uncertainty estimates for each wind result and quality flags are provided;
- Processing options are easily controlled from a parameters and settings file;
- The software is freely available for users to download. See https://software.ecmwf.int/wiki/display/AEOL/Aeolus+Level-2B+Processor+Package for further details. An older description can be found in [2].

L2B wind verification using realistic simulations

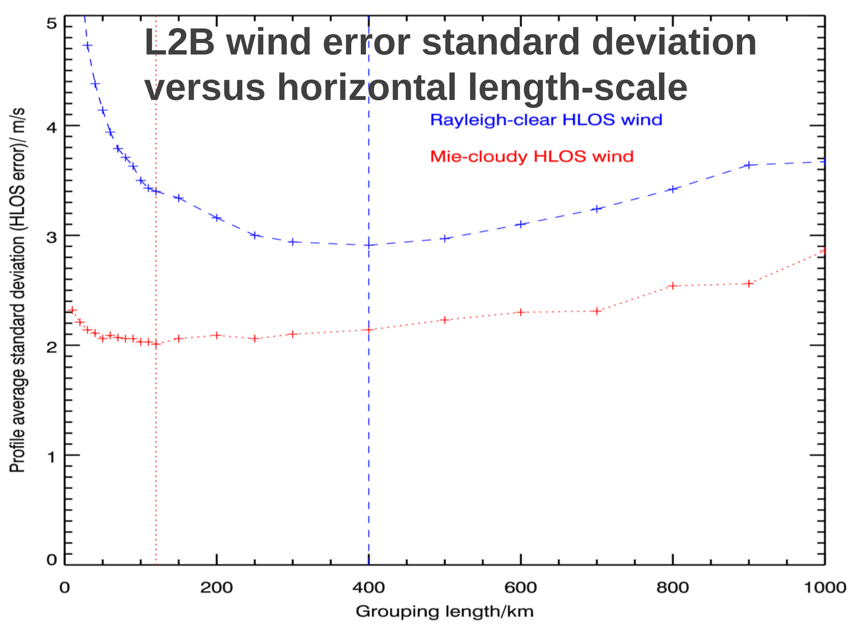
The Aeolus end-to-end simulator (E2S) is used to generate reasonably realistic Aeolus "raw" data using meteorological inputs from the ECMWF global NWP model. The real Ground Segment processing chain is applied to the fake raw data. The L2B winds are then verified against the "true" winds (input to the simulator) to generate error statistics.

Verification of L2B HLOS wind against simulator "truth" with "classic" measurement grouping (1 Basic Repeat Cycle length-scale) and QC using σ estimates



Ray-clear: $abs(|error|) < 1$ m/s; σ_{error}~ 2-4 m/s
Mie-cloudy: $abs(|error|) < 1$ m/s; σ_{error}~1-2 m/s

L2B wind error standard deviation versus horizontal length-scale



Small errors can be achieved for the Mie winds, even with rather short horizontal length-scales (e.g. 20 km) compared to the Rayleigh. It is thought that a length-scale of ~40-80 km will be appropriate to match the effective resolution of the ECMWF model.

Discussion

Simulations suggest Aeolus L2B wind properties are promising for impact in NWP, given the coverage compared to currently available wind observations in global NWP, and the expected errors. ECMWF and KNMI have developed the freely available L2B processor, hence other users have the option of running their own processing with options suited to their use. ECMWF will provide NRT L2B Earth Explorer wind products to ESA for distribution and NRT L2B BUFR for NWP users (via EUMETSAT).

References

[1] European Space Agency ESA, 2008: ADM-Aeolus Science Report, ESA SP-1311, 121 pp.
[2] Tan, D., Andersson., E., de Kloe, J., Marseille, G.-J., Stoffelen, A., Poli, P., Denneulin, M.-L., Dabas, A., Huber, D., Reitebuch, O., Flamant, P., Le Rille, O., Nett, H., 2008: The ADM-Aeolus wind retrieval algorithms. Tellus 60A, 191-205.
[3] European Space Agency ESA, 2016: ADM-Aeolus Mission Requirements Documents, AE-RP-ESA-SY-001, Issue 2, 16/11/2016, 57pp.
[4] Horányi, A., Cardinali, C., Rennie, M. and Isaksen, L. (2015), The assimilation of horizontal line-of-sight wind information into the ECMWF data assimilation and forecasting system. Part I: The assessment of wind impact. Q.J.R. Meteorol. Soc., 141: 1223–1232. doi:10.1002/qj.2430