Aeolus - ESA'S Wind LIDAR Mission and its Contribution to NWP

Paul Ingmann and Anne Grete Straume

European Space Agency, Earth Observation, Mission Science Division, Noordwijk, NL

Ad Stoffelen

KNMI (Royal Netherlands Meteorological Institute), de Bilt, NL

Scientific & Technical Contributions

- The Aeolus Mission Advisory Group
  - Alain Dabas / MeteoFrance
  - Pierre Flamant / IPSL
  - Erland Källén / ECMWF
  - Heiner Körnich / MISU
  - Dave Offiler / MetOffice
  - Harald Schyberg / met.no
  - Ad Stoffelen / KNMI
  - Oliver Reitebuch / DLR
  - Michael Vaughan / Lidar & Optics Associates
  - Werner Wergen
  - M. Hardesty / NOAA, L.P. Riishojgaard / JCSDA
- The Aeolus Project team at ESA (H. Nett and O. Le Rille)
- The Aeolus L1b, L2a and L2b algorithm development teams (DLR, ECMWF, IPSL, KNMI, MeteoFrance)

Overview

- ESA’s Living Planet programme
- The Aeolus Doppler Wind Lidar Mission
  - Mission objectives
  - Mission description
  - Sampling
- Supporting campaigns
- Mission status
- Conclusions

ESA's Living Planet Programme

ERS1
ERS2
Envisat

Meteosat

Earth Explorer
Research driven

Earth Watch
Service driven

Core Missions

Opportunity Missions

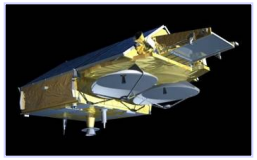
EUMETSAT

- MSG
- MTG
- Metop
- Metop SG

GMES

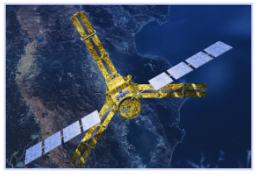
- Sentinel 1
- Sentinel 2
- Sentinel 3
- Sentinel 4
- Sentinel 5

GOCE
2009

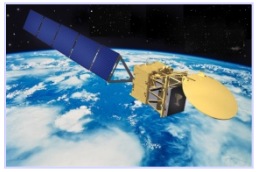


CryoSat 2
2010

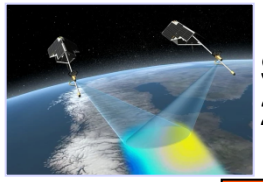
ADM-Aeolus
2014



SMOS
2009



EarthCARE
2015



Swarm
2012

www.esa.int/livingplanet

? EE7 2018/19

? EE8 2018/19

3 candidates
PREMIER, CoReH2

2 candidates
Carbonsat, Flex

Aeolus - Objectives and Benefits

Scientific objectives

Improve understanding of

- Global atmospheric dynamics/transport
- Global cycling of energy, water, aerosols and chemicals through improvements of model dynamics

How are they achieved?

