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DOCUMENT

Aeolus Scientific Calibration and Validation Implementation Plan

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Reference EOP-SM/2945/AGS-ags
Issue 1
Revision 2
Date of Issue 15-Nov-2019
Status Issued
Document Type PL - Plan

European Space Agency
Agence spatiale européenne

Distribution Public

APPROVAL

Title ASCV IP	
Issue 1	**Revision** 2
Authors **A.G. Straume, D. Schuettemeyer, J. von Bismarck, T. Kanitz, T. Fehr**	**Date** 15-Nov-2019
Approved by	**Date**
T. Parrinello (EOP-GM)	29 November 2019

CHANGE LOG

Reason for change	Issue	Revision	Date
First draft by. D. Schuettemeyer including: overall structure based on S-3 CAL/VAL Implementation Plan, inclusion of Aeolus CAL/VAL Requirements doc content, overview of Aeolus CAL/VAL proposals	0	1	February 2015
Second draft, editorial updates based on review by AGS, TK, JvB	0	2	October 2015
Third draft, revisions by A.G Straume of document structure replacing calval requirements text with calval requirements table and mapping to proposals, geographical coverage, various updates.	0	3	January 2016
Fourth draft, inclusion of revisions by J. von Bismarck, T. Kanitz, D. Schuettemeyer	0	4	February 2016
First issue	1	0	February 2018
Update following review R. Koopman	1	1	September 2018
Update including proposals following CAL/VAL AO call reopening February 2018	1	2	November 2019

CHANGE RECORD

Issue 1	**Revision** 2		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Update including proposals after CAL/VAL AO reopening 2018	15/11/2019	all	all

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1 INTRODUCTION

The Aeolus atmospheric wind mission (called Atmospheric Dynamics Mission (ADM) - Aeolus until May 2017) is the second Earth Explorer core mission within ESA's Living Planet program. Aeolus was launched on 22 August 2018, introducing a novel measurement technique from space providing continuous, global observations of atmospheric winds throughout the Troposphere and in the lower part of the Stratosphere. In addition, the mission also provides particle (aerosols and hydrometeors) attenuated backscatter and backscatter and extinction coefficient profiles, which can be used to detect cloud and aerosol layers along the satellite track.

Equipped with a direct detection Doppler Lidar operating in the ultraviolet (355 nm wavelength) and targeting at velocity measurement accuracies of typically 2 m/s over a large dynamic range the mission poses demanding requirements on instrument performance, alignment stability as well as orbit determination and attitude control. In order to verify the overall performance of the spacecraft and the Aladin payload instrument, and to characterize essential parameters required in the on-ground data processing chain, a number of dedicated measurement tasks are performed during the initial period of in-orbit operation. Furthermore, the level2 data product quality is established through CAL/VAL activities.

The design lifetime of Aeolus is 39 months, including an initial 3 months period covering spacecraft commissioning and initial calibration and characterization activities (Phase E1). During this period, observational data are provided to ESA external expert teams assigned to perform specific analysis tasks focusing at instrument calibration and geophysical validation of Aeolus key data products.

The Mission Phase E1 is followed by a 3 years exploitation period (Phase E2) during which the spacecraft is operated according to a stable, repetitive scenario, with systematic processing and archiving of data products within the Aeolus Payload Data Ground Segment (PDGS) and dissemination to both operational users (NWP centres) and the scientific user community. During this mission phase, the main product calibration and validation activities will take place.

2 SCOPE AND RELATION TO OTHER DOCUMENTS

2.1 Scope and Purpose

This document sets out the Implementation Plan (IP) for Aeolus Scientific Calibration and Validation (ASCV) activities. The audience includes Mission Management, Mission Performance Framework activities, national and international validation stakeholders and the ASCV teams themselves. The ASCV Implementation Plan provides an executive overview of all activities that were submitted to the ESA CAL/VAL Announcement of Opportunity (AO) (delta-) call [RD 1] in a common format. Full details of individual projects are provided in the relevant AO proposal and are not duplicated here. An executive summary of each proposal is given in Chapter 10. In addition the ESA (co-)funded and organized campaigns and Data Innovation Science Cluster (DISC) plans are described and linked to the overall ESA external CAL/VAL activities (sections 8 and 9). Aeolus CAL/VAL proposals can also be submitted at any time during the mission Phase E2. This document will not be kept up to date w.r.t. the CAL/VAL proposals throughout Phase E2, but rather the updated overview of the CAL/VAL teams is provided here: https://www.aeolus.esa.int/.

The purpose of the ASCV IP is to provide a reference for the diverse and widespread activities that are expected to occur within in support of the Aeolus mission calibration and validation, following the launch of Aeolus. The IP is in this respect the handbook of the calibration and validation activities by the scientific community and the ESA internal and funded product quality related activities. It should be noted that calibration and validation of Aeolus by the scientific community is a pre-requisite to the acceptance of the Mission as “fit for purpose”: the validation performed is independent and performed by experienced scientists and engineers in specialised disciplines. Independent validation is a critical aspect that provides credibility to a mission. The results from the Aeolus CAL/VAL by the ASCV teams shall be reported at the annual Aeolus Cal/VAL workshops and in reports to ESA as requested in the Aeolus CAL/VAL AO call In addition , the work will be reported at scientific conferences and in the scientific literature (e.g. in peer-reviewed papers). The ASCV IP is a means to help ESA work effectively with the scientific validation of the mission in the interest of an operational mission success.

A schedule of all planned and potential validation activities is provided in section 13 to facilitate effective communication, planning and exchange of results amongst ASCV teams and between ASCV activities and other relevant activities at ESA or under contract by the Aeolus Project (Phase E1) and Aeolus Mission Manager (Phase E2). This spans from the mission and in particular algorithm and ground segment development contracts in phase C/D/E1, to the phase E2 Sensor, Performance, Product and Algorithm work under the DISC contract, the routine mission calibration and monitoring activities and the ground-segment and mission operations etc. As such, the ACVP IP provides the framework for the coordination of the activities performed external to ESA.

The ASCV IP also provides a status analysis (sections 6.6 and 6.7). The purpose of this analysis is to highlight gaps and issues that must be addressed to ensure a successful scientific validation of Aeolus products according to the Aeolus Cal/Val plan.

The ASCV IP will be maintained by ESA for the duration of the Aeolus Mission, but as mentioned above a complete list of activities and analysis results are reported on the Aeolus CAL/VAL wiki page: https://www.aeolus.esa.int/. The drafting and issuing of the first version of the CAL/VAL Implementation Plan was done under the responsibility of the ESA EO Mission Science Division (Mission Scientist and Campaigns Manager) at ESA-ESTEC during the launch preparation and commissioning phases. The ESA EO Mission Science division is supported by the Project in ESA-ESTEC and the Product Quality Manager in ESA-ESRIN. The document is then handed over to and maintained by the ESA Product Quality Manager in ESA-ESRIN with support from the Campaigns Manager and Mission Scientist in ESA-ESTEC.

2.2 Relation to other documents

This document is closely linked to the Aeolus Mission Requirements Document [AD 1], Aeolus Scientific Calibration and Validation Requirements [AD 2], the Aeolus LEOP and commissioning phase plan [AD 3], ESA Instrument and Processor activities during IOCV [RD 13], and the Aeolus CAL/VAL AO delta-call 2014 Review Panel Report [RD 4]. This implementation plan is outlining the activities done by the ASCV teams during the Mission phase E1 and E2. These have to be aligned with all relevant Aeolus in-orbit activities, and shall contribute to the verification of the Mission Requirements.

2.3 Document Structure

This documents starts with a description of the document scope, the Aeolus mission, the Aladin instrument characteristics and operation, and the data products. This is followed by an overview of the Aeolus CAL/VAL requirements, required collocated observation types and techniques and suggestions of activity grouping. The CAL/VAL proposals are mapped to the requirements and gaps are identified. The validation team terms of reference, the CAL/VAL baseline and interactions with the core Aeolus mission activities are then outlined before the presentation of the individual CAL/VAL proposals. This is followed by an outline of the team coordination and tools for the support of the validation activities and their coordination.

2.4 Acronyms and Abbreviations

ACDM	Aladin Control and Data Management Unit
ACMF	Aeolus Calibration and Monitoring Facility
ADF	Auxiliary Data File
Aeolus	Atmospheric Dynamics Mission - Aeolus
ADS	Annotation Data Set
Aladin	Atmospheric Laser Doppler Instrument
ANX(time)	(time of) Ascending Node crossing (intersection of Aeolus orbit with x-y plane in Earth fixed coordinate system)
AO	Announcement of Opportunity (here: shall denote projects initiated via the Aeolus Cal/Val Announcement of Opportunity process)
AOS	Acquisition of Signal
AOCS	Attitude and Orbit Control System
APF	Aeolus Processing Facility
ARF	(short- & medium-term) Archiving Facility
ARTS	Anomaly Report Tracking System
ASCV Team	Aeolus Scientific Calibration and Validation Team
BCK	Background (operation scenario)
BRC	Basic Repeat Cycle
BUFR	Binary Universal Form for Representation of meteorological data
CDAF	Command and Data Acquisition Station
CDMU	Control and Data Management Unit
DCC	Dark Current mapping & Characterization
DEM	Digital Elevation Model
DEU	Detection Electronic Units
DHS	Data Handling Subsystem
DISC	Data and Innovation Science Cluster
DS	Data Set
DSD	Data Set Description
DSR	Data Set Record
ECMWF	European Centre for Medium Range Weather Forecasts
ECSS	European Cooperation on Space Standardization
EDDS	EGOS Data Distribution System
EE	Earth Explorer
EPS	Electrical Power Subsystem
FS	Fixed Header
FOS	Flight Operations Segment
FTP	File Transfer Protocol
GSOV	Ground Segment Overall Validation plan
HLOP	High Level Operations Plan
HLOS	Horizontal Line Of Sight
HPTM	High Priority Telemetry

IAT	Instrument Auto-Test
IDC	Instrument Defocus Characterization
IPF	Instrument Processing Facility
IRC	Instrument Response Calibration
ISP	Instrument Source Packet
ISR	Instrument Spectral Registration
KVT	Key-Value Terminator
L1	Level 1
L1B	Level 1B
L2/Met PF	Level 2/Meteorological Products Processing Facility
L1/2 ADT	L1/2 Algorithm Development Team
LCPA	Laser Chopper Phase Adjustment
LDTA	Laser Diode Temperature Adjustment
LOS	Line-of-Sight
LTA	Long Term Archive
LUT	Look-Up Table
Mbps	Megabits per second
Met	Meteorology
MDS	Measurement Data Set
MOCD	Mission Operations Concept Document
MPC	Mission Performance Centre
MPH	Main Product Header
MRC	Mie Response Calibration
MTL	Mission Timeline
MUSF	Multi-Mission User Service Facility
NRT	Near Real Time
NWP	Numerical Weather Prediction
OBSW	On-Board Software
OCKA	Laser Offset Check and Adjustment
OCM	Orbit Correction Manoeuvre
PCD	Product Confidence Data
PCDU	Power Control and Distribution Unit
PDGS	(Aeolus) Payload Data Ground Segment
PI	Principle Investigator
QA	Quality Assurance
QC(F)	Quality Control (Facility)
QRT	Quasi Real Time
RAOP	Restituted Aeolus Operations Plan
RCS	Reaction Control System
RF	Radio Frequency
RRC	Rayleigh Response Calibration
S/C	Spacecraft
SID	Structure Identifier (for telemetry packets)

SPH	Specific Product Header
SPPA	Sensor Performance and Product Assurance
TC	Telecommand
TDRS	Telemetry Data Receiver System
TDS	Test Data Set
TEP	Test Entry Point
TM	Telemetry
USDF	User Service and Dissemination Facility
UTC	Universal Time Correlated
VC	Vicarious Calibration
VH	Variable Header
w.r.t.	with respect to
WGS	World Geodetic System
WVM	Wind Velocity Measurement
XBS	X-Band sub-System.
XML	Extensible Markup Language
ZWB	Zero Wind Bias
ZWC	Zero Wind Calibration

2.5 Definitions

A summary of definitions valid for this document is given here. The first four definitions are based on ISO standard 3534-1 (ISO, 1993).

Accuracy:

The closeness of agreement between a measurement and the accepted reference value. The term accuracy, when applied to a set of measurements, involves a combination of random components and a common systematic error or bias component, and can be expressed as follows:

$Accuracy = \sqrt{(Precision^2 + Bias^2)}$ (Eq. 1)

Bias:

The difference between the expectation of measurements and the accepted reference value. The bias is the total **systematic error**. There may be one or more systematic error components contributing to the bias.

Free Troposphere:

The Earth atmosphere between 2 km above the surface and 16 km. Please note that this definition is specific to this document and not fully in-line with the exact definition of the free troposphere in meteorology (e.g. Wallace and Hobbs, 1977).

Instrument related observation error:

The root of the sum of the observation precision squared and the observation systematic error squared.

Level 0:

Instrument source packet (ISP) data with raw Aladin measurement data, instrument housekeeping data and Aeolus platform housekeeping data, vertical sampling grid information, calibrated housekeeping data and instrument health parameters.

Level 1:

Geolocated measurement data including processed ground echo data, preliminary HLOS wind measurements and observations (zero wind correction applied), viewing geometry & scene geolocation data, and annotation data including processed calibration data, product confidence data and calibrated housekeeping data

Level 2:

Fully processed wind (Level 2B), ECMWF forecast model winds on the location of the Aeolus L2B observations after assimilation of Aeolus L2B data (L2C), and optical properties profile (Level 2A) data, fully processed error information and product confidence data.

Measurement:

Horizontal average of the atmospheric backscattered signals from a number of laser pulses from a vertical bin. The horizontal averaging laser pulses from Aeolus takes place on-board the spacecraft to reduce the data size before data downlink.

Medium-range forecast:

Forecast for the following 72 to 240 hours, see http://www.wmo.int/pages/prog/www/ DPS/GDPS-Supplement5-AppI-4.html

Observation:

In order to achieve sufficient signal-to-noise levels, Aeolus measurements are further horizontally averaged by the on-ground Level 1 and Level 2 data processors within a vertical bin. The resulting product is called an observation. Adjacent observations in the vertical form an observation profile.

Observation profile:

An observation profile is a collection of adjacent observations along the lidar line-of-sight from the surface up to the highest vertical bin.

Observation representativeness error:

When observations are assimilated into numerical weather prediction models, the associated observation error is increased adding the so-called observation representativeness error to the instrument-related error. This is done to compensate for the introduction of an observation with a given geographical representativeness in a discretized numerical representation of the atmosphere by the forecast models. The total associated observation error is mostly defined through the use of statistics, comparing the observations with the model first guess and analysis.

Phase E1:

The commissioning phase. For Aeolus, this is defined as the first 3 months after launch. Within this period the instrument will be switched on and the platform, instrument and ground segment operation and performance is calibrated and/or validated.

Phase E2:

The operational phase of the Aeolus satellite. In this phase, the instrument is assumed to operate in a stable measuring mode. Routine instrument calibration and product validation is performed. Only minor changes to the instrument settings, measurement modes, and algorithm updates are expected.

Planetary Boundary Layer (PBL):

Earth atmosphere between the surface and 2 km above the surface. Please note that this definition is specific to this document, and not fully in-line with the exact definition of the planetary boundary layer in meteorology (e.g. Wallace and Hobbs, 1977).

Precision:

The closeness of agreement between independent test results obtained under stipulated conditions. It depends only on the distribution of the **random errors**. It is computed as the standard deviation of the measurements.

Precision of a lidar observation:

The random part of the wind-speed estimation error. It is defined as the standard deviation of the estimates (σ_{LOS}) (good estimates) falling under the bell shape part of the Probability Density Function (PDF) described below, and is hence the calculated precision after the removal of gross errors.

Probability Density Function (PDF) of a line-of-sight wind speed:

For wind observation by Doppler Wind Lidars in the low-backscatter regime, the number of events (photons) per measurement interval, detected at receiver level, can be close to the number of 'noise' events. The retrieved wind speeds from measurements with a low signal-to-noise ratio (SNR) are less accurate, especially for cases where the noise resembles the measured signal characteristics. A PDF of the Line-Of-Sight wind speed (V_{LOS}) can be estimated by retrieving the wind speed from a synthetic measurement applying the estimated error distribution. The resulting wind speed distribution looks like a cluster of localised good estimates (bell shape) around the defined true mean speed (V_{true}), as shown in Figure 1.

An approximate model of the estimated PDF for any observing system – here with terminology appropriate for Aeolus-type line-of-sight winds – is as follows:

$$PDF(V_{LOS}) = \frac{P_{ge}}{V_S} + \frac{1-P_{ge}}{(2\pi)^{\frac{1}{2}}\sigma_{LOS}} \exp\left[\frac{-(V_{LOS}-V_{true})^2}{2\sigma_{LOS}{}^2}\right] \qquad \text{(Eq. 2)}$$

where σ_{LOS} is the random part of the wind-speed estimated error (precision of a lidar observation), P_{ge} is the probability of gross error of a lidar observation, and V_s is the wind search window (horizontal axis in Figure 1).

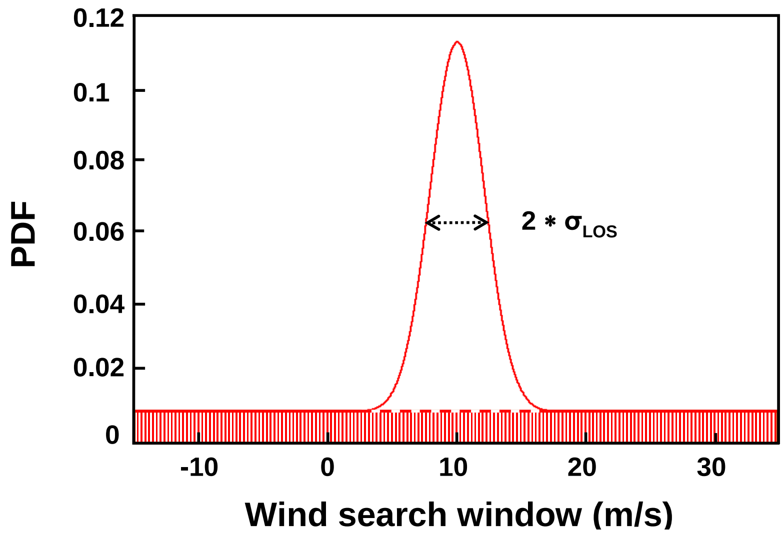

Figure 1: *The PDF of wind estimates looks like a cluster of localised good estimates (bell shape) around the true mean speed (here 10 m/s) sitting on a pedestal of uniformly distributed bad estimates (shaded zone), or gross errors, extending over the wind search window. Here the systematic error equals 0. The wind search window is linked to the LOS dynamic range (± 90 m/s).*

Probability of gross error (P_{ge}) of a lidar observation:

The complement to unity of the percentage of estimates (bad estimates) contained in the pedestal of uniform distribution over the 'search window' wind speed range (V_S). This is shown by the shaded area in Figure 1. Estimates outside the search window should always be considered 'bad' and thus rejected. It is expected that the on-ground data processing will be able to remove most gross-errors through quality control (QC). The requirement in this document refers to the maximum amount of gross errors not being detected by the data processing and QC.

Short-range forecast:

Forecast for the following 12 – 72 hours (see http://www.wmo.int/pages/prog/www/ DPS/GDPS-Supplement5-AppI-4.html

Stratosphere:

The Earth atmosphere between about 16 and 50 km. Please note that this definition is specific to this document and not fully in-line with the exact definition of the range of the stratosphere in meteorology (e.g. Wallace and Hobbs, 1977).

Systematic error of a lidar observation:

Originated from the instrument and platform characterization, calibration and data processing. In the case of Aeolus, this will include **biases** due to undetected/uncorrected instrument misalignments, platform miss-pointing and errors in the instrument response calibration.

Trueness:

The closeness of agreement between the average value obtained from a large series of measurements and an accepted reference value. The measure of trueness is in the document expressed in terms of bias.

Vertical bin:

The return signal from an emitted laser pulse can be averaged over time on the detector, resulting in an atmospheric return signal representative of an atmospheric layer with a thickness equal to the speed of light divided on the averaging time.

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable Documents

Ref #	Reference	Issue	Title
[AD 1]	AE-RP-ESA-SY-001	1.3	Aeolus Mission Requirements Document
[AD 2]	AE-RS-ESA-GS-005	3.0	Aeolus: Scientific Calibration and Validation Requirements
[AD 3]	AE-PL-ESA-GS-023	0.2	Aeolus LEOP and commissioning phase plan

3.2 Reference Documents

Ref #	Reference	Issue	Title
[RD 1]	-	-	Announcement of Opportunity for Aeolus CAL/VAL https://earth.esa.int/aos/AeolusCalVal
[RD 2]	SP-1311	2008	Aeolus Science Report. Available on http://www.esa.int/Aeolus
[RD 3]	AE-OF-ESA-GS-002	1.0	External Calibration and Validation of the Aeolus Mission, Announcement of Opportunity, delta-call
[RD 4]	AE-RP-ESA-SY-166	1.0	Aeolus CAL/VAL AO delta-call 2014, Review Panel Report (Internal to ESA)
[RD 5]	ADM-IC-52-1666	4.11	Aeolus Level 1B Input/Output Data Definition ICD
[RD 6]	AE-IF-DLR-L2A-004	3.09	Aeolus Level 2A Processor Input/Output Data Definition
[RD 7]	AE-IF-ECMWF-L2BP-001	3.20	Aeolus Level 2B/2C Processor Input/Output Data Definition ICD
[RD 8]	AE-RP-DLR-L1B-001	4.4	Aeolus, Algorithm Theoretical Basis Document (ATBD), Level1B Products, Document Reference: AE-RP-DLR-L1B-001, Issue 4.0, Available from ESA.
[RD 9]	AE-TN-IPSL-GS-001	5.5	L2A Product, Algorithm Theoretical Basis Document (ATBD), Document number: AE-TN-IPSL-GS-001, Issue 5.4, Available from ESA.
[RD 10]	AE-TN-ECMWF-L2BP-0024	3.2	Aeolus level-2B algorithm theoretical baseline document, Document number: AE-TN-ECMWF-L2BP-0024, Issue 2.4, Available from ESA
[RD 11]	AE-FR-VHAMP	1.0	VHAMP, Vertical and Horizontal Aeolus Measurement Positioning. Final report of CCN2 to ESA contract 4200020940. Available from ESA.
[RD 12]	ESCC-P-001B	-/-	ECSS - Glossary of Terms (version: 14 July 2004)
[RD 13]	AE-PL-ESA-SY-021	2.0	ESA Instrument and Processor activities during IOCV
[RD 14]	AE-TN-ECMWF-L2BP-0181	1.3	TN18.1, Aeolus L2B Team Scientific Commissioning Plan
[RD 15]	*Appl. Opt.*, **46**, 26, pp 6606-6622		Ansmann, A. *et al.,* Particle Backscatter and Extinction Profiling with the Spaceborne HSR Doppler LIDAR ALADIN: methodology and simulations
[RD 16]	AE.OM.ASF.AL.00003	05.0	AEOLUS Flight Operations Manual Volume 7: ALADIN Instrument
[RD 17]	ESA-EOPG-MOM-PL-0012	1.0	Aeolus Phase E Management Plan
[RD 18]	AE-PL.ASU.SY.026	8	In-Orbit Commissioning and Verification Plan
[RD 19]	AE-PL-ESA-SY-002	0.6	Aeolus Commissioning, Calibration and Validation Plan (NO LONGER VALID, SUPERSEEDED BY [AD 3])
[RD 20]	-	1.1	Description of Aeolus online data dissemination system, data reading and conversion, and orbit software tools. Available at: https://earth.esa.int/aos/AeolusCalVal
[RD 21]	AE-TN-ESA-GS-090	1.4	Recommendations for Aeolus operations and data downlink based on user and CAL/VAL needs
[RD 22]	ESA-EOPSM-AEOL-TN-3426	1.0	Analysis of Aeolus reference orbit location
[RD 23]	AE.FR.DLR.A2D.150612	1.0	Final Report ADM-Aeolus campaigns, (2006-2009)
[RD 24]	FR.DLR.WindVal.190517	1.0	WindVal, Final Report Joint DLR-ESA-NASA Wind Validation for Aeolus
[RD 25]	FR.DLR.WindVal_II.260618	1.1	WindVal II Final Report, Wind Validation II for Aeolus

4 BACKGROUND

4.1 Aeolus Mission Objectives

ESA's Earth Explorer missions are developed in direct response to priorities identified by the scientific community. Carrying novel technologies, each satellite in the series is developed to improve our understanding of how the planet works as a system and the impact that human activity is having on natural Earth processes. By providing timely and accurate profiles of the world's winds along with information on aerosols and clouds, the Aeolus mission will not only advance our understanding of atmospheric dynamics, but will also provide much-needed information to improve weather forecasts. This state-of-the-art mission will also contribute to climate research.

It goes without saying that accurate weather forecasts are important both for commercial activities such as farming, fishing, construction, transport, energy exploitation and, of course, for generally planning our daily affairs. Although weather forecasts have advanced considerably in recent years, meteorologists urgently need reliable global wind-profile data to improve the accuracy of forecasts even further. Currently, wind information is either derived from temperature observations and is hence low resolution, or is measured directly but does not cover the whole globe. The World Meteorological Organization has, therefore, identified the lack of global direct wind profile measurements as one of the major deficits in the current Global Observing System. By filling this gap, Aeolus will improve weather forecasts and climate modelling along with considerable socio-economic benefits. In particular, better forecasts of extreme weather events will be of importance. Reliable knowledge of Earth's wind fields will also advance our knowledge of atmospheric energy, water, aerosol and chemistry cycles.

Long-term records of aerosol and cloud properties are needed to further our understanding of climate change. Currently, a number of passive ground and satellite-based instrumentation provide atmospheric total column observations of aerosol optical depth and cloud distribution. However, forecast and air quality models need observations of the vertical distribution of aerosol layers in the atmosphere in order to determine their transport and radiative effects. NASA's CloudSat and CALIPSO satellites currently supply vertical profiles of these important variables, but these missions have already well exceeded their goal mission lifetime. The further provision of aerosol and cloud profile information from Aeolus will help bridge the gap until ESA's dedicated cloud, aerosol and radiation mission, EarthCARE, is launched.

The purpose of the ASCV IP is to outline the CAL/VAL objectives and requirements and how these are addressed by the CAL/VAL proposals. The plan will serve as a handbook for the planning, coordination and execution of the Aeolus CAL/VAL activities from launch until the end of the mission.

4.2 Aeolus Mission Overview

A detailed instrument description is provided in the Aeolus Science Report [RD 2]. A short summary of the main instrument features is provided here.

