EPS-Aeolus, Status of the European Doppler Wind Lidar Programme at EUMETSAT

Thomas Flament
On behalf of the EPS-Aeolus team

IWW16, 11 May 2023

Agenda

End User Requirements

Overview of specified mission performance

Schedule

Overview

- With the objective to have an affordable mission through re-use, EPS-Aeolus is based on strong heritage of Aeolus

- Yet, many lessons learned have been taken into account, ending up in a significantly different instrument.

Main performance requirements

- Timeliness
- Random error
- Bias
- Aerosol observation
- Vertical resolution

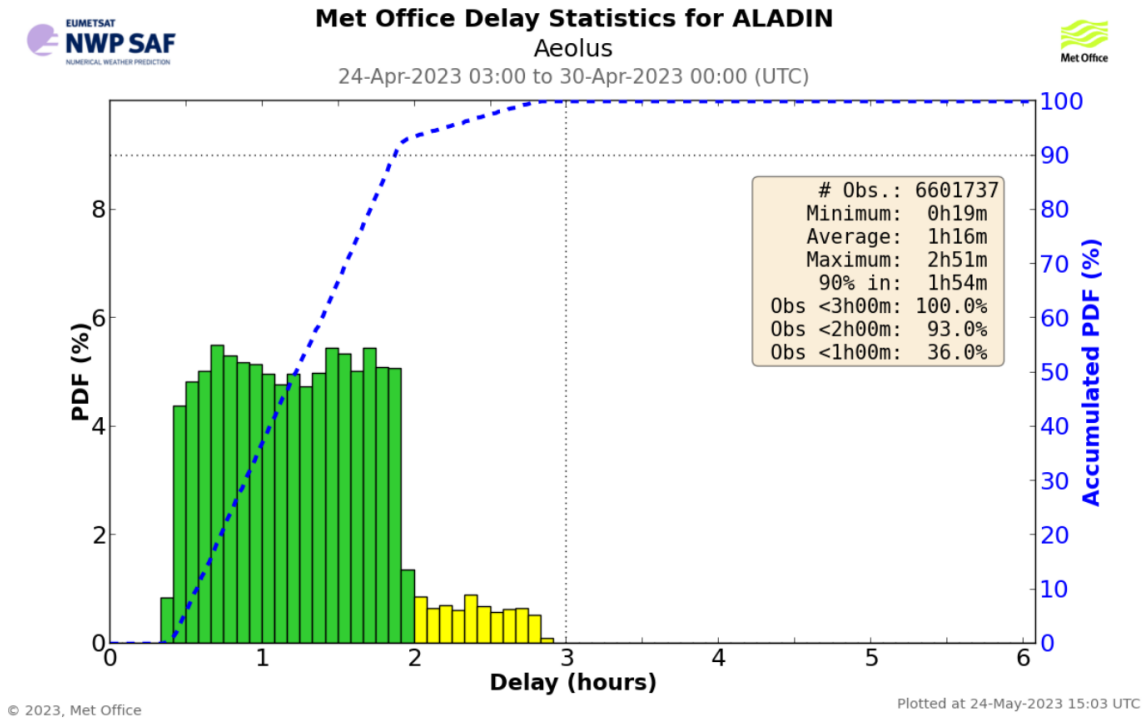
Timeliness

The *timeliness* of *Level 2* products at global level shall be

Threshold: 120 min for 100 % of the data

Breakthrough: 60 min for 90 % of the data

- Aeolus: 3 hours for 100 %
  - Fulfilled
  - 90 % in 2 hours
  - Only one third under 1 hour
- Main impact on design and cost: number of ground stations
- Rationale:
  - Impact of “fresh” data is larger (McNally, 2019)
  - Enable shorter window assimilation systems to use the data.