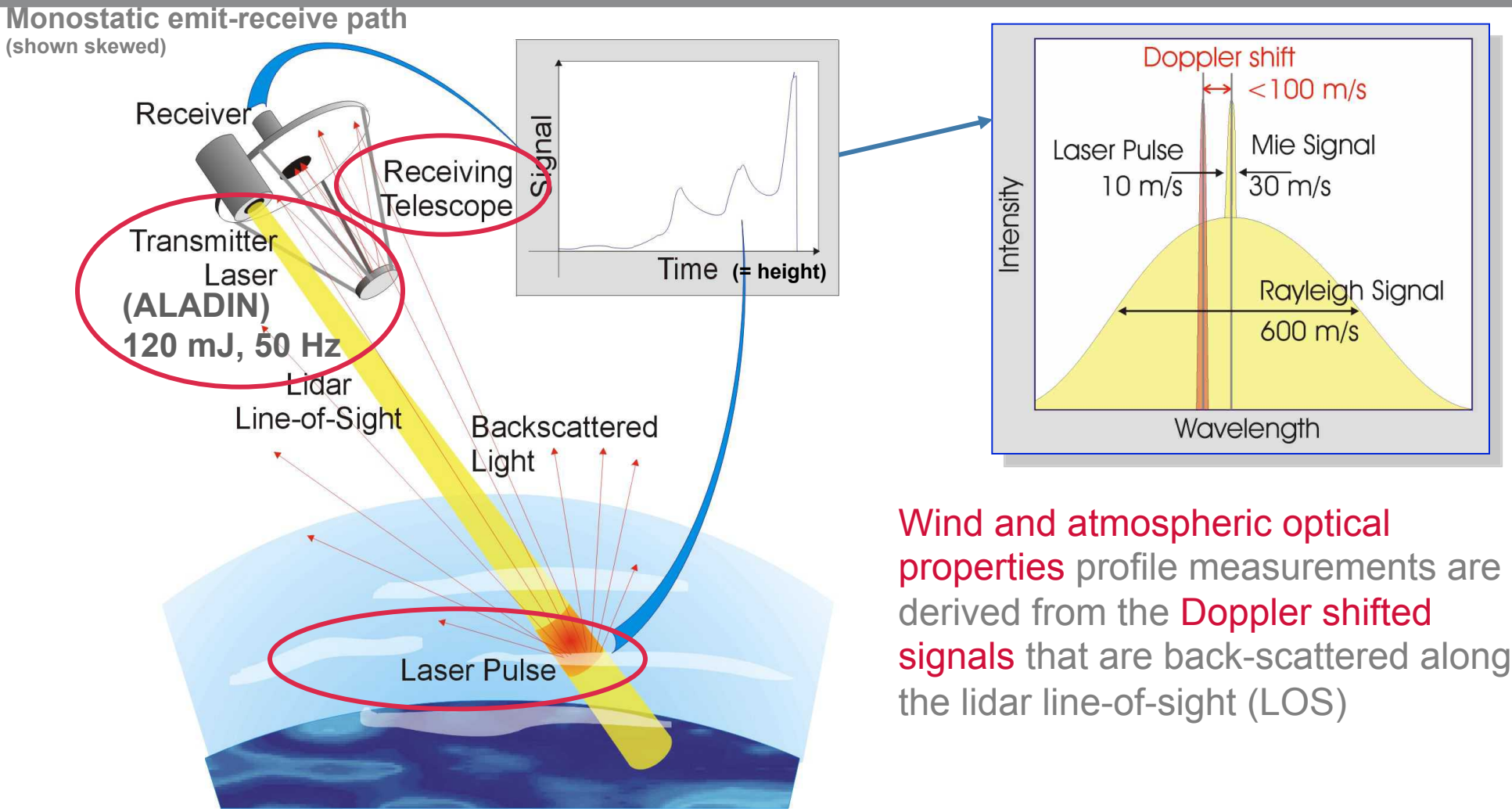
- Improved representation of winds in atmospheric analysis, in particular:
  - Tropics: Wind fields governs dynamics
  - Mid-latitudes: Intense storm developments and mesoscale circulation systems

Benefits

- Better initial conditions for weather forecasting
- Improved parameterisation of atmospheric processes in models
- Advanced climate and atmospheric flow modelling

Demonstrate the capabilities of space-based HSR Doppler Wind LIDARs (DWLs) for global wind profiling and its potential for operational use

