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

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On behalf of the EPS-Aeolus team

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Agenda

End User Requirements

Overview of specified mission performance

Schedule

Short description for second agenda point.

Overview

- EPS-Aeolus is based on strong heritage of Aeolus
- Objective to have an affordable mission through re-use

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

Summary of the Mission

- Key Observational requirements
  Source: Draft EURD – All requirements remain under consolidation

		Planetary Boundary Layer (PBL)	Troposphere	Stratosphere
Vertical Domain	km	0 - 2	2 - 16	16 – 30 (40)
Vertical Resolution Threshold Breakthrough	km	0.5 (Mie) 0.25 (Mie)	1.0 (Rayleigh & Mie) 0.5 (Rayleigh & Mie)	2.0 (Rayleigh & Mie) 1.0 (Rayleigh & Mie)
Number of vertical Samples Threshold Breakthrough		> 54 (per channel) > 75 (per channel)		
Horizontal Observation Resolution	km	100	100	200
Precision (Random Error) ★	m/s	2	2.5	5
Systematic Error (Bias) ★ Threshold Breakthrough	m/s	1 (TBC) 0.5 (TBC)		
Dynamic Range	m/s	± 120 (150)		
L2 Timeliness ★ Threshold Breakthrough	min	120 (100% of data) 60 (90% of data)		

Comparison with Aeolus

Aeolus specified to 20 km altitude, but can measure to 30 km with degraded vertical resolution

Improvement by factor of x2

Improvement compared to Aeolus (24)

Aeolus average random error over full atmosphere:
6-8 m/s for Rayleigh;
3-4 m/s for Mie.

Aeolus bias is ~2.5m/s without M1 mirror correction and ~1m/s after M1 mirror correction.

Aeolus dynamic range is ±100 m/s to meet performance requirements.

Was 180 min for 100% of data

Timeliness

DWL-DIS-0080	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

- Compared to 3 hours for 100 % for Aeolus
  - achieved, 90 % in 2 hours but little data under 1 hour
- Main impact on design and cost: number of ground stations
- Rationale:
  - Impacts 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. (breakthroug h)	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

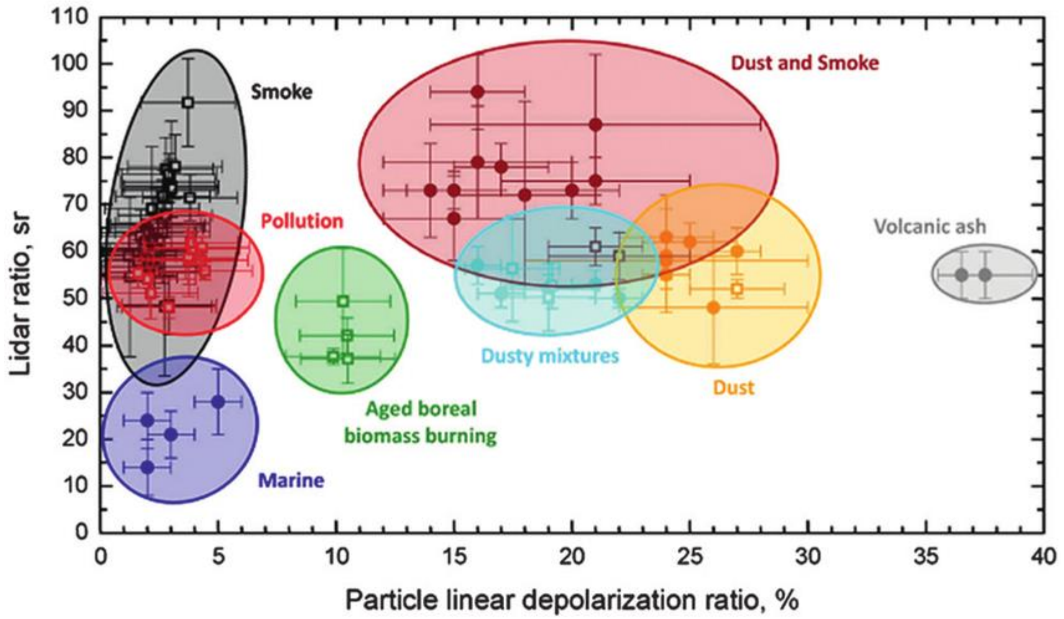
Measurement bias

DWL-DAG-0060	**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. It could be relaxed to 10-minute.
- 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.

