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Prepared by:	Oliver Reitebuch (DLR, Oberpfaffenhofen, Germany) Alain Dabas (Météo-France/GAME, Toulouse, France) Ad Stoffelen (KNMI, de Bilt, Netherlands)

0.1 Document Change Log

Issue.	Datum	New pages	Modified pages (after introducing new pages)	Observations	Name
Draft	19.08.2004	--	--	Draft	Reitebuch
Draft	07.10.2004			AC02 objectives	Stoffelen
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V0.9	03.01.2005			AC01 revisions	Dabas
V0.9	18.01.2005			minor revisions	Reitebuch
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V1.1	15.02.2005	16, 23, 26	4,7, 14,15, 18, 19, 20, 28	revisions after PM2	Reitebuch
V1.1	28.02.2005		chapter 5	revisions after PM2	Stoffelen
V1.1	28.02.2005		chapter 6	revisions after PM2	Dabas

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1 Introduction and Purpose of Document

This technical note TN 1.2 defines the objectives of ADM-Aeolus Campaigns and covers Task 1 of the SoW AE-SW-ESA-AD-015, Issue 01a (ESA 2004, DLR 2004a). This is a “living” document which will be updated regularly after each campaign.

A first version of the TN was prepared by Oliver Reitebuch (chapter 1-4), Alain Dabas (chapter 5) and Ad Stoffelen (chapter 6) and circled among all participants of WP1200 for review. A revision of the document was prepared after the Campaign Objectives Review – Progress Meeting 2.

Chapter 2 defines the overall objectives for the ADM-Aeolus campaigns and chapter 3 summarizes the constraining elements. Chapter 4 outlines the objectives for the Aeolus Ground Campaign AGC, chapter 5 for the Aeolus Airborne Campaign AC01 and chapter 6 for the Aeolus Airborne Campaign AC02.

The detailed implementation of each campaign (“experimental plan”) will be provided within a dedicated document for each campaign called “AGC Implementation Plan” (TN 3.1), “AC01 Implementation Plan” (TN 4.1), and “AC02 Implementation Plan” (TN 4.4). These TN will be issued about 3 months before the start of each campaign.

2 ADM-Aeolus Campaign Objectives

The ADM instrument ALADIN (Atmospheric Lidar Doppler Instrument) is based on an incoherent Doppler lidar operating at 355 nm. The receiver consists of two interferometers, which sense the Doppler shift from aerosol as well as from molecules, yielding profiles of the line-of-sight LOS wind speed throughout the whole troposphere and part of the stratosphere. The molecular channel uses the double-edge technique with a sequential Fabry-Perot interferometer, whereas the aerosol channel is based on a Fizeau interferometer (Schillinger et al. 2003). The instrument concept of ALADIN combines new techniques, like a novel combination of the molecular and aerosol receiver, and the use of an Accumulation Charge Coupled Device ACCD to improve detection sensitivity. Also the use of a sequential Fabry-Perot with different maximum transmissions and spectral widths for the two channels of the Fabry-Perot was never applied before. There is a need to validate these features from ground and from aircraft, which is the most comparable to the downward looking geometry from space. Also the use of novel technologies within this instrument raises several topics for the ground processing algorithm development, which can be optimised with datasets from real atmospheric measurements.

Several ground campaigns have been performed in the past to validate the incoherent Doppler lidar principle through comparisons of radiosondes wind profiles with lidars based on double edge technique at 355 nm (Flesia et al. 2000, Gentry et al. 2000). Comparisons of wind measurements from incoherent detection Doppler lidars with coherent Doppler lidars and other sensors were made in Europe (Delaval et al. 2002a, Delaval et al. 2002b) and USA (Hardesty et al. 2001). Up to now no direct detection Doppler lidar was operated onboard an aircraft, whereas airborne validations of coherent Doppler lidars were performed in the last years (Reitebuch et al. 2001, 2003). A comparison of LOS wind profiles from a radar profiler with a coherent Doppler lidar has been published recently (Cohn and Goodrich 2002), which presents a similar approach as foreseen for the ADM-Aeolus ground campaign.

The main objectives of the ADM-Aeolus campaigns are

- Validation of the predicted instrument radiometric and wind measurement performance.
- Establishing a dataset of atmospheric measurements obtained with an ALADIN type instrument to improve algorithm development for L1B (uncorrected horizontal line-of-sight HLOS wind speed), L2A (aerosol and cloud products) und L2B products (corrected HLOS wind speed) (ESA 2004, EADS-Astrium 2004).

The logic of deriving the campaign objectives is presented in Fig. 1. Starting from the main objectives, the instrumental setup of the ALADIN airborne demonstrator A2D, its instrumental constraints and user-definable parameters were discussed during the A2D Critical Design Review by the study team. In parallel the shortcomings of the operational algorithm definition and processors were discussed during several algorithm reviews (DLR 2004b).

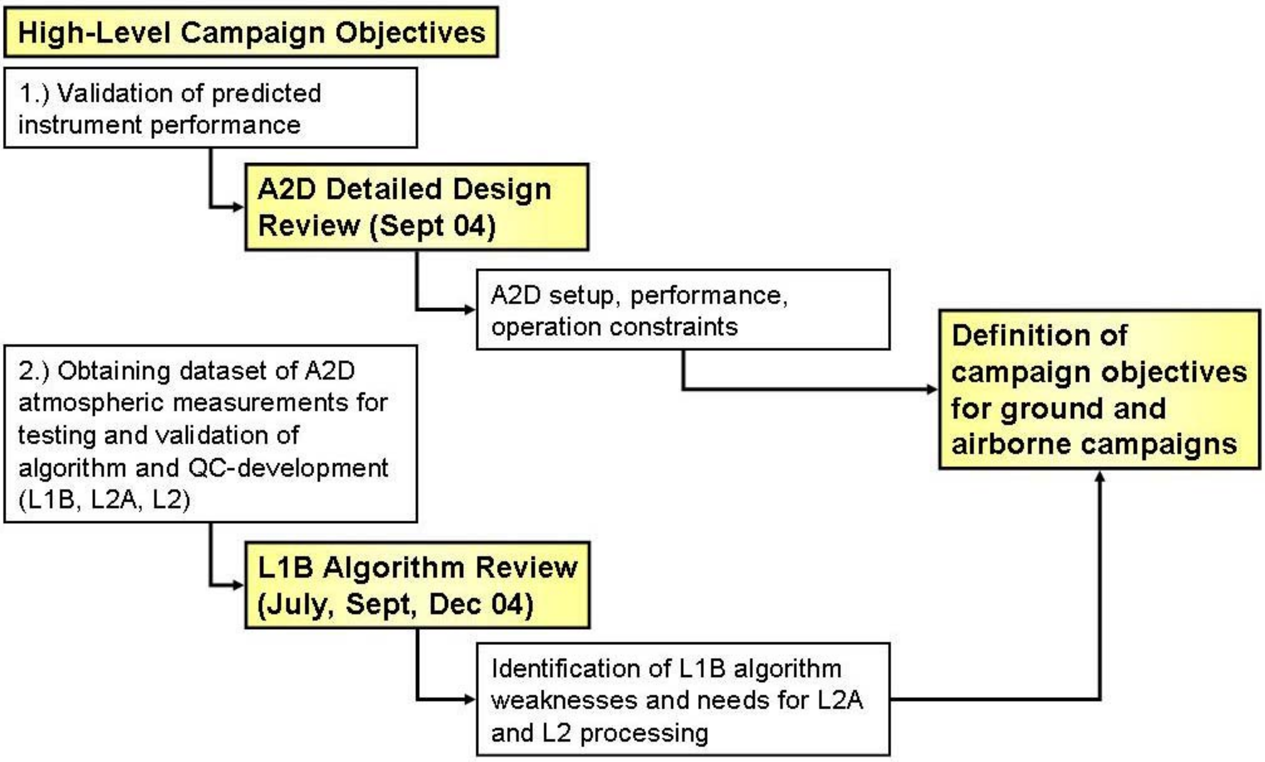

Fig. 1: Definition of Campaign Objectives.