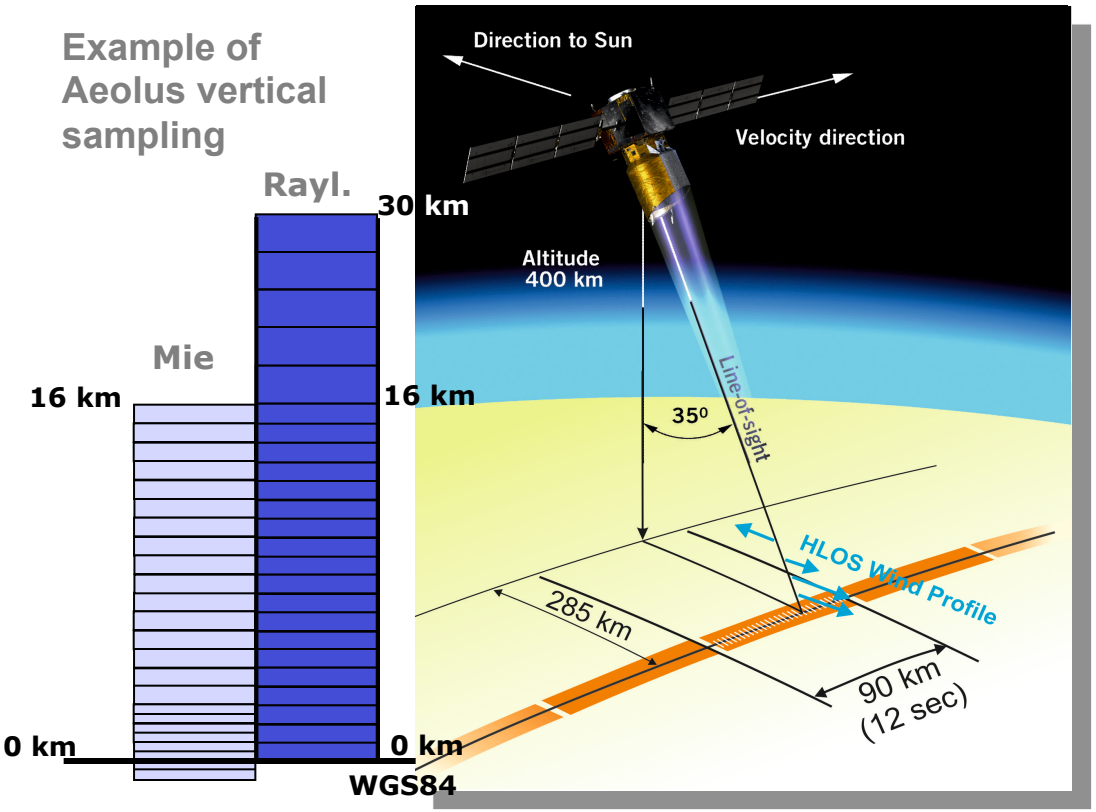
Aeolus Measurement Concept



Wind and atmospheric optical properties profile measurements are derived from the Doppler shifted signals that are back-scattered along the lidar line-of-sight (LOS)

Measurement Baseline

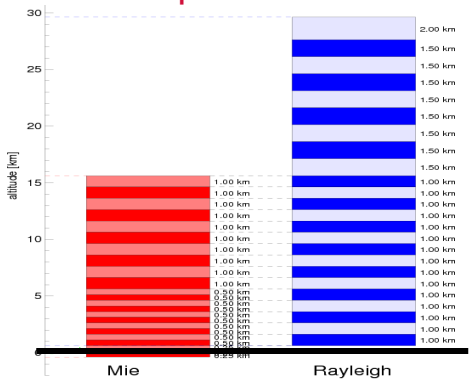
New measurement baseline



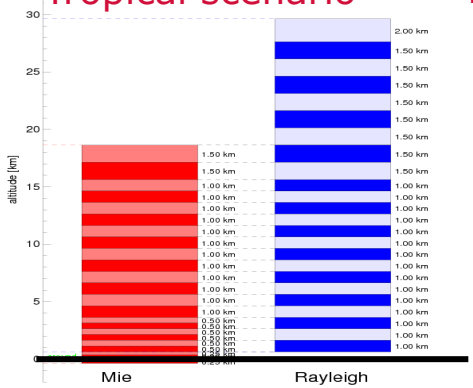
- UV lidar (355 nm , circularly polarized)
- High Spectral Resolution: Separate molecular and a particle backscatter receivers
- No polarization detection
- Adjustable vertical sampling of atmospheric layers
  - Δz: 0.25–2 km
  - z: 0-30 km