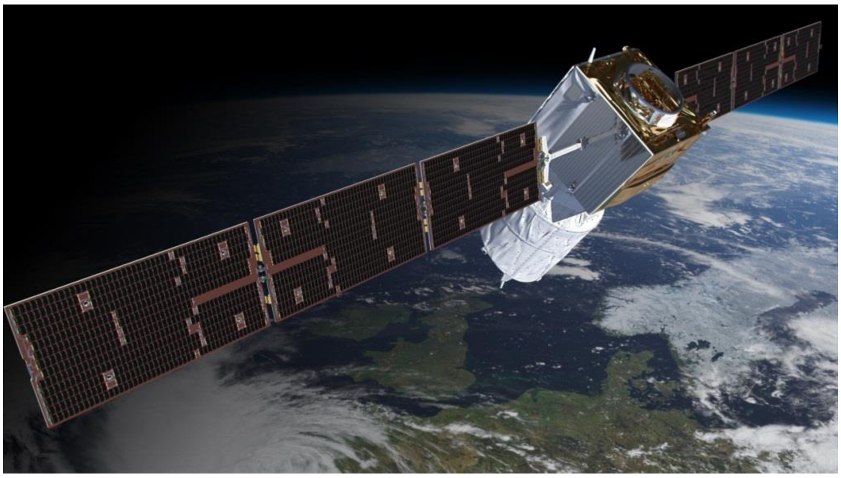

Figure 4.2-1: An artists' view of the Aeolus satellite in-flight, illustrating the dusk-dawn orbit configuration

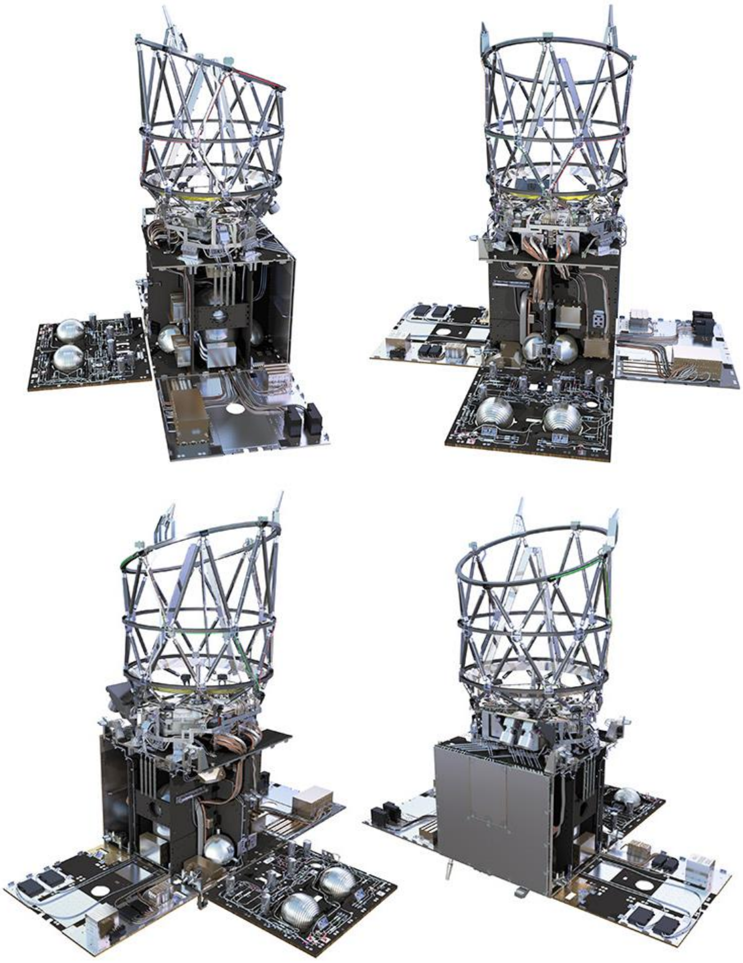

Figure 4.2-2: An "emploded" (satellite bus panels are "folded out" on three sides to reveal the inner part of the satellite) view of the Aeolus platform revealing the satellite interior from 4 different angles. Three of the four platform side panels are flipped down to display the platform interior. The telescope baffle (on top) is shown without its MLI and Kevlar wrappings. The Aladin instrument is situated on top of the satellite bus, directly behind the primary telescope. The upright side panel is the passive cooler.

The Aeolus satellite (Figure 4.2-1) carries a single instrument – a Doppler wind lidar called Aladin (Figure 4.2-2). This sophisticated instrument is designed to probe the lowermost 30 km of the atmosphere to provide profiles of wind, aerosols and clouds along the satellite's orbital path (Figure 4.2-3). Comprising a powerful laser, a large telescope and a very sensitive receiver, Aladin is the first wind lidar in space.

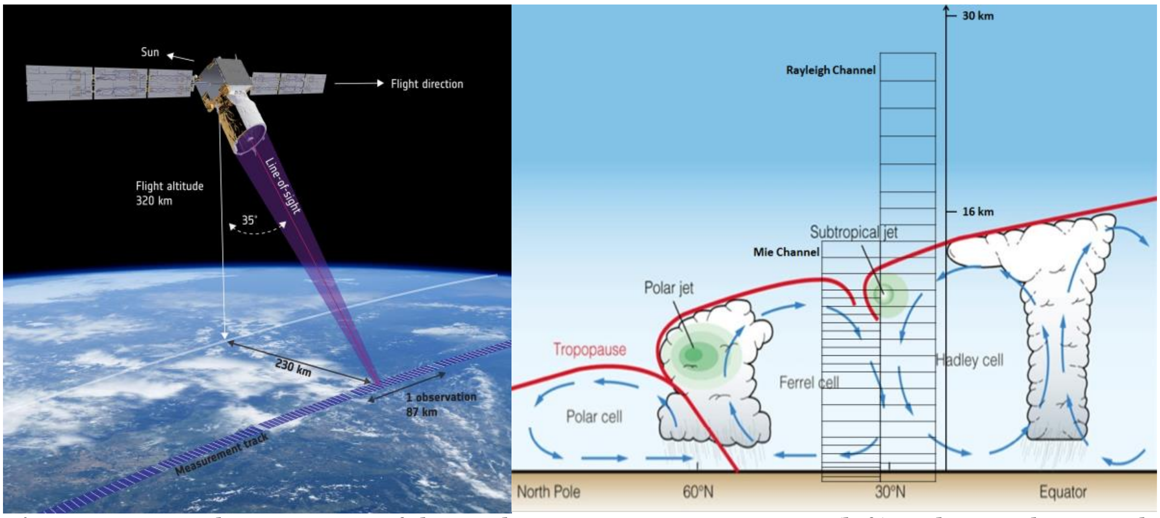

Figure 4.2-3: Schematic view of the Aeolus measurement geometry (left) and example vertical sampling by its molecular (Rayleigh) and particle (Mie) channels (right).

The laser system emits short powerful pulses of ultraviolet light down into the atmosphere (Figure 4.2-4). The telescope collects the light that is backscattered from air molecules, aerosol particles and hydrometeors. The receiver analyses the Doppler shift of the backscattered signal to determine the wind speed at various altitudes below the satellite.

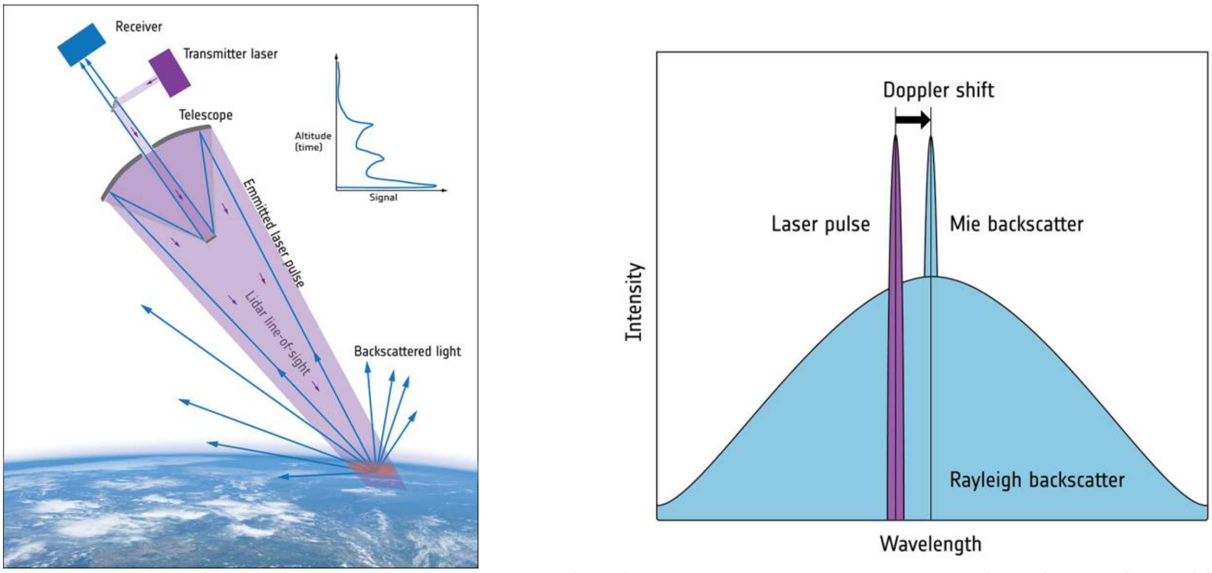

Figure 4.2-4: The Aladin measurement principle. The monostatic emit-receive path is shown skewed here. Wind and atmospheric optical properties profile measurements are derived from the Doppler shifted signals that are back-scattered along the lidar line-of-sight (LOS).

The satellite is flying in a polar dawn-dusk orbit at an altitude of 320 km, with an equatorial crossing time of the orbit descending node of 6 AM. The number of orbits per day is about 15, and the orbit repeat cycle is weekly, covering 111 orbits. The satellite track coverage in approximately 24 hours is illustrated in Figure 4.2-5.

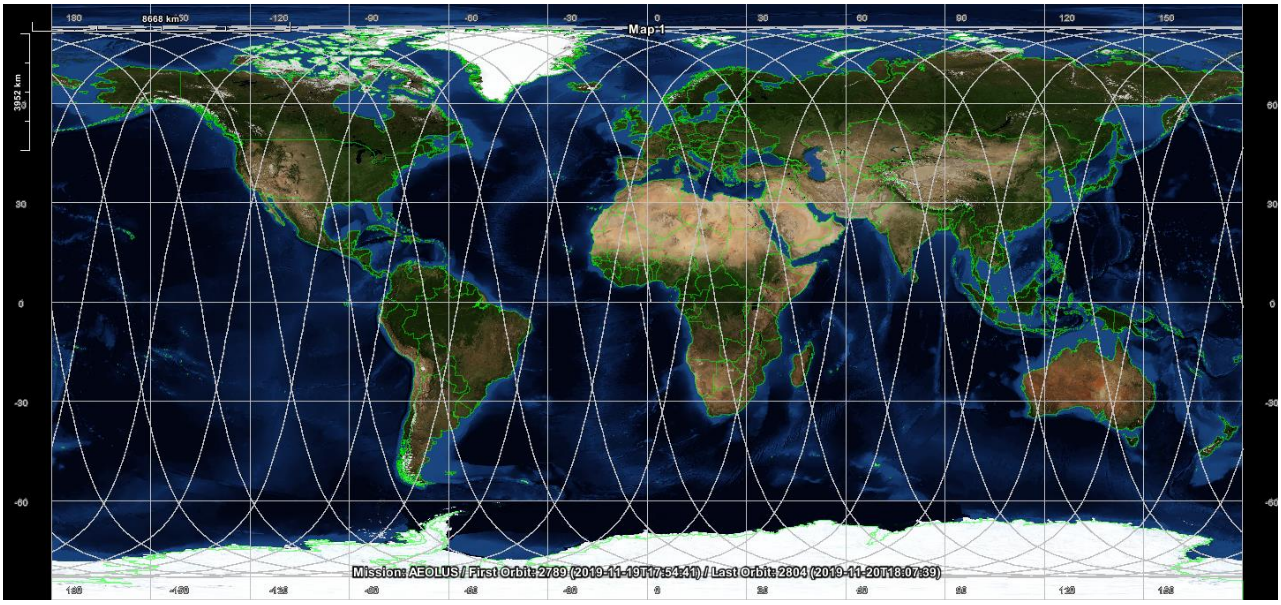

Figure 4.2-5: Illustration of Aeolus ground track coverage in approximately 24 hours. The number of orbits per day is approximately 16, and the orbit repeat cycle is 7 days. The Aeolus reference ground track is ANX of 4.5 longitude East (± 0.22 degrees) as reported in [RD 22].

As explained in [RD 16], the Aladin instrument is operated in six different modes, as summarized in Table 4.2-1. Besides the nominal Wind Velocity Measurement (WVM) mode, five calibration, characterisation and health-check modes are implemented.

Table 4.2-1: Aladin Instrument operation modes. For an explanation of acronyms, see chapter 2.5.

Instrument Operation	**Acronym**	**Occurrence**	**Purpose**	**Transmitter frequency (range/step)**	**Processed data**
Instrument Spectral Registration	ISR	On-ground and during Commissioning phase	To centre laser transmitter frequency	[-5.5, +5.5 GHz] Step 25 MHz	Internal
Instrument Auto test	IAT	On-ground and/or in-orbit health check (oR)	To verify Mie/Rayleigh receiver spectral transfer functions	[-5.0, -0.75 GHz] And [0.75, 5.0 GHz] With 250 MHz steps [-0.75, +0.75 GHz] with 25 MHz steps	Internal
Dark Current Calibration	DCC	On-ground In-orbit (oR)	to characterise detection chain in darkness	fixed	Internal
Instrument Defocus Characterization	IDC	On-ground characterization, in-orbit, Commissioning phase, every 100 orbits	to characterise defocus or optics by measuring Rayleigh spot size	fixed	External on RSP
Instrument (Mie, Rayleigh) Response Calibration	IRC MRC RRC	On-ground functional testing, in-flight every 100 orbits	To measure MSP and RSP response with satellite in nadir, including centring of frequency	[-0.5, +0.5 GHz] Step 25 MHz	Internal and ground return on MSP and RSP, and atmosphere on RSP
Wind Velocity Measurement	WVM	On-ground characterization, nominal mode	nominal wind measurement mode	fixed	Internal and atmosphere and ground return on MSP and RSP

4.3 Aeolus Data Processing steps and Product Description

The Aeolus products and how they are derived are described in the product Algorithm Theoretical Basis Documents (ATBDs) [RD 8 - 10]. The main data processing steps for the Aeolus wind and aerosol products is illustrated in Figure 4.3-1.

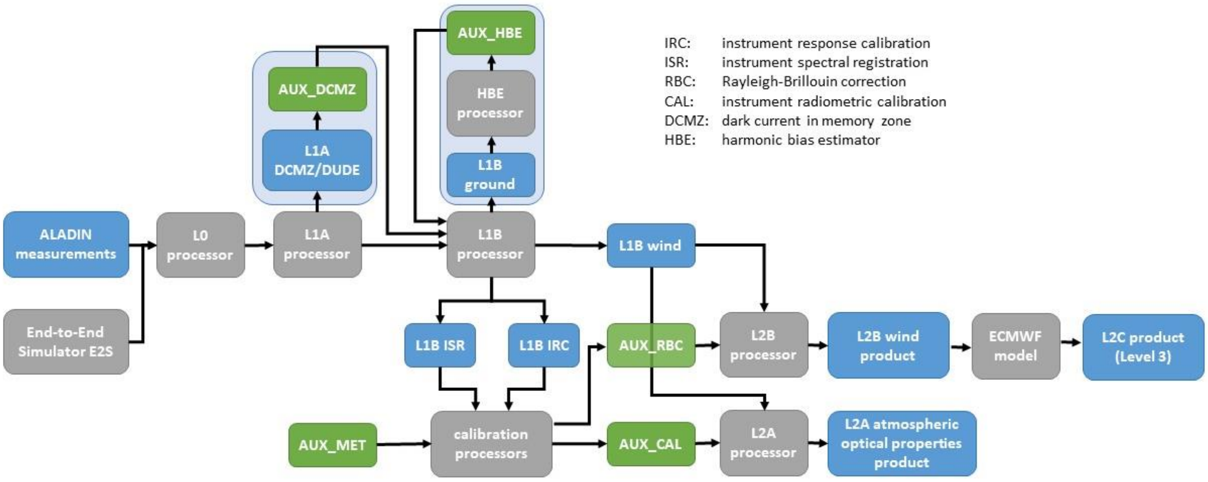

Figure 4.3-1: *Schematic overview of the Aeolus data processing steps. IRC: instrument response calibration, ISR: instrument spectral registration, RBC: Rayleigh-Brillouin correction, CAL: instrument radiometric calibration, DCMZ: dark current in memory zone, HBE: harmonic bias estimator. Figure design with curtesy Aeolus DISC.*

The main product from Aeolus will be horizontally projected line-of-sight (HLOS) wind observation profiles (approximately zonally oriented) from the surface up to about 30 km. The product levels and individual products are described in the product Input Output Data Definition documents (IODDs) ([RD 5], [RD 6], [RD 7]) and an overview is provided in Table 4.3-1.

Product/ Data Set	Contents	Approx. size [Mb/ orbit]	Remarks
AISP ("Raw Data")	**Header Data** FH **Measurement data** Instrument source packet data with raw Aladin measurement data and platform housekeeping/AOCS data (CDMU)	50	Actual sensing period will typically cover 1 orbit but may vary in the range ~ 0.5 … 1.5 orbits, depending on actual X-band downlink scenario
Level 0	**Header Data** FH, VH (MPH + SPH) **Measurement data** Instrument source packet (ISP) data with - Raw Aladin measurement data (DEU output) - Instrument housekeeping data (ACDM) - Aeolus platform housekeeping/AOCS data (CDMU) **Annotation data** - Vertical sampling grid information - Calibrated housekeeping data (ACDM + CDMU) - Instrument health parameters	55	
Level 1A	**Header Data** FH, VH (MPH + SPH) **Measurement data** - Reconstructed Aladin measurement data (DEU output data, no processing performed) - Pre-processed AOCS and orbit geometry data **Annotation data** - Vertical sampling grid information - Calibrated housekeeping data (ACDM + CDMU) - Instrument health parameters	70	
Level 1B	**Header Data** FH, VH (MPH + SPH) **Measurement data** - Processed ground echo data - Preliminary HLOS wind observations (calibrations applied (zero wind correction, receiver response calibration, harmonic and range dependent bias corrections) - Viewing geometry & scene geolocation data **Annotation data** - Processed calibration data - Product confidence data (PCD) - Calibrated housekeeping data (ACDM+CDMU)	90	Preliminary HLOS data for Rayleigh channel based on standard (default) atmospheric corrections

Product/ Data Set	Contents	Approx. size [Mb/ orbit]	Remarks
Level 2A	**Header Data** FH, VH (MPH + SPH) **Measurement data** - Geo-located consolidated backscatter and extinction profiles, backscatter-to-extinction (BER) ratio per observation - Scene classified backscatter, extinction and BER profiles - Error information **Annotation data** - Product confidence data (PCD) - Others	20	
Level 2B	**Header Data** FH, VH (MPH + SPH) **Measurement data** - Geo-located consolidated HLOS wind observations, after applying actual atmospheric corrections to Rayleigh channel data - Error information **Annotation data** - Product confidence data (PCD) - Others	22	
Level 2C	**Header Data** FH, VH (MPH + SPH) **Measurement data** - Vertical profiles of wind vectors (horizontal components, u and v) - Supplementary geophysical parameters - Fully processed error information **Annotation data** - NWP model settings - Definition of non-Aeolus model input data - Product confidence data (PCD) - Others	25	Aeolus assisted wind fields, resulting from NWP assimilation processing. Data co-located in time and space with Aeolus wind observations
Higher level data products	No processing, dissemination of higher level data products by the PDGS envisaged	-/-	

Product/ Data Set	Contents	Approx. size [Mb/ orbit]	Remarks
Auxiliary data	**<u>Header Data</u>** FH, VH (MPH + SPH) **<u>Data blocks</u>** - Instrument characterisation data (AUX_CHAR) - Miss-pointing / geometry correction data (AUX_HBE, AUX_RDB) - In-flight calibration data (AUX_RRC, AUX_MRC, AUX_HBE, AUX_CAL, AUX_RBC, …) - Algorithm configuration parameters, settings (AUX_PAR) - Information on atmospheric state (e.g. pressure, temperature, humidity etc. from a forecast model) (AUX_MET) and an atmospheric backscatter-to-extinction ratio climatology (AUX_CLM) - Validation thresholds / templates - Others	40	Examples of Aeolus auxiliary files: AUX_PAR_1B AUX_PAR_2A AUX_PAR_2B AUX_PAR_CL AUX_RRC_1B AUX_MRC_1B AUX_HBE_1B AUX_RDB_1B AUX_MET_12 AUX_RBC_L2 AUX_CAL_L2 AUX_CLM_L2 For further details, see section 4.3.6 below

Table 4.3-1: *Aeolus data products and product levels. For an explanation of acronyms and abbreviations, see chapter 2.4.*

4.3.1 Data down-link and data preparation (L0 and L1A)

The data that is sent from the satellite to the ground station in Svalbard is called Annotated Instrument Source Packets (AISP). These "raw data" contain instrument, platform, orbit and measurement related information. The scientific data contains the averaged detector signal from each altitude bin together with information on the frequency of the individual outgoing laser pulses. In addition, instrument calibration data (mainly spectral calibration) will be obtained from on-board calibration measurements. These calibration data will be used on ground for the L1B processing. As reported in section 4.2, the atmospheric returns from individual laser pulses (shots) are averaged on-board the spacecraft to a so-called measurement. The current instrument baseline is a measurement size of 3 km (average over 0.4 s or 20 shots). The instrument also measures the laser frequency for every laser shot via the so-called "instrument internal path" (internal reference). These measurements are not averaged on-board.

The AISP is further processed to Level 0 (L0) and to Level 1A (L1A) at the Aeolus Processing Facility (APF) in Tromsø, Norway. This processing is in preparation of the Level 1B (L1B) processing, and consists of "cleaning" and time-ordering of the raw data (L0), and measurement geo-location and full processing of satellite house-keeping data (L1A).

4.3.2 Data processing to Level 1B

At the APF the further L1B processing results in the L1B data product, which contains preliminary horizontally projected line-of-sight (HLOS) winds, processed calibration files (including instrument characterization, instrument settings and calibration processor output), product confidence data (e.g. random and systematic errors and product quality flags), and Mie and Rayleigh useful signal profiles. The Aeolus L1B product is calibrated using information on instrument offsets, atmospheric background and the instrument responses in both channels. The data are further corrected with information on the satellite pointing both from the satellite attitude information and through the use of a so-called Harmonic Bias Estimator. The Harmonic Bias Estimator collects valid ground returns over a number of orbits to characterize the instrument pointing, altitude and thermal effects as a function of orbit position. The output of the tool is used to correct the retrieved wind Doppler shifts for these effects. Also, range-dependent errors in the instrument responses are corrected by a range-dependent bias correction algorithm after a dedicated instrument characterization observation campaign.

4.3.3 Dedicated calibration for Level 2 retrieval (CAL Suite)

A dedicated chain of calibration processors for the further Level 2A (L2A) and Level 2B (L2B) processing (the so-called Calibration Suite) is run in the Aeolus Calibration and Monitoring Facility (ACMF) in ESA-ESRIN. The Calibration Suite produce auxiliary data files used in the L2 processing described in the sections below.

One of the files produced by the Calibration Suite allows for a Rayleigh-Brillouin scattering correction of the atmospheric backscatter. The monochromatic Aladin emitted laser light that is backscattered by molecules undergoes a frequency broadening which is both temperature (Rayleigh) and pressure (Brillouin) dependent. The atmospheric temperature and pressure along the lidar line-of-sight is in general unknown during the time of the L1B processing. Thus the output from the molecular channel will be given for a standard temperature and pressure profile. This simplification is corrected during the Level 2 processing, making use of NWP 6-h forecast information (AUX_MET, see section 4.3.6 below) on the local temperature and pressure throughout the measurement volume. The effectiveness of the correction is strongly dependent on the provision of a well-characterized instrument spectral response. The Calibration Suite prepares a look-up table for the instrument Rayleigh responses as a function of atmospheric temperature and pressure (AUX_RBC, see section 4.3.6 below).

The Calibration Suite further calculates instrument performance information (transmissions and calibration coefficients), which is used in the L2A processing. This information is stored in the AUX_CAL file (see section 4.3.6 below).

4.3.4 Data processing to Level 2B and Level 2C (wind products)

The L1B product is then further processed to Level 2B (pressure and temperature corrected HLOS wind profile product) and Level 2C (L2C, ECMWF forecast model wind profiles at the Aeolus observation location after assimilation of Aeolus Level 2B winds) at the European Centre for Medium-Range Weather Forecasts (ECMWF). The L2B and L2C are the primary data products from Aeolus.

The main L2B processing steps concern the correction of the Rayleigh wind processing for atmospheric temperature and pressure broadening effects (using the so-called AUX_RBC look-up table). This is done using a priori temperature and pressure information, collocated to the wind observations, from the weather forecast model (AUX_MET). Particle (aerosols or hydrometeors) detection is performed using the so-called scattering ratio provided by the L1B processing (called scene classification). The wind observations are then classified into cloudy and cloud free, as illustrated in Figure 4.3.4-1. Finally, the data are averaged to form a representation of the actual wind observation over the 87 km long pixels (illustrated for Rayleigh winds in Figure 4.3.4-2). The processor also performs L1B and L2B data quality control and estimates error quantifiers.

The Aeolus L2B wind observations are then assimilated in the ECMWF model. The output assimilated winds (zonal and meridional wind component profiles at the location of the L2B wind profiles) are then used to populate the L2C product.

The vertical resolution of the layer-average winds vary from 0.25 to 2 km, and can be adapted as a function of the under-laying topography and/or climate zone. An example of terrain following sampling is clearly visible in the upper panel of Figure 4.3.4-2. The required wind accuracies (a combination of bias and precision, as defined in section 3) are 2 m/s in the planetary boundary layer (PBL), 2-3 m/s in the free troposphere, and 3-5 m/s in the stratosphere. A detailed description of the Aeolus wind retrievals can be found in [RD 10].