The ADM-Aeolus campaigns will be planned to address the following questions:

1. a) Is the actual instrument radiometric performance (number of detected photons) in the expected range?

   b) Is the actual instrument wind observation performance (accuracy and bias of wind observation) within the expected range?
2. What is the influence of real homogenous atmospheres on the instrument performance including operational L1b algorithms?
3. Do temperature and pressure corrective schemes devised for Rayleigh winds operate well?
4. What is the influence of real atmospheres under mostly inhomogenous conditions (clouds, wind shear, and aerosol) on the instrument performance including operational L1b algorithms?
5. Can an improvement be achieved by other algorithm implementations and Quality-Control-methods? Have further correction schemes to be implemented in the processing?
6. What is the performance of the calibration using the laser pulse as internal reference? What are the implications of the Mie and Rayleigh response calibration modes, which rely on atmospheric targets and ground return?
7. What is the effect of the atmosphere on the ground return bin? Does the proposed detection scheme for the ground return work under different conditions?
8. What is the detectability and strength of the return from water under 0° (specular reflection) and 35°? What is the detectability and strength of the ground return over land, e.g. ice/snow surfaces or deserts?
9. What is the effect of real atmospheric conditions including inhomogeneity on L2B processing?
10. What L2A products (aerosol, cloud) could be derived under different atmospheric conditions?
11. What is the variability of geophysical parameters (atmospheric backscatter, extinction, ground return albedo, clouds) during different conditions and over different locations?

These questions will be addressed during the Aeolus Ground Campaign AGC, and two Aeolus Airborne Campaigns AC01 and AC02 according to Tab. 1.

	1	2	3	4	5	6	7	8	9	10	11
AGC	x	x	x	x	x	x				x	x
AC01	x	x	x	(x)	x	x	x	(x)		x	x
AC02		(x)		x	x	x		x	x	x	x

Tab. 1: Objectives of the Aeolus campaigns, which will be addressed during AGC, AC01, AC02; a x-symbol in parentheses is indicating that this objective is partly addressed during the campaign

3 Campaign Constraints

3.1 Technical and operational constraints from the A2D

The A2D is currently under development at EADS-Astrium, Toulouse with EADS-Astrium, Friedrichshafen as the supplier of the A2D laser. The major component is the receiver breadboard PDM (Pre-Development Model) developed within the ESA pre-development program. The optical and mechanical design of this breadboard will be very similar to the satellite instrument, except for some changes in the front optics of the receiver. An electro-optical modulator EOM will be introduced to attenuate the near field signal next to the aircraft. The dynamical range and altitude dependence of the signal differs strongly from the satellite operating at 408 km compared to the aircraft with a flight level of 10 km. Tab. 2 summarises the main instrument specifications of the airborne demonstrator compared to the satellite instrument. The A2D is designed to achieve comparable specifications for the statistical wind measurement error as the satellite instrument over 700 shots. This corresponds to a time resolution for ground measurements of 14 s with a pulse repetition rate of 50 Hz, and a horizontal resolution for airborne measurements of about 3 km assuming an aircraft ground speed of 200 ms^{-1}.

	satellite ALADIN	A2D
transmitter	Nd:YAG, tripled, diode-pumped	
wavelength	355 nm	
operation	burst-mode	continuous
repetition rate	100 Hz	50 Hz
energy / pulse	150 mJ	70 mJ
laser linewidth	< 50 MHz (FWHM)	
freq. stability	4 MHz rms over 7s	4 MHz rms over 14 s
telescope ∅	1.5 m	0.2 m
receiver FOV	15 µrad	100 µrad
receiver aerosol	fringe imaging Fizeau interferometer, 16 channels	
receiver molecules	double edge Fabry-Perot interferometer, 2 channels, sequential	
detection	accumulation CCD, quantum efficiency 0.85	
nadir angle	35°	20°
altitude	408 km	10 km
min. vertical resolution	250 m	300 m
platform speed	7600 ms^{-1}	200 ms^{-1}

Tab. 2: Specifications of the satellite and airborne ALADIN instrument A2D

The following differences of the ALADIN Airborne Demonstrator A2D and the satellite ALADIN instrument have to be taken into account in the analysis of the data, the adaptation of the processing algorithms and the conclusions:

- Same timing of ACCD with minimum readout of 2.1 µs (315 m) results in different vertical ranges (296 m at 20° nadir instead of 251 m at 37° nadir)
- different horizontal resolution for 700 shots: 2.8 km instead of 50 km
- Co-axial transmitter/receiver telescope arrangement instead of transceiver-telescope
- Receiver FOV 100 µrad instead of 20 µrad => footprint on ground Ø 1 m from range 11 km instead of Ø 10 m from 500 km
- Difference in front-optics (Airborne Front Optics AFRO) with Electro-Optical Modulator EOM and additional CCD for co-alignment of laser transmitter and telescope FOV
- Quasi-continuous operation (4 s readout for 14 s measurement) instead of burst mode operation with laser PRF 50 Hz instead of 100 Hz
- Non-perfect Pre-Development Model PDM (ghost images, polarising beamsplitter problems, trans-mission losses, spacing Rayleigh Fabry-Perot 2.65 pm instead of 2.3 pm) instead of “perfect” Flight Model FM
- Reference pulse from transmitter is accumulated with the same number of shots than atmospheric signal instead of single shot acquisition => but single shot acquisition will be realised with separate heterodyne unit
- energy*aperture/range^2 product (70 mJ, Ø 0.2 m, 11 km) is 17 times higher than satellite (150 mJ, 1.5 m, 500 km)
- Different sensing ranges of 11 km (10 km, 20 °) instead of 500 km (408 km, 35 °) lead to different dynamical range of signal => strong signal dynamics for airborne platform instead of “flat” dynamics from satellite due to 1/R2-factor