Possible Variation of the Aeolus Sampling Along the Orbit

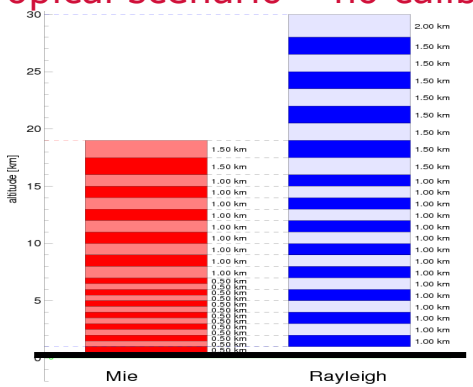
Extra-tropical scenario



Tropical scenario[1)]



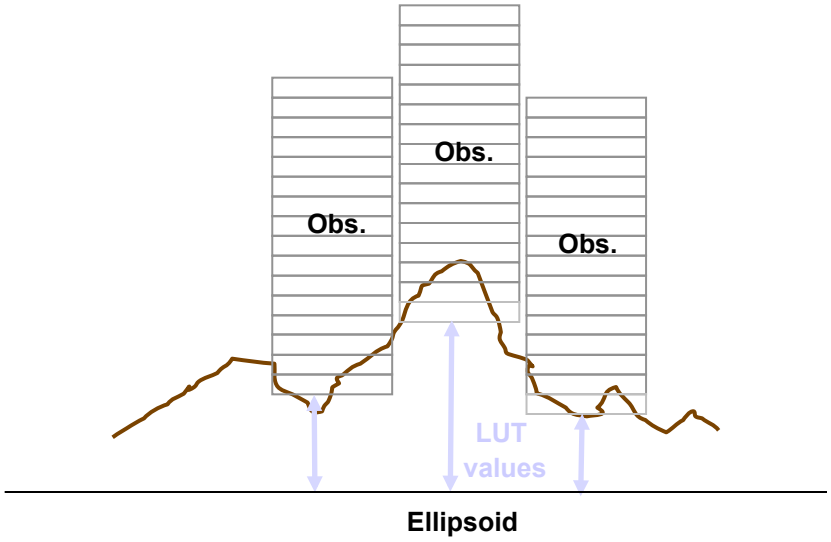
Tropical scenario – no calibration



Courtesy, G.J. Marseille, KNMI

1. Mie and Rayleigh sampling adjustable up to 8 times along the orbit (on average)
2. Terrain- Following model
3. Co-location of Mie and Rayleigh channel sampling within an observation is essential in order to allow cross-talk correction

   These options and processing needs could potentially restrict super-obbing strategies