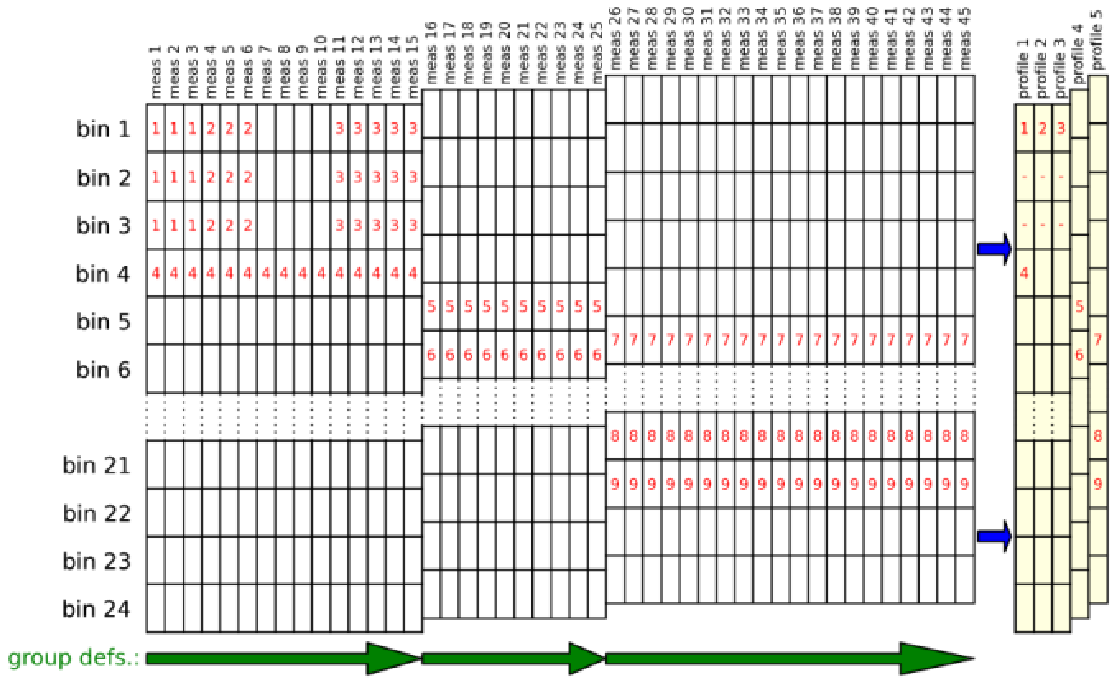

Figure 4.3.4-1: *Schematic view of the Aeolus L2B wind observation processing. The number indicate different scene classifications (clouds versus no clouds), resulting in a number of wind profiles for an observation. These are partial or full wind profiles for the Rayleigh (cloud free) and Mie (cloud or aerosol layer winds) channels. Courtesy: J. de Kloe (KNMI).*

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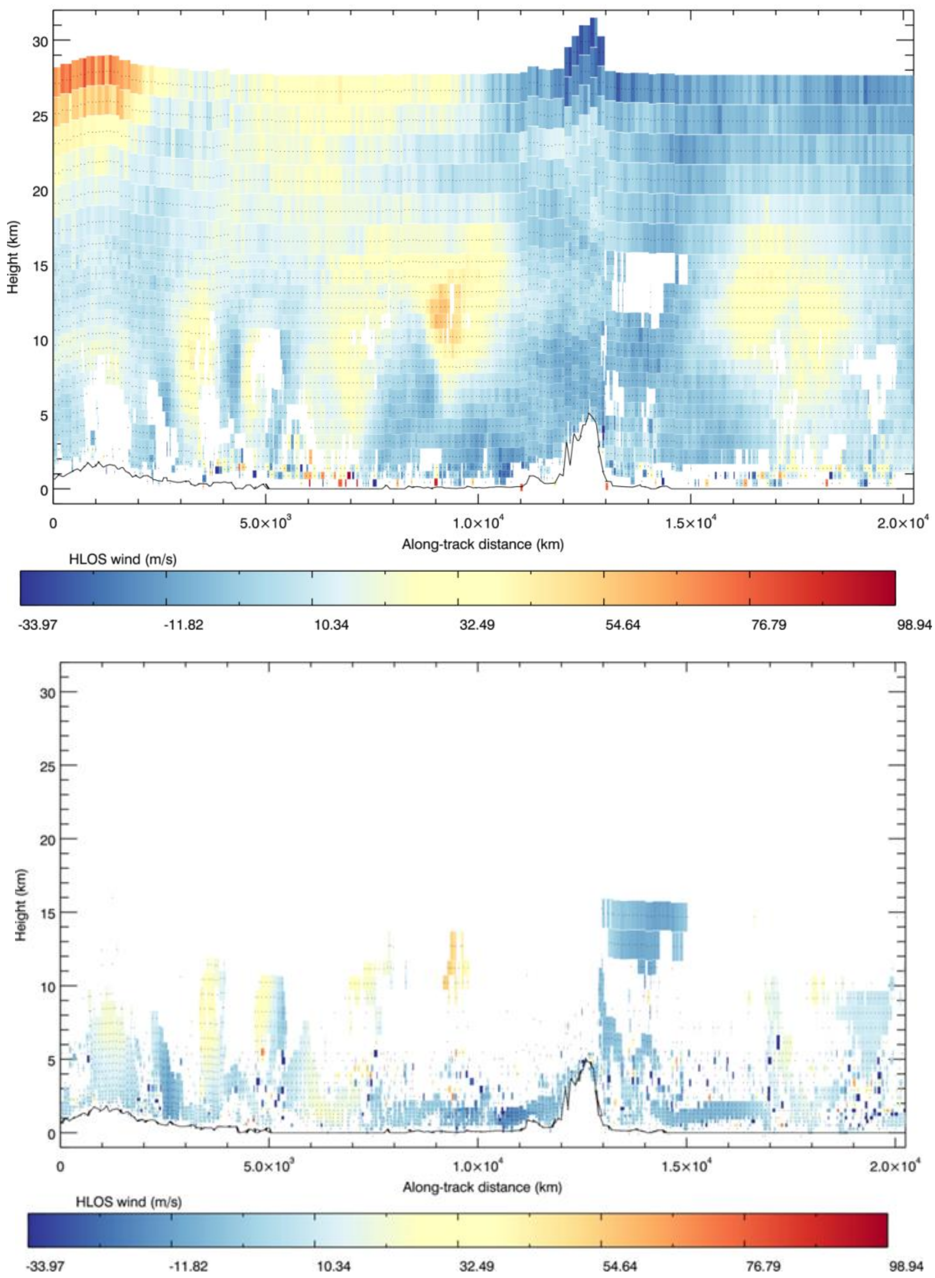


Figure 4.3.4-2: *Example of simulated Aeolus L2B Rayleigh clear air wind observations (ms^{-1}) (upper panel) and Mie cloud/aerosol wind observations (ms^{-1}) (lower panel). Courtesy: M. Rennie (ECMWF).*

4.3.5 Data processing to Level 2A (atmospheric backscatter and extinction coefficient products)

At the APF, the L1B product is also further processed to Level 2A (atmospheric optical properties product). The Level 2A product is defined as an Aeolus spin-off product.
The L2A product contains height profiles of Mie and Rayleigh co-polarized backscatter and extinction coefficients, scattering ratios and lidar ratios ([RD 6], [RD 9]] along the lidar line-of-sight. From these parameters it is possible to derive cloud and aerosol information such as layer height, multi-

layer cloud and aerosol stratification, cloud and aerosol optical depths (integrated light-extinction profiles), and some information on cloud/aerosol type (lidar ratio).

The profiles will be provided both on observation scale (87 km averages) and on smaller scales after applying scene classification. An example of simulated Aeolus backscatter and extinction profiles on observation scale is given in Figure 4.3.5-1.

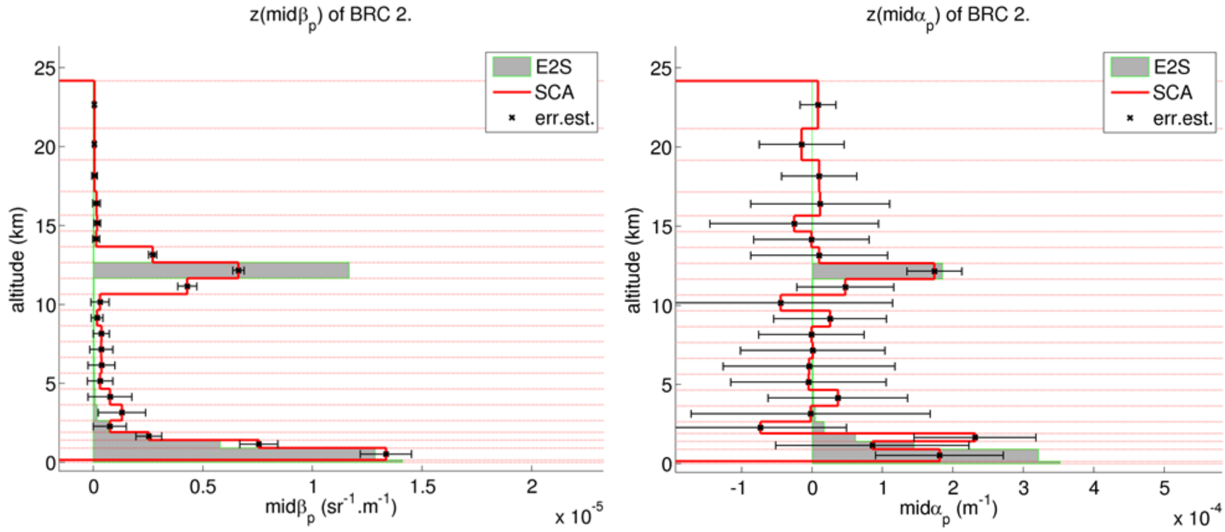


Figure 4.3.5-1: *Examples of simulated Aeolus L2A co-polar backscatter (left) and extinction profiles, retrieved from a scene measured by the NASA LITE mission. E2S: The original backscatter profile used to feed the end-to-end simulator, SCA: results from the so-called Standard Correct Algorithm (SCA), Err.est.: Retrieved error estimate. Courtesy: P. Martinet (MétéoFrance).*

4.3.6 Auxiliary files

As described in sections 4.3.4 and 4.3.5, the L2A and L2B data processors make further corrections w.r.t. instrument transmission, responses and channel crosstalk (AUX_CAL), the Rayleigh-Brillouin scattering broadening of the backscattered signal (AUX_RBC) using a priori temperature and pressure information (AUX_MET) and a priori lidar ratio information (AUX_CLM). These corrections require a set of auxiliary files produced by the ECMWF NWP model, a dedicated calibration processor called the Calibration Suite running in the Aeolus Calibration and Monitoring Facility (ACMF) in ESA-ESRIN, and forward model simulations. The Aeolus auxiliary files used during the L2 processing listed in Table 4.3.6-1.

AUX file name	Generated by	Content
AUX_PAR_2A	PDGS	Generated with input from Aeolus L1/2 Algorithm Development Team (L1/2 ADT) / DISC
AUX_PAR_2B	PDGS/ECMWF	Generated with input from Aeolus L1/2 ADT / DISC
AUX_MET_12	Aeolus AUX_MET processor within the ECMWF Integrated Forecast System (IFT)	Forecasted temperature and pressure information at the (predicted) location of the Aeolus L1B observations. Predicted locations are used in the case of late L1B arrival at the Aeolus L2B processing facility at ECMWF
AUX_RBC_L2	Aeolus AUX_CSR processor at the ACMF	Look-up-table of Rayleigh responses corresponding to atmospheric temperature and pressure combinations
AUX_CAL_L2	Aeolus AUX_CSR processor at the ACMF	Calibration coefficients defining the instrument transmissions for the Mie and Rayleigh channels (K_{Ray}, K_{Mie}) Calibration coefficients defining the atmospheric Mie and Rayleigh backscatter contributions to the measured Rayleigh and Mie signals (C_1, C_2, C_3, C_4) Spectral transmission characteristics of the Fabry-Perot and Fizeau interferometers (T_A, T_B)
AUX_CLM_L2	Forward model simulations performed by Aeolus L2B algorithm team, KNMI	Global map of extinction-to-backscatter ratios based on climatological information

Table 4.3.6-1*: Auxiliary files used in the Aeolus L2A and L2B processing together with the L1B product.*

4.4 Data downlink, processing and distribution

The raw measurement data is received by the ground stations and submitted to the Aeolus data processing centres. These are located in Tromsø (Norway), Reading (United Kingdom) and Frascati (Italy). Data processing up to L1B is done in Tromsø. Processing up to L2B and L2c is done by ECMWF, and further data monitoring, calibration and the data distribution (all product levels) is done by ESA-ESRIN in Frascati (see Figure 4.4-1).

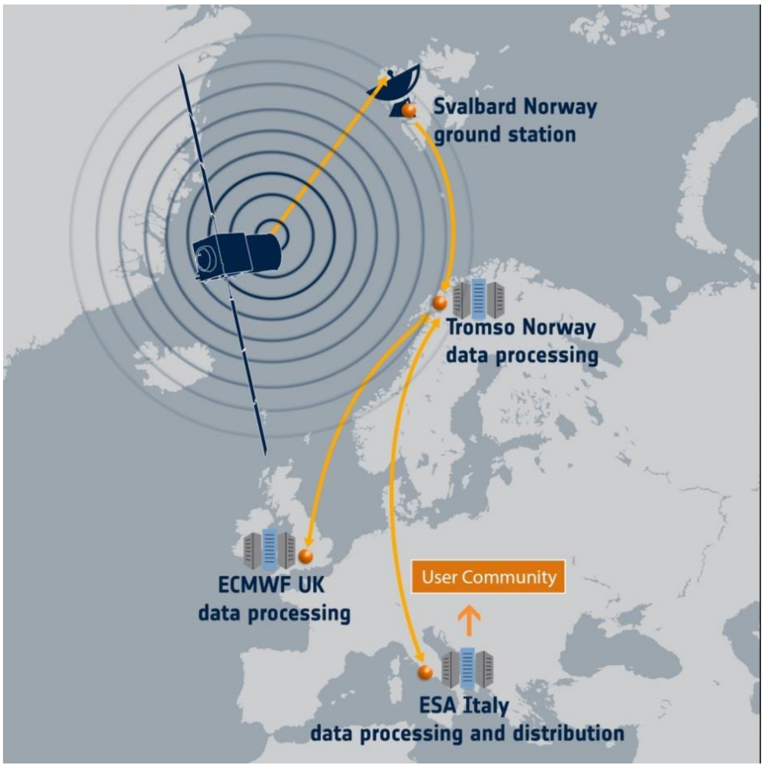


Figure 4.4-1: *Illustration of the Aeolus data downlink and data processing facilities*

The data are made available to the users on the Aeolus Online Data dissemination page via the "ESA Earth Online" web site, http://aeolus-ds.eo.esa.int/oads/access/. The Aeolus data user interface is illustrated in Figure 4.4-2.

The Aeolus CAL/VAL teams (ACVT) will be given exclusive access to early Aeolus data during the satellite commissioning phase (first 3 months in orbit). The access to the Aeolus database will be provided at a time decided by the Aeolus project, pending the speed of the satellite and instrument commissioning and Aeolus data quality.

Only after the initial CAL/VAL activities have been completed and the data have been declared to be of sufficient quality, the Aeolus data will be released and fully available to any party around the world. This normally takes place after the first CAL/VAL and Science workshop, which is scheduled during the last week of March 2019.

To access the data, the user needs to register by requesting an ESA Single Sign On account (ESA SSO). The instructions for requesting this is provided here:

https://earth.esa.int/. Registration for ESA Single Sign On is provided in the top right corner.

During the initial CAL/VAL phase, a list of CAL/VAL team members is provided to the Aeolus PDGS manager, who will grant access to the CAL/VAL team members as soon as they have registered and successfully requested an ESA SSO account.

Aeolus data can be ordered either by using the web interface and selecting data, or through automatic data down-load.

For manual data selection, follow the instructions as described in the Help button on the upper left of the web page.

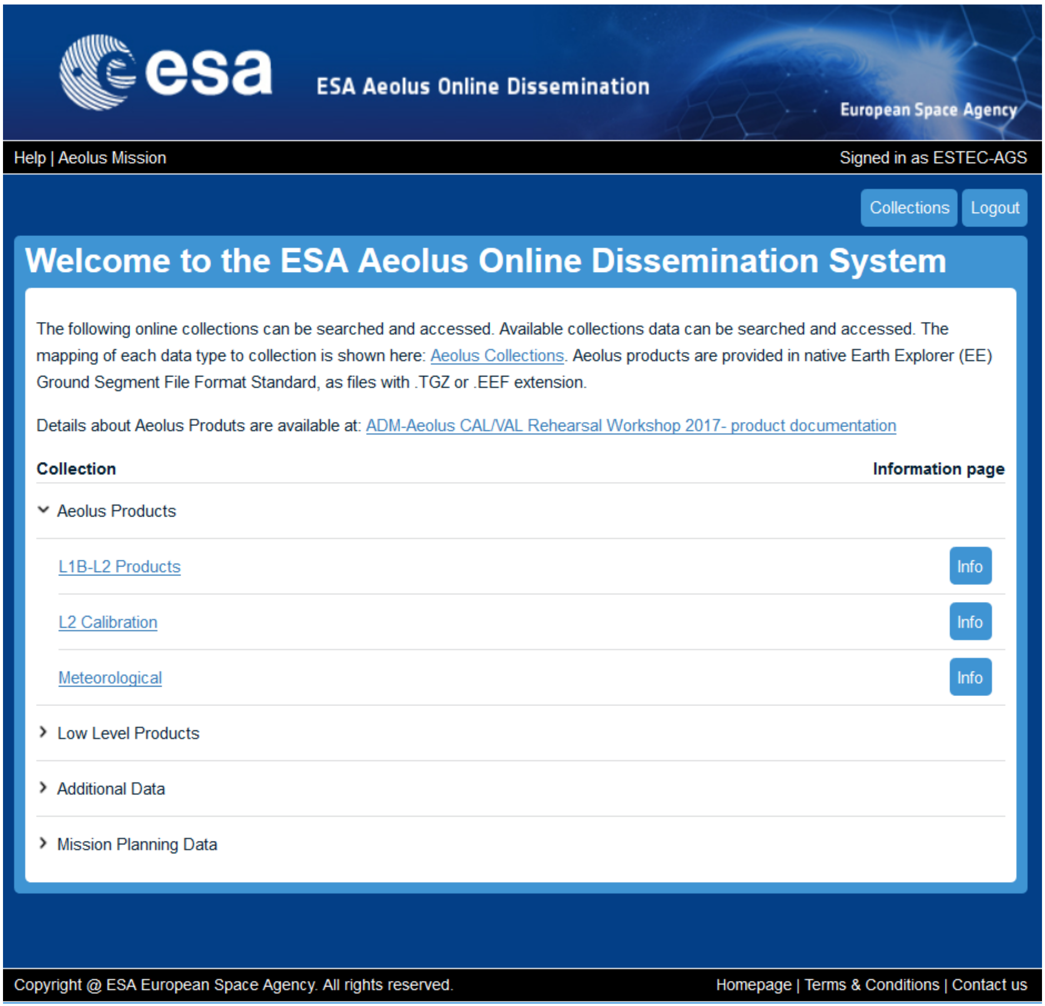


Figure 4.4-2: *Illustration of the ESA web site for the ordering of Aeolus data (https://aeolus-ds.eo.esa.int/oads/access/).*

For automatic data download, any ftp client of choice may be used. The help pages (https://aeolus-ds.eo.esa.int/aeolus/faq.html) present various options for downloading the Aeolus products in bulk, e.g.:

- Download via FTP
- Advanced query and download via command line

The ordering of Aeolus data automatically using FileZilla is illustrated in Figure 4.4.3.

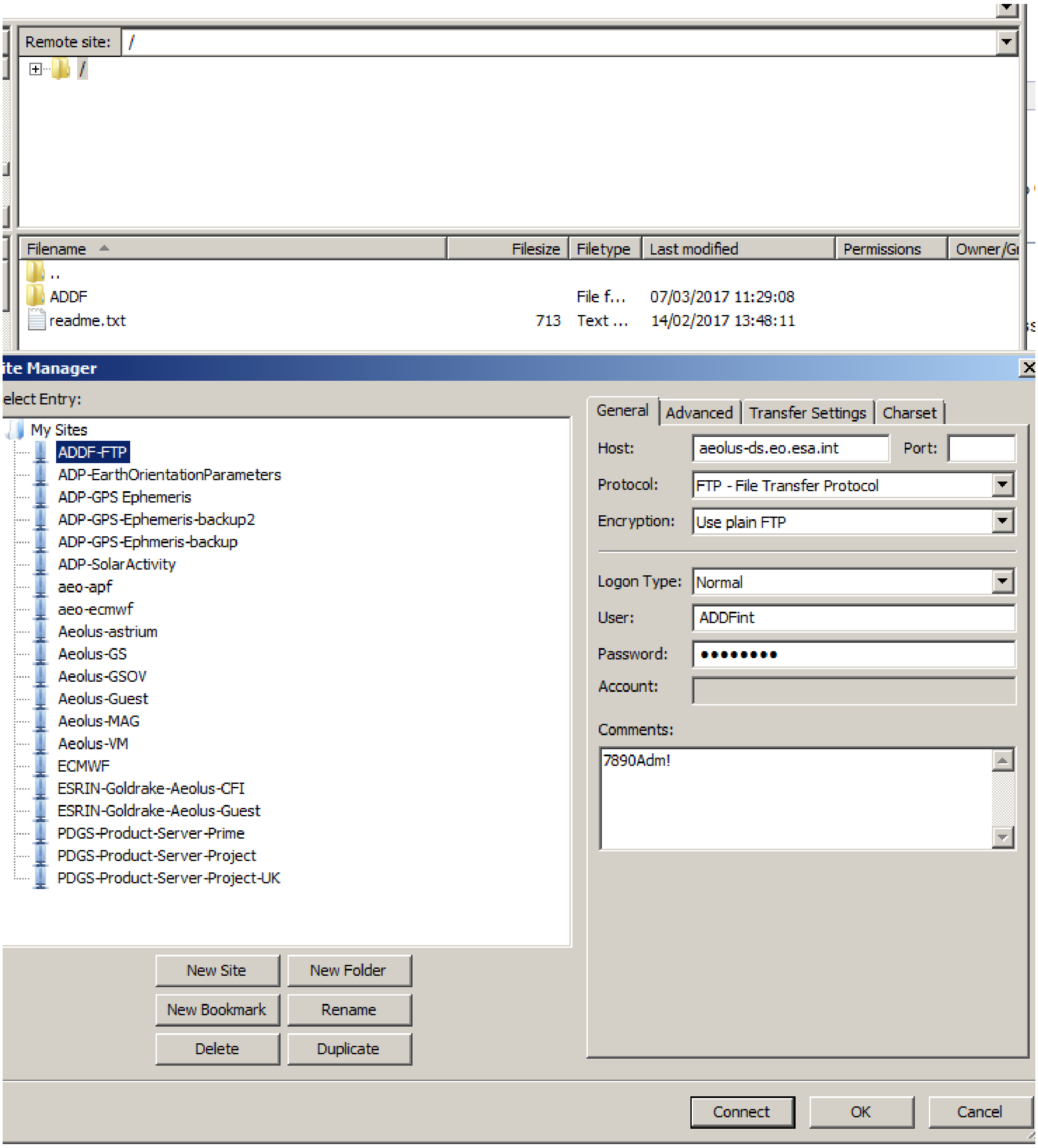


Figure 4.4.3: *Ordering Aeolus data using FileZilla ftp client and an ESA SSO example user and password.*

5 THE AEOLUS MISSION ORGANIZATION

Aeolus is an ESA Earth Explorer Mission, and it is led by the ESA Aeolus Project in ESA-ESTEC for the definition, implementation and in-space commissioning phases (phases C/D/E1). In the mission exploitation and post-deorbiting phase (phases E2 and F), the mission is led by the Mission Manager in ESA-ESRIN.
The Aeolus project elements at ESA are organised as outlined in Figure 5-1.

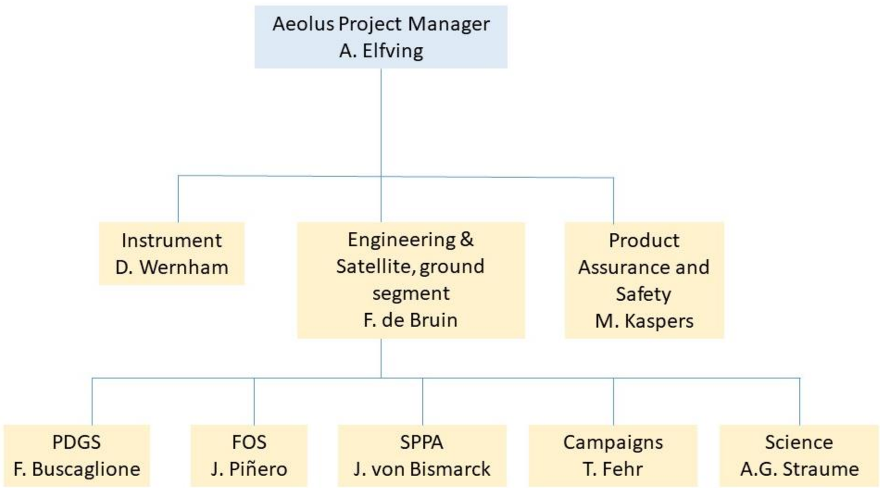


Figure 5-1: *ESA Aeolus Project organization, phase C/D/E1 until January 2019. Project control and contracts is not shown. PDGS: Payload Data Ground Segment, FOS: Flight Operations Segment, SPPA: Sensor Performance, Products and Algorithms. The names of the activity managers are listed.*

After the satellite commissioning, the Aeolus Mission is handed over from the Aeolus Project Manager in ESTEC to the Aeolus Mission manager in ESRIN. The Aeolus Mission elements at ESA in phase E2 (operational) and F (post operational) are organised as shown in Figure 5-2.

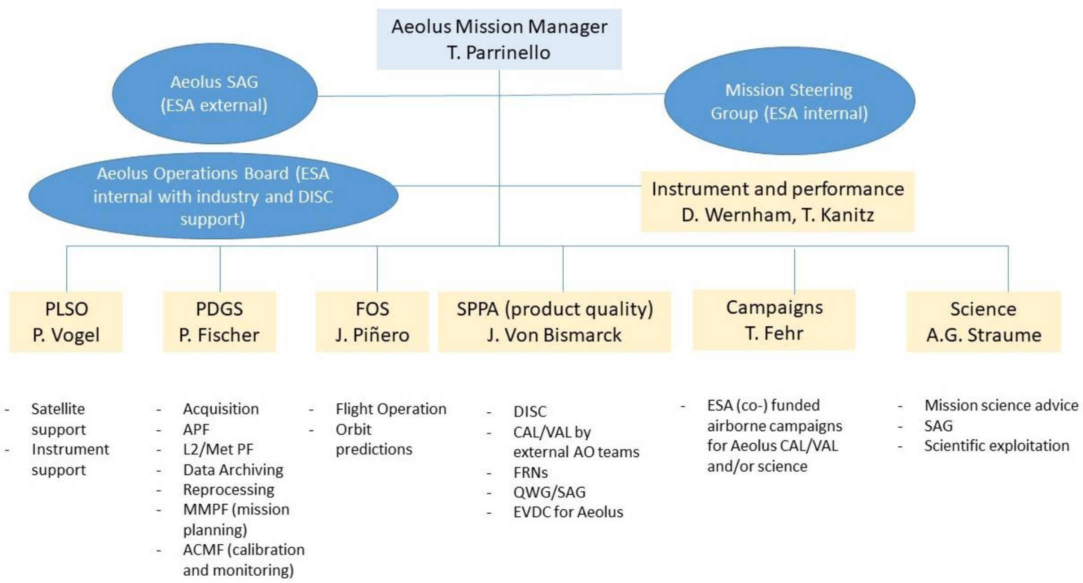


Figure 5-2: *ESA Aeolus Mission organization, Phase E2 from February 2019. PSLO: Post-launch Support Office, PDGS: Payload Data Ground Segment, FOS: Flight Operations Segment, SPPA: Sensor Performance, Products and Algorithms. The names of the activity managers are listed.*

6 AEOLUS PRODUCT VALIDATION

6.1 Product requirements

The Aeolus Mission requirements are listed in [AD 1], and are summarized in Table 5.1-1. A number of these requirements shall be addressed and evaluated with pass/fail criteria in the Aeolus CAL/VAL work. The requirements to be addressed by the ASCV IP are MR-50, MR-90, MR-95, MR-100, MR-110, MR-120 and MR-130, MR-140 and MR-150. Recommendations for mission operation regarding MR-85, MR-60, MR-80, MR-70 and MR-160 may also be provided by the ASCV Team.

Requirement ID			Observation Requirements		
			PBL	Troposphere	Stratosphere
MR-85	Vertical Domain	[km]	0-2	2-16	16-20 (30)*
MR-60	Vertical Resolution	[km]	0.5	1.0	2.0
MR-80	Horizontal Domain		Global		
MR-70	Number of Profiles (sampling)	[hour^{-1}]	>100		
MR-150	Minimum horizontal track data availability	[%]	95		
MR-75	Temporal sampling	[hour]	12		
MR-50	Horizontal observation size	[km]	15 (goal) – 100 (threshold)		
MR-50	Horizontal measurement size	[km]	3 km		
MR-110	Precision (HLOS Component)	[m/s]	1	2.5	3* (3-5)*
MR-100	Systematic error (HLOS component)	[m/s]	0.7		
MR-90&95	Dynamic Range, HLOS	[m/s]	±100 (150)**		
MR-120	Error Correlation (per 100 km and between adjacent vertical bins)		< 0.1		
MR-130	Probability of Gross Error	[%]	5		
MR-140	Timeliness	[hour]	3		
MR-160	Length of Observation Dataset	[yr]	3		

Table 6.1: *Observational requirements of the Atmospheric Dynamics Mission Aeolus for a realistic (heterogeneous) atmosphere. ()*: Desirable, (i) atmospheric sampling from the surface up to 20 km altitude is required whereas sampling up to 30 km is highly desirable, (ii) above 16 km there is no formal requirement on the HLOS precision, but a precision of 3 m/s between 16 and 20 km and 3-5 m/s between 20 and 30 km is desirable. ()**:Wind observation performance requirements are linked to a dynamic range of +/-100 m/s, wind observations shall not saturate up to +/-150 m/s.*

6.2 Scientific Calibration and Validation requirements

The Aeolus Scientific CAL/VAL requirements are linked to the mission requirements, and are listed in [AD 2], and available at https://earth.esa.int/aos/AeolusCalVal and https://www.aeolus.esa.int/.

The calibration and validation of the Aeolus satellite instrument Aladin is during commissioning phase addressed by five parties as listed in [AD 3].