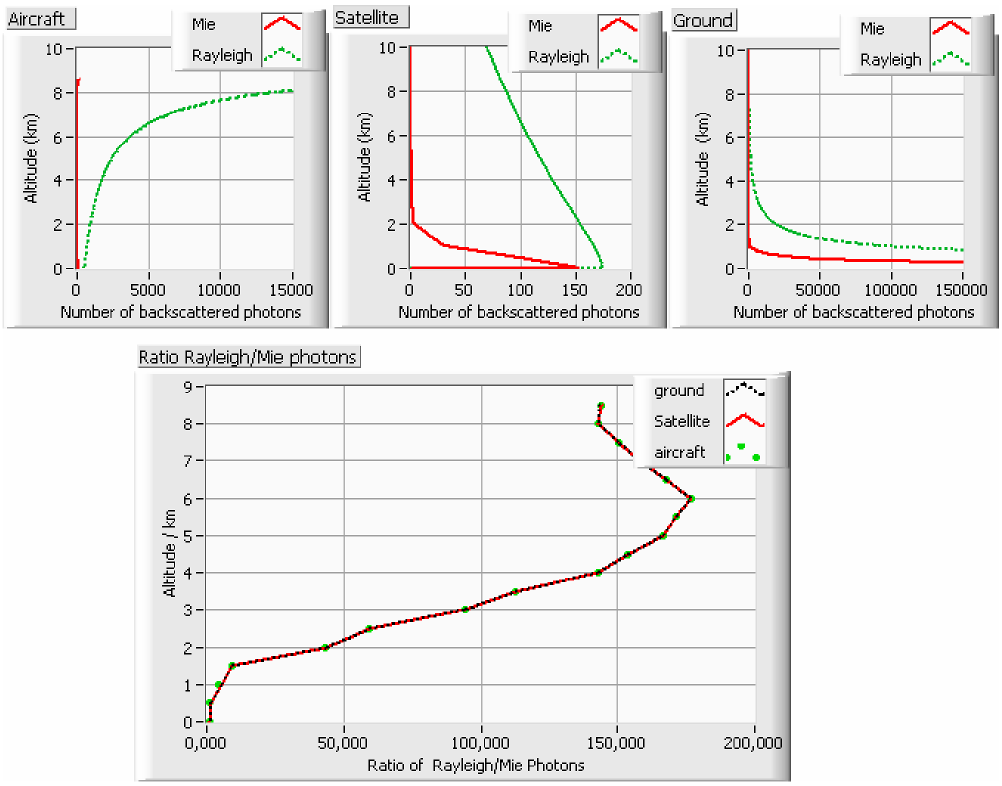

Fig. 2: Signal dynamics from aircraft platform (left), satellite (middle) and ground (right); Ratio of Rayleigh and Mie Photons for different sensing platforms (bottom); aircraft and ground instrument parameters (70 mJ laser energy, 20 cm telescope, 11 km altitude, no EOM), satellite (130 mJ, 1.5 m telescope, 400 km altitude)

The user can define and change the following parameters before and/or during operation of the A2D:

- vertical binning of the Mie and Rayleigh channel independently in steps of 2.1 µs, 4.2 µs and 6.3 µs and 8.4 µs, which corresponds to a minimum vertical resolution of 300 m at a nadir angle of 20 °; the maximum number of range bins for atmospheric measurements is limited to 22 out of 25, because one range gate is lost due to timing, and two due to the acquisition of the laser reference and the background radiation
- time offset for Mie and Rayleigh channel independently to start data acquisition on ACCD from 0 to 71 µs (10650 m) in steps of 20.83 ns (3.1 m)
- number of pulses P for on-board accumulation on the CCD in range of [3,700] and number of measurements per observation N in range of [1,70] with the constrain that N*P<=700
- laser energy with a polarising attenuator
- attenuation settings for the EOM with a adjustment dynamic of 1 to 1/15

The following items constrain the operation of the A2D

- Operation of A2D within container with roof opening allows operation day and night during no-precipitation conditions
- 3 beam pointing modes from ground with 0° zenith pointing, 15° off zenith, and 0°-20° elevation angle for ground operation
- Operation of A2D together with 2µm Doppler lidar on DLR Falcon aircraft pointing downwards
- 1 beam pointing mode for airborne operation with 20° off nadir and perpendicular to aircraft flight axis
- Calibration of A2D before every flight on ground in hangar with duration of about 1.5 hours and temperature stabilisation of A2D before calibration of 2.5 to 4 hours
- Aircraft operations of the A2D only from sites with an aircraft hangar, which should be preferably temperature controlled, due to environmental requirements during temperature stabilisation and calibration
- Need for on-ground equipment (ground chiller, batteries, calibration equipment); airborne campaigns are restricted to operate from one site
- Temperature stabilisation of A2D laser during flight for about 0.5 hour before nominal operation
- Eye safety of the outgoing laser beam is achieved at a range of 1000 m (70 mJ, 15 ns, 50 µrad full angle divergence)
- No detectable signal on the ACCD before 500 m, 20 % at 1 km and 90 % at 2km, because of defocus and central obscuration effect of the telescope
- A2D receiver main component is the modified Pre-Development Model PDM, which is enclosed in a thermally and dust isolating hood, which can only be opened in a laboratory or clean room environment (tbd by EADS-Astrium); diagnostics on the modified PDM and modifications can only be performed by EADS-Astrium

3.2 Technical and operational constraints of other instruments

The reference lidar instrument for line-of-sight LOS wind speed during AGC, AC01 and AC02 will be the 2µm lidar. The reference instrument for wind speed during the AGC und AC01 will be the 482 MHz windprofiler radar WPR at the Meteorological Observatory Lindenberg MOL of DWD (Deutscher Wetterdienst). The aerosol lidar MULIS (Munich University Lidar System) will be operated on ground during AGC. The characteristics of the instruments are summarized in the following table:

Parameter	2µm lidar	WPR	MULIS
measurement	LOS wind speed wind vector (when scanning) uncalibrated aersol/cloud backscatter at 2µm	LOS wind speed wind vector (when all LOS are used) virtual temperature	backscatter coefficient at 355 nm, 532 nm extinction coefficient at 355 nm, 532 nm
vertical resolution	100 m	250 m (low mode) 500 m (high mode)	10 m – 200 m
temporal resolution	several s to 1 min	40 s (LOS) 30 minutes (wind vector with DBS) 5 minutes (virtual temperature)	30 s to 30 minutes
beam pointing zenith angles	0°, 15°, 70°-90° (ground) 20 ° (aircraft) VAD scans possible	0°, 15 ° fixed LOS total of 5 LOS	scanning in zenith angle
range	depending on aerosol: from ground: in boundary layer 8 km (70°-90° pointing) 2-4 km (0-20° pointing) from aircraft: in boundary layer and range gates close to aircraft	up to 12 – 16 km (wind) up to 3 – 4 km (virtual temperature)	depending on aerosol up to tropopause (10 km)

Tab. 3: Specifications of the satellite and airborne ALADIN instrument (DBS: Doppler Beam Swinging)

In addition the following constraints apply when operating these instruments:

- operation of 2µm and MULIS is done in separate containers from ground and is limited to no precipitation conditions
- change of pointing directions for the 2µm lidar from 0°, 15° to 70°-90° needs modification of the system which takes several hours
- nominal duty cycle of the WPR is ~40 s with change of the LOS azimuth direction; special operation during the campaign can be performed with longer measurement time for one LOS azimuth direction; measurement of the virtual temperature needs special operation mode with RASS (Radio Acoustic Sounding System) and vertical velocity measurement only

3.3 Technical and operational constraints of Falcon aircraft equipped with A2D

The A2D will be operated together with the 2µm Doppler lidar onboard the DLR Falcon 20 aircraft. The table lists the technical and operational constraints.

parameter	value	remark
max. altitude	10 – 12 km	Falcon maximum altitude
min. altitude	5 km	min. altitude of A2D laser operation due to eye-safety and laser cooling with aircraft cooler
nominal altitude	10 km	nominal altitude for A2D operation
max. endurance	4:00 – 4:30 hours	Falcon maximum endurance depending on flight altitude
max. range	2500 – 3500 km	Falcon maximum range depending on flight altitude
operation base	airport with temperature controlled hangar and electrical power	temperature controlled hangar necessary for A2D calibration
crew	2 pilots, 1 flight technician, 1 operator for 2µm, 1 operator for A2D	only 1 operator for A2D
operation time	24 hours / 7 days	this is depending on the opening hours of the airport
pre-flight preparation time	6.5 hours	4 hours temperature stabilisation of A2D receiver + 1.5 hours calibration, 1 hour roll-out and fuelling

Tab. 4: Operational constraints of Falcon 20 aircraft with A2D

3.4 Availability of instruments, Falcon aircraft and timeline

The following table lists the availability constraints of the involved instruments and the Falcon aircraft:

Instrument	2005	2006
A2D	A2D delivery to DLR in June 2005 3 months Functional Test at DLR available from Sept 2005	A2D aircraft frame not available in May/June/July 2006 due to operation of WIND during AMMA
2µm	available in Sept 2005 not available in May/June/July/Aug and mid Oct to mid Nov due to wake vortex cam-paigns (AWIATOR, A380)	not available during March 2006 (T-REX)
MULIS aerosol lidar	not available during SAMUM campaign until End of July 2005	not available in Jan/Feb 2006
Falcon	available in 2 weeks in October 2005 not available in Nov/Dec 2005 (SCOUT)	available for 2 weeks in January 2006 available for 3 weeks in April 2006 available for 3 weeks in end Sept/Oct 2006 not available during June- Mid-Sep 2006 (AMMA)