Measurement quality

- Random error:

Rayleigh wind profile	Horizontal resolution	Vertical res. (Threshold)	Vertical res. (breakthrough)	Precision (RMS)
Planetary boundary layer (0-2 km)	100 km	0.5 km	0.25 km	5 m/s
Troposphere (2-16 km)	100 km	1 km	0.5 km	2.5 m/s
Stratosphere (16-30 km)	200 km	2 km	1 km	5 m/s
Mie wind profile				
Planetary boundary layer (0-2 km)	10 km	0.5 km	0.25 km	2 m/s
Troposphere (2-16 km)	10 km	1 km	0.5 km	2.5 m/s
Stratosphere (16-30 km)	100 km	2 km	1 km	5 m/s

- Largely improved through instrument design, thanks to implementation of lessons learned
- Laser power increased and less problematic thanks to bi-static design (major change)
- Noise from the electronics is better handled for improved SNR

Measurement bias

Aeolus:
MR-100: The bias of the HLOS wind observations shall not exceed 0.7 m/s over all mission time periods (1 minute to 3 years), over the required dynamic range (MR-95), and over the required vertical measurement domain (MR-85)

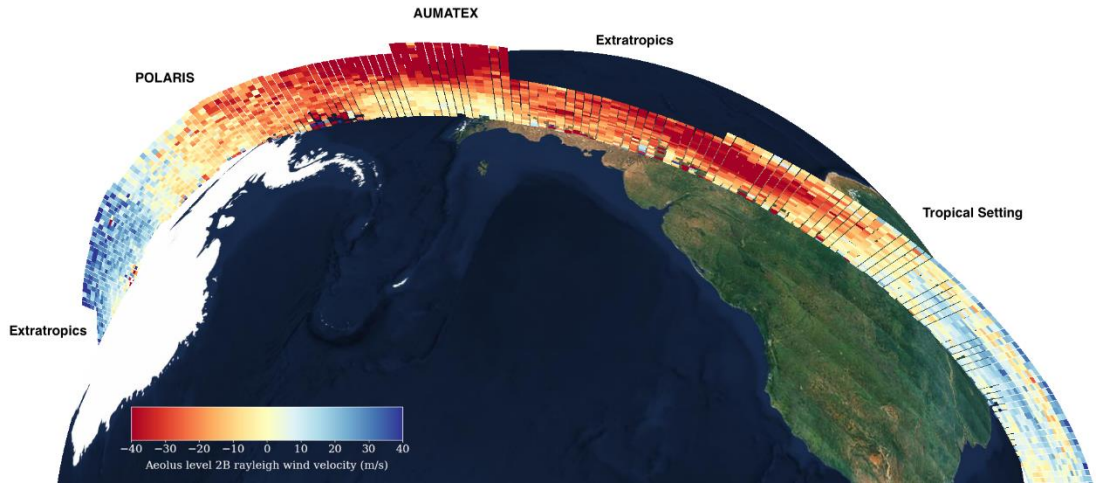
Measurement bias

The L2 wind bias (systematic error) of the HLOS wind observations shall not exceed 2.1 m/s (3-sigma) (Threshold) and 1.1 m/s (3-sigma) (Breakthrough) over the dynamic range +/- 60 m/s.

The wind bias requirement shall be applicable for all time scales.
The minimum duration of the data set for calculation of the bias is 2 minutes.

- Bias requirement is tighter than actual Aeolus performance.
- New, more robust interferometer implementation is being studied by ESA.
- The stability is specified over 2-minute periods.
- Rationale:
  - Bias was the most significant problem for data quality on Aeolus-1
  - The underlying objective is to correct bias without using NWP data, hence the study of the feasibility of using a field compensated Michelson interferometer.

- Accumulation CCD, as for Aeolus
- Improved noise handling
- Improved vertical sampling:
  - Better resolution of shear zones
  - Clearer ground echoes (less atmospheric contamination)
  - Easier use of the data (no or fewer changes of the range bin settings)
- Interleaved dark current measurement