- Industry (Airbus Defence and Space and subcontractors) [RD 18]
- The project Support team at ESA and the Aeolus L1/2 Algorithm Development Team (L1/2 ADT) under ESA contract [RD 13]
- The Aeolus L2B team [RD 14]

- CAL/VAL Team (as described in this document)
- Aeolus campaigns (section 8 of this document)

In phase E2, the Aeolus calibration and validation related activities are addressed by the following four parties:

- The ESA Post Launch Support Office (PSLO) and their ESA internal and industrial contracts
- The Aeolus DISC (called L1/2 ADT in phase C/D and EDAFECS in phase E1)
- CAL/VAL Team (as described in this document)
- Aeolus campaigns (section 8 of this document)

A summary of the CAL/VAL requirements to be addressed by the CAL/VAL teams are listed here. The requirements are linked to the Scientific CAL/VAL technique requirements listed in [AD 2], and for completeness it is also mentioned when these are addressed by [RD 13] (L1/2 ADT/EDAFECS/DISC), [RD 14] (DISC / ECMWF), and [RD 18] (Airbus Defence and Space, ADS).

The Aeolus CAL/VAL requirements can be divided in roughly two main categories;

- imperfections in the measurement system leading to errors in the L1B and/or calibration data
- imperfections in the knowledge of the atmosphere impacting the L2 product retrieval and product representativeness.

The first category is mainly characterized by calibration, and the second category by validation. However, in practice such a division is not straightforward since the verification of a L2 product requires a characterization and combination of the errors from the instrument, retrieval and atmospheric variability.

Nu	Error Source / Parameter / Functionality for verification	Scientific CAL/VAL Requirement ref. [AD 2]	[RD 18] ADS [RD 13] Edafecs [RD 14] ECMWF	Description
	Data access			
CVR-1	Aeolus data access	-	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Access to APF Access to ESA Aeolus Data Dissemination Facility (ADDF) during CAL/VAL rehearsal and upon commissioning data release
CVR-2	Access, data upload and download to the ESA atmospheric Validation Data Centre (EVDC)	-	[RD 18]: - [RD 13]: - [RD 14]: -	Request and test access EDVC Upload CAL/VAL team collocated datasets
	Instrument characterization, calibration and L1B processing			
CVR-3	Radiometric characterization	SCVR_wind-3 SCVR_OptP-3 Campaigns_DQO-1	[RD 18]: - [RD 13]: Yes [RD 14]: -	Budget of emitted and received energy for internal and atmospheric path. For atmospheric path using NWP information and experimental aerosol characterisation by aircrafts and from ground
CVR-4	Aladin optical transmission characterization and trends	SCVR_wind-3 SCVR_OptP-3 Campaigns_DQO-1	[RD 18]: Yes [RD 13]: Yes [RD 14]: Yes	Aeolus L1/2 ADT, DISC and calibration teams using internal and atmospheric path IAT and ISR measurements
CVR-5	Spectral Response Calibration	SCVR_wind-3 SCVR_OptP-3 Campaigns_DQO-1 Campaigns_DQO-3	[RD 18]: Yes [RD 13]: Yes [RD 14]: Yes	Investigation of RRC and MRC data by L1B algorithm expert teams NWP monitoring of L2 product quality after ingestion of updated RBC Collocated instrument calibrations A2D
CVR-6	Zero-wind calibration / harmonic bias correction	SCVR_wind-3 Campaigns_DQO-3	[RD 18]: Yes [RD 13]: Yes [RD 14]: Yes	L2 product monitoring by NWP models Airborne wind profile measurements in Arctic / Antarctic and along orbits Ground-based wind profile measurements in Arctic / Antarctic and along orbits
CVR-7	Range-dependent biases	SCVR_wind-3 SCVR_OptP-3 Campaigns_DQO-3	[RD 18]: Yes [RD 13]: Yes [RD 14]: Yes	Analysis of dedicated RDB measurements by algorithm expert teams, NWP L2B product monitoring, Ground based wind profile measurements, Airborne wind profile measurements

CVR-8	Characterization of systematic LOS miss-pointing errors	SCVR_wind-3 Campaigns_DQO-1	[RD 18]: Yes [RD 13]: Yes [RD14]: Yes	Analysis of ground echo measurements from controlled miss-pointing
CVR-9	Characterization of laser frequency stability	SCVR_wind-3	[RD 18]: Yes [RD 13]: Yes [RD14]: -	Analysis of Mie signal from internal reference
CVR-10	Laser pulse energy stability	SCVR_wind-3 SCVR_OptP-3	[RD 18]: - [RD 13]: Yes [RD14]: -	Analysis of Aladin HKTM data and signal strength
CVR-11	Optimization of offset pointing angle for nadir viewing	SCVR_wind-3	[RD 18]: Yes [RD 13]: - [RD14]: -	Analysis of ground echo data for variable ground targets and offset angles
CVR-12	Terrain model verification	SCVR_wind-1 SCVR_wind-3 Campaigns_DQO-3	[RD 18]: Yes [RD 13]: Yes [RD14]: -	Verify terrain model LUT by comparison to ground echo heights using LOS miss-pointing information
CVR-13	L1B calibration verification and optimization	SCVR_wind-3 SCVR_OptP-3	[RD 18]: Yes [RD 13]: Yes [RD14]: Yes	Analysis of routine calibration data inspecting error information and comparing with on-ground characterization and simulations. Optimize algorithm settings and threshold parameters (e.g. ground return processing, “Mie ground for Rayleigh or Rayleigh ground for Rayleigh”, suitable targets (e.g. land, ocean, , geographical and altitude regions))
CVR-14	Calibration cycle optimization	SCVR_wind-3 SCVR_OptP-3	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Trend analysis of calibration and recommendations for optimization of calibration cycles
CVR-15	Verification, optimization and validation of ACMF calibration (AUX_CAL, AUX_RBC, AUX_CSR)	SCVR_wind-3 SCVR_OptP-3	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Analysis of processed calibration (random and systematic errors) data
CVR-16	Verification and validation of Aeolus L1B processing and NRT delivery	SCVR_wind-3 SCVR_OptP-3	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Data collection from APF, analysis of L1B key parameters (geolocation data, Mie/Rayleigh results, ground echo data) and comparison to expected results
CVR-17	L1B error budgets	SCVR_wind-3 SCVR_OptP-3	[RD 18]: Yes [RD 13]: Yes [RD14]: Yes	Analysis of instrument related random and systematic error sources, analysis of ground returns, analysis of unconsolidated winds, atmospheric returns etc.

CVR-18	Optimization of Aeolus observation strategies	SCVR_wind-1 SCVR_OptP-1	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Assessment of Aeolus operation and planning for **wind and calibration mode** including spatial and vertical sampling, geographical target areas for calibration, etc.
	Aeolus wind product (L2B)			
CVR-19	Verification of L2B processor speed for NRT processing of Aeolus L2B data	Aeolus SCVR_wind-5 CAL/VAL techniques	[RD 18]: - [RD 13]: - [RD14]: -	NWP centres doing L2B processing for NRT assimilation The L2B NRT delivery requirement is verified by the Aeolus PDGS
CVR-20	L2B wind random errors	SCVR_wind-1 SCVR_wind-2 SCVR_wind-3 SCVR_wind-5 SCVR_wind-6 SCVR_wind-7 Campaigns_DQO-4 Campaigns_DQO-5 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: Yes	NWP monitoring Ground-based observations Airborne observations Satellite-based observations Alternative retrieval algorithms
CVR-21	L2B wind total systematic errors	SCVR_wind-1 SCVR_wind-2 SCVR_wind-3 SCVR_wind-5 SCVR_wind-6 SCVR_wind-7 Campaigns_DQO-4 Campaigns_DQO-5 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: Yes	NWP monitoring Ground-based observations Airborne observations Satellite-based observations Alternative retrieval algorithms
CVR-22	L2B algorithm processor settings and auxillary information verification	SCVR_wind-2 Campaigns_DQO-3	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Analysis of L2B algorithm processor settings and Auxiliary input files used to optimize L2B data quality. This shall include e.g investigations to optimize the scene classification, auxiliary file input, wind processing algorithm steps etc. The different data processing options shall be compare with expected results e.g. from collocated data or weather models.
CVR-23	L2B algorithm performance – scene classification	SCVR_wind-2 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Aeolus L1/2 ADT, DISC Non-operational L2B retrieval products NWP product monitoring Comparison with collocated observations

CVR-24	L2B algorithm performance - Imperfect signal cross-talk correction	SCVR_wind-2 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Aeolus L1/2 ADT, DISC CAL/VAL NWP centres doing own L2B retrieval Comparison with collocated observations
CVR-25	L2B Random and systematic errors due to variability of vertical sampling	SCVR_wind-1 SCVR_wind-2 Campaigns_DQO-4	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Ground-based wind observations Airborne wind observations NWP monitoring and case studies
CVR-26	L2B Random and systematic errors due to variability of horizontal sampling (scene classification scheme)	SCVR_wind-2 SCVR_wind-3 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Aeolus L1/2 ADT, DISC Ground-based wind observations Airborne wind observations NWP monitoring and case studies
CVR-27	Aeolus Vertical and horizontal sampling strategy for wind profiling	SCVR_wind-2 SCVR_wind-2	[RD 18]: - [RD 13]: Yes [RD14]: Yes	Dedicated Aeolus in-orbit sampling campaigns Impact Studies
CVR-28	Aeolus L2B product impact on (global) NWP	SCVR_wind-2 SCVR_wind-5	[RD 18]: - [RD 13]: - [RD14]: Yes	NWP product monitoring and assimilation
	Aeolus aerosol and product (L2A)			
CVR-29	L2A backscatter profile random errors	SCVR_OptP-1 SCVR_OptP-2 SCVR_OptP-3 SCVR_OptP-5 SCVR_OptP-6 SCVR_OptP-7 Campaigns_DQO-2	[RD 18]: - [RD 13]: Yes [RD14]: -	Airborne validation Ground-based validation Satellite intercomparison Air quality model monitoring Intercomparison with independent retrieval algorithms
CVR-30	L2A backscatter profile systematic errors	SCVR_OptP-1 SCVR_OptP-2 SCVR_OptP-3 SCVR_OptP-5 SCVR_OptP-6 SCVR_OptP-7 Campaigns_DQO-2	[RD 18]: - [RD 13]: Yes [RD14]: -	Airborne validation Ground-based validation Satellite intercomparison Air quality model monitoring Intercomparison with independent retrieval algorithms
CVR-31	L2A extinction profile random errors	SCVR_OptP-1 SCVR_OptP-2 SCVR_OptP-3 SCVR_OptP-5 SCVR_OptP-6 SCVR_OptP-7 Campaigns_DQO-2	[RD 18]: - [RD 13]: Yes [RD14]: -	Airborne validation Ground-based validation Satellite intercomparison Air quality model monitoring Intercomparison with independent retrieval algorithms
CVR-32	L2A extinction profile systematic errors	SCVR_OptP-1 SCVR_OptP-2 SCVR_OptP-3 SCVR_OptP-5 SCVR_OptP-6 SCVR_OptP-7 Campaigns_DQO-2	[RD 18]: - [RD 13]: Yes [RD14]: -	Airborne validation Ground-based validation Satellite intercomparison Air quality model monitoring Intercomparison with independent retrieval algorithms

CVR-33	L2A algorithm performance – scene classification	SCVR_OptP-2 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: -	Aeolus L1/2 ADT, DISC Non-operational L2A retrieval products Air quality model product monitoring
CVR-34	L2A algorithm performance - Imperfect signal cross-talk correction	SCVR_OptP-2 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: -	Aeolus L1/2 ADT, DISC CAL/VAL teams doing own L2A retrieval
CVR-35	L2A Random and systematic errors due to variability of vertical sampling	SCVR_OptP-1 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: -	Ground-based aerosol and cloud observations Airborne aerosol and cloud observations Air quality model monitoring and case studies
CVR-36	L2A Random and systematic errors due to variability of horizontal sampling (scene classification scheme)	SCVR_OptP-2 SCVR_OptP-3 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: Yes [RD14]: -	Aeolus L1/2 ADT, DISC Ground-based observations Airborne observations Air quality model monitoring and case studies
CVR-37	Aeolus Vertical and horizontal sampling strategy for aerosol and cloud profiling	SCVR_OptP-1 SCVR_OptP-2 SCVR_OptP-3	[RD 18]: - [RD 13]: Yes [RD14]: -	Dedicated Aeolus in-orbit sampling campaigns Impact Studies
CVR-38	Aeolus L2A impact on global air quality modelling	**Not Required**	**Not required**	Product monitoring and assimilation in air quality models such as CAMS
CVR-39	L2A algorithm performance in atmospheric layers with depolarizing aerosols and/or ice	SCVR_OptP-2 SCVR_OptP-3 Campaigns_DQO-4 Campaigns_DQO-6	[RD 18]: - [RD 13]: - [RD14]: -	Aeolus emitting circularly polarizing light and detecting co-polar backscatter. Ground-based aerosol observations with polarization detection capability. Aerosol models

Table 6.2-1*: Lists the CAL/VAL requirements (CVR-X) as a function of error source for Aeolus Calibration, operation, Aeolus L2A (optical properties product) and L2B (HLOS wind profile) products. The coverage of the requirements by the various industrial, ESA, L1/2 ADT/EDAFECS/DISC, and CAL/VAL partners is listed in Table 5.7.1 and 5.7.2 below.*

6.3 Required CAL/VAL observation types and techniques

Post-launch (Phase E1 and E2):

- **Airborne validation:** Validation by airborne instrumentation (e.g. the A2D, Doppler lidars, radars, dropsondes, backscatter lidars) underflying the satellite, probing the same volume secures good colocation in space and a good but less accurate collocation in time. During overflights, the satellite speed is much higher than the speed of the aircraft, hence the aircraft measurements cannot be perfectly collocated in time during the whole orbit segment that is being underflown. This makes it an important validation tool. Airborne campaigns should cover both different geographical regions and seasons. The maximum altitude of the aircrafts will probably be on the order of 12 (e.g. Falcon) to 15 km (e.g. HALO) as opposed to 30 km probed by Aeolus. In order to probe the atmosphere above an upward viewing port must be used.
- **Ground based validation:** Useful for case studies and temporal monitoring. On short-term, ground based validation is of limited use because of strict collocation criteria [R2]. To compensate for this, it is possible to use ground based measurements to acquire a large number of observations. The lack of representativeness due the sampling of slightly different volumes can then be averaged out. Within the EU project PREVIEW, the capability of launching radiosondes on demand was built in order to take part in campaign activities. This may be an option for dedicated Aeolus CAL/VAL campaigns. Links to relevant WMO and EUMETSAT programmes such as GRUAN (https://www.gruan.org/) and EUMETNET (http://eumetnet.eu/) should be sought. Another option is to make use of mobile systems.
- **Satellite-based observations:** Comparison with other satellite based measurements (ATOVS (mass), scatterometers, AMVs from geostationary and polar orbiting satellites, CALIPSO (if still operational, for cross-talk validation), etc.).
- **NWP monitoring / model studies:** The first comparisons to be made will focus on comparing Aeolus data with the forecast analysis. The model error distribution is relatively well known. NWP monitoring will have to be performed over a certain time span. The first NWP validation may be on a case study basis and run offline. The best way of comparing the Aeolus measurements with other GOS measurements is probably through the assimilation of Aeolus measurements, although the comparison will be biased by the model characteristics. This can only happen after extensive offline comparisons of the Aeolus products with NWP analysis (after a few months in orbit). The statistics (e.g. monthly) will reveal the magnitude of random errors and identify gross errors [AD2].
- **Alternative retrieval algorithms:** Intercomparison of Aeolus operational products with products using different retrieval algorithms and/or auxiliary parameter files (e.g. assumed extinction-to-backscatter ratios, calibration, Rayleigh-Brillouin scattering correction etc.) can be very useful for the studying of product quality and its dependence on a priori information and/or retrieval scheme.

The errors will be a function of the instrument and processing chain. The validation results should feed back into improvements of the processing chain.

6.4 Guidance for comparisons of Aeolus products with collocated data

The comparisons by the CAL/VAL teams should be comparable in order to make general conclusions about the Aeolus data quality base on observations made by the various teams worldwide. A description of the Scientific CAL/VAL requirement techniques are provided in [AD 2].

In this chapter provides an overview of common collocation criteria, data analysis methods, and reporting for the comparison of the Aeolus observations with collocated data. The text is based on panel meetings and plenary discussions at the Aeolus Science and CAL/VAL workshops in 2015, 2017 and 2019. At the workshops, it was agreed that the use of common collocation criteria, analysis methods and reporting are very useful in order to compare CAL/VAL results by the different teams. It was also pointed out that it is very important to provide as complete measurement error information as possible both for Aeolus observations and the collocated observations. Details on the Aeolus data calibration and calculation and provision of the Aeolus L2B product error quantifiers and quality control are provided in [RD 5] – [RD 10]. The teams are therefore encouraged to provide results applying these common agreed guidelines in addition to their own selected analysis and reporting methods.

The Aeolus product sampling is summarised in Table 6.4.1 for the L2A and L2B products

Table 6.4.1: Aeolus L2A product geographical coverage and sampling characteristics.

		PBL	Troposphere	Stratosphere
Vertical Domain	**[km]**	0-2	2-16	16-20 (30)
Vertical Resolution	**[km]**	0.5	1.0	2.0
Horizontal Domain		global		
Number of Profiles	**[hour^{-1}]**	>100		
Horizontal Integration Length	**[km]**	<100		
Horizontal Sub-sample Length	**[km]**	≤3 km		
Length Observational Data Set	**[yr]**	3		

The summaries of the Aeolus CAL/VAL and Science Workshops are available here:

http://www.aeolus-science-calval-2015.org/
http://www.aeolus-calval-2017.org/
http://www.aeolus-science-calval-2019.org/

The guidelines are provided separately for the wind (L2B, section 6.4.1) and Aerosol and cloud (L2A, section 6.4.2) products.

6.4.1 *Collocation criteria, analysis and reporting for comparison wind product with collocated data*

Collocation criteria:
The correlation criteria for the comparison of Aeolus L2B wind observations with collocated data was discussed at the Aeolus CAL/VAL Rehearsal Workshop in Toulouse 2017 in the Splinter Working Group Panel B, and are provided in the Panel B discussion summary (https://earth.esa.int/web/sppa/meetings-workshops/aeolus-2017/programme)

The following criteria were suggested for the comparison of the Aeolus L2B wind observations with collocated data. They have been further amended by suggestions after ESA review (e.g. 1st column Table 6.4.1-1, 4th column of Table 6.4.1-2) and collocation criteria recommendations provided at the 2019 workshop CAL/VAL plenary session.

Table 6.4.1-1: *Suggested common collocation criteria for the comparison of collocated observation for comparison with Aeolus L2B wind data*

Criteria	**Planetary Boundary Layer (0-2 km)**	**Free-Troposphere (2-16 km)**	**Stratosphere (16-30 km)**
Space, horizontal	Goal: 50 km Threshold: 100 km	100 km	100 km
Space, vertical	250 m centred around the Aeolus bin centre	500 m centred around the Aeolus bin centre	500 m centred around the Aeolus bin centre
Time	Goal: 15 minutes centred around the overpass Threshold: 1 hour centred around the overpass	1 hour centred around the overpass	1 hour centred around the overpass

It is further recommended to request special vertical sampling during Aeolus campaigns. CAL/VAL and campaigns PIs may request special Aeolus vertical sampling as detailed in Section 12 below.

Data analysis methods:

The L2B wind product CAL/VAL requirements to be addressed by the ASCV Team are listed in Table 6.2-1. Further to this table, the following points were out-lined at the Aeolus CAL/VAL workshops for attention of the CAL/VAL teams:

The CAL/VAL teams are asked to address the spatial and temporal representativeness of the Aeolus observations and the validation dataset. For example, the spatial representativeness of image tracking cloud-top winds and Aeolus Mie cloudy winds may differ largely in cases with large wind shear or vertical motion. A careful assessment and description on how to compare the two, within which error margins, and the use of the results, shall be reported.

The CAL/VAL teams are asked to address possible differences in information content of the Aeolus and collocated observations. For example, care shall be taken to pick the most representative Aeolus data product (Rayleigh clear or Mie cloudy) when comparing with collocated particle or clear air wind observations.

CAL/VAL PIs were asked to take the following into particular consideration:

- When comparing the Aeolus L2B HLOS winds with collocated observations, the collocated vector winds need to be projected onto the Aeolus LOS before comparison. This is explained under in the Wind Product L2B/C Discussion page on the CAL/VAL wiki, L2B CalVal Comparison, ID CC_CV_2B_003. See also the discussion at the bottom of this page, and the link to the document at the ECMWF Aeolus wiki page with further explanations of the mathematical approach.
- For Aeolus wind product validation, the L2B product shall be use. The Level 1B product is preliminary and does not contain the necessary correction for the atmospheric temperature broadening of the Rayleigh atmospheric backscatter
- Consistent QC filters should be used. The L2B product error quantifier has been found to be very robust and of the good order of magnitude (based on NWP O-B statistics). An inflation of the L2B EQ errors are provided on the Aeolus CAL/VAL wiki page.

Table 6.4.1-2: *Suggested classification of the CAL/VAL statistics in order to address Aeolus Scientific CAL/VAL Requirements*

Cal/Val Requirement (CVR) addressed	**Aeolus data to be considered, horizontal**	**Aeolus data to be considered vertical**	**Wind speed regimes**
Random errors: CVR-20 Not ACVT core task but where ACVT output can help: CVR-9, CVR-23, CVR-24, CVR-25, CVR-26	Mie cloudy Rayleigh clear Orbit phase (ascending, descending) Zonal data (70N-90N) Zonal data (20N-70N) Zonal data in Tropics (+/- 20 degrees N/S) Zonal data (20S-70S) Zonal data (70S-90S) Global statistics	Below 700 hPa 700 hPa – 400 hPa Above 400 hPa All altitudes	All wind speeds Zonal Winds (Easterly, Westerly) +- 10 m/s 10-50 m/s 50-100 m/s > 100 m/s
Systematic errors: CVR-21 Not ACVT core task but where ACVT output can help: CVR-6, CVR-7, CVR-8, CVR-9, CVR-14, CVR-15, CVR-23, CVR-24, CVR-25, CVR-26	Mie cloudy Rayleigh clear Orbit phase (ascending, descending) Zonal data (70N-90N) Zonal data (20N-70N) Zonal data in Tropics (+/- 20 degrees N/S) Zonal data (20S-70S) Zonal data (70S-90S) Global statistics	Below 700 hPa 700 hPa – 400 hPa Above 400 hPa All altitudes	Wind-speed dependent biases (slope errors)

The CAL/VAL teams are asked to assess, where possible, Aeolus observation error correlations. As outlined in [A1], it is expected that the Aeolus observation errors are not correlated provided that the laser frequency jitter is close to the system specifications. However, it is important to flag possible observation error correlations, should this be found, since this is of importance to the use of the data in NWP.

The CAL/VAL teams are asked to assess carefully the spatial or temporal accumulation or averaging of the Aeolus or collocated model fields or measurements before comparisons. Spatial and temporal averaging of measurement remove small-scale variability, which will affect the calculated random and systematic error estimates. A careful trade-off whether averaging or a nearest-neighbour approach is more representative shall be performed.

Provision of collocated data and reporting of CAL/VAL results:

The CAL/VAL Teams are expected to provide systematic and random error estimates for the collocation measurements as well as a description and discussion of differences in information content w.r.t. the Aeolus observations.

- Results from collocated observations and Aeolus observations shall be presented together with error bars (Aeolus: found in the L2B product EQ field)
- Consistent QC filters shall be applied (for Aeolus it shall be based on the reported EQs and recommendations provided on the Aeolus CAL/VAL wiki)

These analysis should be presented in the CAL/VAL reports and presentations.

The Aeolus 2017 workshop Panel B recommended to provide collocated reference data to the EDVC within 7 days for raw data and within 1 month for quality controlled data.

6.4.2 *Collocation criteria, analysis and reporting for comparison optical properties product with collocated data*

The correlation criteria for the comparison of Aeolus L2A atmospheric optical properties observations with collocated data was discussed at the Aeolus CAL/VAL Rehearsal Workshop in Toulouse 2017 in the Splinter Working Group Panel C, and are provided in the Panel C discussion summary (https://earth.esa.int/web/sppa/meetings-workshops/aeolus-2017/programme)

The following collocation criteria were suggested for the comparison of the Aeolus L2A atmospheric optical properties observations with collocated data (Table 6.4.2-1). They have been further amended by suggestions after ESA review and collocation criteria recommendations provided at the 2019 workshop CAL/VAL plenary session.

Table 6.4.2-1: *Suggested common collocation criteria for the comparison of collocated observation for comparison with Aeolus L2A atmospheric optical properties observations*

Criteria	**Planetary Boundary Layer (0-2 km)**	**Free-Troposphere (2-16 km)**	**Stratosphere (16-30 km)**
Space, horizontal	100 km	100 km	100 km
Space, vertical	250 m centred around the Aeolus bin centre	500 m centred around the Aeolus bin centre	500 m centred around the Aeolus bin centre
Time	150 minutes centred around the overpass	150 minutes centred around the overpass	150 minutes centred around the overpass

In addition, figure 6.4.2-1 shows the recommended collocation technique with the help of trajectory analysis.

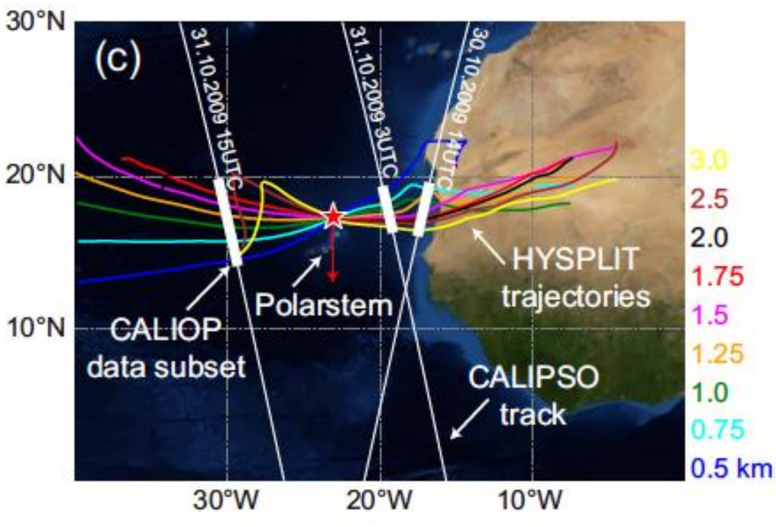


Figure 6.4.2-1: Recommended trajectory analysis for data selection.

Data analysis methods:

The L2A atmospheric optical properties product CAL/VAL requirements to be addressed by the ASCV Team are listed in Table 6.2-1. Further to this table, the following points were out-lined at the Aeolus CAL/VAL workshops for attention of the CAL/VAL teams.

The CAL/VAL teams are asked to address the spatial and temporal representativeness of the Aeolus observations and the validation dataset. For example, the spatial and temporal homogeneity of an aerosol or cloud layer matters for the comparison of observations by Aeolus and the collocated model field or instrumentation. A careful assessment and description on how to compare the two, within which error margins, and the use of the results, shall be reported.

An image of typical Aerosol type global distributions and Aeolus CAL/VAL stations (status March 2017) was presented at the 2017 CAL/VAL workshop Panel C. This map (Figure 6.4.2-2) can be used as a guideline for the CAL/VAL proposal analysis.