Tab. 5: Availability of instruments and Falcon 20 aircraft

Thus the following timeline is proposed for the A2D campaigns and functional tests:

Campaign	location	period	duration
A2D Functional Tests	DLR Oberpfaffenhofen	June – end Aug 2005	3 months
Aeolus Ground Campaign AGC	MOL Lindenberg	begin Sept – end Sept 2005	4 weeks
A2D Functional Test Flights	DLR Oberpfaffenhofen	mid Oct 2005 or mid Jan 2006	1 week
Aeolus Campaign 1	DLR Oberpfaffenhofen	April 2006	15 days / 25 hours
Aeolus Campaign 2	tbd	October 2006 or later	17 days / 50 hours

Tab. 6: Timeline for A2D campaigns and tests

4 Objectives for Aeolus Ground Campaign AGC

4.1 AGC Objectives

The baseline for AGC is a 4-week campaign in September 2005 at the Meteorological Observatory Lindenberg MOL of the German Weather Service DWD close to Berlin (Neisser et al. 2002 for an overview of MOL).

Objective	No.	Method	Parameters	Instruments
Radiometric Performance	1a	Hard-Target measurements with A2D (tbc) Vertical pointing A2D	A2D Mie/Rayleigh signal strength Profiles of wind, temp., aerosol backscatter and extinction background radiation	A2D pointing on hard target and vertical WPR vertical Radiosonde Aerosol lidar UV-pyranometer
Mie Response Calibration MRC Rayleigh response calibration RRC	6	Hard-Target measurements with A2D (tbc) Vertical pointing A2D	A2D Mie wind A2D Rayleigh wind Profiles of wind, temp., aerosol backscatter and extinction background radiation	A2D pointing on hard target or vertical WPR vertical Radiosonde Aerosol lidar UV-pyranometer
Wind Velocity Performance Assessment of A2D LOS measurement statistical error	1b	Statistical comparison of A2D wind with reference wind	Mie/Rayleigh LOS wind of A2D Reference wind in LOS of WPR and 2µm Profiles of wind, temp., aerosol backscatter and extinction	A2D (15 °) WPR (15 °) 2µm (15 °) Radiosonde Aerosol lidar UV-pyranometer
Development of QC and correction schemes for homogenous and inhomogenous conditions (clouds, aerosol, wind shear)	2 4 5	Measurement of A2D under various characterized, conditions Test of various processing and quality control algorithms	Mie/Rayleigh intensity and wind of A2D Profiles of wind, temperature, aerosol backscatter and extinction, cloud heights, optical depth background radiation	A2D (70-90°, 15 °) WPR (15° and DBS) 2µm (70-90°, 15°, scan) Radiosonde RASS Aerosol lidar Sun-photometer UV-pyranometer
Level 2A products (aerosol, clouds)	10	Comparison of A2D derived L2A products with other instruments	cloud heights, optical depth aerosol backscatter and extinction background radiation	A2D (0°, 15°) Radiosonde Aerosol lidar cloud radar Sun-photometer UV-pyranometer
Rayleigh Wind Correction	3	Comparison of Rayleigh corrected winds with WPR	Rayleigh wind uncorrected/corrected temperature, pressure	A2D (15 °) WPR (15 °) Radiosonde
Geophysical Parameters	11	Compiling derived L2A products and additional parameters	Level 2A products (aerosol, clouds)	A2D (0°, 15°) Aeorosl lidar

Tab. 7: Campaign Plan Matrix for AGC; the objectives of row 1 and 2 will be partly followed during functional tests at DLR; the hard-target measurements at MOL depends on the availability of a hard-target at MOL; no. refers to the objective number in Tab. 1; objectives are sorted from top to bottom in order of priority

The main reference instruments for comparison will be the 2 µm Doppler lidar from DLR (Rahm et al. 2003, Köpp et al. 2004, Weissmann et al. 2005), and the 482 MHz windprofiler radar WPR from DWD (Görsdorf 2000, Steinhagen et al. 1998). Additional instruments from DWD-MOL will be operated to allow comprehensive characterisation of the A2D under various atmospheric conditions: a laser ceilometer (Münkel et al. 1999), a sun-photometer (Leiterer et al. 1998, Weller et al. 1998), additional radiosondes Vaisala RS92-SGP, and a cloud-radar (http://www.metek.de/produkte.htm). For evaluation of the received backscatter intensity of the A2D, an aerosol lidar operating at 355 nm from the Meteorological Institute of the University Munich MIM will be deployed (Böckmann et al., 2004; Matthias et al. 2004).

The objectives of the AGC, the methodology, the necessary measurement parameters and the instruments are listed in Tab. 7 in order of priority. Other implicit objectives of the AGC are preparation of the airborne campaigns, optimisation of alignment, calibration and measurement operations and characterisation of A2D functionality over an intensive measurement period.

4.2 Outline of AGC implementation

The AGC is foreseen with duration of about 4 weeks in September 2005. The first week of this period is planned for setup of the instruments A2D, 2µm lidar, and aerosol lidar MULIS at MOL and an engineering verification of their performances. Week 2 to 4 are planned for nominal campaign operation with daily weather and campaign briefings. The details of the implementation will be given in the “AGC Implementation Plan”, available about 3 months before begin of the AGC.

The AGC is targeting for about 10 events of 3-4 hours within 15 days of operation (Tab. 8). The actual achievement of the target events depends on the actual weather conditions and the instrumental status and is considered as an ambitious goal. The instruments will not be operated during precipitation, due to the roof opening in the container, and fog or low level stratus clouds were the lidar signal is attenuated in its first range bins.

event	time	BL-aerosol	clouds	wind	A2D pointing
1	day	no criteria	no clouds in LOS	no criteria	hard-target (tbc)
2	day	low	no clouds	low wind shear	0°, 15°
3	night	low	no clouds	low wind shear	0°, 15°
4	day	no criteria	cirrus	no criteria	0°, 15°
5	day	no criteria	broken clouds, e.g. cumulus	no criteria	15°
6	day	no criteria	cirrus	high altitude jet	15°
7	day	no criteria	no clouds	high altitude jet	15°
8	day	high	no clouds in BL	moderate wind speeds	15°, 70-90°
9	day	low	no clouds in BL	moderate wind speeds	15°, 70-90°
10	night	no criteria	no clouds in BL	low-level jet	15°

Tab. 8: Targeted events during AGC (BL: Boundary Layer) in order of priority to achieve objectives

4.3 Outline of AGC Data Analyses

The following chapter gives a brief outline of the data analyses tasks performed during and after AGC:

during AGC:	daily quicklooks from radiosonde, WPR, ceilometer, 2µm, MULIS, A2D processed/QC data available from radiosonde; daily reports on instrument status, weather
end of AGC:	selection of events based on quicklook data, instrument status, weather
AGC+2weeks:	Campaign Event Summary: Content of data-set, events summary, brief oulook campaign results and lessons learned; justification of selection of events
AGC+1 month:	processed/QC data available for selected events of each instrument: WPR (LOS, wind-vector, Intensity.), 2µm (LOS, Intensity), MULIS (backscat-ter/extincition), A2D (raw data ("L0"), calibration results, Mie/Rayleigh winds / intensity with baseline algorithm ("L1B")) => Consolidated Data Set + Content/Format Description
AGC+3 months:	processed/QC data available for all events of each instrument and combined analysis of instrument data for selected events; preliminary conclusion on objectives => update of consolidated data set
AGC+6 months:	combined analysis of instrument data for all events and conclusion on objectives => update of consolidated data set

The data analyses tasks and responsibilities, timeline, data-streams, data products content and format will be detailed in AGC Campaign Implementation Plan, delivered about 3 months before start of the AGC.