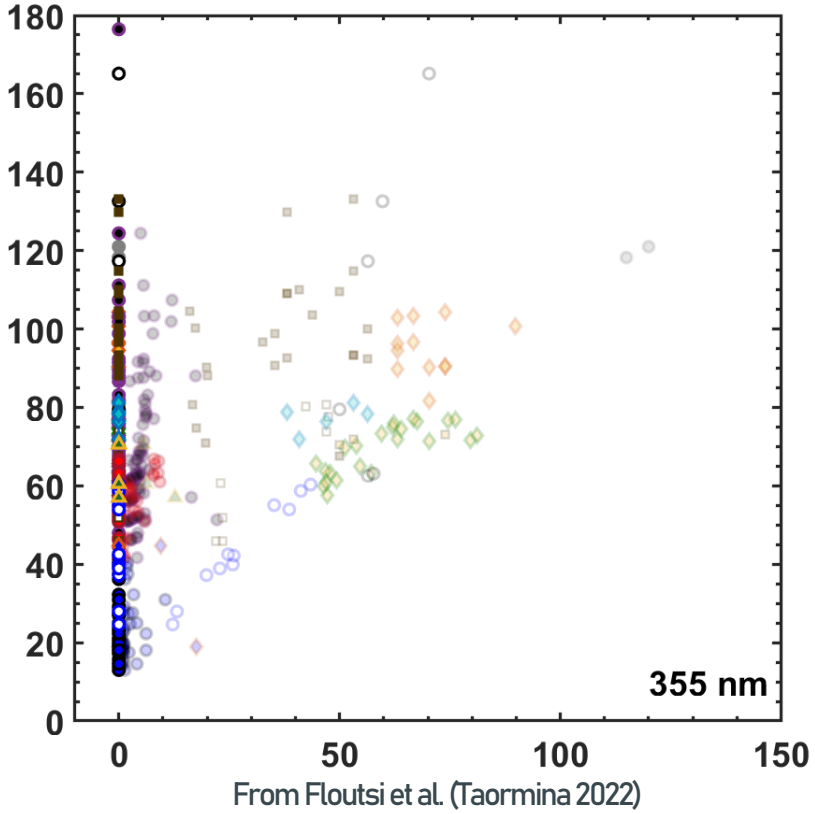


Example of range bin settings used on 16 July 2020
Visualised with VirES (https://aeolus.services/)

Cross-polarization channel

sat.int

- Still considered as an option being studied
- Benefits:
  - Improved aerosol and cloud classification
  - Also benefiting NWP directly, see next slide
  - Easier validation with other sources (most lidars are linearly polarised and measure along both polarization direction)

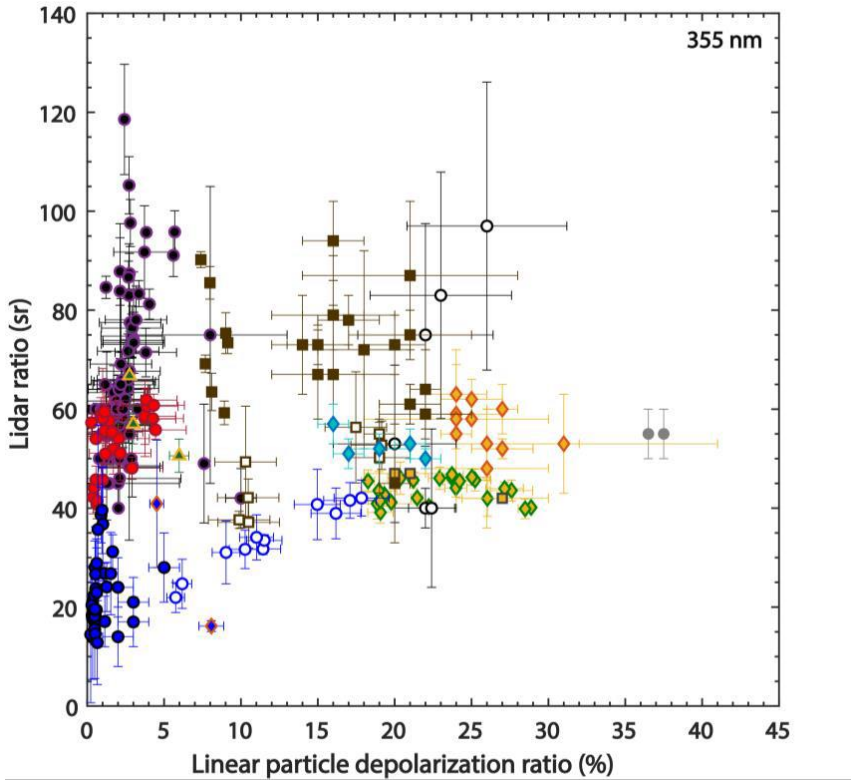


From Floutsi et al. (Taormina 2022)

- Rationale:
  - Made easy by the choice of bi-static architecture
  - Cloud assimilation is in preparation for EarthCARE, aerosol assimilation might become part of NWP during the lifetime of the EPS-Aeolus mission.
  - And only European profiling mission in preparation “post-EarthCARE”