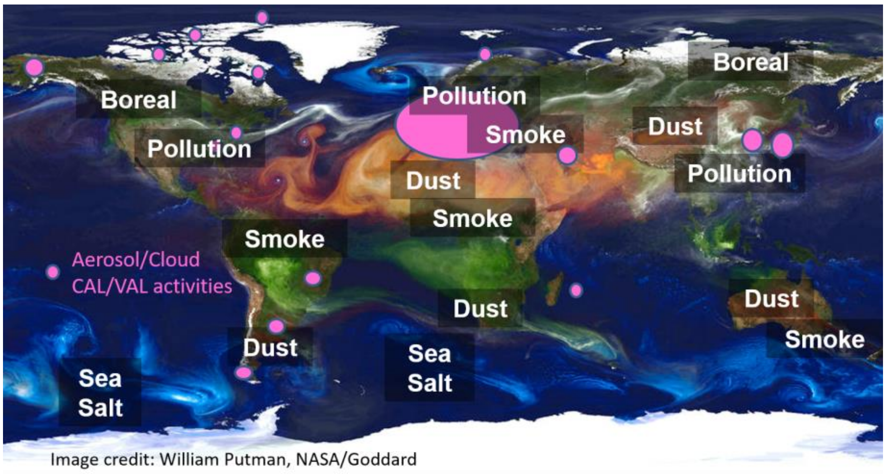


Figure 6.4.2-1: *Typical global aerosol distributions, overlaid on an image by W. Puttman (NASA/Goddard).*

The CAL/VAL teams are asked to address possible differences in information content of the Aeolus and collocated observations. For example, the ASVC Team shall consider the following;

- Special care shall be taken to pick the most representative Aeolus data product (SCA or MCA) when comparing with different types of collocated lidar instruments and retrieval methods.
- In case an a priori lidar ratio is used, it should be assessed how representative it is expected to be and whether different assumptions are used for the Aeolus and collocated data.
- Spectral dependencies in the backscatter and extinction coefficients shall be considered.
- Aeolus emits circularly polarized light, and detects the parallel-polarized part of the atmospheric backscatter. This means that Aeolus will measure less backscatter in and below strongly polarizing atmospheric layers.
- Multiple scattering is not taken into account in the Aeolus L2A processing. This effects the product in and below cirrus clouds.
- Possible surface contamination of observations in the lowest Aeolus atmospheric bin shall be assessed

- The low vertical resolution of Aeolus L2A observations, and the provision of backscatter and extinction coefficient products on observation (87 km horizontal averaging) and sub-observation (< 87 km, including scene classification) scale

The CAL/VAL teams are asked to assess carefully the spatial or temporal accumulation or averaging of the Aeolus or collocated model fields or measurements before comparisons. Spatial and temporal averaging of measurement remove small-scale variability, which will affect the calculated random and systematic error estimates. A careful trade-off whether averaging or a nearest-neighbour approach is more representative shall be performed.

The CAL/VAL teams are asked to assess, where possible, Aeolus observation error correlations. As outlined in [A1], it is expected that the Aeolus observation errors are not correlated. However, it is important to flag possible observation error correlations, should this be found, since this is of importance to the use of the data in air quality models.

Table 6.4.2-2 lists expected overall uncertainties in the Aeolus L2A products as provided in [R 15]. This table may be taken as a guideline for the expected L2A product accuracies when preparing the validation activities. When assessing the product errors, the effectiveness of the following algorithm steps shall be investigated:

- Channel cross-talk correction (the L2A product contains cross-talk corrected useful signals)
- The correction for the frequency shift caused by the atmospheric wind speed in the view direction
- The effectiveness of the calculation of the Rayleigh-Brillouin line broadening

Table 6.4.2-2: *Expected overall uncertainties in the retrievable quantities considering input uncertainties, statistical errors, depolarization, and multiple scattering effects, and that cirrus cloud depth is typically <3 km. Only uncertainties < 50% are listed. PBL: planetary boundary layer, FT: free troposphere, CI: Cirrus, SA: volcanic stratospheric aerosols, PSC: polar stratospheric clouds. From [R 15].*

Layer (ext. value)	**$\delta\beta_a/\beta_a$ Backscatter**	**$\Delta\sigma_a/\sigma_a$ Extinction**	**$\delta OD/OD$ Optical Depth**	**$\delta S_a/S_a$ lidar ratio**	**$\delta S_{col}/S_{col}$ Column lidar ratio**
PBL (σ_a = 200 Mm^{-1})	10%	15%	10%	20%	15%
FT (σ_a = 50 Mm^{-1})	15%	30%	20%	35%	25%
DUST (σ_a = 100 Mm^{-1})	15%	20%	15%	25%	20%
CI (σ_a = 200 Mm^{-1})	25%	-	25%	-	35%
SA (σ_a = 10 Mm^{-1})	15%	-	-	-	-
PSC (σ_a = 20 Mm^{-1})	30%	-	-	-	-

The product errors at different altitudes may also be assessed as a function of atmospheric scene. Typical aerosol and cloud study cases are listed in Table 6.4.2-3.

__Table 6.4.2-3__: Suggested aerosol and cloud cases for Aeolus CAL/VAL

Scene type	PBL	FA	Strat
Cirrus clouds		X	
Polar stratospheric clouds			X
Elevated dust layer		X	
Biomass burning layer	X	X	X
Mixed continental aerosol	X	X	
Clean marine aerosol	X		
Stratospheric aerosol (e.g. volcanic ash)			X

Provision of collocated data and reporting of CAL/VAL results:

The CAL/VAL Teams are expected to provide systematic and random error estimates for the collocation measurements as well as a description and discussion of differences in information content w.r.t. the Aeolus observations. These analysis should be presented in the CAL/VAL reports and presentations.

It is recommended to make use of existing quality assurance strategies, e.g. as implemented in EARLINET/ACTRIS. This includes the LICAL calibration facility. It is noted that this is now also introduced in Lalinet.

It is recommended to make use of existing data formats and protocols, and that data harmonization is done by EVDC.

6.5 Grouping and/or coordination of the Aeolus CAL/VAL activities

At the 2015 Aeolus Science and CAL/VAL Workshop it was suggested that the proposed validation activities are grouped in order to form smaller validation teams that will exchange comparable validation results on a more frequent basis. This also facilitates the overall evaluation of the validation results.

So far the following three Aeolus CAL/VAL activity groups have been formed:

Aeolus NWP Impact Assessment working group
The Aeolus NWP Impact Assessment working group contains the ASCV Team members performing impact experiments. The first meeting of this group was held in ESA-ESOC, Darmstadt, on 12 September 2019. The next meeting is planned during the 2020 Aeolus CAL/VAL and Science Workshop, followed by a working meeting in September 2020. See also section 13.1 below.

Aeolus aerosol validation working group
During the 2019 Aeolus CAL/VAL and Science workshop, a working group on the Aeolus L2A product quality formed and held a first splinter meeting. A further small telecon with some CAL/VAL partners is planned for December 2019. The next meeting is planned during the 2020 Aeolus CAL/VAL and Science Workshop, followed by a working meeting in September 2020. See also section 13.1 below.

Aeolus 2020 Tropical Campaign working group:
ESA is performing a CAL/VAL campaign from Cabo Verde in summer 2020. Angela Benedetti and Vassilis Amirides took the initiative to form the accompanying ASKOS campaign. NASA's Weather Focus Area Programme Manager is also supporting the campaign with the NASA DC-8 hosing a number of payloads. The first joint meeting was held in conjunction with the Aeolus CAL/Val and Science Workshop in 2019. This has been followed by further planning telecons. The next meeting is planned during the 2020 Aeolus CAL/VAL and Science Workshop. For further details, see section 8 below.

Further working groups may be formed as required. Initiatives for new groups may be requested/communicated to ESA at the annual CAL/VAL and Science workshops and/or per email to info.aeolus-calval@esa.int.

6.6 Mapping of Aeolus CAL/VAL proposals to the CAL/VAL requirements

An overview of the Aeolus CAL/VAL AO delta-call proposals are provided in chapters 10.1 and 10.2 below. The proposal numbers and names of PIs listed below can be found there.

Table 6.6.1: *Contribution to testing of Aeolus data access, delivery of collocated data, instrument characterization, calibration and L1B processing requirements by Industry (Commissioning Phase), L1/2 ADT/DISC, and CAL/VAL teams.* ***CVR:*** *Calibration and Validation Requirement.* ✓***:*** *The requirement addressed by CAL/VAL team.*

CVR: Proposal nu:	CVR-1	CVR-2	CVR-3	CVR-4	CVR-5	CVR-6	CVR-7	CVR-8	CVR-9	CVR-10	CVR-11	CVR-12	CVR-13	CVR-14	CVR-15	CVR-16	CVR-17	CVR-18	
Industry				✓	✓	✓	✓	✓	✓		✓	✓	✓				✓		
Aeolus DISC	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
ESA Campaigns	✓	✓	✓	✓	✓	✓	✓					✓	✓				✓	✓	
5156 France	✓	✓			✓	✓	✓	✓										✓	
5166 EARLINET	✓	✓																	
5177 NOAA, USA	✓	✓			✓	✓	✓	✓										✓	
5188 CESAR, NL	✓	✓																	

CVR: Proposal nu:	CVR-1	CVR-2	CVR-3	CVR-4	CVR-5	CVR-6	CVR-7	CVR-8	CVR-9	CVR-10	CVR-11	CVR-12	CVR-13	CVR-14	CVR-15	CVR-16	CVR-17	CVR-18	
5190 **KNMI, NL**	✓	✓			✓	✓	✓	✓										✓	
5192 **Met.no, NO**	✓	✓			✓	✓	✓	✓										✓	
26989 **Andøya, NO**	✓	✓																	
27329 **Germany**	✓	✓			✓	✓	✓	✓										✓	
27409 **GR, DE, FIN**	✓	✓																	
27411 **Ocean U. China**	✓	✓				✓	✓	✓											
27529 **Met Office, UK**	✓	✓			✓	✓	✓	✓										✓	
27589 **NICT, Japan**	✓	✓			✓	✓	✓	✓										✓	
27590 **Environ. Canada**	✓	✓			✓	✓	✓	✓										✓	
28295 **U. Toronto, CA**	✓	✓																	
41467 **U. Hertfords. UK**																			
44100 **LALINET**																			
44512 **CALIPSO**																			
44812 **Paradigm Factory UK**																			
44648 **NASA GMAO USA**																			
46032 **CMA, China**																			

CVR: Proposal nu:	CVR-1	CVR-2	CVR-3	CVR-4	CVR-5	CVR-6	CVR-7	CVR-8	CVR-9	CVR-10	CVR-11	CVR-12	CVR-13	CVR-14	CVR-15	CVR-16	CVR-17	CVR-18	
46417 **DTU, DK**																			
47571 **SMHI, SE**																			
47692 **Canada**																			
48932 **?**																			
49937 **Korea**																			
49974 **IPSL, FR**																			

Table 6.6.2: Contribution to Aeolus L2B (wind) and L2A (aerosol/cloud) product validation requirements. **CVR:** Calibration and Validation Requirement. ✓**:** The requirement addressed by CAL/VAL team.

CVR: Proposal nu:	CVR-19	CVR-20	CVR-21	CVR-22	CVR-23	CVR-24	CVR-25	CVR-26	CVR-27	CVR-28	CVR-29	CVR-30	CVR-31	CVR-32	CVR-33	CVR-34	CVR-35	CVR-36	CVR-37	CVR-38	CVR-39
Aeolus DISC	**DAMI**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**A3S**	
ESA Campaigns		✓	✓				✓	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓
5156 France		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
5166 EARLINET											✓	✓	✓	✓		✓	✓	✓	✓		
5177 NOAA		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		
5188 CESAR, NL		✓	✓								✓	✓	✓	✓		✓	✓	✓	✓		
5190 KNMI, NL		✓	✓		✓		✓	✓	✓	✓											
5192 Met.no, NO		✓	✓		✓		✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
26989 Andøya, NO											✓	✓	✓	✓		✓	✓	✓	✓		
27329 Germany		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		
27409 GR, DE, FIN											✓	✓	✓	✓		✓	✓	✓	✓		✓
27411 Ocean U. China		✓	✓								✓	✓	✓	✓		✓	✓	✓	✓		
27529 Met Office, UK		✓	✓		✓		✓	✓	✓	✓											
27589 NICT, Japan		✓	✓		✓		✓	✓		✓						✓	✓	✓	✓		
27590 Envir. Canada		✓	✓		✓		✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓		

CVR: Proposal nu:	CVR-19	CVR-20	CVR-21	CVR-22	CVR-23	CVR-24	CVR-25	CVR-26	CVR-27	CVR-28	CVR-29	CVR-30	CVR-31	CVR-32	CVR-33	CVR-34	CVR-35	CVR-36	CVR-37	CVR-38	CVR-39
282954 U. Toronto, CA		✓	✓				✓	✓		✓											

6.7 Identified gaps in the Aeolus CAL/VAL

Aeolus CAL/VAL activities are currently performed at the stations displayed in figure 6.7-1 and in section 13 below. ECMWF have also presented statistics for the geographical coverage of winds from the global observing system (representative for May 2019), shown in figure 6.7-2. Some ASCV teams perform comparisons of the Aeolus winds with some selected radiosondes (see section 13). The Aeolus CAL/VAL Requirement coverage by the Aeolus DISC and CAL/VAL proposals was assessed in section 6.6. Planned Aeolus campaigns are listed in section 8 below.

It should be noted that Aeolus campaigns will be limited to typically 1 month, and there may be 1-2 campaigns per year. However, some non-ESA campaigns spontaneously offer collocated observations to be shared on the EVDC during the mission lifetime. These campaigns are announced under the campaigns page on the Aeolus CAL/VAL wiki.

It should also be noted that not all CAL/VAL activities are on-going through the mission lifetime, and that they may also not cover all seasons. No attempt is made in this section to fully analyse all temporal and spatial gaps in the current Aeolus CAL/VAL coverage, but rather geographical areas of particular concern where more collocated observations would be needed are identified here.

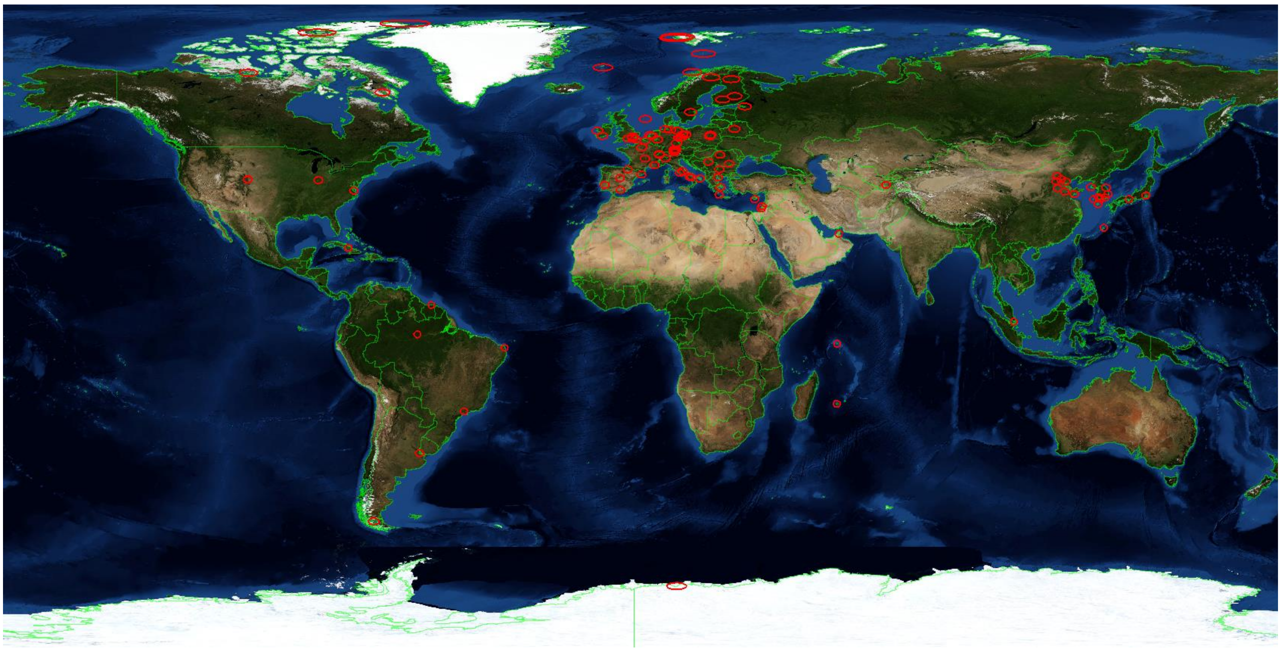


Figure 6.7-1: *Aeolus ground-based CAL/VAL stations and campaign sites, status on 1 October 2019. The Aeolus CAL/VAL station list and map is kept up-to-date on the CAL/VAL wiki page https:/www.aeolus.esa.int/. CAL/VAL activities validating Aeolus products globally with the help of (global) NWP and/or air quality models, future airborne campaigns and other satellites are not shown. An overview of the Aeolus airborne campaigns is provided in section 8 and on https://www.aeolus.esa.int/. It should be noted that not all stations shown measure both wind and aerosol profiles. Further details of the measurements capability of the stations is provided on the CAL/VAL wiki page and in section 13 below.*

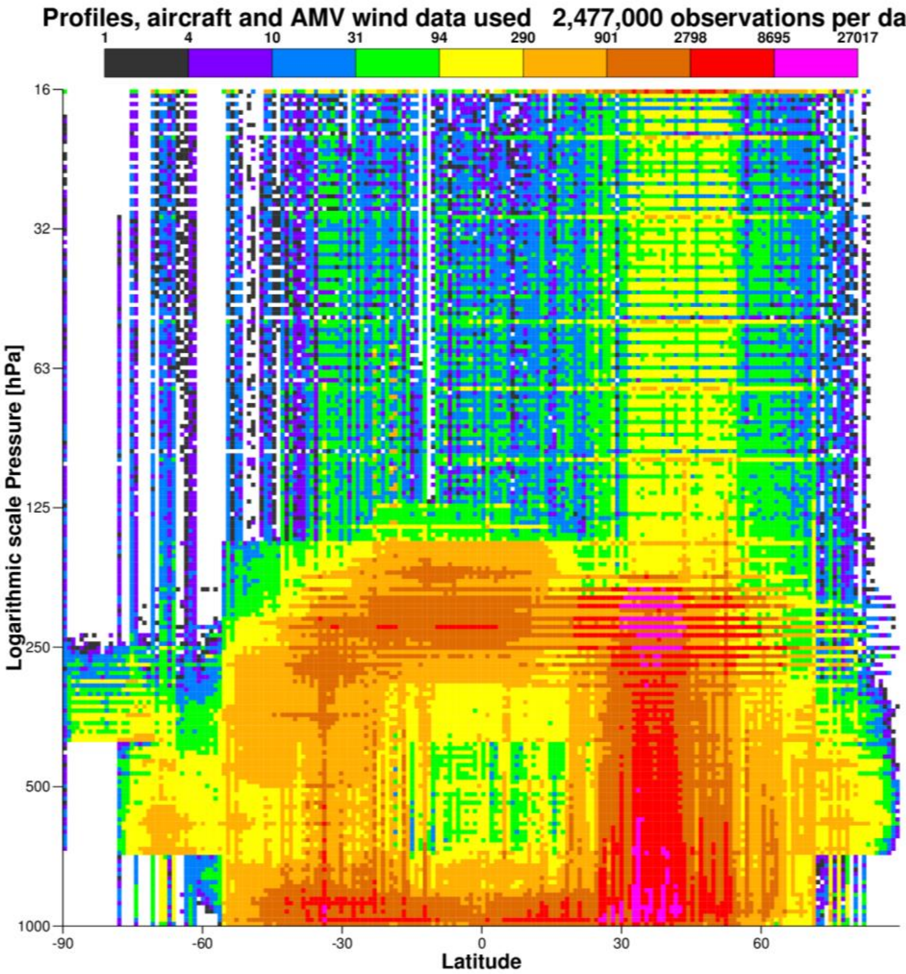


Figure 6.7-2: *Example of umber of wind profile data used by the ECMWF model per day, courtesy L. Isaksen ECMWF.*

As can be seen in figures 6.7-1, the tropical and polar regions and the southern hemisphere is not well covered by the current CAL/VAL activities. It can also be seen from Figure 6.7-2 that the tropics, polar areas, southern hemisphere, upper troposphere and lower stratosphere is currently not well covered by direct wind profile observations in the current GOS. It should be mentioned that the tropical campaigns, such as the TAPAPA/Strateole-2 campaign and the Aeolus 2020 tropical campaign, will therefore be very important for the validation of the Aeolus products in the tropics and upper troposphere, together with comparisons of wind obtained by radiosondes (various CAL/VAL teams) and ozone sondes (KNMI).

Recent contacts between the ESA Aeolus mission team and Eumetnet where Aeolus Cal/VAL team access to the Eumetnet database is offered by Eumetnet is very welcome. The Eumenet database contains amongst others vertical profiles of wind, temperature, humidity, clouds and aerosol by various (E-Profile) instrumentation. This information is currently available a.o. to the European NWP centres.

Ideas for further CAL/VAL activities to fill current gaps:
At the 2015 Aeolus Science and CAL/VAL workshop it was suggested

- to contact WMO station networks and offer cooperations within the Aeolus CAL/VAL efforts. Some progress has been made through contacts with Eumetnet.
- to solicit CAL/VAL proposals from institutes with access to high-resolution radiosonde data. No proposals for such investigations have been received so far.
- to solicit methods in support of the radiometric calibration of Aeolus, using well characterized homogeneous surface targets or on-ground receivers that could detect the Aeolus emitted laser beam, were discussed. However, no proposals for suitable targets or ground-based facilities have been identified or received so far.
- to contact potential CAL/VAL teams in the tropics and southern hemisphere. A number of CAL/VAL activities from these areas have been submitted in response to the 2018 Aeolus CAL/VAL AO. Discussions with Bureau of Meteorology in Australia for participation in Aeolus CAL/VAL has been done, but so far BOM has not submitted a CAL/VAL proposal. BOM hosts an extensive ground-based wind profiler network, and is very interested in Aeolus observations due to the sparse coverage of observations in South-East Asia.

This is also in-line with the gaps in the CAL/Val requirements coverage in section 6.6.

7 DEVELOPMENT AND VALIDATION OF NEW MISSION SPIN-OFF PRODUCTS

New Aeolus spin-off products are expected to be developed during phase E. These shall be described here, together with suggested validation needs. Examples of possible spin-off products are e.g. subsurface reflectivity, ocean surface and sub-surface properties, surface direct backscatter reflection, gravity wave parameterization.

8 AEOLUS CAMPAIGNS

A number of campaigns with the Aladin Airborne Demonstrator (A2D) was held before the Aeolus launch in order to validate the Aeolus Aladin lidar instrument concept, calibration and data processing. The campaigns also had scientific objectives related to the Aeolus scientific objectives listed in [AD 1]. The campaigns also supported the Aeolus Phase E1/2 campaigns preparations, involving CAL/VAL partners from NASA and IPSL, France. An overview of the Aeolus pre-launch campaign activities can be found in [RD 23] – [RD 25].

In phase E1/E2, the ESA supported Aeolus campaigns cover key Aeolus data product validation activities as well as answering scientific questions and support the development of new mission scientific exploitation and new data products. The campaigns are supplementary to the CAL/VAL efforts submitted to ESA in response of the CAL/VAL Announcement of Opportunity calls. The Aeolus campaigns requirements and high-level scientific objectives are provided in [AD 2]. In particular, the campaigns can be used to fill gaps in the CAL/VAL efforts such as in the Tropics and Upper Troposphere and Lower Stratosphere (UTLS). Aeolus is expected to give the largest NWP impact in the tropics and UTLS due to the lack of observations in this area and the importance of dynamic observations to fully describe the tropical circulation and its interaction with the sub-tropics.

8.1 ESA supported Aeolus post-launch CAL/VAL campaigns

Figure 8-1 gives an overview of the planned ESA supported Aeolus campaigns in Phase E1/2.

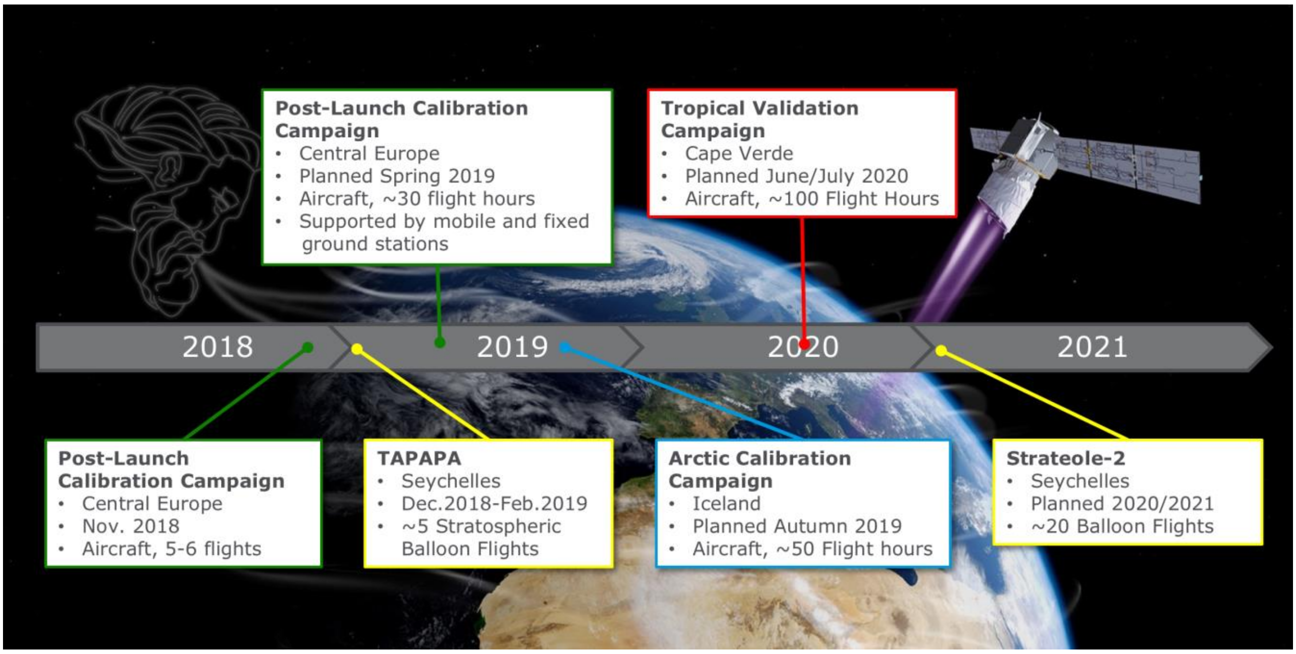


Figure 8-1: *ESA supported campaigns for the Aeolus Mission in Phase E1/E2, from the launch on 22 August 2018 to the end of its operational phase (August 2021).*

A brief overview of the campaigns objectives, organization and participation can be found on the Aeolus CAL/VAL wiki page. The list below gives the status of the campaigns planning as reported on this site in November 2019.