5 Objectives for Aeolus Airborne Campaign AC01

AC01 campaign follows a 4-week ground based campaign AGC and two technical flights during which the lidar will be characterized at ground and functionally tested in flight. It will be followed by a second airborne campaign AC02 during which extensive measurements will be acquired with the objective to test the processing chain of ADM-Aeolus and the ability of the satellite system to make useful observations in a real, mostly inhomogeneous atmosphere.

The AC01 campaign is thus an intermediate step. The main objective is to verify that the airborne implementation of the A2D is correct and the system is ready for the extensive campaign AC02. Besides, data acquired during this campaign will be delivered to the teams working on L1B and L2B/C processing and used to check the processors are working properly.

5.1 Objectives

The main objectives of the AC01 campaign are listed in Tab. 9:

- In lines 1 & 3 of Tab. 9, the main characteristics of the signals (power, spectral characteristics) are studied and compared to model/simulator predictions (DLR-E2S). It will be verified that the transfer characteristics of the optics and the interferometers are well characterized by the calibration procedures. This will lead to verify the system can be properly calibrated before the flights, so that near-optimal operations can be achieved. If not, the reason will be investigated.

  Comparing the signal characteristics with simulation model predictions require the lidar is well calibrated and the state of the atmosphere is known. The thermodynamic state of the atmosphere can be measured by radiosondes (temperature, pressure). The optical properties of the atmosphere cannot be obtained the same way. For this, a backscatter lidar is required. Due to the limited space available on board the aircraft, no backscatter lidar can be installed in the DLR Falcon 20 with the A2D and the 2µm Doppler system. We therefore propose to start the AC01 with one or two missions during which the F20 will fly rectangular flight patterns around a fixed location where a backscatter lidar is deployed and radiosondes are launched, mainly the Meteorological Observatory Lindenberg MOL.

- In line 2, the processing scheme for pressure and temperature correction of Rayleigh winds is tested in flight. The temperature, pressure and aerosol profiles needed for that are first taken from ground observations. For this, we propose to fly several missions in meteorological conditions as homogeneous as possible, which are over a flat terrain, with no crossing of a front, no clouds, etc. Temperature and pressure profiles from radiosondes will be used to correct L1B Rayleigh responses. Corrected winds will be compared to the wind velocities provided by the 2µm systems and statistics will be derived and compared to the quality indices delivered by the L1B processor.

  In a second step, a possible contamination from the Mie retrun will be derived from Mie signals themselves and the atmospheric parameters will be obtained from NWP analysis. This second step will implement the full correction scheme developed for the space-borne lidar.

- In line 4, it is verified that the navigation parameters of the aircraft are available and can be used for computing the precise direction of the line-of-sight and for removing the aircraft-induced Doppler shift. The correction scheme is first applied on the 2µm system for which a precise detection and analysis of the ground return can be carried out owing to the fast rate of the acquisition system. The correction is then tested on Mie winds of the A2D. A first test consists in flying around the WPR and compare corrected winds to the WPR. Then the winds measured during two coincident legs flown in opposite directions are compared.

- In line 5, the ability of the L1B processor to detect ground returns and to derive useful velocity information is tested. The current version of the L1B Master Algorithm Document (EADS-Astrium 2004d) assumes ground returns can be detected, processed and their Doppler shift can be used to correct Mie velocities from residual errors from unknown origins. The correction is based on the assumption that the Doppler shift of the ground-return must be equal to zero. This assumption has been questioned in the past because Mie signals are integrated over vertical bins much longer than the pulse width (250 meters versus ~10 meters) with fixed, pre-set bottom and top altitudes. It follows there is a high probability that the range bin containing the ground return mixes a significant amount of light backscattered from aerosols above. As these aerosols are drifting with the wind, the mean frequency estimated by the L1B processor is likely may well correspond to a non-zero velocity, thus introducing a bias in the corrective procedure.

A2D data acquired during AC01 will be used to test the processing technique proposed by Astrium to detect and process the ground returns. Estimated ground-return velocities will be compared to the ground-return velocities measured by the 2µm system. As it implements a large bandwidth, this system allows for a precise detection of the ground return and should thus produce accurate ground velocity estimates.

The return strength from water (20 °, possibly 35°, possibly 0° specular reflection) and land will be studied to assess the possibility to make zero-wind calibrations over this type of surface (see also Menzies et al, 1998).

- In line 6, the quality of L1B data is verified against a "ground-truth" (companion airborne 2µm lidar and windprofiler radar at MOL on ground). Error statistics are built and compared to performance predictions. Quality figures may reveal unknown deficiencies from either the calibration products or the L1B processor (for instance, improper correction from Mie contamination in Rayleigh signals). In that case, possible improvements will be studied in collaboration with the teams responsible for the consolidation of ADM L1B processor and the development of ADM L2B processor.
- In line 7, the derivation of L2A products for clouds and aerosol is tested.
- In line 8, the collection of geophysical parameters at 355 nm from the A2D is contained, including aerosol backscatter variability and ground return variability.

Objective	No.	Method	Parameters	Instruments
Radiometric performances	1a	Comparison with the signal strength predicted by the lidar equation with instrument and atmos-pheric parameters provided by calibration and observations made at ground while the A2D is flying a rectangular pattern around.	Mie and Rayleigh signal strength. Temperature and pressure profiles Aerosols backscatter and attenuation	A2D Radio-sonde Backscatter lidar
Pressure and temperature correction	3	Apply the correction scheme and compare corrected winds to observations	Wind Temperature Pressure Aerosol backscatter and attenuation coefficients	2µm lidar WPR Radio-sonde and NWP fields Backscatter lidar
Spectral charac-teristics of lidar returns	1b	Compare Mie spectra with model predictions. Compare number of photons in FP A & B with model predictions	Wind Temperature Pressure Aerosol backscatter and attenuation coefficients	2µm lidar WPR Radio-sonde and NWP fields Backscatter lidar
Navigation parameters	7 8	Compare Mie winds, possibly from ground returns with ground-truth (zero for ground winds, otherwise WPR) Compare winds measured during two opposite legs perpen-dicular to the main wind direction.	Mie winds Wind profiles.	A2D WPR
Zero-wind calibration and ground return	6 8	Average Mie/Rayleigh return strength and winds derived from ground returns	Ground return strength and wind from the Mie/Rayleigh channel 2 µm ground return	A2D 2µm ground return
Wind error statistics	1b 2 5	Statistical comparison of A2D wind with reference wind	Mie/Rayleigh LOS wind of A2D Reference wind in LOS of WPR and 2µm Profiles of wind, temp., aerosol backscatter and extinction	A2D WPR 2µm Radiosonde Aerosol lidar
Level 2A products (aerosol, clouds)	10	Comparison of A2D derived L2A products with other instruments	cloud heights, optical depth aerosol backscatter and extinction	A2D (0°, 15°) Radiosonde Aerosol lidar cloud radar
Geophysical Parameters	11	Compiling derived L2A products, ground return variability and additional parameters	Level 2A products (aerosol, clouds) ground return	A2D (0°, 15°) 2µm lidar

Tab 9: Campaign Plan Matrix for AC01.

5.2 Mission profiles

As listed in Tab. 6, DLR F20 will be available for AC01 during 15 days and the number of flight hours is limited to 25. Three days will be necessary at the start of the campaign to integrate the A2D aboard the F20 and test it functionally. Two days will be necessary at the end of the campaign to remove the A2D from the aircraft. A technical verification flight in the vicinity of Oberpfaffenhofen is planned after installation of the A2D with duration of about 1-2 hours. Thus, ten days are left for the flights during which a maximum of 4 or 5, 1-day missions with a maximum of 5 hours each are possible. Tab. 10 proposes profiles for all of them.