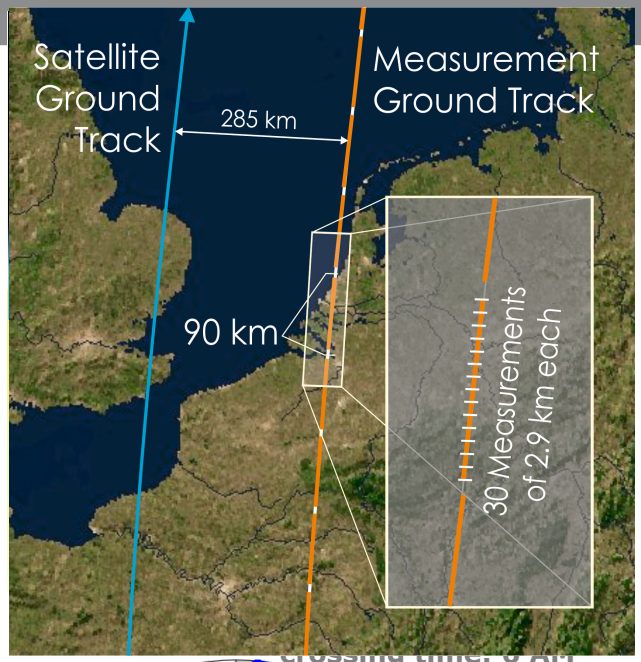


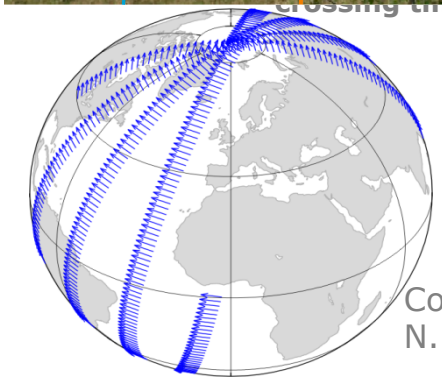
More in talk by Ad Stoffelen

Atmospheric products

- **Primary (L2b) product:**
  - Horizontally projected LOS wind profiles
    - Approximately zonal at dawn/dusk
    - 3 km-averaged measurements and ~90 km observation averages – scene classified
    - From surface to ~30 km in 24 vertical layers
    - Random errors: 1 (PBL), 2 (Trop), 3-5 (Strat) m/s

- **Spin-off (L2a) products:**
  - Optical properties profiles
    - β, σ, OD, scattering ratio
    - Cloud/aerosol cover/stratification
    - Cloud/aerosol top heights
    - Cloud/aerosol base height (optically thin)
    - Aerosol typing (backscatter-to-extinction ratio)
    - 3 km averaged measurements and <90 km observation averages – scene classified