Post-Launch Calibration Campaign Nov 2018

Objectives
- Early correlative observation at the end of the commissioning phase
- Rehearsal for Aeolus Cal/Val activities
- Verification of airborne instrument modifications and test of calibrations

Campaign and instrument details
- Europe
- DLR Falcon campaign, 5-6 flights
- ALADIN Airborne Demonstrator (A2D)
- 2-m wind lidar

Participants
- DLR

Post-Launch Calibration Campaign April/May 2019

Objectives
- Correlative observations underflying the satellite and overflying on-ground reference sites

Campaign and instrument details
- Europe
- DLR Falcon campaign from Oberpfaffenhofen
- Coordination with Safire Falcon-20 activities
- ALADIN Airborne Demonstrator (A2D)
- 2-m wind lidar

Participants
- DLR
- LMD / IPSL

Post-Launch Calibration Campaign Sep 2019

Objectives
- Correlative observations in dynamically variable conditions
- Validation of Aladin instrument nadir and off-nadir calibration

Campaign and instrument details
- North-Atlantic
- DLR Falcon campaign from Iceland
- ALADIN Airborne Demonstrator (A2D)
- 2-m wind lidar

Participants
- DLR

TAPAPA: Stratospheric balloons Nov. 2019 - Jan. 2020

Objectives

- Support to Aeolus Cal/Val activities using wind observations from CNES stratospheric balloons during the LMD/CNES Strateole-2 Campaign

Campaign and instrument details

- Super-pressure long-duration balloons, lower tropical stratosphere (18-20 km), up to 3 months
- ~5 flights, launched from Seychelles
- TSEN instrument providing flight level, pressure, temperature and GPS every 30 s
- 3D winds deduced from successive GPS positions
- 200-300 collocations with Aeolus
- Data transmitted in near-real time through Iridium, downlink within 1 hour of observation

Participants

- CNES
- LMD

Tropical Validation Campaign Cape Verde, June and July 2020

Objectives

- Correlative observations for Aeolus validation in the Tropics
- Study of tropospheric dynamics, tropical cyclogenesis, long-range transport of dust and air pollution and its impact on tropical dynamics

Campaign and instrument details

- 4 aircraft (DLR, LMD, NASA, IJS)
- Ground-based instrumentation (NOA, …)

Participants

- DLR
- ECMWF
- IJS
- IMAA
- KIT
- LMD / IPSL
- LMU
- Météo-France
- NASA
- NOA

Strateole-2, 2020/2021

Objectives

- Study of lower stratospheric tropical dynamics
- Validation of NWP models

Campaign and instrument details

- Super-pressure long-duration balloons, lower tropical stratosphere (18-20 km), up to 3 months
- ~20 flights planned, launch: Seychelles
- More information: https://strateole2.cnes.fr/en/strateole-2-0

Participants

- CNES
- LMD
- Météo-France

8.2 Further campaigns relevant for Aeolus CAL/VAL

Further to the ESA supported campaigns, a number of relevant campaigns are taking place across the world, sometime involving ASCV team members. The following campaigns relevant to Aeolus CAL/VAL have been identified

- The Years of the Maritime Continent, July 2017 to July 2019: https://www.pmel.noaa.gov/ymc/
  Contacts between YMC and Aeolus CAL/VAL has not yet been laid.
- The 2018/2019 Year of Polar prediction campaign activities, involving more frequent radiosonde launches in Arctic areas. https://www.polarprediction.net/. A related YOPP campaign is MOSAIC:
  - The 2019 MOSAIC Arctic campaign activities, AWI Polarstern ice-breaker drift, http://mosaicobservatory.org/. MOSAIC will provide wind and aerosol measurements from the ship (Doppler lidar, backscatter lidar) and from radiosondes. A mesoscale surface meteorological and aerosol/cloud lidar network is planned. Airborne campaigns are planned in Spring 2020 at lower latitudes.

  Contacts between the YOPP campaign activities and Aeolus CAL/VAL has not yet been laid.
- The Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex) campaign, August-September 2019 (https://espo.nasa.gov/camp2ex/content/CAMP2Ex)
  - Aeolus satellite under flights were performed by the NASA P-3 aircraft on Saturday 14 September. The P-3 payloads are listed here: https://espo.nasa.gov/camp2ex/instruments. Correlated data will be provided by C. Hostetler.
- The SOUTHTRAC gravity wave campaign, autumn 2019, e.g. https://www.pa.op.dlr.de/southtrac/tag/gravitywaves/
  Contacts between the SOUTHTRAC campaign and Aeolus CAL/VAL has not yet been laid.
- Atlantic Meridional Transect (AMT) cruises are performed since 1995 by Plymouth marine laboratory. During the cruises spatially extensive and internally consistent observations on the structure and biogeochemical properties of planktonic ecosystems in the Atlantic Ocean are performed to validate models addressing questions related to the global carbon cycle. During the cruises radiosonde launches are performed twice a day at the ship location during its journey from the North to the South Atlantic. The radiosonde data are available amongst others to ECMWF, and could be made available also to Aeolus CAL/VAL teams.

9 AEOLUS PERFORMANCE, ALGORITHMS AND PRODUCT ACTIVITIES

The ESA Sensor Performance, Products and Algorithms (SPPA) section is responsible for the overall data quality related work for the ESA Earth Observation missions [RD 17]. For Aeolus, the following activities will be performed and/or coordinated under the responsibility of the SPPA Aeolus Data Quality Manager, Jonas von Bismarck:

- Data Innovation Science Cluster (DISC)
- CAL/VAL by ESA external teams (ACVT)
- Quality Working Group (QWG) which will be part of the Aeolus Science and Data Quality Advisory Group (Aeolus SAG)
- ESA Atmospheric Validation Data Centre (EVDC)
- Fiducial Reference Network related activities

The SPPA managed activities are interlinked and interacting with several parts of the Aeolus Mission activities shown e.g. in Figure 5.2, such as the PDGS, Aeolus Operations Board (AOB), Campaigns and Science activities.

The DISC activity contains a group of performance, algorithm and product expert teams under ESA contract both within and externally to ESA.

The Aeolus CAL/VAL confluence Page is the information exchange platform for Aeolus CAL/VAL Teams, and is maintained by the SPPA Aeolus Data Quality Manager and his team. See https://www.Aeolus.esa.int

The SPPA web site is hosted on https://earth.esa.int/web/sppa/home

10 AEOLUS SCIENTIFIC VALIDATION TEAM GENERAL TERMS OF REFERENCE

ESA seek the involvement of the international community with experience in conducting scientific verification and validation of Aeolus data, field experiments and campaigns.

The ASCV team will bring together world leaders in relevant mission validation activities **to provide independent validation evidence, experimental data and recommendations** from such work that will be reported formally to ESA to characterize the quality and performance of the Mission. Specifically, the Agency seek the interest of institutes, research groups and scientists with expertise to address the following:

- validation using other satellite, airborne or ground-based experiments providing independent measurements of wind profiles, clouds and aerosols;
- experiments to assess accuracy, resolution, and stability of the Aeolus instrument Aladin (Atmospheric Laser Doppler Lidar Instrument);
- assessment and validation of the Aeolus retrieval and processing

The **aim** of the ASCV IP is:

> ***"To engage world-class expertise and activities, through mutual benefit collaboration, that support the implementation of the Aeolus validation activities and ensure the best possible outcomes for the Aeolus mission"***

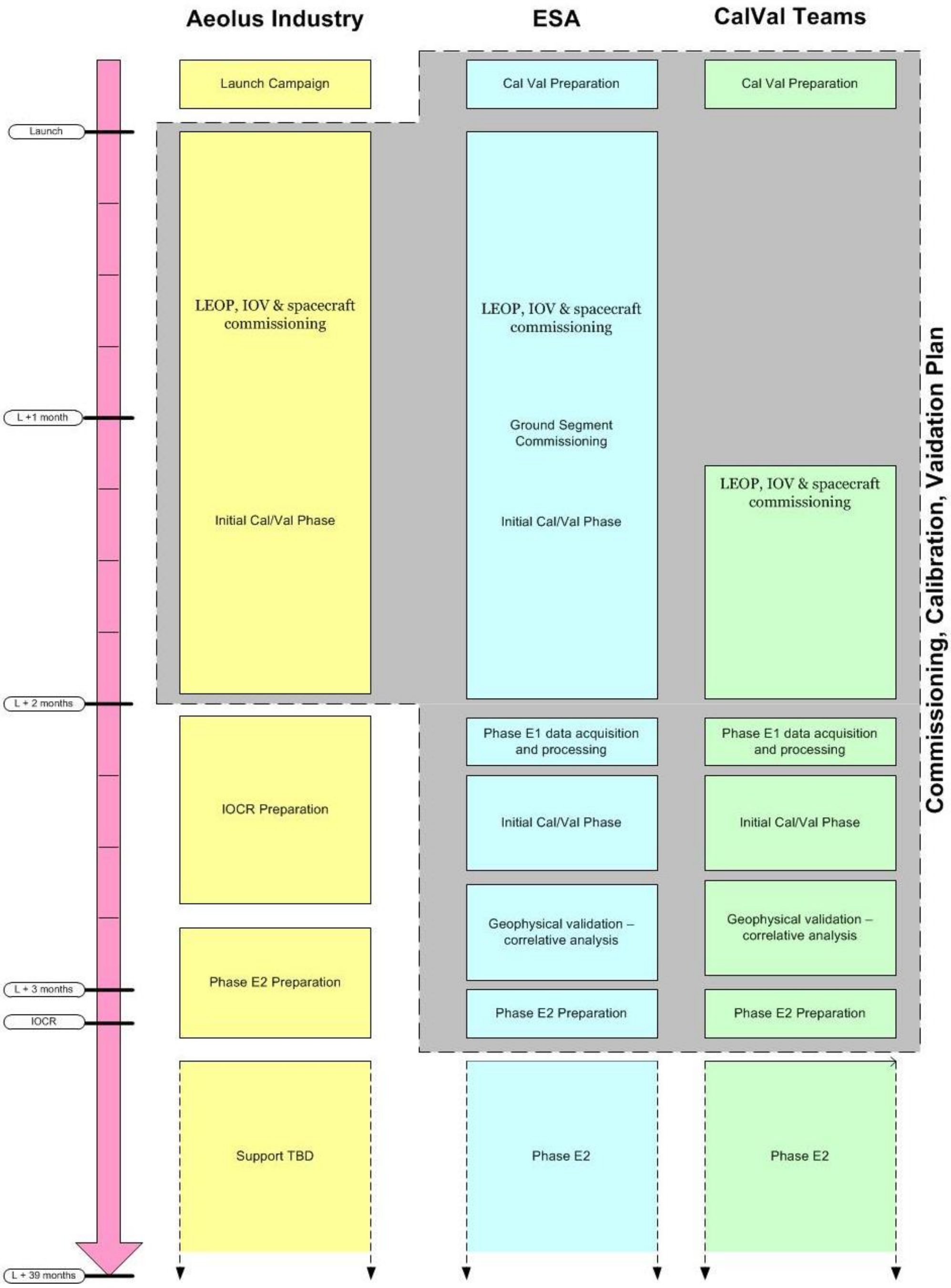
The **objective** of the ASCV team is:

> ***"To provide independent validation evidence, experimental data and recommendations to the Aeolus Mission"***

11 AEOLUS CAL/VAL E1 TIMELINES AND KEY ACTIVITIES

The overall Aeolus Commissioning Phase (Phase E1) timeline is provided in figure 9.1.

Figure 9.1: Aeolus Commissioning Phase (Phase E1) overall timeline



12 INTERFACES BETWEEN ASCV TEAMS AND AEOLUS MISSION ACTIVITIES

During Phase E1, the team organization and projects are coordinated by the Aeolus Project and Mission Scientist. During Phase E2, the team organization and projects are coordinated by the Data Quality Manager under the direction of the Mission Manager.

Information, updates and communications regarding Aeolus CAL/VAL are done via the Aeolus Cal/Val portal (https://www.aeolus.esa.int/). Should you not find the information or get the answer you need on the portal, the ESA Aeolus CAL/VAL team can be contacted via the following email address: info.aeolus-calval@esa.int.

Table 10.1: Outline of the organization of the Cal/Val team, including both ESA staff and external experts / support groups.

Team / Role	Function / tasks	Name	Organization / Affiliation
ESA support teams			
Aeolus Mission Management	Mission Manager	T. Parrinello	ESRIN, EOP-GM
Data Quality, CAL/VAL and Campaigns support	Aeolus Data Quality and CAL/VAL Manager CAL/VAL coordination Manager Aeolus Performance Manager Campaigns Manager Mission Scientist	J. von Bismarck S. Bley T. Kanitz T. Fehr A.G. Straume	ESRIN, EOP-GMQ ESRIN, EOP-GMQ ESTEC, EOP-PEP ESTEC, EOP-SMA ESTEC, EOP-SMA
PDGS Support Team (members supporting CAL/VAL are listed)	Manager Aeolus PDGS Aeolus Mission Planner Aeolus Calibration and Monitoring Facility (ACMF) Tasks - facility operations & maintenance - calibration processing, analysis - mission planning - data distribution - etc.	Peggy Fischer M. de Laurentis Paola D'Aulerio	ESRIN, EOP-GEE
Aeolus Flight Control Team (FOS) (members supporting CAL/VAL are listed)	Aeolus S/C Operations Manager mission experts in charge of - mission planning tasks - flight dynamics analyses - anomaly investigations - etc.	Viet Duc Tran Gabriela Ansteeg Juan Piñeiro	ESOC, OPS-OEA

Aeolus Post Launch Support Office (PLSO) **Instrument & Performance** (members supporting data quality and CAL/VAL are listed)	Aeolus PLSO support Manager Tasks: - payload operations - satellite operations - mission analysis - performance verification - anomaly investigations - etc.	Pierre Vogel Emilio Alvarez Denny Wernham Thomas Kanitz Elena Checa	ESTEC, EOP-PEL ESTEC, EOP-PEL ESTEC, EOP-PN ESTEC, EOP-PEP ESTEC, TEC-MTT
Support teams on ESA contract			
Phase C/D: L1/2 Algorithm Development Team (L1/2 ADT) **Phase E1: EDAFECS** **Phase E2: DISC** (scientific DISC participants are listed)	L1B/2A/2B algorithm development, validation expert team in charge of: - algorithm development verification, and maintenance - aux. data base generation - specific processing tasks - performance analyses / error budget compilation - etc	O. Reitebuch U. Marksteiner K. Schmidt F. Weiler M. Meringer B. Witschas O. Lux C. Lemmerz D. Huber I. Nikolaus K. Reissig A. Dabas T. Flament D. Trapon M. Savli V. Pourret J.-F. Mahfouf L. Isaksen M. Rennie A. Stoffelen J. de Kloe G.-J. Marseille D. Donovan M. Vaughan	DLR, MétéoFrance, ECMWF, KNMI, DoRIT, PSol, IB Reissig, OLA Non-scientific DISC partners: Serco, ABB
ECMWF Operations Team	Team responsible for the L2 MetPF	I. Mallas R. Prithiviraj	ECMWF
Announcement of Opportunity (AO) CAL/VAL teams			
CAL/VAL AO Teams	***Independent performance analysis*** - consistency analyses of instrument calibration data, systematic error sources - long-term trend analyses of spacecraft equipment, payload instrument - evaluation of algorithm (model) induced errors - error budgets in engineering calibration data - end-to-end error budgets in L1B/L2A/L2B/C product - etc. ***collocated measurement campaigns*** - airborne campaigns (aerosol / wind lidars, radars, ...) - ground based experiments - satellite intercomparisons - data analysis and interpretation - etc. ***Atmospheric modelling & assimilation experiments*** - monitoring of Aeolus product quality - NWP and air quality assimilation experiments		See Table 11-1

The communication between the CAL/VAL teams and ESA is going via the Aeolus CAL/VAL portal (see section 13.9) and email (**info.aeolus-calval@esa.int**). In particular the L1/2 ADT/EDAFECS/DISC will be in close contact with ESA and industry concerning algorithm and product verification. As outlined in [RD 21], requests for special Aeolus operations during campaigns or for targeted CAL/VAL activities may be raised towards ESA. Such requests shall be sent to the Aeolus Mission Manager via the email **info.aeolus-calval@esa.int**. Assessments and decisions for changes to the Aeolus operation is done by the Aeolus Operations Board (AOB, see Figure 5-2 above), which is chaired by the Aeolus Mission Manager.

Key results from the DISC team and the ASCV team data quality analysis work will be published on the CAL/VAL portal. It is in particular importance to the CAL/VAL teams to be kept informed about the DISC product quality work and the PDGS (re-)processing plans in order to assess when and how to perform CAL/VAL activities and the associated CAL/VAL analysis.

13 DETAILED PLANS OF THE ASCV

13.1 High-level schedule Phase ASCV Team activities E1/E2

The following table lists the plans and timing of the ASCV activities and related major events in Phase E1 (Satellite Commissioning) and Phase E2 (Mission exploitation Phase)

Table 13.1: Plans and timing of the ASCV activities and related major events in Phase E1 and E2

Event	When	Comments
Receiving of first scientific data	L+3 weeks	
Start of Aeolus collocated measurements	L+3 months	
Data Access to ASCV Teams	L+ 4 months	Full data access for ASCV Teams world-wide
Commissioning Phase Review	L+5 months	
First reporting ASCV Teams	L+7 months	At 1st Aeolus CAL/VAL and Science workshop
1st Aeolus CAL/VAL Workshop	L + 7 months	
Regular ASCV reporting	Every 6 months	Through-out mission lifetime
Aeolus L2B data release	Q1 2020	
Presentation of Aeolus NWP Impact on Quadrennial WMO NWP impact Assessment Workshop	May 2020	Seoul, Republic of Korea, 2020
Aeolus L2A data release	Q3/Q4 2020	
Aeolus CAL/VAL and Science Workshop	Yearly	March 2019, March 2020, March 2021, March 2022
NWP Impact Working Meetings	Yearly	September 2019, September 2020, September 2021, September 2022
Aerosol Quality Working Meetings	Yearly	December 2019, September 2020, September 2021, September 2022
End Phase E2	Summer 2021	Delivery of ASCV Final Reports

13.2 Overall summary of planned ASCV validation activities

Following the Aeolus CAL/VAL AO delta-call in 2014, and subsequent coordination activities, a "top-level" summary of currently active VT "projects" for all the sub-groups is presented in the table below. The Project Identifier (PI) allows an easy look-up of the project proposal. A coarse timeline is provided to assist planning in the pre-launch, E1 and over the following period of E2.

Table 11-1: *Top-level summary of CAL/VAL projects, status on 17/11/2019. For an up-to-date list, see: https://www.aeolus.esa.int/*

Activity Schedule

ID	PI	Products	Techniques	Phase C/D	Phase E1	Phase E2	Remarks
5156	Dabas, Alain, FR	W, A	RO, AC, GC				
5166	Apituley, Arnoud, NL	W, A, C	GC				
5177	Hardesty, Robert Michael, US	W, A, C	RO, AC, GC, M, S				
~~5186~~	~~Baumgarten, Gerd, DE~~	~~W, A~~	~~RO, GC, M~~	-	-	-	Withdrawn
5188	Apituley, Arnoud, NL	W, A, C	RO, GC				
5190	Stoffelen, Ad, NL	W, A	M				
5192	Schyberg, Harald, NO	W, A, C	RO, M				Linked to 5186
26989	Gausa, Michael, NO	W, A, C	AC, GC				
27329	Weissmann, Martin, DE	W, A	AC, GC				
~~27389~~	~~Stebel, Kerstin, NO~~	~~W, A~~	~~RO, GC, S~~	-	-	-	Withdrawn
27409	Amiridis, Vassilis, GR	A, C	RO, GC				
27411	Wu, Songhua, CN	W, A, C	GC				
~~27449~~	~~Zagar, Nedjeljka, SLO~~	~~W~~	~~M~~				Resubm. planned
27529	Forsythe, Mary, UK	W, A	AC, M, S				
27589	Ishii, Shoken, JP	W	GC				
27590	Joe, Paul, CA	W, A, C	RO, GC, M, S				
28295	Kushner, Paul, CA	W	M				
41467	Tesche, Matthias, UK	A	RO,GC				
44100	Landulfo, Eduardo, BR	A	RO,GC				
44512	Tackett, Jason, US	W	S				
44812	Rees, Davind, UK	W	RO,GC				
44648	McCarty, Will, US	W	M				
46032	Lu, Feng, CN	W	S,M				
46417	Karagali, Ioanna, DK	W	RO,GC				
47571	Körnich, Heiner, SE	W	GC,M				
47692	O'Neill, Norm, CA	W	GC,M,S				
48932	Avdikos, Georg, GR	A	GC				
49937	Chung, ChuYong, KR	W	RO,GC,AC,M,S				
49974	Feofilov, Artem, FR	CAL	RO,M				

W = Wind

A = Aerosol

C = Clouds

RO = Routine Operations

AC = Airborne Campaigns

GC = Ground Based Campaigns

M = Model Studies

S – Other satellite obs

A – Alternative L2 products

funding fully secured

funding partly or largely secured

no secured funding

unknown

Figure 11-1: *Geographical coverage of Aeolus ground-based CAL/VAL activities and campaign sites, status 28 October 2019. The map is kept up to date on https://www.aeolus.esa.int/. CAL/VAL activities validating Aeolus products globally with the help of (global) NWP and/or air quality models, future airborne campaigns and other satellites are not shown. An overview of the Aeolus airborne campaigns is provided in section 8 and on https://www.aeolus.esa.int/. It should be noted that not all stations shown measure both wind and aerosol profiles. Further details of the measurements capability of the stations is provided on the CAL/VAL wiki page and in section 13 below.*

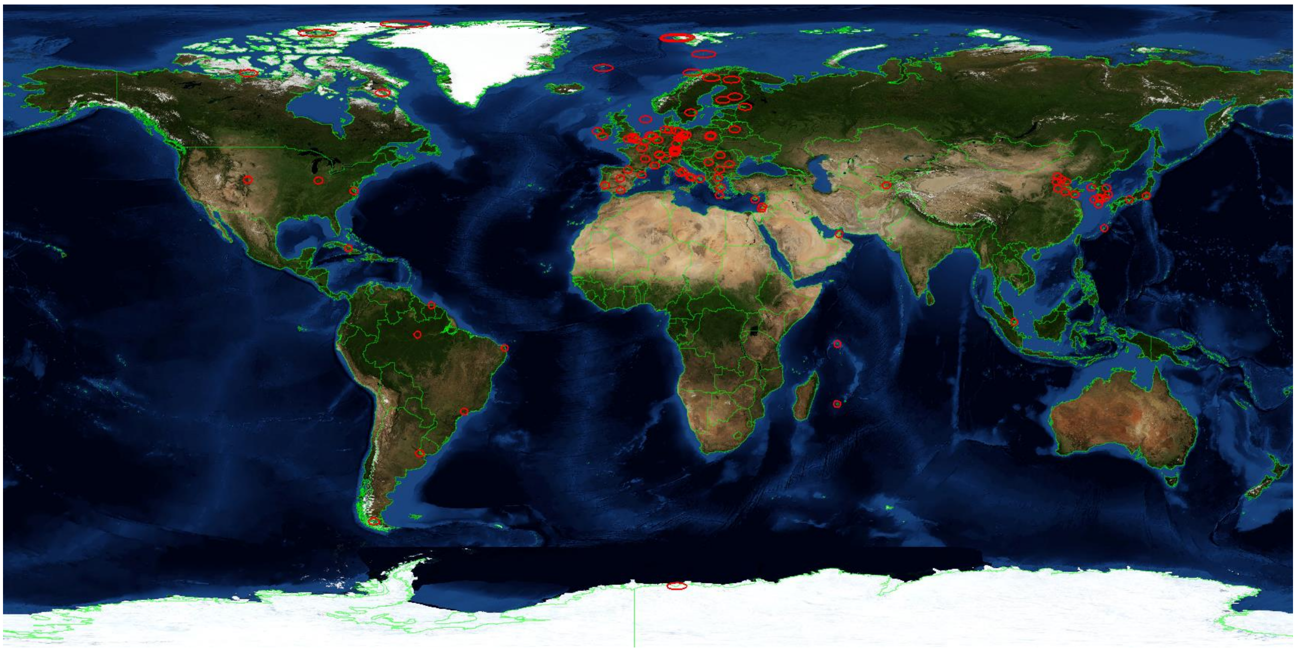


Table 11-2: *List of ground-based CAL/VAL stations. Symbol / pin number refers to Figure 11.1. This Table is according to the CAL/VAL proposal status in November 2019. An up-to-date CAL/VAL station list is available on the CAL/VAL ftp pages: ftp.eopp.esa.int, /aeolus_calval/aeolus_calval_stations.EEF.*

Site nu	Site and/or instrumentation description	Location	Lat/Lon
1	DLR site: A2D (wind), MULIPS/POLIS aerosol	Oberpfaffenhofen, Weßling, Germany	48.08 / 11.28
2	TROPOS: PollyXT, CIMEL, WiLi, EARLINET	Leipzig, Germany	51.353 / 12.435
3	TROPOS Chile: PollyXT (aerosol), CIMEL Sun Photometer (aerosol), Cloud Radar, Wind Lidar Halo Photonics (wind)	Punta Arenas, Chile	-53.134 / -70.884
4	Lindenberg supersite: Radar-Wind-Profiler (wind), Wind Lidar Halo Photonics, Raman Lidar RAMSES (aerosol), Sun Photometer (aerosol), Radiosondes (wind), Microwave Radiometer, Cloud Radar, Sodar/RASS	Lindenberg, Tauche, Germany	52.216 / 14.116
5	Wind profiler	Nordholz, Wurster Nordseeküste, Germany	53.78 / 8.67
6	Wind profiler	Ziegendorf, Germany	53.31 / 11.84
7	Wind profiler	Bayreuth, Germany	49.98 / 11.68
8	A2D, 2 micron windlidar, DLR Falcon	DLR, Germany, Keflavik, Iceland, Sal, Cape Verde	
9	Mode-S	London, UK	51.29 / -0.27
10	Mode-S	Amsterdam Airport Schiphol, Netherlands	52.18 / 4.46
11	Mode-S	Berlin, Germany	52.23 / 13.31
12	Polarization Raman lidar, PollyXT, CIMEL	Limassol Crete, Greece	34.674996 / 33.041193
13	PollyXT (from February 2019), CIMEL, windcube, EARLINET	Kuopio, Finland	62.7379 / 27.5431
14	PollyXT, CIMEL, windcube, POLIS	Antikythera, Greece	35.8608 / 23.3103
15	PollyXT, CIMEL, windcube, EMORAL, EARLINET	Warsaw, Poland	52.2109 / 20.9826
16	FMI PollyXT (September 2018 to February 2019)	Al Dhaid, UAE	25.2358 / 55.9778
17	Andøya: ~~Wind radar, wind lidar, temperature lidar,~~ radiosondes, sunphotometer (AERONET),-EARLINET	Andoya, Norway	69.30 / 16.13, very limited funding, observations to be confirmed
18	Cabauw supersite: wind profiler (< 5 km), cloud radar, aerosol lidar (EARLINET), radiosonde de Bilt (~30 km north east), sun photometer, radiometer, composition measurements, …	Cabauw, Netherlands	51.967922 / 4.929362
19	Mobile HSRL Doppler wind lidar, raman lidar, coherent Doppler wind lidar, radiosondes	Qingdao, Shandong, China	36.04 / 120.20
20	Haute Provence: Radiosondes, Rayleigh wind lidar 3 months	Saint-Michel-l'Observatoire, France	43.930415 / 5.71362
21	Radiosondes, Rayleigh wind lidar 3 months	Reunion	-21.0796 / 55.3841, altitude 2160 m.a.s.
22	Airborne HSRL aerosol lidar on Falcon 20	Toulouse, France	48.86 / 2.35