Cross-polarization channel

- Still considered as an option being studied
- Benefits:
  - Improved aerosol and cloud classification
  - Also benefiting NWP directly, see next slide
  - Easier validation with other sources (most lidars are linearly polarised and measure along both polarization direction)

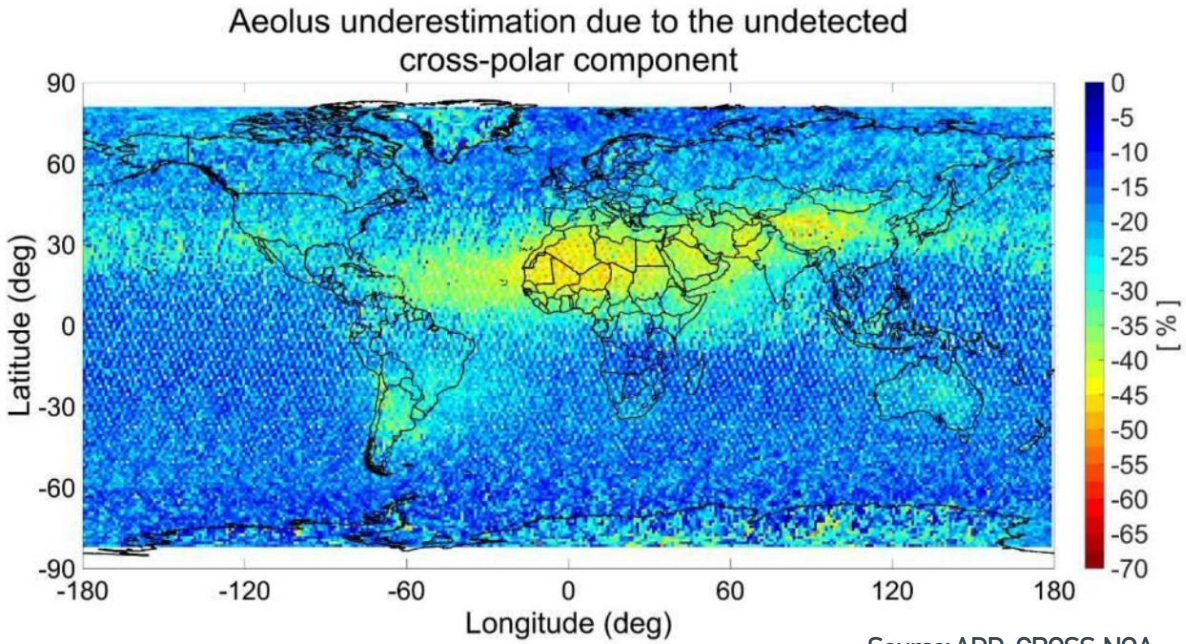


From Floutsi et al. (Taormina 2022)

- Rationale:
  - Made easy by the choice of bi-static architecture
  - Cloud assimilation is in preparation for EarthCARE, aerosol assimilation might become part of NWP during the lifetime of the EPS-Aeolus mission.
  - And only European profiling mission in preparation “post-EarthCARE”

ADD-CROSS study

- ADD-CROSS is studying the effect on NWP of measuring the full backscatter rather than only the collinear component (as Aeolus today)
- Based on the conversion of real CALIPSO observation into Aeolus-like observations
- See presentation by A. Gkikas



Source: ADD-CROSS, NOA

Radio occultation

- Piggy-back instrument (Opportunity mission)
- Identical instrument to EPS-SG
- Minimal modification under assessment, due to lower orbit ionosphere observation is not possible.
- Rationale:
  - Low risk and small payload
  - No saturation in RO data (i.e. every additional data point increases the overall impact)

Major design changes

- EPS-Aeolus/Aeolus-2 will be based on a bi-static architecture
  - Completely redundant
  - Need for co-alignment system
- Robustness and operability are improved
  - e.g. fully pressurised lasers
- Structural and thermal stability improved to cope with biases

- New challenges in understanding and exploiting the instrument

Next steps and schedule

- Creation of a dedicated Science Advisory Group for 2024
  - It will work closely with ESA's Aeolus "Phase F SAG"
- First round of "Elements of Programme Proposal" in Spring 2023
- Full Programme Proposal to Member States: mid-2024
  - with approval expected in 2025
- Launch slated for end 2031

Thank you!

Questions are welcome.