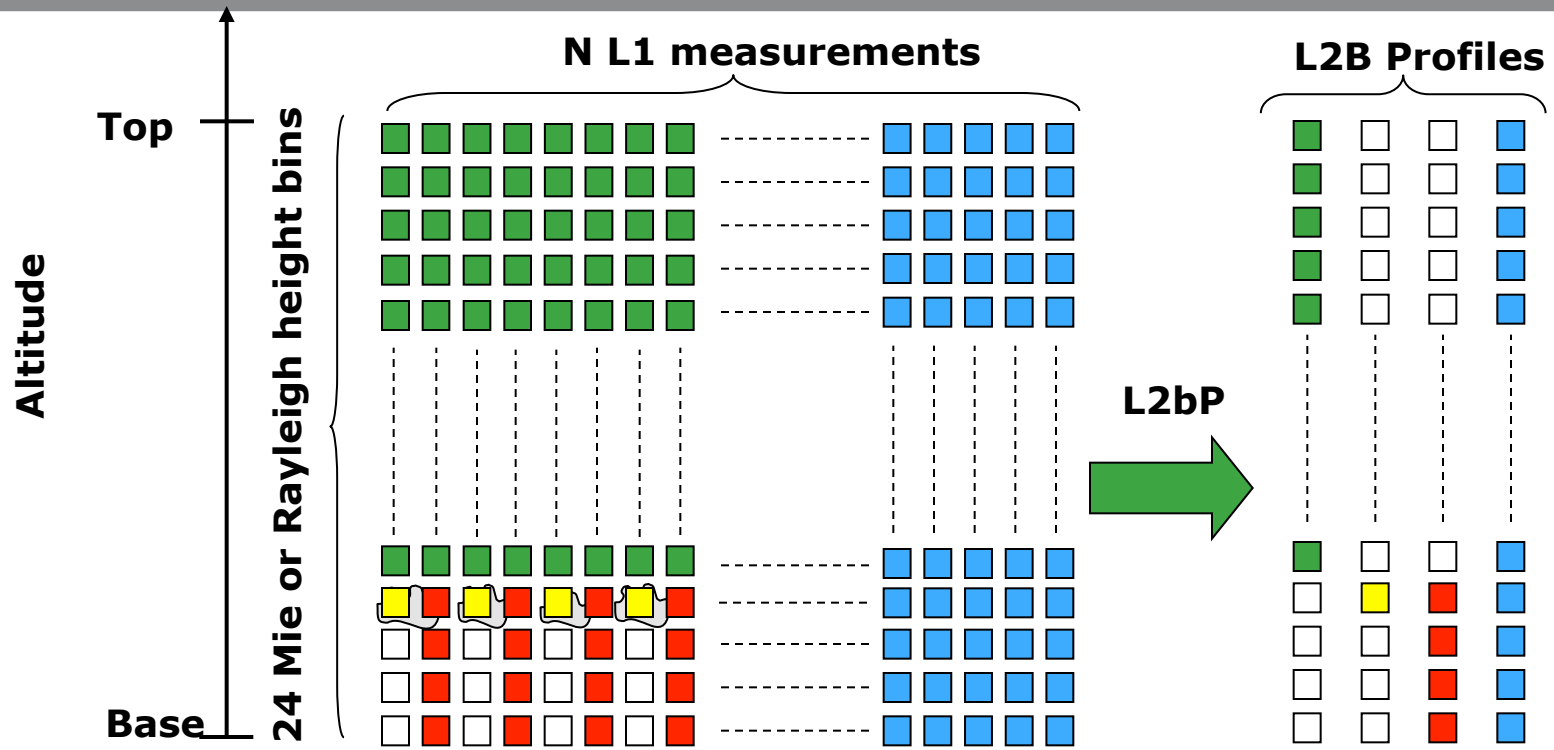
Courtesy N. Žagar

Dusk/dawn orbit

Aeolus L1b <-> L2b data Products

- Aeolus L1b product:
  - NRT delivery (within 3 hours)
  - Calibrated HLOS wind profiles on measurement (3 km) and observation (90 km) level
  - Not corrected for temperature and pressure effects
  - No scene classification or QC applied
- Aeolus L2b product, produced at ECMWF (every 12 hours, could become more often at/after launch) and likely at KNMI in NRT (EUMETSAT funding) or locally with a stand-alone processor:
  - Scene classified observation profiles (<90 km) from temperature and pressure corrected and quality-controlled measurements
  - Further super-obbing may be performed using the stand-alone L2b processor
    - Options for vertically independent horizontal averaging on super-observation level are looked into by KNMI and partners
  - Some investments are needed to operate the stand-alone processor. The Aeolus L2b team (lead by ECMWF) are ready to assist users in getting up-to-speed with their own processing

Aeolus L2b Wind Profile Processing



After Tan *et al.*, 2008

The averaging scheme of *N* measurements at 24 height levels (left) in a single Aeolus observation into several partial or complete wind profile retrievals

Strategies for the Optimization of Aeolus Data Processing

- A survey amongst NWP centres has been performed to ask for their needs and preferences w.r.t. the Aeolus wind observation processing strategy (more in talk by Michael Rennie, ECMWF)

- Science studies have been initiated to investigate which strategies give maximum impact in NWP (more in talk by Ad Stoffelen, KNMI)

- R&D is performed to look for the most cost-effective and practical implementation of a flexible L2b observation data processing (more in talk by Michael Rennie, ECMWF)

ADM-Aeolus Campaign Activities

DLR has and will support ADM-Aeolus activities with

- **Ground-based campaigns with the Aeolus Airborne Demonstrator (A2D) at DWD Lindenberg and DLR**
- **Airborne campaigns with the Falcon aircraft with A2D, 2-µm wind lidar and additional payloads**
- **Extended flight campaigns planned for the Aeolus CAL/VAL activities after launch with the A2D onboard the HALO aircraft**

DLR Falcon 20 and HALO (High Altitude and Long Range Research Aircraft, modified Gulfstream G550) in April 2006