23	Stratospheric Balloons	To be launched from Seychelles)	-4.674444 / 55.521944
24	French mobile station, aerosol lidar (at 355nm), PBL UHF profiler, radiosoundings. L+6 to L+9 months	Toulouse	43.6 / 1.44
25	EARLINET	Athens, Greece	37.96 / 23.78
26	EARLINET	Barcelona, Barcelona, Spain	41.389 / 2.112
27	EARLINET	Belsk Duży, Poland	51.84 / 20.79
28	EARLINET	Bucharest, Romania	44.48 / 26.13
29	EARLINET	Clermont-Ferrand, France	45.47 / 3.10
30	EARLINET	Cork, Ireland	51.89 / -8.49
31	EARLINET	Evora, Portugal	38.568 / -7.912
32	EARLINET	Garmisch-Partenkirchen, Germany	47.48 / 11.06
33	EARLINET	Granada, Granada, Spain	37.16 / -3.60
34	EARLINET	Hamburg, Germany	53.57 / 9.97
35	EARLINET	Ispra VA, Italy	45.80 / 8.63
36	EARLINET	L'Aquila, Italy	42.37 / 13.35
37	EARLINET	Lecce LE, Italy	40.30 / 18.10
38	EARLINET	Limassol, Cyprus	34.686 / 33.04
39	EARLINET	Madrid, Madrid, Spain	40.45 / -3.72
40	EARLINET	Maisach, Germany	48.211 / 11.26
41	EARLINET	Minsk, Belarus	53.83 / 27.47
42	EARLINET	Naples, Italy	40.85 / 15.25
43	EARLINET	Palaiseau, France	48.72 / 2.21
44	EARLINET	Payerne, Switzerland	46.81 / 6.94
45	EARLINET	Potenza, Italy	40.60 / 15.72
46	EARLINET	Sofia, Bulgaria	42.82 / 23.38
47	EARLINET	Thessaloniki, Greece	40.63 / 22.969
48	FARM aircraft, in-situ and remote sensing aerosol, cloud, radiation, composition	England, UK	
49	Radiosonde	Jan Mayen, Svalbard and Jan Mayen	70.56 / -8.4
50	Radiosonde	Bjørnøya 9176, Svalbard and Jan Mayen	74.31 / 19.01
51	Radiosonde	Ekofisk, North Sea	56.5 / 3.2
52	Radiosonde	Ny-Ålesund, Svalbard and Jan Mayen	78.55 / 11.56
53	Airborne wind observations TWILITE, DAWN, OAWL	USA airborne campaign, locations TBD	
54	Airborne HSRL-2 aerosol observations	USA airborne campaign, locations TBD	
55	Doppler wind lidars	Boulder, CO, USA	40.05 / -105.01
56	NASA-Langley Doppler lidar VALIDAR	Hampton, VA, USA	37.03 / -76.34
57	NOAA P-3 Doppler lidar, dropsondes	North Atlantic Ocean	
58	NICT coherent Doppler wind lidar, wind profiler, radiosonde	Koganei, Tokyo, Japan	35.69 / 139.71
59	Leosphere coherent doppler lidar	Kobe, Hyogo Prefecture, Japan	34.69 / 135.1
60	Leosphere coherent Doppler lidar, wind profiler, radiosondes	Kunigami District, Okinawa Prefecture, Japan	26.87 / 128.25
61	MST wind radar (wind vector 2-12 km)	Esrange, Sweden	67.89 / 21.06
62	MST wind radar (wind vector 2-12 km)	Maitri station, Antarctica	-75.21 / 1.25

63	Alert supersite: Radiosonde, wind profiler, doppler lidar, doppler radar, celiometer, doppler cloud radar	Alert, NU, Canada	82.50 / -62.34
64	Eureka supersite: Radiosonde, wind profiler, doppler lidar, doppler radar, celiometer, doppler cloud radar	Eureka, NU, Canada	80.05 /-86.42
65	Iqaluit supersite: Radiosonde, wind profiler, doppler lidar, doppler radar, celiometer, doppler cloud radar	Iqaluit, NU, Canada	63.75 / -68.55
66	Cambridge Bay supersite: Radiosonde, wind profiler, doppler lidar, doppler radar, celiometer, doppler cloud radar	Cambridge Bay, NU, Canada	69.12 / -105.06
67	NRC Convair 580 aircraft with Doppler radar (X and W band), cloud-aerosol lidar (355 nm), Ka-band radar, microphysics instrumentation, aerosol (in-situ)	Airborne campaign Canada. Location TBD	
68	Ground-based Raman/polarization lidar instruments, Raymetrics	Singapore	1.3 / 103.85
69	WindCube 70 (WLS70) lidar	Pamplona, Spain	42.9 / -1.65
70	RAOBS stations in China	-	-
71	LALINET	Buenos Aires, Argentina	-34.56 / -58.51
72	LALINET	Bariloche, Argentina	-41.15 / -71.16
73	LALINET	Comodoro Rivadavia, Argentina	-43.24 / -65.33
74	LALINET	La Paz, Bolivia	-16.54 / -68.07
75	LALINET	Manaus, Brazil	-2.89 / -59.97
76	LALINET	São Paulo, Brazil	-23.46 / -46.23
77	LALINET	Concepcion, Chile	-36.84 / -73.02
78	LALINET	Medellín, Colombia	6.14 / -75.34
79	Ground-Based Direct Detection Doppler Wind LIdar System	Lyons Building, Millham, Robertsbridge, UK	50.98 / 0.47
80	Spectrometric aerosol Raman lidar	United Kingdom	51.75 / -0.24
81	Spectrometric aerosol Raman lidar	Republic of Korea	35.23 / 126.84
82	PollyXT	Dushanbe, Tajikistan	38.56 / 68.86
83	PollyXT	Haifa, Israel	32.77 / 35.02
84	Radiosonde	Baengnyeong Island, Republic of Korea	37.97 / 124.71
85	Radiosonde	N Gangneung, Republic of Korea	37.81 / 128.85
86	Radiosonde	Pohang, Republic of Korea	36.03 / 129.38
87	Radiosonde	Changwon, Republic of Korea	35.17 / 128.57
88	Radiosonde	Heuksan Island, Republic of Korea	34.69 / 125.45
89	Radiosonde	KMA, Republic of Korea	33.33 / 126.68
90	Radiosonde	Bosung Gun, Republic of Korea	34.76 / 127.21

13.3 Executive Summary of planned validation activities

The proposals below were the proposals received by 1 November 2019. This document will not be kept up-to-date regularly during phase E2 w.r.t. the Aeolus CAL/VAL proposals. Rather, and up-to-date list of the proposals will be provided on https://www.aeolus.esa.int/.

Validation Project Title	**Contribution of French research teams to ADM Cal/Val: ground-based and airborne comparative experiments for optical and wind products.**
Link to full Proposal	5156
Team Leader name, affiliation and email	Dr. Alain Dabas, MétéoFrance, alain.dabas@meteo.fr
Support team-members names and emails	Dr. Thomas Flamant, thomas.flament@meteo.fr Dr. Dimitri Trapon, Dimitri.Trapon@meteo.fr Dr. Jean-François Mahfouf, jean-francois.mahfouf@meteo.fr Prof. Albert Hertzog, albert.hertzog@lmd.Pollytechnique.fr Alain Hauchecorne, alain.hauchecorne@latmos.ipsl.fr Dr. Patrick Chazette, patrick.chazette@lsce.ipsl.fr Dr. Jacques Pelon, jacques.pelon@latmos.ipsl.fr Dr. Jean-Pierre Cammas, jean-pierre.cammas@univ-reunion.fr Dr. Pierre Flamant, pierre.flamant@lmd.Pollytechnique.fr Dr. Christophe Payan, christophe.payan@meteo.fr Dr. Vivien vivien.pourret@meteo.fr, Dr. Matic Savli, matic.savli@meteo.fr
Summary of activity	Several French research teams interested by a participation to, and equipped with observation systems relevant to ADM Cal/Val have decided to coordinate their efforts. Since 2006, they make proposals to the French space agency CNES. With CNES support they have worked on the detailed organization and technical preparation of 6 different "experiments". Experiment 1 involves ground-based instruments operated at fixed sites, namely the Observatoire de Haute-Provence in the French Alps, and the Observatoire de Physique de l'Atmosphère de la Réunion, Reunion Island. Both sites are equipped with similar observation systems: radiosounding units, a Rayleigh wind lidar operating in the-visible (532 nm), a backscatter lidar, and a radar wind profiler. All those systems will be run every time AEOLUS is passing by. The wind observations will be compared to AEOLUS wind products and the ground-based, optical products will help in the analysis (detection of potential contaminations from aerosol backscatter). A special attention will be brought during the analysis to the natural, spatial variability of the wind products and its impact on data quality. Experiment 2 will involve the High-Spectral-Resolution backscatter lidar Léandre Nouvelle Génération (LNG) operating in the UV aboard the French research aircraft Falcon 20. The lidar will be flown along AEOLUS tracks for an optimal co-location. A coordination with A2D flights (proposed by DLR, Germany) is not necessary but will be sought. Experiment 3 is an opportunity. In 2017, 2018 and 2019, stratospheric, long duration super-pressure balloons will be launched in the equatorial band in the frame of the STRATEOLE 2 project (4 balloons in 2017, 20 in 2018 and 20 in 2019). Equipped with conventional meteorological sensors and dropsondes, the vehicles have a lifetime of up to several months, enabling them to circle around the Earth several times at an altitude of about 20km. Wind measurements at that altitude will be compared to AEOLUS products. Dropsondes will be launched giving one vertical profile of pressure, temperature and wind each time AEOLUS is passing by. About 50 co-location events are anticipated. for each balloon. Experiments 4 and 5 will involve mobile backscatter lidars deployed close to AEOLUS orbit cross-points in Europe. With 2 sites, up to 8 coincidences are possible each week. The system would stay operational for a month or two depending on available resources. At last, experiment 6 will work towards the assimilation of wind data by Météo-France numerical weather prediction system. Funding of the activities has not been secured yet except for experiment 3. For the other experiments, funding will the object of specific support requests to CNES as an answer to the call for proposals issued every year by the agency.

Expected innovation for Aeolus	Not filled
Expected results for Aeolus	The data acquired at OHP (Northern Hemisphere, mid-latitude) and Observatoire de la Réunion (Southern Hemisphere, tropics) will combine horizontal winds up to the top of AEOLUS profiles and optical parameters (aerosol backscatter and attenuation, clouds). Optical parameters will help in the analysis of wind data versus AEOLUS, it will show where aerosols or clouds are likely to perturb the retrieval of AEOLUS winds. Data from ground-based lidars will also help in validating the scene classification algorithms of the satellite. The data from LNG/HRS aboard the Falcon 20 will provide independent information on aerosol backscatter and extinction in the UV. This information will be obtained along AEOLUS track at nearly the same time, thus with a quasi-optimal co-location. The optical information will be highly valuable for the assessment of the quality of AEOLUS wind data. The data collected during the long-duration balloon campaign will provide independent observations of zonal and meridional wind components, as well as of temperature at 18-22 km. The campaign will be held in the equatorial region (+/-10° about the Equator), where the impact of AEOLUS on operational analyses and forecasts is expected to be the greatest. The long-duration balloon campaign will provide a validation of AEOLUS wind products over two years and over the whole equatorial belt. It will furthermore help characterize the representativeness of AEOLUS line-of-sight winds in the different wind patterns (in particular different equatorially-trapped planetary waves) associated with both phases of the Quasi-Biennial Oscillation. The independent temperature observations will be also used to validate the temperature information used in the AEOLUS processing algorithm.

Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, L2B data	**Data Coverage** all	**Specific Timeline of Validations** L+6 – L+9 months for mobile station. Time period for measurements at other stations not specified. STRATEOLE-2: winter 2020 and 2022.

Validation data to be collected	Airborne hsrl lidar, ground based lidar, stratospheric balloons, wind profiler, Mobile station near Bordeaux, OHP, La Reunion, stratospheric balloon launches from Seychelles, airborne HSRL French Falcon Saphire
Special data needs	n.a.

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Aeolus L2A aerosol and cloud product validation using the European Aerosol Research Lidar Network EARLINET**
Link to full Proposal	5166
Team Leader name, affiliation and email	Ir. Arnoud Apituley, KNMI, apituley@knmi.nl
Support team-members names and emails	Dr. Gelsomina Pappalardo, pappalardo@imaa.cnr.it Dr. Ulla Wandinger, ulla@tropos.de Dr. Vassilis Amiridis, vamoir@noa.gr Prof. Lucas Alados-Arboledas, alados@ugr.es Dr. Lucia Mona, mona@imaa.cnr.it Dr. Doina Nicolae, nnicol@inoe.ro
Summary of activity	Aeolus will be the first High-Spectral Resolution lidar to be flown in space. This type of lidar is capable of providing vertically resolved aerosol and cloud backscatter and extinction profiles as well as the lidar ratio without critical assumptions. For global aerosol and cloud profiling, Aeolus can be regarded the follow-up of the CALIPSO/CALIOP lidar instrument presently operational on the A-train and Aeolus will bridge the gap until the launch of the next lidar instrument on EarthCARE. Although the main product from Aeolus will be wind profiles and aerosol and cloud data are secondary data products, valuable data is expected on aerosol and cloud properties, needed for advancement in climate and air quality research. EARLINET is a leading network in quantitative aerosol profiling performing a schedule of routine measurements and presently consists of 28 stations distributed over EUROPE. The construction of an un-biased spatio-temporal database of vertical profiles of aerosol optical properties on a regional scale for climate and air quality research is the main objective of EARLINET and is accomplished by the application of Raman lidars. Raman lidars, like HSRL, are capable of providing vertically resolved aerosol and cloud backscatter and extinction profiles as well as the lidar ratio without critical assumptions. The perspectives from space observations and ground based measurements are complementary: from space a global overview is obtained, built up from snap-shot like observations over different locations, while a temporal development over one place is obtained from a ground based station. A network of ground-based stations, therefore, has the ability to provide spatio-temporal development of aerosol fields and offers a unique opportunity for validation of observations from space. These notions are the basis for this proposal. The main objectives of this proposal are: 1) Validation of Aeolus L2A products of aerosol and cloud profiles of backscatter, extinction and lidar-ratio, 2) Assessment of spatiotemporal representativeness of Aeolus aerosol and cloud products. The objectives will be accomplished through correlation between ground based lidar data from EARLINET stations. For this, data will be used from: 1) The (historical) EARLINET database, 2) Collocated measurements performed by selected EARLINET stations during close proximity Aeolus overpasses. EARLINET stations perform regular lidar measurements simultaneously at three fixed instances a week, guaranteeing unbiased data collection: one daytime measurement around noon, when the boundary layer is well developed, and two night-time measurements per week, in low background-light conditions, to perform Raman extinction measurements. Since the launch of CALIPSO in April 2006, EARLINET maintains a collocated measurement schedule that takes advantage of the network structure. This is done so that close overpasses are captured by a particular station and also by its nearest-neighbour stations to capture the spatio-temporal variability. It is proposed to use a similar strategy for the validation of Aeolus. Deliverables are: 1) Vertical profiles of aerosol optical properties (backscatter, extinction and lidar ratio) obtained from routine network observations, 2) Vertical profiles of aerosol optical properties obtained from collocated observations. 3) Report The routine EARLINET measurement programme is run on National/Institutional funding obtained by the individual partners and is secured by individual stations. Since most of the EARLINET lidar instruments cannot measure unattended, substantial effort is involved in special and additional/collocated measurements, for which additional funding is needed. National/international agencies will be approached to cover these costs.
Expected innovation for Aeolus	- The EARLINET network spanning over Europe offers a uniquely provides the spatio-temporal variability of the aerosol fields observed from space on a regional scale. - EARLINET provides extinction, backscatter, and lidar ratio at 355 nm which can be directly compared to Aeolus aerosol and cloud profiles and is a main source for L2A validation.

	- Raman lidar and HSRL are similar in the ability to provide aerosol and cloud backscatter, extinction and lidar ratio without critical assumptions. However, for HSRL the cross talk between the Rayleigh and Mie channels has to be properly removed. This may lead to biased aerosol and cloud data in the HSRL case. The Raman lidar method does not have this bias and provides a basis for error budget estimations for Aeolus. - EARLINET provides extinction, backscatter, and lidar ratio at 532 nm in addition to the UV wavelength. This information is useful to better characterise the aerosol fields observed by the satellite and provides a solid base for conversion of Aeolus data from the UV to longer wavelengths. - EARLINET provides aerosol and cloud profiles at much higher spatial resolution than Aeolus. - Error budgets in Aeolus aerosol and cloud data related to polarisation effects can be studied. Aladin emits circular polarisation, but measures at a single linear polarisation. Substantial effects are expected in aerosol optical property retrievals. - EARLINET has 17 multi-wavelength lidars, providing backscatter at three wavelengths (1064, 532 and 355 nm) and extinction at two wavelengths (532 and 355 nm). Inversion algorithms have been developed to obtain microphysical aerosol properties such as effective radius, volume and surface-area concentration, real and imaginary part of the complex refractive index, and single scattering albedo based on such multi-wavelength data sets. This enables identification of aerosol types. - Separate treatment of aerosols and clouds is warranted, which can be provided by the lidar network.
Expected results for Aeolus	- Quantify accuracy of aerosol and cloud geometrical and optical parameters using a ground-based network of quantitative aerosol and cloud lidars. - Characterise deviations of the Aeolus -L2A products from ground truth established by the lidar network. - Recommendations for improvement to processing algorithms based on intercomparison between observations from space and ground. Initial results, based on a limited dataset from ground-based measurements, can be provided after completion of Phase E1. - Monitoring of product stability over the observational period foreseen in the proposal.

Data requirements, data coverage and timeline	**Aeolus Product Names** Level 2A data	**Data Coverage** Study area Latitude 30°N to 75°N, Longitude 20°W to 45°E	**Specific Timeline of Validations**
Validation data to be collected	Earlinet lidar data, Study area Latitude 30°N to 75°N, Longitude 20°W to 45°E		
Special data needs	n.a.		

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	A US Effort for ADM/Aeolus Calibration and Validation
Link to full Proposal	5177
Team Leader name, affiliation and email	Dr. Mike Hardesty, Cooperative Institute for Research in Environmental Sciences/University of Colorado/NOAA, mike.hardesty@noaa.gov
Support team-members names and emails	Mr. Jason Dunion, jason.dunion@noaa.gov Dr. G. David Emmitt, gde@swa.com Dr. Richard Ferrare, richard.a.ferrare@nasa.gov Dr. Iliana Genkova, igenkova@ssec.wisc.edu Dr. Sid Boubarka, sid.boukabara@noaa.gov Dr. Robert Atlas, robert.atlas@noaa.gov Dr. Lidia Cucurull, lidia.cucurull@noaa.gov Dr. Johnathan Hair, johnathan.w.hair@nasa.gov Dr. Ross Hoffman, ross.hoffman@aer.com Dr. Chris Hostetler, chris.a.hostetler@nasa.gov Dr. Michael Kavaya, michael.j.kavaya@nasa.gov Dr. Matthew McGill, matthew.j.mcgill@nasa.gov Dr. Zhaoxia Pu, zhaoxia.pu@utah.edu Dr. Christopher Velden, chris.velden@ssec.wisc.edu Dr. Sara Tucker, stucker@ball.com Dr. James Yoe, james.g.yoe@noaa.gov Dr. Sid Boukabara, sid.boukabara@noaa.gov Dr. Alan Brewer, alan.brewer@noaa.gov Dr. Will McCarty, will.mcwill.mccarty@nasa
Summary of activity	A comprehensive US effort for Aeolus validation will include direct comparison of Aeolus measurements with observations from remote and in situ sensors over the course of the Aeolus mission. Airborne lidars will underfly the Aeolus track to characterize and validate Aeolus wind and aerosol measurements in coordination with other science missions. Available airborne instruments will include direct detection and coherent Doppler lidars as well as state-of-the art aerosol lidars to examine the precision of Aeolus measurements and the impact of clouds and aerosol inhomogeneities on the wind estimates. The data will also be used to examine and improve Aeolus processing algorithms. Airborne campaigns will be supplemented by long-term measurements from surface remote sensors, radiosondes and dropsondes. Wind and aerosol observations will be gathered when the Aeolus track is reasonably close to the comparison station. The long term measurements will enable investigation of Aeolus stability and extended performance characteristics. Observations will be obtained at several locations within the United States as well as in the Arctic and over ocean regions. Atmospheric motion vector (AMV) winds derived from satellite observations will be compared with Aeolus observations. ADM vector coverage, quality and differences with AMVs will be documented, thus assessing the complementary value of the ADM winds to the existing upper-air winds observing system. Data assimilation studies are an important component of this proposal. Innovation statistics (observation minus forecast residuals) will be studied both for level 1 and level 2 products as functions of latitude and height as well as of parameters such as cloud cover and aerosol loading. In addition, data impact experiments with ADM level-2 LOS wind observations will be performed, and a broad range of standard forecast diagnostics will be calculated. Deliverables for the various components of this proposal are: 1) Data from aircraft intercomparisons will be made available to the Aeolus calibration and validation team in a timely manner after the data are taken. Data will include, depending on the type of measurements performed, estimates of wind and aerosol characteristics and variability over Aeolus measurement volumes. Additionally, progress reports summarizing scientific analysis of results will be provided on an annual basis. 2) Data from long term comparisons will be made available to the Aeolus calibration/validation team as the data are analyzed and become available. Data will include wind and aerosol parameters measured at the cooperating sites. Progress reports summarizing analysis of results will be provided on an annual basis.

	3) Atmospheric Motion Vector Winds: A final report will be provided describing Aeolus comparison with Atmospheric Motion Vector Winds. During the research, significant results will be described as they become available. 4) Data assimilation: Results of data assimilation studies, including innovation statistics over different length scales and the results of data impact experiments with Aeolus data, will be made available in a timely manner. While specific funding for this post launch effort has not been finalized, NASA is currently funding two ADM Cal/Val preparatory missions in the Arctic using DWLs on agency aircraft. Upon acceptance of the proposal by ESA, funding will be requested from several United States funding agencies, including NOAA, NASA, and the National Science Foundation. Discussions with program managers from these agencies are already underway. The range of activities and the projected outcomes of this proposed effort will provide significant additional resources and data sets for Aeolus calibration and validation studies. In addition, the proposal team brings a broad spectrum of experience associated with obtaining and analyzing lidar and satellite data and in the assimilation of meteorological data for forecasting and scientific applications.
Expected innovation for Aeolus	The proposal brings state-of-the-art instruments, aircraft platforms, experienced investigators, and measurements in unique locations such as around hurricanes and in the Arctic to Aeolus cal-val effort. Airborne campaigns will answer important questions on the effects of clouds, vertical shear, and aerosol inhomogenities on Aeolus measurements. Surface measurements, in combination with measurements from investigators from other parts of the world, will provide the necessary data to assess Aeolus performance over the long term. Comparison with cloud and water vapor winds will provide insight to the performance and value added of Aeolus relative to a wind product that is currently assimilated for operational forecasting. Data assimilation studies will provide important information on the usability of the data as determined from forecast models.
Expected results for Aeolus	The proposal contributes to AO objectives by providing direct measurements in conjunction with Aeolus observations. Such data are necessary to establish instrument accuracy, reveal problems, and understand the characteristics of the measurements. Comparison with existing wind measurements based on atmospheric motion vectors, and data assimilation studies, will provide comparative information on the relative impact of the data and its properties relative to currently applied measurements. The scope of the proposed work will result in significant and major contributions to the primary objectives as specified in the AO.

Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, L2B data	**Data Coverage**	**Specific Timeline of Validations**

Validation data to be collected	Profiles of wind speed and direction, aerosol backscatter, aerosol extinction and other relevant parameters for this investigation will be collected from airborne and surface remote and in situ sensors operated by the investigators
Special data needs	n.a.

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Aeolus Validation at ALOMAR and IAP using Doppler radar, Doppler lidar, and radiosondes:** **ALOVAL-IAP PROPOSAL WITHDRAWN**
Link to full Proposal	5186
Team Leader name, affiliation and email	Dr. Gerd Baumgarten, Leibnits-Institute of Atmospheric Physics, baumgarten@iap-kborn.de
Support team-members names and emails	Dr. Michael Gerding, gerding@iap-kborn.de Dr. Gunter Stober, stober@iap-kborn.de Prof. Jorge Chau, chau@iap-kborn.de
Summary of activity	This project supports the validation of Aeolus wind and aerosol measurements by performing radar, lidar, and radiosonde observations in the tropo- and stratosphere. The measurements will be compared in detail to Aeolus products level 1B through 2C for nearby observations. Extended measurements will be used to investigate the effect of small scale perturbations on the quality of the validation and also on the precision of single measurements. The observations will be performed at two locations, the Leibniz-Institute of Atmospheric Physics (IAP) at Kühlungsborn in Germany (54°N, 12°E) and the Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) in Norway (69° N, 16°E). At both sites the IAP operates high power VHF radars and Rayleigh/Mie/Raman (RMR) lidars. The VHF radars measure Doppler velocities in freely selectable directions up to 30° off zenith. The instrument setup allows also for calculating the 3-dimensional wind field and turbulence from continuous soundings. The lidar at ALOMAR is a combined RMR and Doppler wind lidar observing simultaneously two components of the horizontal wind in the strato- and mesosphere using Doppler Rayleigh Iodine Spectroscopy (DoRIS). The instruments at ALOMAR measure winds in the tropo- and stratosphere by using Doppler radar from 2-16 km and Doppler lidar data from 5-80 km, supplemented by aerosol and temperature measurements from 5-85 km. At Kühlungsborn we are able to measure winds from 2-16 km by radar and aerosols and temperatures in the altitude range of 1-85 km by lidar. In addition, we will launch radiosondes at times of Aeolus measurements in the core validation campaign. We will compare in detail our observations to the Aeolus products and quantify the agreement of the observations by means of accuracy and precision. We will use temperature measurements performed at both sites to investigate the performance of the retrieval of L2B products. Simultaneous Doppler radar and lidar measurements will be performed to quantify the precision of the ground based instruments. With the combined dataset we will investigate the Aeolus precision and accuracy in detail. During the core validation campaign we also will investigate the differences between the Eulerian measurements by the ground based instruments and Aeolus in comparison to the Lagrangeian observations by radiosondes. The project benefits from the state of the art instruments supplied by IAP. The VHF radars (53.5 MHz) are designed to study the meso-, strato-, and troposphere (MST Radars) and are operated continuously throughout the year, independent on the weather conditions. The daylight capability of the lidars increases the number of coinciding measurements with Aeolus. The Aeolus validation will benefit from the observation at the two stations as they are located in areas with different sources for atmospheric gravity waves and hence wind variances. ALOMAR is located close to the Scandinavian mountains and at the edge of the polar vortex in wintertime. The observations by the lidars might include observations of strong aerosol signals in the stratosphere, so-called Polar Stratospheric Clouds (PSCs). All costs for the operation of the different lidar and radar systems are supplied by the IAP. We apply for additional funding, e.g. through DLR and NRS, especially, to cover personnel costs for data acquisition and data analysis of the ADM validation measurements and reporting. Personnel costs for the data acquisition are used to operate the lidar instruments and to release radiosondes. Funding for radiosondes as well as for travel due to additional maintenance of the radars and lidars and to communicate and present the results on dedicated workshops and conferences is required.
Expected innovation for Aeolus	The team will measure Doppler wind, temperature and aerosol data at two locations providing different atmospheric conditions. One is surrounded by a flat orography and in middle latitudes; the other is at high latitudes and close to the Scandinavian mountain ridge. Doppler velocities will be determined from the VHF radar in the line-of-sight of the Aladin instrument. Additionally, the investigation of stratospheric-tropospheric exchange processes can effectively be supported by

<table>
<tr><td></td><td colspan="3">hourly monitoring the radar-derived tropopause heights estimated from mean values of range corrected backscattered VHF radar echo power.
The team will acquire Doppler wind lidar measurements, with a unique lidar at high latitudes. The lidar uses two steerable telescopes which allow performing quasi coaxial measurements with the Aeolus LOS. In combination with the Doppler velocities from the VHF radar, reliable wind vectors can be measured in the altitude range from 2 to about 70 km. Furthermore, the results of simultaneous ground based lidar measurements of temperatures and aerosols in a common volume during the Aeolus overpasses at both locations will contribute to the post-processing and validation of the ADM retrieval algorithm.</td></tr>
<tr><td>Expected results for Aeolus</td><td colspan="3">Doppler wind measurements by VHF radars will be performed in the altitude range from 2 - 16 km at middle and high latitudes. During the core validation period the Doppler velocities in the line-of-sight direction of the ADM satellite will be provided together with the 3-dimensional wind field and its variability. The radars operate continuously and the team can provide regular wind measurement for the validation. Accuracy and reliability of the wind measurements are proved by simultaneous radiosonde launches.
Furthermore, the team provides measurements by a Doppler wind lidar (DWL) at polar latitudes for wind measurements in the stratosphere. Stratospheric DWL measurements are available only at limited locations globally. Optionally, a DWL could be implemented at Kühlungsborn to provide stratospheric winds extending the altitude range for direct wind validations. Additionally, aerosol measurements and temperatures from ground up to mesospheric heights can be provided at both stations, contributing e.g. to the validation of the L2B data products.
During the preparation period the team would test and justify the experiments and analysis methods for the core validation phase. The core validation period is used for extensive acquisition and analysis of the data at tropospheric and stratospheric heights. During the extended validation phase the team will provide the routinely acquired data and focus on special projects especially the variances due to gravity waves at high and middle latitudes by radars and lidars.</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names
AUX data, calibration files, Level 1B, Level 2A, L2B data
Overpass tables</td><td>Data Coverage</td><td>Specific Timeline of Validations</td></tr>
<tr><td>Validation data to be collected</td><td colspan="3">n.a.</td></tr>
<tr><td>Special data needs</td><td colspan="3">n.a.</td></tr>
</table>

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Aeolus L2A/L2B aerosol, cloud and wind product validation using the Cabauw Experimental Site for Atmospheric Research CESAR**
Link to full Proposal	5188
Team Leader name, affiliation and email	Ir. Arnoud Apituley, KNMI, apituley@knmi.nl
Support team-members names and emails	Dr. Dave P. Donovan, donovan@knmi.nl Dr. Henk Klein-Baltink, henk.klein.baltink@knmi.nl Prof. Herman Russchenberg, H.W.J.Russchenberg@tudelft.nl Steven Knoop, steven.knoop@knmi.nl
Summary of activity	The Aeolus mission will provide global wind profile observations with the aim to demonstrate improvement in atmospheric wind analyses for the benefit of numerical weather prediction and climate studies. In addition to wind profile measurements Aeolus will also use the abilities of the High Spectral Resolution Lidar Aladin, at the heart of the mission, to provide aerosol and cloud optical parameters. Aeolus will be the first High-Spectral Resolution lidar to be flown in space. This type of lidar is capable of providing vertically resolved aerosol and cloud backscatter and extinction profiles as well as the lidar ratio without critical assumptions. For global aerosol and cloud profiling, Aeolus can be regarded the follow- up of the CALIPSO/CALIOP instrument presently operational on the A-train and ADM will bridge the gap until the launch of EarthCARE. Even though the main product from Aeolus will be wind profiles and aerosol and cloud data are secondary data products, valuable data is expected on aerosol and cloud properties, needed for advancement in climate and air quality research. CESAR, the Cabauw Experimental Site for Atmospheric Research, is the Dutch focal point for collaboration on climate monitoring and atmospheric research and is situated on the KNMI meteorological research site near Cabauw. CESARs strengths lie in the integrated approach of atmospheric profiling and on studying aerosol-cloud interactions using advanced multi-sensor techniques aimed to fill one of the largest gaps for improving the understanding of our climate. CESAR is one of the leading research facilities in this field world-wide. CESAR integrates many essential measurements that are needed to increase understanding of climate, air quality issues and observations needed for assimilation in NWP models. These observations include profiles of wind, aerosols, clouds and water vapour. The resulting anchor-point provides much needed interrelationships between the fields of research. CESAR will also serve as a test bed for an in-depth understanding of existing measurements, development of new measurement techniques, intercomparisons for climate research and air quality monitoring. Last but not least, use will be made of the unique possibilities of the CESAR research station for validating and improving satellite measurements. The perspectives from space observations and ground based measurements are complementary: from space a global overview is obtained, built up from snap-shot like observations over different locations, while a temporal development over one place is obtained from a ground based station. Ground-based stations have the ability to provide spatio-temporal development of the state of the atmosphere for many parameters simultaneously, and in much greater detail than from space. This offers a unique opportunity for validation of observations from space. These notions are the basis for this proposal. Main objectives are: 1) Validation of Aeolus wind, aerosol and cloud profiles of backscatter, extinction and lidar-ratio using CESAR observations during close proximity overpasses. 2) Assessment of representativeness of Aeolus wind, aerosol and cloud products using time series of CESAR observations. 3) Assessment of local cloud and aerosol conditions on Aeolus retrieved wind profiles based on CESAR records of the atmospheric state. For this, data will be used from the operational CESAR suite of instrumentation, in particular the wind profiler, radars and lidars. Deliverables 1) Vertical profiles of the atmosphere, in particular of wind, aerosol optical properties (backscatter, extinction and lidar ratio) and water vapour obtained from routine CESAR observations. 2) Analysis report. Routine observations are partly secured by institutional funding and through national agencies. Additional funding will be needed for some dedicated measurements and Aeolus analyses and use of additional equipment and consumables and will be applied for.