Mission #	Met. conditions	Flight pattern	Comments
1	Temperature and pressure fields as horizontally homogeneous as possible. No cloud. Night.	Squares around instrumented site + 2 coincident legs flown in opposite directions, perpendicular to main wind direction.	Check the radiometric performances, and the removal of aircraft induced Doppler shift. Build error statistics (A2D versus 2µm, A2D vs. WPR)
2	Temperature and pressure fields as horizontally homogeneous as possible. No cloud. Day.	Squares around instrumented site + 2 coincident legs flown in opposite directions, perpendicular to main wind direction.	Check the radiometric performances, and the removal of aircraft induced Doppler shift. Build error statistics (A2D versus 2µm, A2D vs. WPR)
3	Temperature and pressure fields as horizontally homogeneous as possible. weak surface winds. No cloud. Day.	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site.	Test the zero-wind calibration operation in favourable conditions (weak surface wind).
4	Weak horizontal variations of temperature and pressure fields. No cloud.	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site.	Test the operational correction of Rayleigh winds from Mie contamination, temperature and pressure effects. Test the zero-wind calibration in realistic conditions with significant surface winds.
5	Weak horizontal variations of temperature and pressure fields. Clouds possible.	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site.	Test the performances of the A2D under meteorological conditions with an increased level of complexity.

Tab 10: Mission profiles for AC01.

5.3 Implementation

In Tab. 10, many flights are to be flown in the vicinity of an instrumented site where a reference profiler, a radio-sonde station and possibly a lidar are available to characterize the dynamic and optical state of the atmosphere. The Meteorological Observatory of Lindenberg will be our candidate number one. However, inappropriate weather conditions may forbid any useful validation there. To avoid waiting too much time for favourable conditions, alternative solutions shall be prepared. One of the following European wind-profiler radar sites could be used as an alternative:

Site	Location	Profiler	Additional	Distance to DLR
Ziegendorf, North-Germany	53.31 °N 11.84 °E	482 MHz and RASS	Raso Greifswald (135 km) and Bergen (140 km)	~ 590 km ~ 320 nm
Nordholz, North-Germany	53.78 °N 08.67 ° E	482 MHz and RASS in 2004	Raso Schleswig (100 km), Emden (183 km)	~ 660 km ~ 360 nm
Bayreuth, South-Germany	tbd in mid 2005	482 MHz and RASS in mid 2005	Raso Kuemmersbruck 49.43/11.90	~ tbd km ~ tbd nm
Cabauw, Netherlands	51.95 °N 04.88 °E	1290 MHz	213 m tower RASS, Raso de Bilt (40 km)	~ 620 km ~ 340 nm
La Ferte Vidame, France	48.62 °N 00.88°E	52.05 MHz	Raso Trappes (100 km)	~ 760 km ~ 410 nm
Toulouse, France	43.37°N 01.26 °E	45 MHz	possible Raso, and aerosol lidar	~ 930 km ~ 500 nm
Lannemezan, France	43.133 °N 00.367 °E	45 MHz	no	~ 1000 km ~ 540 nm
Payerne, Switzerland	46.82 °N 06.95 °E	1290 MHz	Raso	~ 350 km ~ 190 nm
Camborne, UK	50.13 °N 05.19 °W	915 MHz	Raso	~ 1200 km ~ 650 nm
Aberystwyth, UK	52.40 °N 04.00 °W	46.5 MHz	915 MHz, 1290 MHz, surface sensors	~ 1200 km ~ 650 nm
Chilbolton, UK	51.14 °N 01.43 °E	no windprofiler, but 1275 MHz scanning Doppler radar	35 GHz Doppler cloud radar, IR lidar ceilometer, UV Raman lidar	~ 800 km ~ 420 nm

Tab 11: Alternative sites for AC01 overflights from CWINDE network and Chilbolton facility (http://www.chilbolton.rl.ac.uk/default.htm)

The following figures 3 and 4 show the location of the windprofiler sites of the CWINDE network and the radiosonde sites in Europe:

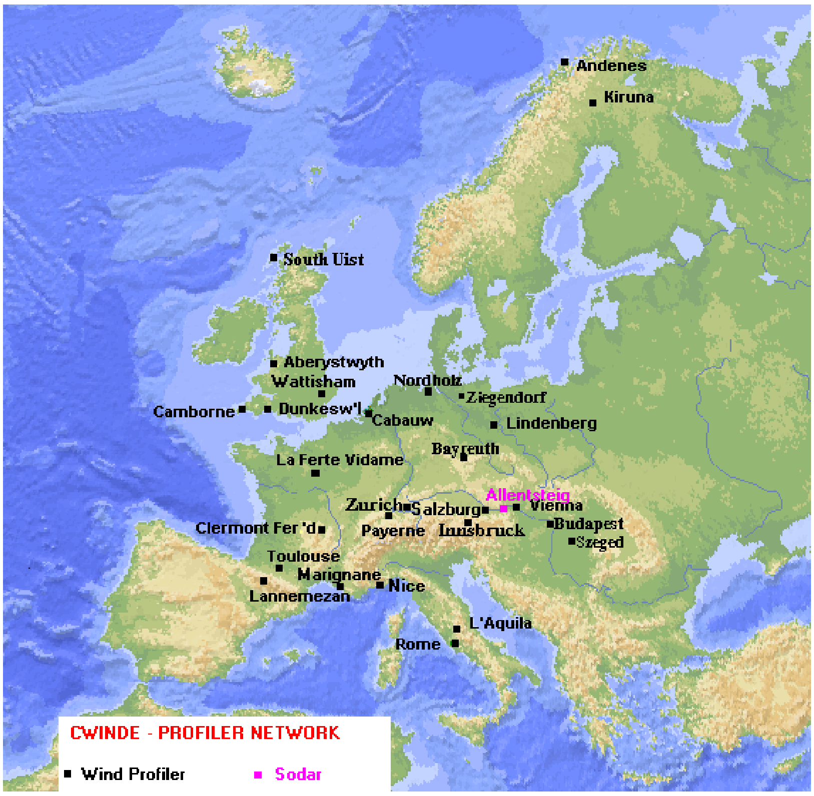

Fig. 3: CWINDE Profiler Network (http://www.meto.gov.uk/research/interproj/cwinde/)

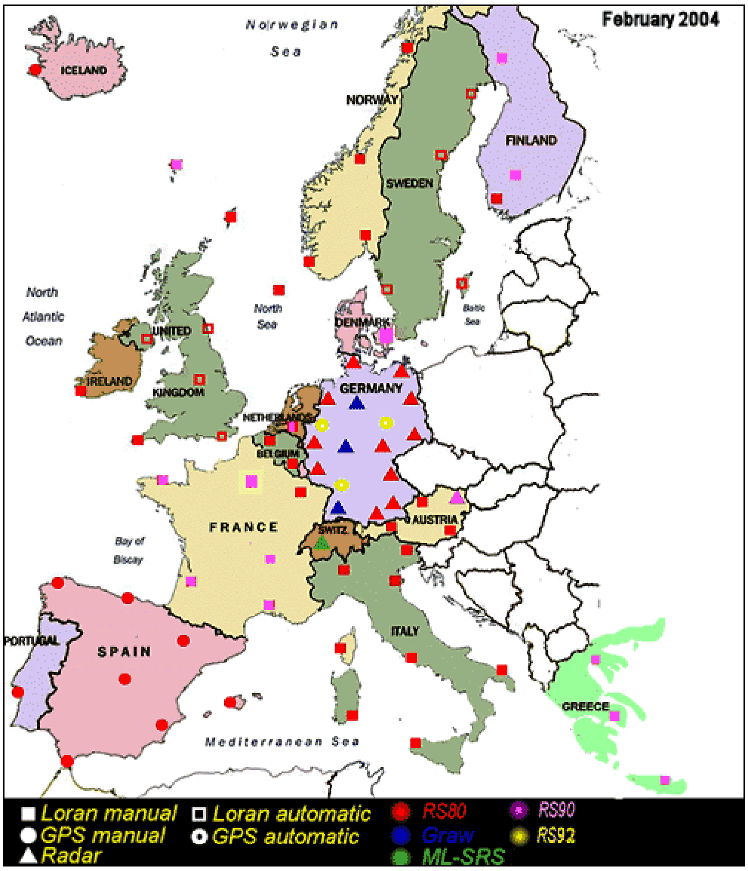

Fig. 4: Radiosonde Network (http://www.met-office.gov.uk/research/interproj/radiosonde/index.html)

Among the sites listed in Tab. 11, several run a high-frequency UHF radar (Chibolton, Camborne, Cabauw and Payerne) with maximum altitudes of the order of 3 to 6 km. This is not enough for the validation of the A2D as one of the campaign objectives is to test the capacity of the lidar to operate in the upper troposphere. These sites must be discarded.