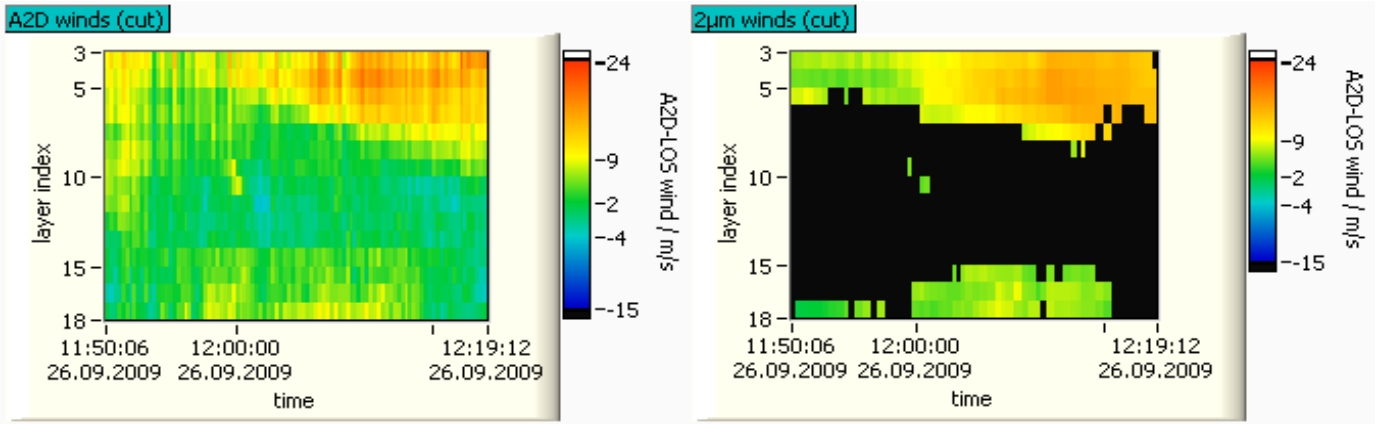
HALO aircraft delivered to DLR in November 2008
www.halo.dlr.de

Aeolus campaigns, DLR

- Objectives:
  - Validation of the predicted instrument radiometric and wind measurement performance
  - Establishing a dataset of atmospheric measurements obtained with an Aeolus type Lidar to improve algorithm development

- Campaigns:
  - Two ground-based (2006, 2007) and three airborne (2007, 2008 and 2009)
  - So far, on the order of 100 recommendations for the Aeolus mission (instrument and algorithm development and testing)
  - First atmospheric measurements worldwide with a Fizeau and Double Fabry-Perot UV lidar system

Preliminary comparisons of A2D and DLR 2µm wind lidar measurements on-board the Falcon, near Greenland, 2009. With courtesy, U. Marksteiner, DLR