Cross-polarization channel

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

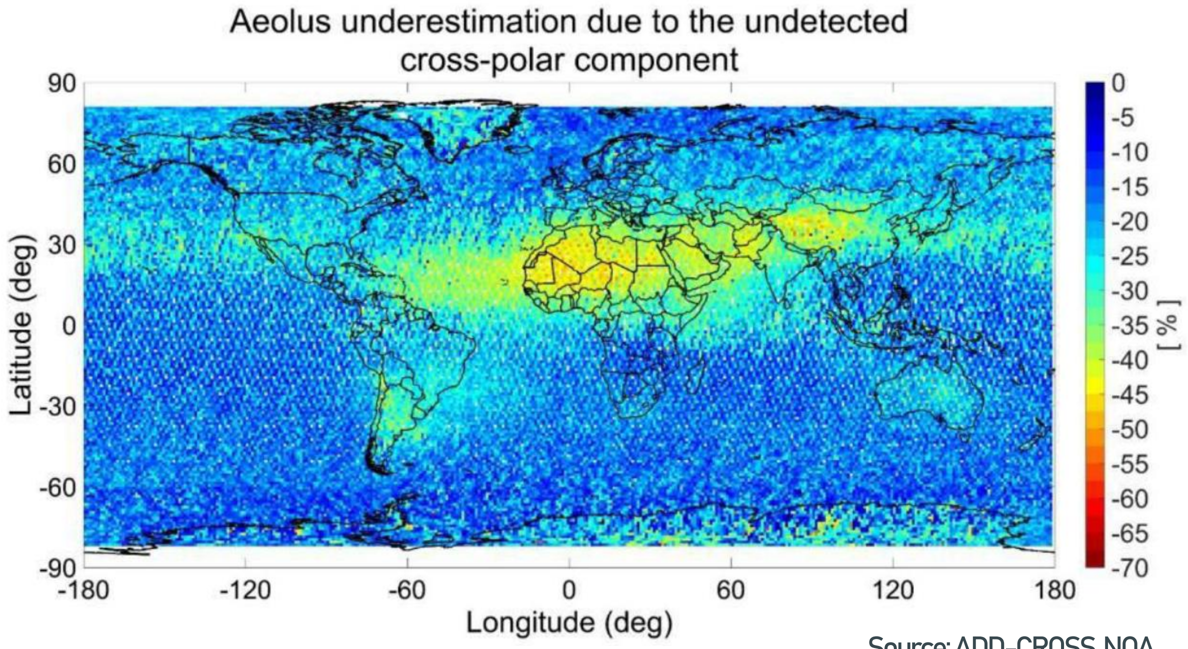


From Illingworth et al. (2015), https://doi.org/10.1175/BAMS-D-12-00227.1

- Rationale:
  - Made easy by the choice of bi-static architecture
  - Fostering the interest of a second community beside winds
  - Cloud assimilation in preparation for EarthCARE, aerosol assimilation might become part of NWP within EPS-Aeolus mission duration
  - And only European profiling mission in preparation “post-EarthCARE”

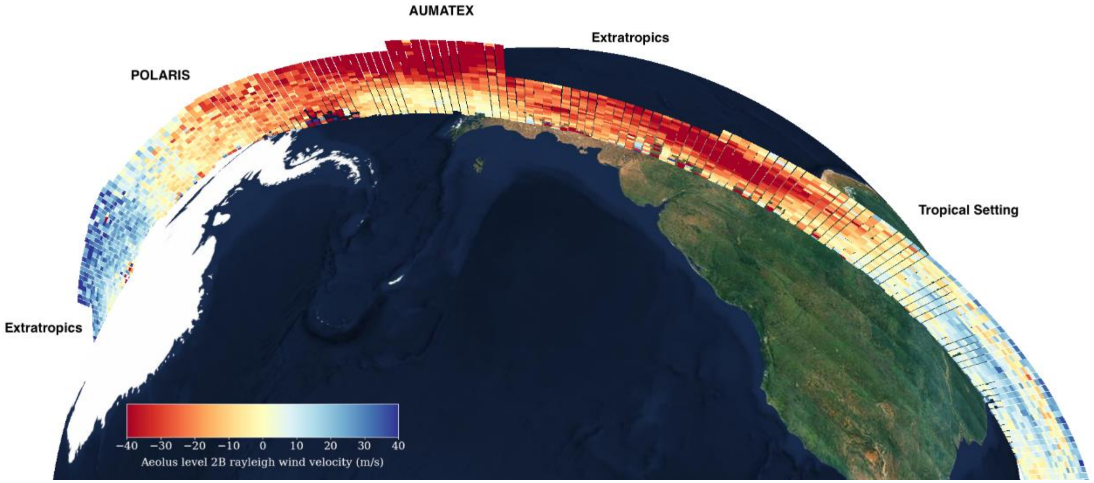
ADD-CROSS study

- 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
- Only exploring a small fraction of the benefits of a cross-polarisation channel but preliminary results show an impact on NWP outputs



Source: ADD-CROSS, NOA

- Same technology 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)



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

Major design changes

- EPS-Aeolus/Aeolus-2 will be based on a bi-static architecture
  - 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 the instrument

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)

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 2023
- Full Programme Proposal to Member States: mid-2024
  - with approval expected in 2025
- Launch slated for end 2031

Thank you!

Questions are welcome.