Several other sites are operating radars at a frequency around 500MHz (Ziegendorf, Nordholz, and Bayreuth). These radars routinely provide hourly profiles of winds up to altitudes of ~15 km. They are potentially interesting for the validation of the A2D, but none of them has a radio-sonde station in close proximity. In addition, they are in Northern Germany (except for Bayreuth which is half-way between Munich and Lindenberg), so meteorological conditions there are likely to be similar to Lindenberg.

All remaining sites are operating VHF radars at lower frequencies. They reach maximum altitudes of about 15 km. Among them, Toulouse must be discarded because the VHF radar there will not be operational at the time of AC01. La Ferté Vidame has the advantage it is an operational site from the French Weather Service, so its data are routinely monitored. Besides, the radar is placed in a region of flat orography where rather homogeneous atmospheric conditions are to be met. However, the nearest radio-sonde station is about 100km away. For Lannemezan, it is a test site operated by a research laboratory. The advantage is many other meteorological sensors are deployed on the site. There is no radio-sonde station, but one could be brought from Toulouse and be activated at short notice (it is less than 200km). The major drawback is the proximity of the Pyrénées mountains inducing strong dynamic heterogeneities in the atmosphere. The last site, Aberystwyth, is also run by a research laboratory. Many sensors are available on site including a lidar which could usefully document the aerosol loading of the atmosphere during he AC01. Unfortunately, there is no regular radio-sounding there, but a research station could be available (tbc).

To summarize, two sites could be of particular interest for validating the A2D during the AC01: Lannemzan and Aberystwyth. Both are at a distance of about 1.5-2 hours from Munich requiring a ferry time of approximately 1.5-2 hours. For both a radio-sonde station would have to be operated specifically for the campaign. Aberystwyth has the advantage it is equipped with a larger array of sensors including a lidar, but its location to the North does not favour clear-sky conditions. Such conditions should be more probable at Lannemezan, but the site is close to the Pyrénées, that is, in a region where we might expect heterogeneous meteorological conditions.In case a mobile radio-sonde station can be placed to La Ferte Vidame (tbc), this could be also a suitable backup place.

6 Objectives for Aeolus Airborne Campaign AC02

AC02 will be, towards the end of 2006, the second and longer airborne campaign during which extensive measurements will be acquired with the objective to test the processing chain of ADM-Aeolus and the ability of the space-borne system to make useful observations in a real atmosphere, including its anticipated heterogeneities.

In the AC01 campaign it will be verified that the airborne implementation of the A2D is correct and the system is ready for the extensive campaign AC02. Also before AC02, data acquired during AC01 will be delivered to the teams working on L1B and L2B processing and used to check the processors are working properly in a real environment.

As a consequence, the power and spectral characteristics of the signal are verified, procedures to determine aircraft-induced Doppler shift, line-of-sight direction and ground surface velocity are validated, and the quality of L1B data is checked against a “ground-truth” for homogeneous, but also for some atmospheric heterogeneous cases.

6.1 Objectives

The main objectives of the AC01 campaign are listed in Tab. 12:

Signal characteristics

During AC01, procedures to check the radiometric budget, transfer characteristics of the optics and the interferometers will be established and the system will be properly calibrated, so that near-optimal operations can be achieved.

As in AC01, for validation, we propose to start the AC02 with a mission during which the DLR Falcon 20 will fly rectangular flight patterns around a fixed location where a backscatter lidar is deployed and radiosondes are launched, e.g. the MOL in Lindenberg.

Ground returns

As in AC01, A2D data acquired during AC02 will be used to test the processing technique proposed by Astrium to detect and process the ground returns. Estimated ground-return velocities will be compared to the ground-return velocities measured by the 2µm system. The different characteristics of the ground return over water (35 °, specular), land (e.g. deserts or ice) and its implication for calibration strategy and processing could be studied (see also Menzies et al, 1998).

L1B data quality

The availability of 2µm lidar winds is a good opportunity to study the accuracy of A2D velocity measurements and check the validity of quality indices provided by the L1B processor.

The comparison of Mie winds with the 2µm lidar is straightforward since both measure parameters of the same nature (Doppler shift of aerosol and cloud particles).

As far as the Rayleigh channel is concerned, the comparison is more difficult because its winds are affected by pressure and temperature. Pressure and temperature information of sufficient quality will be obtained from NWP analyses. In AC01 corrections to L1B responses will be investigated. Again in AC02, corrected winds will be compared to the wind velocities provided by the 2µm systems and statistics will be derived and compared to the quality indices delivered by the L1B processor. In AC01 possible improvements of the ADM L1B processor and the ADM L2B processor were investigated. For AC02, the processors should work fine in uniform atmospheric conditions.

Heterogeneous conditions

The challenge of AC02 is studying the ability of the A2D to cope with complex meteorological situations characterized by different types of heterogeneities.

A first objective will be to analyse the quality of the data in vertically sheared wind fields of several meters per second over a distance of about 50km (horizontal extension of one ADM Basic Repeat Cycle). The tropopause, PBL and at fronts and jets such conditions may be found. In particular, in cases where shear is present in combination with optically substantial aerosol or cloud, the interpretation of the Mie (Fizeau) and Rayleigh (Fabry-Perot) receiver output is challenging. The L1B and L2B processors should be able to identify such cases, and eventually provide a wind estimate of known quality. In this respect, also multiple aerosol or cloud layers should be considered. “True” wind velocities may be provided by the 2µm lidar, after averaging over the A2D range gates.

A second type of heterogeneity of particular interest is the presence of a broken cloud cover in combination with updrafts and downdrafts (convection, showers, and streets of cloud). The data acquired under these conditions could be of great help during the development of the L2B algorithm:

- To develop QC algorithms;
- To develop more complex wind processing algorithms.

ADM-Aeolus accumulation and integration strategy will be simulated with the AC02 data, i.e., 50-km BRC, composed of 1-km length measurements in about 1 km deep vertical ranges. Sampling artefacts will be identified. Detailed priorities for campaign objectives for AC02 concerning the major issue of heterogeneities will become clearer by using the Aeolus atmospheric data base (ADB) in the ongoing developments of L1b and L2 processing studies.

6.2 Mission Profiles and site planning

A main decision on the campaign concerns location. Some of the most challenging conditions noted above arise mainly in the tropics, whereas others occur in high-latitude winter. To arrange supporting data, it may be difficult to select tropical sites. However, we may consider joining an international measurement campaign. The DLR Falcon participates for instance in AMMA in the main campaign of 2006, such that A2D could only be flown outside this main period. Another international campaign effort is being planned for the International Polar Year (IPY), but which is earliest in spring 2007. All opportunities should be evaluated nearer the time of site selection.