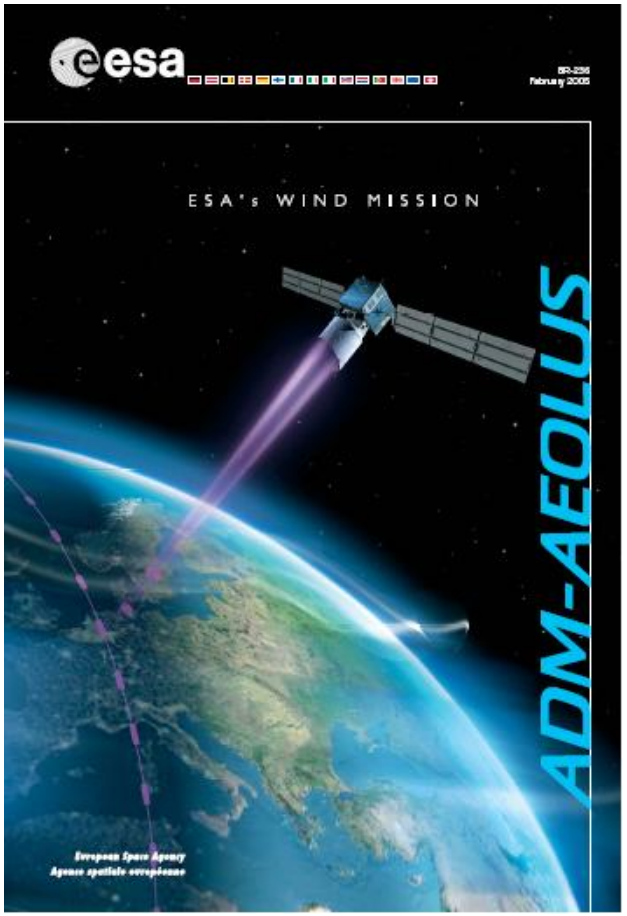
Status of the Aeolus program

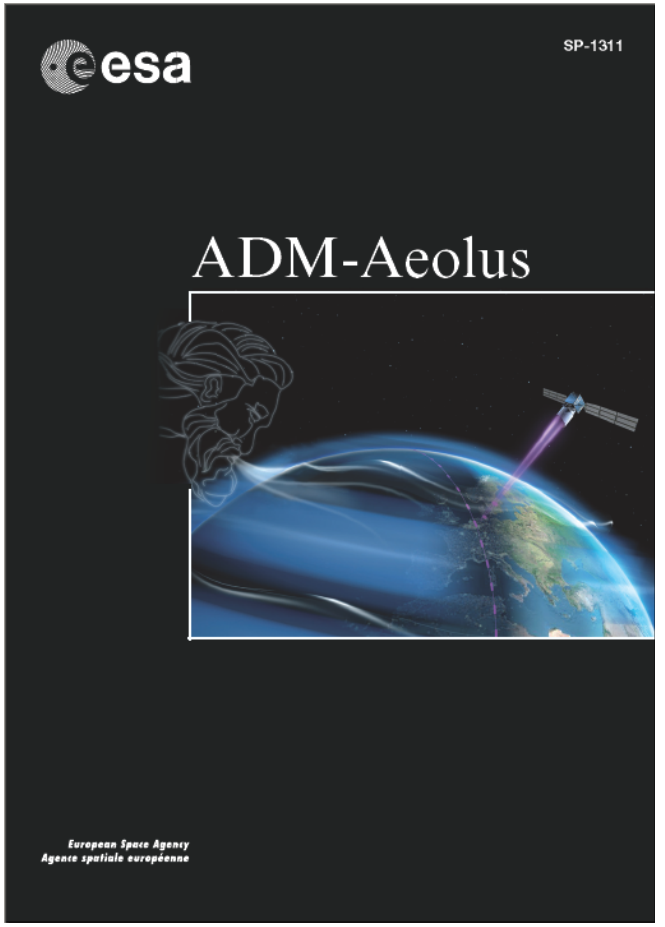
- The platform was completed in 2009 and in storage; modifications for In-situ Cleaning System required
- The Aeolus ALADIN Lidar subsystems have all been delivered and qualified on subsystem level, but the qualification of some recent modifications are still on-going
- The transmitter laser qualification is the most challenging:
  - The transmitter laser qualification in vacuum, with an oxygen purging system implemented, is on-going. Preliminary results look promising. Results are expected by the end of March 2012.
- Schedule launch date: 1st Q 2014.

Conclusions

- Aeolus wind lidar mission will deliver wind (suitable for data assimilation) and atmospheric optical properties products (could become suitable for NWP assimilation after R&D)
- Aeolus L1b wind profiles (not corrected for temperature and pressure effects and no scene classification) will be delivered NRT together with a stand-along processor
- Aeolus L2b scene classified wind profile products will be delivered off-line by ECMWF (every 12 hours)
- The Aeolus off-line L2a optical properties products will be made available to users off-line (now every 12 hours) but could in the future become available every 4 hours or more often
- Aeolus platform in storage, instrument delivery scheduled for 1st Q 2013 with a launch in 2014

ADM-Aeolus Brochure (Left) and Science Report (Right)





http://www.esa.int/esapub/br/br236/br236.pdf

http://esamultimedia.esa.int/docs/SP-1311_ADM-Aeolus_FINAL_low-res.pdf


ADM-AEOLUS
ESA's WIND MISSION
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