ADM-Aeolus pre-launch campaigns with an airborne instrument demonstrator

Oliver Reitebuch
Background

- The ADM-Aeolus instrument ALADIN uses several novel techniques, like
  - **Fizeau** interferometer for aerosol return
  - **Sequential** Fabry-Perot interferometer for molecular return
  - **Accumulation** CCD as detectors
- Characterization of ALADIN is done by industry with "artificial" signals and no "real" signals from the atmosphere
- No direct-detection Doppler lidar was operated in downward looking scheme as from space
- Need for validation of ALADIN with real atmospheric signals identified by DLR, ESA and ADMAG
- Development of ALADIN Airborne Demonstrator A2D started in 2003 in order to perform ground and airborne campaigns, which is funded by ESA and DLR
Objectives of pre-launch campaigns

- Validate the predicted instrument performance:
  - radiometric performance
  - wind measurement performance
- Optimize and test algorithms for ground segment (L1B, L2A, L2B) with real atmospheric signals:
  - homogenous and heterogeneous conditions (clouds, horizontal and vertical gradients in backscatter and wind)
  - corrections and quality control
  - derivation of aerosol and cloud products; ALADIN as a High-Spectral-Resolution-Lidar
  - assess calibration schemes
- Definition of objectives for a ground campaign and two airborne campaigns by team from DLR, Meteo-France, KNMI, IPSL
Development of the A2D from 2003-2006 by

- EADS-Astrium France: design, telescope, receiver
- EADS-Astrium Germany: laser
- DLR: aircraft, flight testing
A2D receiver optics

Fizeau spectrometer

Fabry-Perot spectrometer
First flight of a direct-detection Doppler lidar in 2005

A2D instrument parameters during flights on October 18 and 20, 2005
- 8.2 km flight altitude
- 20 mJ laser energy
- 700 laser pulses per observation
- Vertical resolution and distance:
  - 300 m for 0-2 km
  - 1200 m for 2-8 km

- Atmospheric signals from Mie and Rayleigh backscatter
- Return from clouds and ground detected
- First flight of a direct-detection Doppler lidar worldwide in nadir pointing geometry
Ground and cloud signals during flight

- Ground signal on Mie and Rayleigh receiver detected in range bin as expected from elevation.

- Enhanced Mie backscatter on Rayleigh and attenuation below cloud.

- Cloud signal detected in 3 km distance.
A2D for ground operation

Opening in the container roof

Backscattered signal

Transmitted laser beam

Mirror at the bottom of the container

Receiver

Laser

Telescope
Hard target test at DLR

Mie random error of below 1 m/s can be achieved

fluorescence of laser on target in 1.6 km horizontal distance (Ø20 cm)
Analysis of Mie algorithms

Simulations of Mie signal without noise

Investigation of several Mie algorithms in parallel study at DLR for L1B products (Dorit Huber, Jürgen Streicher, Ines Leike)

Systematic Error

Random Error

1 Pixel ≈ 100 Mhz

1 Pixel ≈ 18 m/s
Instrumentation from DLR
- ALADIN Airborne Demonstrator A2D
- 2-µm Doppler Lidar (wind up to 2-3 km)

Instrumentation from University Munich
- Aerosol lidar MULIS (backscatter, extinction coefficient up to 10 km, depolarisation) 355 nm, 532 nm, 1064 nm, Raman channels

Instrumentation from DWD
- 482 MHz windprofiler with RASS (wind up to 16 km, temperature up to 3 km)
- 1290 MHz windprofiler (wind up to 1.5 km)
- Ceilometer (clouds 12 km, aerosol backscatter in boundary layer)
- Microwave radiometer (profiles of water vapour and temperature up to 10 km)
- 355 nm Raman-lidar (profiles of water vapour mixing ratio and backscatter ratio during night)
- Sun photometer (aerosol optical depth during day)
- 35.5 GHz cloud radar (reflectivity, vertical velocity)
- 4 routine radiosondes per day (0, 6, 12, 18 UTC)
  additional 10 radiosondes (3, 9, 15, 21 UTC)
ADM-Aeolus ground campaign in October 2006

Windprofiler Site at DWD Lindenberg (photo DWD)

A2D container at Lindenberg on September 19, 2006
1st airborne campaign in April-May 2007

Objectives:
- Validate A2D under mainly homogenous atmospheric conditions
- Test of Level-1B and Level-2A algorithms

Implementation
- ALADIN Airborne Demonstrator and DLR 2-µm Doppler lidar on Falcon aircraft
- Overflights of observatory Lindenberg with 482 MHz windprofiler radar or backup sites with windprofiler radars in Lannemezan, Aberystwyth, or Chilbolton
2nd airborne campaign in fall 2007

Objectives:
- Validate A2D under mainly heterogenous atmospheric conditions (clouds, wind shear)
- Test of Level-2 algorithms

Implementation
- ALADIN Airborne Demonstrator and DLR 2-µm Doppler lidar on Falcon aircraft
- Operating site in North-Atlantic or Tropics

approximate transfer times from DLR-OP:
Reykjavik (4 h), Dakar/Sal (6.5h), Ascencion (10 h), Recife (10 h),
circles approximate one-way/two-way endurance of Falcon (2500-3500 km)
Airborne in-orbit validations with DLR lidars

- Airborne validation of LITE performed in 1994
- Several airborne campaigns performed for validation of ENVISAT instruments, e.g. SCIAMACHY, MIPAS

Flight track
DLR Falcon for SCIAMACHY validation with ozone lidar
Conclusion and Outlook

- First atmospheric signal with ALADIN instrument detected from ground in October 2005
- First direct-detection Doppler lidar in nadir pointing geometry flown on aircraft in October 2005 with molecular, aerosol, cloud and ground signal
- End-to-end simulators for airborne and satellite instrument developed at DLR
- Setup of ALADIN Airborne Demonstrator for ground campaign at Meteorological Observatory Lindenberg of DWD started last week for a 3-weeks ground campaign in October 2006
- First airborne campaign with overflights over Lindenberg in April 2007, second campaign with flights in Tropics or North Atlantic in fall 2007
- DLR proposes to use ALADIN Airborne Demonstrator for in-orbit validation of ADM-Aeolus
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