Advantages of joining an international measurement campaign (site) are:

- Additional verification and validation measurements;
- Additional and independent analysis of meteorological conditions by collaborating expert groups;
- Co-ordinated logistics;
- Improved scientific visibility of Aeolus.

Disadvantages are:

- No freely selectable site and possibly associated limitations in atmospheric variability (wind, aerosol/ cloud and surface);
- More logistical constraints.

As listed in table 13, the first mission will be over MOL. The other missions are proposed from a site where variable atmospheric winds and clouds are very probably. Moreover, for verification purposes, aerosol backscatter conditions should be favourable for the 2 micron lidar. Site selection should include the consideration of the climatology of these atmospheric constraints. Subtropical or polar sites may be less favourable in this respect.

As listed in Tab. 6, DLR F20 will be available for AC02 during 17 days and the number of flight hours is limited to 50. About 4-5 days will be necessary at the start of the campaign to integrate the A2D aboard the F20, to test it functionally and to remove it from the aircraft after the campaign. One dedicated mission of 4 hours should be planned to characterize the system with an overflight of Lindenberg. 2 to 3 days are foreseen for transfer of Falcon aircraft from DLR-Oberpfaffenhofen to the operation site and back. Typical one-way transfer times from DLR-Oberpfaffenhofen to a North-Atlantic location, e.g. Keflavik Iceland are about 5 hours, to a middle Atlantic location, e.g. Sal on Cabo Verde are 7 hours, and to South-Atlantic location, e.g. Ascension are 10 hours. Thus, about ten days with 26 to 36 hours are left for the on-site flights, during which 5 to 7, 1-day missions with a maximum of 5 hours each are possible.

A trade-off between a campaign site in the North Atlantic or Tropics has to be performed, considering the priority for objectives for AC02, operation constraints for the Falcon and the A2D, and additional measurements for characterizing the atmosphere from ground or other platforms, e.g. by a combination with parallel campaign activities. The site selection for AC02 should be performed about 1 year before the start of AC02.

Objective	No.	Method	Parameters	Instruments
Verification radiometric performance (including temperature and pressure correction)	1a 3	Comparison with the signal strength predicted by the lidar equation with instrument and atmos-pheric parameters provided by calibration and observations made at ground while the A2D is flying a rectangular pattern around.	Mie and Rayleigh signal strength. Wind, Temperature and pressure profiles Aerosols backscatter and attenuation	A2D Radio-sonde/NWP fields 2µm Backscatter lidar
Verification Spectral charac-teristics of lidar returns	1b	Compare Mie spectra with model predictions. Compare number of photons in FP A & B with model predictions	Wind Temperature Pressure Aerosol backscatter and attenuation coefficients	2µm lidar Radio-sonde/NWP fields Backscatter lidar
Verification navigation parameters	7 8	Compare Mie winds, possibly from ground returns with ground-truth (zero for ground winds, otherwise profiler)	Mie winds Wind profiles	A2D Wind profiler
Zero-wind calibration and ground return	6 8	Average Mie/Rayleigh return strength and winds derived from ground returns	Ground return strength and wind from Mie/Rayleigh 2µm ground return	A2D 2µm
Wind error statistics	1b 2 5	Statistical comparison of A2D wind with reference wind	Mie/Rayleigh LOS wind of A2D Reference wind in LOS of NWP and 2µm Profiles of wind, temp., aerosol backscatter and extinction	A2D NWP fields 2µm
Geophysical Parameters	11	Compiling ground return variability and additional parameters	Level 2A products (aerosol, clouds) ground return	A2D 2µm
Heterogeneities	9 4	Effect of running 0-2B level processing on challenging atmospheric cases	Mie/Rayleigh measure-ments of A2D L2B processor Reference 2µm LOS wind NWP profiles of wind, temp., pressure	A2D NWP fields 2µm
Level 2A products (aerosol, clouds)	10	Comparison of A2D derived L2A products with other instruments	cloud heights, optical depth aerosol backscatter and extinction	A2D Radiosonde Aerosol lidar NWP fields

Tab 12: Campaign Plan Matrix for AC02.

Mission #	Met. conditions	Flight pattern	Comments
1	Temperature and pressure fields as horizontally homoge-neous as possible. weak surface winds. Eliminate clouds.	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site, e.g. MOL	Verify the radiometric performances, aircraft Doppler shift correction, zero-wind calibration operation in favourable conditions (weak surface wind).
2-4	Cloudy case with transparent (undeep) stratiform clouds.	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site.	Verify the L2B processor, particularly QC and advanced wind processing
5-6	Cloudy case with broken and deep clouds, featuring substantial vertical motion	Long legs (1000km) over various types of surfaces (land, lakes, sea…) + square around instrumented site.	Verify the L2B processor, particularly QC and advanced wind processing
7	no-clouds or broken clouds but preferably high backscatter near ground (blowing snow or sand)	Long legs (1000km) over various types of surfaces (ice or desert, and sea)	Study ground return strength and variability over different surfaces

Tab 13: Mission profiles for AC02.

Table 14 summarizes the constraints from the A2D operation onboard Falcon aircraft for the selection of the site and operation for AC02 (see also chapter 3.3, 3.4).

constraint	value	remark
Falcon max. altitude	10 – 12 km	max. altitude is below cloud top heights and tropopause on a tropical site
Falcon max. range	2500 – 3500 km	max. range limits accessibility from operation base to other sites; refuelling stops could be performed but proper operation of A2D after stop is tbc after AC01
A2D operation	low vibration levels for A2D operation preferable	A2D performance might suffer during strong vibrations (tbc after AC01), e.g. caused by excessive turbulence in PBL and around thunderstorms
accuracy of navigation parameters	need for straight flight legs	accuracy of Falcon aircraft and attitude data is higher during straight flight legs than in curves
on ground equip-ment	need for on-ground equipment	flights have to be performed from 1 operation base, because on ground equipment is needed (e.g. for calibration);
operation base	airport with temperature controlled hangar and electrical power	temperature controlled hangar necessary for A2D calibration => this limits site selection significantly
legal overflight issues	if issues exists and can be handled has to be checked, no issues over ocean	performing overflights over other countries while measuring with remote sensing instruments could be limited, which has to be checked in parallel with site selection (e.g. Brasil for TROCCINOX)
pre-flight preparation time	6.5 hours	only 1 mission per day is feasible due to long pre-flight preparation time
non-availability of Falcon	June-Sept 2006	limits period to perform AC02 starting earliest in end September 2006, which has also implications to site selection (season of year)
variability on atmospheric state	cloud coverage, aerosol content	cloud coverage and aerosol content show strong and limited-predictable variability on non-tropical sites on the synoptic scale . On the other hand, the position of the Inter-Tropical Convergence Zone ITCZ is very predictable.

Tab. 14: Constraints for AC02 site selection and operation.

7 Abbreviations

A2D	ALADIN Airborne Demonstrator
AC01	Aeolus Airborne Campaign 1
AC02	Aeolus Airborne Campaign 2
ACCD	Accumulation CCD
AGC	Aeolus Ground Campaign
ALADIN	Atmospheric Laser Doppler Instrument
BL	Boundary Layer
CCD	Charge Coupled Device
DBS	Doppler Beam Swinging
DEM	Digital Elevation Model
E2S	End-to-End Simulator
EOM	Electro-Optical Modulator
GPS	Global Positioning System
IMU	Inertial Measurement Unit
ITCZ	Inter-Tropical Convergence Zone
L1	Level 1
L1B	Level 1B
L1BP	Level 1B Processor
LOS	Line-of-Sight
MAG	Mission Advisory Group
MULIS	Munich University Lidar System
NWP	Numerical Weather Prediction
QC	Quality Control
RASS	Radio Acoustic Sounding System
SoW	Statement of Work
TN	Technical Note
WPR	WindProfiler Radar

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