Expected innovation for Aeolus	- CESAR is one of few atmospheric observatories offering and integrated approach to atmospheric profiling. As such, a very detailed record of the atmospheric state is obtained which provides an excellent opportunity to test assumptions made in retrievals for satellite observations. - CESAR provides wind, aerosol and cloud profiles at much higher spatial resolution in relation to Aeolus. Influence of cloud and aerosol dynamics and errors in height assignments on the Aeolus L2B wind product can be studied in detail using the high resolution data from CESAR. - The CESAR suite of instruments includes a high-performance Raman lidar that provides extinction, backscatter, and lidar ratio at multiple wavelengths, including 355 nm which can be directly compared to Aeolus L2A aerosol and cloud profiles. Lidar inversion algorithms have been developed to obtain microphysical aerosol properties such as effective radius and single-scattering albedo based on such multi-wavelength data sets. This enables remote identification of aerosol types. - Data from co-located lidar, radar and other instruments at CESAR are analysed synergistically to obtain detailed cloud classifications and cloud microphysical parameters. - The geographic location of CESAR offers the possibility to study strongly different airmasses, varying from clean marine air to polluted continental, in one location with the same instrumentation, and thus the relation of the airmasses to the Aeolus retrievals. - Regarding the aerosol and cloud properties, Aeolus polarisation effects are expected to have important effects due to emission of circular polarisation and detection of a single linear polarisation state. CESAR lidars also measure depolarisation so that these effects can be studied.		
Expected results for Aeolus	- Quantify accuracy of L2A and L2B data products by measurements obtained from the CESAR station for integrated atmospheric profiling. - Characterise deviations of the Aeolus-L2A products from ground truth established by the station. - Recommendations for improvement to processing algorithms based on intercomparison between observations from space and ground. - Monitoring of product stability over the observational period foreseen in the proposal.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 2A and L2B data	**Data Coverage** Latitude: 51.95°N Longitude: 4.88°E	**Specific Timeline of Validations**
Validation data to be collected	Latitude: 51.95°N Longitude: 4.88°E		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

<table>
<tr><td>Validation Project Title</td><td colspan="3">VAAC - Validation of Aeolus by Atmospheric model Comparison</td></tr>
<tr><td>Link to full Proposal</td><td colspan="3">5190</td></tr>
<tr><td>Team Leader name, affiliation and email</td><td colspan="3">Dr. Ad Stoffelen, KNMI, ad.stoffelen@knmi.nl</td></tr>
<tr><td>Support team-members names and emails</td><td colspan="3">Dr. Jos de Kloe, kloedej@knmi.nl
Dr. Gert-Jan Marseille, marseill@knmi.nl</td></tr>
<tr><td>Summary of activity</td><td colspan="3">Aeolus data will be rather sparse compared to some other satellite data types. Therefore, comparison to ground measurements will be rather challenging and much mission time will be needed before statistically relevant validation results can be obtained. KNMI proposes to contribute with a proven method of validation that provides a collocation with every measured profile and apply it to the Aeolus system. Using Aeolus measurement system parameters and atmospheric NWP model analyses and forecasts, statistically reliable results may be obtained of random and systematic differences between the atmospheric model and the Aeolus data as a function of all relevant system parameters in a relatively short time period. This depends obviously on the accuracy of the NWP model used for comparison. This accuracy is generally well known since NWP models are routinely confronted with many different observing systems, both ground-based and satellite. We plan to use the ECMWF model for global comparisons and HiRLAM/HARMONIE regionally. The analyses and syntheses will take into account the errors in these models and the geophysical sampling space used. Statistical comparisons will be made on different Aeolus aspects, namely, optical Rayleigh and Mie channel signal, ground calibration, and wind profiles. Aeolus parameters used will be, e.g., time since last calibration, calibration parameters and functions, orbit phase, latitude, altitude, etc. Reports on systematic differences and trends between NWP model simulations and Aeolus measurement data will be provided as well as suggestions on how to prevent these. KNMI is heavily involved in the Aeolus development and currently participating in the L1B/L2A, campaign, L2B/L2C, and V(H)AMP scientific ESA studies. During the Aeolus Cal/Val KNMI experts will be working with the data. Moreover, KNMI applied for a EUMETSAT grant for a post-doc to contribute to the Aeolus Cal/Val and to provide a NRT L2B wind service in support of (regional) NWP.</td></tr>
<tr><td>Expected innovation for Aeolus</td><td colspan="3">The innovative character of the contribution lies in a statistical assessment of the quality and trends in Aeolus system components (optical, wind, ground calibration). We aim to complement the planned monitoring of the Aeolus wind profiles by, e.g., ECMWF by more detailed Aeolus system statistical analyses.</td></tr>
<tr><td>Expected results for Aeolus</td><td colspan="3">The statistical assessment will include in depth validation of the Aeolus optical and wind observation and retrieval techniques, geophysical validation and numerical weather prediction data assimilation procedure.

Moreover, (regional) NWP centres expressed an interest to obtain NRT Aeolus wind profiles, further confirmed at EUMETSAT delegate body level. The involvement of EUMETSAT and its delegate bodies is obviously critical in the assessment of the Aeolus mission by the European weather and climate user community.</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names

AUX data, calibration data Level 1B and Level 2A, L2B data</td><td>Data Coverage</td><td>Specific Timeline of Validations</td></tr>
</table>

Validation data to be collected	n.a.
Special data needs	NRT and archived data

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**High Resolution, High Latitude Regional Model Cal-val of AEOLUS**
Link to full Proposal	5192
Team Leader name, affiliation and email	Cand. scient. Harald Schyberg, met.no, h.schyberg@met.no
Support team-members names and emails	Mrs. Svetlana Tsyro, s.tsyro@met.no Dr. Roger Randriamampianina, rogerr@met.no Dr. Michael Schulz, michael.schulz@met.no Mr.. Jan Jurgen Griesfeller, jan.griesfeller@met.no
Summary of activity	The purpose of the planned activity is to contribute to calibration and validation of the Aeolus wind LIDAR by provision and analysis of (a) corresponding model output from high-resolution limited-area numerical weather prediction (NWP) models, (b) corresponding aerosol extinction profiles and aerosol optical depth (AOD) fields from the regional EMEP chemical transport model, and also integrate Aeolus measurements through the model with CALIOP and AERONET data, and (c) radiosonde data at high latitudes. The correspondence between these data sources and the Aeolus measurements will be investigated. Calibration and validation using model data allows interpolation to get an exact collocation in space and time of model data with the satellite observations. Using short-range model forecasts (0-6 hr) has the advantage vs in situ observations in avoiding the separation in time and space from the satellite observations that must occur (although there will still be representativeness issues related to the different averaging present in model fields and measurement). Through the data assimilation cycling the model implicitly integrates information from other available observation data. Also, the NWP model error statistics are usually well characterized. This proposal has focus on utilization of model and observation data on high latitudes, in particular the North-East Atlantic and part of the Arctic. Since Aeolus is a polar orbiter, the orbit pattern gives increasing Aeolus observation density with increasing latitude, up to the maximum latitude near the North Pole. Focussing on high latitudes allows a higher than average size of the collocation dataset for a given domain size. Covering both the mid-latitude storm tracks and the lowermost part of the polar winter stratospheric jet should also give suitable wind climatology for calibration. We propose to produce collocations of Aeolus with NWP data from a convection permitting model with 2,5 km horizontal resolution, which is the present resolution of our operational regional NWP system. This will be done for two different domains, one covering Scandinavia and adjacent ocean areas, and one covering an Arctic domain. With this we will characterize the Aeolus horizontal line-of-sight wind product, and it will also provide information on the smaller scale wind variability and cloud field variability within the track accumulation distance for each measurement. The EMEP chemical transport model, driven with meteorology from the ECMWF-IFS NWP model, will be set up to calculate 3-dimentional aerosol concentrations, including their chemical composition, as well as aerosol extinction profiles and integrated AOD on both regional and global scales. Flexible design of the EMEP model allows calculations with fine resolutions, down to approximately 7 km. Main activities to calibrate and validate Aeolus measurements will be based on gridded daily mean aerosol extinction and AOD. Through the EMEP model, Aeolus measurements will be integrated with aerosol extinction data from CALIOP LIDAR (on board CALIPSO) and with AOD from AERONET sun-photometers, making use of the AeroCom system (http://aerocom.met.no/). This, facilitated by additional model information on aerosol chemical composition and size distribution, will make a good basis for analysing biases and regional differences (see below description of aerosol model). In order to perform along-track comparison of modelled and Aeolus aerosol data, further development of the model observational operator and post-processing routines is needed. Work will be initiated to prepare the model for calculating the aerosol extinction profiles collocated with Aeolus. In addition to the collocated NWP and aerosol model data, we propose also to collect high latitude radiosonde observations which provide wind vector observations (as well as pressure, temperature and dewpoint). Funding for the project will be sought from the ESA PRODEX programme.

Expected innovation for Aeolus	The main idea of the proposal is to provide regional atmospheric modelling input to cal-val of Aeolus with higher resolution than global models, both for NWP wind fields, auxiliary data such as cloud, pressure, temperature and aerosol extinction data from the EMEP model; to integrate Aeolus with CALIOP and AERONET data. A focus on high latitudes allows a higher density of Aeolus observations than on average. It is also an option to utilize high latitude radiosonde observations.		
Expected results for Aeolus	The proposed project will provide the following reference datasets collocated with ADM: - model datasets of HLOS winds - model datasets of additional quantities influencing the ADM observations such as cloud, temperature profile and pressure - model datasets of evaluated aerosol extinction profiles and column integrated optical depth (AOD), supplemented with aerosol physical and chemical characteristics The analysis of these data has the potential to - help assess the absolute accuracy of level 2 products - help assess biases and systematic errors and help trace error sources, and “artefacts” connected to atmospheric conditions, the processing or the instrument - provide model data to help characterizing wind quality as a function of atmospheric scene		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A L2B data, AUX_MET, AUX_RBC, AUX_PAR files for L2 processing	**Data Coverage** All phase E2	**Specific Timeline of Validations** All phase E2
Validation data to be collected	Routine NWP radiosoundings within LAM model domain, AMVs in model domain		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Airborne and Lidar Validation of ADM Aeolus at ALOMAR (ALIVO ALOMAR)**
Link to full Proposal	26989
Team Leader name, affiliation and email	Dr. Michael Gausa, Andøya Space Center, michael@sndoyaspace.no
Support team-members names and emails	Dr. Carlos Toledano, toledano@goa.uva.es Mrs. Sandra Blindheim, sandra@andoyaspace.no Prof. Jens Bange, jens.bange@uni-tuebingen.de
Summary of activity	The present project aims to support the validation of Aeolus by performing wind and aerosol measurements at the ALOMAR Observatory/Andøya Space Center (Andøya Island, Norway, 69N,16E) using airborne and ground-based platforms. Our location is distinguished for the validation of polar orbiting satellites due to a 2-4 times higher number of near-by overpasses compared to mid-latitude sites. At ALOMAR we collect aerosol profiles with a tropospheric lidar and aerosol columns are measured by a co-located sun/moon photometer. In addition we will conduct five air-borne campaigns (à 2 weeks) to get altitude dependent winds and aerosol content. These campaigns are closely correlated with ALOMAR measurements, can be coordinated with other airborne activities and will cover satellite overpasses within a radius of 200 km. From late summer 2014 Andøya has regular launches of weather balloons, operated by the Norwegian met-service. The balloons will contribute with wind profiles when the satellite overpass is close to the regular balloon schedule. In addition, we can launch weather balloons manually at the ASC launch site to achieve GPS wind profiles. Further Aeolus Cal/Val activities are foreseen at ALOMAR with radars and other lidar systems, initiated by the Leibniz Institute, IAP in Germany. All measurements at and in the vicinity of ALOMAR are closely coordinated and performed simultaneously, as far as possible. We use different instrumentation for airborne and ground-based measurements. For aerosol profiling from ground we use a tropospheric lidar, which is part of the EARLINET network. The system went through an EARLINET internal inter-comparison and follows the EARLINET quality assurance protocol. The system has three elastic channels (1064 nm, 532 nm and 355 nm; depolarisation capability at 532 nm and an inelastic N2 – Raman channel) and covers a height range from ca. 700 m asl. to the lower stratosphere. The laser system of our lidar is capable of Doppler-wind measurements; an additional receiver branch would require an additional funding of about 350 kEuro. Aerosol properties are achieved by applying our lidar pre-processed data to the EARLINET "Single Calculus Chain". The main data products which can contribute to the validation are extinction coefficient and lidar elastic backscatter. For aerosol column measurements, we use the latest version of the Cimel-318T sun/moon photometer, which is part of the Spanish sun photometer network RIMA and the global AERONET. The participation in those networks requires and assures annual calibrations of the system. The main data products we can use for validation purposes are spectral aerosol optical depth and derived Angstrom exponent, which also provide information on aerosol typing needed in satellite retrievals. For the envisaged airborne measurements we use a research plane of the type Stemme S10 VTX, provided by the University of Applied Science Aachen, Germany, and our own unmanned platform with 5,2 m wing span to carry the instruments for wind and aerosol profiling. The endurance of both platforms allows reliable operations even outside the 200 km radius, however for better special coincidence with the ground-based instruments, we aim to limit the operation to the vicinity of ALOMAR. The airborne instrumentation comprises of a well-proven package of meteorological sensors (temperature, humidity, pressure) together with a miniature 5-hole probe for 3D wind measurements, developed at the University of Tübingen. Additionally we probe the atmospheres aerosol content with AE51 Aethalometer and a recently in-house developed three-colour laser scatter sensor. With additional funding available we will invest in a particle counter, which achieves a detailed aerosol size distribution. Both airborne platforms are able to carry all the mentioned instrumentation in one mission. Each project partner is expected to use national funding sources.

Expected innovation for Aeolus	The main purpose of this proposal is to provide unique and comprehensive data sets at high latitude through the combination of ground-based and airborne measurements to support the Cal/Val activities of Aeolus wind and aerosol products. At our site, we have three different technologies for wind measurements in the troposphere, provided through three independent proposals, AO ID # 5186 (MST radar), AO ID # 5192 (GPS balloon) and AO ID # 26989 (Fixed wing 5-hole probe). Two of them, MST radar and fixed wing probe are able to acquire LOS winds. This is an exclusive asset at our latitude. We use two well-established remote sensing techniques, lidar and sun photometer for characterizing aerosol profiles and the total aerosol content. Co-located radiosoundings improve the data analysis due to a more accurate air density profile and enables us to provide a precise daily Rayleigh background profile. In addition, aerosol probing from the fixed wing platforms facilitate comprehensive information on the aerosol-physical properties (extinction, backscatter). To our knowledge, these airborne platforms have not been used for satellite validation to this extent.		
Expected results for Aeolus	The proposed project will provide the following data sets for the calibration and validation of the Aeolus satellite: - HLOS wind profiles - LOS wind profiles - 3D wind vectors from airborne platform - Lidar ß, σ, OD, backscatter, extinction ratio - Cloud/aerosol cover/stratification - Cloud/aerosol top/base height - Spectral aerosol optical depth and derived Ångstrom exponent The analysis of these data have the potential to assist in validation of the level 2 products (wind profiles, clouds and aerosols) from Aeolus. It can also help to assess the accuracy, resolution and stability of the Aeolus instrument Aladin at high latitudes and at the same time understand error sources specific for high latitudes in different seasons.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1, Level 2A L2B data	**Data Coverage**	**Specific Timeline of Validations**
Validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Experimental Validation Aeolusand Assimilation of Aeolus observations (EVAA)**
Link to full Proposal	27329
Team Leader name, affiliation and email	Dr. Martin Weissmann, LMU, martin.weissmann@lmu.de
Support team-members names and emails	Dr. Ulla Wandinger, ulla.wandinger@tropos.de Dr. Volker Lehmann, volker.lehmann@dwd.de Dr. Volker Freudenthaler, volker.freudenthaler@lmu.de Prof. Dr. Markus Rapp, markus.rapp@lmu.de Dr. Alexander Geiss, alexander.geiss@lmu.de Mrs. Anne Martin, anne.martin@lmu.de Dr. Albert Ansmann, albert.ansmann@tropos.de Dr. Holger Baars, holger.baars@tropos.de Dr. Johannes Bühl, johannes.buehl@tropos.de Dr. Ronny Engelmann, ronny.engelmann@tropos.de Dr. Alexander Cress, Alexander.Cress@dwd.de Dr. Oliver Reitebuch, oliver.reitebuch@dlr.de
Summary of activity	The objective of the proposal is to validate the Aeolus L1B and L2B wind product and the related instrument calibration modes and algorithms and assess the benefit of the observation for numerical weather prediction (NWP). The validation will be performed by means of co-located wind observations gathered during a ground and two airborne campaigns, a long-term comparison, and a thorough characterisation of the observed atmospheric state (aerosol content, clouds, temperature, pressure). The representativeness of the co-located observations w.r.t. the satellite observations will be assessed by use of high-resolution model simulations. The ground campaign is planned at the sites of the Richard-Aßmann Observatory of DWD Lindenberg (and for long-term comparison also at other DWD wind profiler sites), the Leibniz Institute for Tropospheric Research Leipzig and at DLR Oberpfaffenhofen during a period of 10-12 weeks. Two airborne campaigns are planned for a duration of 2-3 weeks each with DLR Oberpfaffenhofen as operation base of for the first campaign and an operation base in Northern latitudes for the second campaign. In addition the validation of Aeolus will be one of the objectives of the international aircraft experiment T-NAWDEX in September/October 2016. The Aladin airborne demonstrator A2D will be the key reference instrument for the satellite Aladin instrument during ground and airborne campaigns. The ground campaign instrumentation includes up to four tropospheric radar wind profilers (482 MHz), radiosondes and two coherent wind lidars (at Lindenberg and Leipzig) as reference for wind observations. The characterisation of the atmospheric state will be performed by the Raman lidar RAMSES (355 nm), radiosondes, ceilometers and sun photometers at Lindenberg, by the multiwavelength Raman lidar MARTHA , the automatic Raman lidar PollyXT (both at 355/532/1064 nm with Raman and polarization capabilities), ceilometer, sun photometer and additional instrumentation at Leipzig and by the aerosol lidar POLIS or MULIS (both at 355/532/1064 nm with Raman and polarization capabilities) at DLR Oberpfaffenhofen. The payload for the airborne campaigns will be the Aladin airborne demonstrator A2D combined with a 2-µm wind lidar. Deliverables are co-located observations during satellite overpasses and its analyses as well as conclusions on the Aeolus performance including its calibration modes and algorithms. The benefit of the observations for NWP will be assessed through data denial experiments with the experimental global ensemble data assimilation system of DWD and a recently developed tool for ensemble-based estimates of observation impact. The team is composed of well experienced scientists on wind observation techniques, aerosol and cloud observation techniques, wind intercomparisons, the assimilation of wind lidar observations and the performance of ground and airborne campaigns including pre-launch validation activities for Aeolus. The team is composed of experts in the Aladin instrument and the satellite mission Aeolus, and the related ground processing algorithms for L1B, L2A, and L2B products. After approval of the proposal by ESA, the responsible institutions at national and international level will be approached to obtain funding for the proposed activities. Thus, no commitment to perform these activities can be provided with the submission of this proposal.

Expected innovation for Aeolus	The proposal is innovative, because it combines solid experimental and modelling expertise for the validation of ADM Aeolus observations with the ground and airborne platforms, the estimation of their representativeness and the assimilation of ADM Aeolus observations in NWP. A close link between instrument, algorithm, processor, and assimilation experts, as established in this proposal will be essential for an optimal use of these unprecedented observations.		
Expected results for Aeolus	The proposal contributes to the Aeolus Mission and to all AO Objectives (AE-OFESA- GS-002, 29.04.2014, p. 5, ch. 3) by 1. Validation of Aeolus wind products with airborne and ground-based experiments 2. Experiments to assess the accuracy, resolution and stability of Aladin 3. Assessment and validation of the Aeolus wind retrieval algorithms In particular the proposal contributes to the following objectives (AE-RS-ESA-GS-005, 22.04.2014): 1. Assessment of L1B algorithm and instrument calibration, including correction for zero-wind (ground), sun background light, and Mie contamination in Rayleigh 2. Comparison with wind products from ground-based and airborne observations including assessment of representativeness 3. Assessment of Aladin accuracy, including major error sources and error budgets mainly related to the random error 4. Assessment of the benefit of the observations for NWP		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1, Level 2A, L2B data auxiliary files (e.g. MET, HBE, ZWC, RDB, CAL) Overpass tables	**Data Coverage** Not specified	**Specific Timeline of Validations** Not specified
Validation data to be collected	Radiosonde, wind and aerosol lidar, radar wind profiler and sun photometer observations		
Special data needs	n.a.		

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

<table>
<tr><td>Validation Project Title</td><td colspan="3">Validation of Aeolus in polar regions
PROPOSAL WITHDRAWN</td></tr>
<tr><td>Link to full Proposal</td><td colspan="3">27389</td></tr>
<tr><td>Team Leader name, affiliation and email</td><td colspan="3">Dr. Kerstin Stebel, NILU, kst@nilu.no</td></tr>
<tr><td>Support team-members names and emails</td><td colspan="3">Dr. Philipp Schneider, ps@nilu.no
Prof. Sheila Kirkwood, sheila.kirkwood@irf.se</td></tr>
<tr><td>Summary of activity</td><td colspan="3">The goal of the proposed activity is to validate both aerosol and wind products from Aeolus specifically in Scandinavia and the polar region, using observations from multiple ground-based instruments as well as inter-comparisons with existing satellite products of proven quality. We propose to validate aerosol products retrieved from Aeolus data using two separate validation approaches: First, absolute validation will be carried out against highly accurate ground-based remote sensing datasets (focus on total column products from sun-photometer in Arctic/Antarctic including Scandinavia). Second a relative validation will be carried out by inter-comparing Aeolus aerosol information against other existing EO datasets which supply similar data, such as MODIS, CALIOP and OSIRIS (lowermost stratosphere), as well as climatological aerosol information coming from the ESA-aerosol CCI project. We further propose to validate wind products derived from Aeolus data using observations from MST-radar systems located at Esrange, Sweden (ESRAD) and Maitri, Antarctica (MARA). These systems provide continuous operational profiles of wind vectors in the troposphere/lower stratosphere and are thus well suited for validation of wind product from Aeolus. Funding for the project will be sought from the ESA PRODEX programme</td></tr>
<tr><td>Expected innovation for Aeolus</td><td colspan="3">The proposed work will provide a unique perspective on the quality and accuracy of Aeolus data specifically over high-latitude regions. Using both ground-based remote sensing observations and inter-comparison with other earth observation dataset of proven quality, the proposed validation efforts will deliver valuable information on the quality of the Aeolus aerosol and wind products in polar regions.</td></tr>
<tr><td>Expected results for Aeolus</td><td colspan="3">The proposed project will provide the following reference datasets collocated with ADM:
- total column aerosol datasets in polar regions (Arctic and Scandinavia, Antarctica)
- vertical and horizontal MST radar wind data (N-Sweden and Antarctic site)
- extracted satellite aerosol total column/backscatter profiles

The analysis of these data has the potential to
- help assess the absolute accuracy of level 2 products
- help assess biases and systematic errors
- help understand error sources in polar regions, connected to different atmospheric conditions/seasons
- assess representativeness with respect to regions phenomena</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names

Level 2A, L2B data</td><td>Data Coverage</td><td>Specific Timeline of Validations</td></tr>
<tr><td>Validation data to be collected</td><td colspan="3">total column aerosol datasets in polar regions (Arctic and Scandinavia, Antarctica) [POLAR-AOD] sites (AERONET, PFR-AOD and institutional data), MPLNET backscatter profile data] - vertical and horizontal MST radar wind data (N-Sweden and Antarctic site) [ESRAD Sweden, MARA (Antarctica), - extracted satellite aerosol total column/backscatter profiles (e.g. CALIOP, MODIS, OSIRIS)</td></tr>
<tr><td>Special data needs</td><td colspan="3">ADM L2A Particle spin-off geophysical parameters (aerosol information, optical properties: profiles of aerosol and molecular backscatter, extinction, LOD, SR) ADM</td></tr>
</table>

	L2B/2C Consolidated HLOS wind observations (L2B) and vertical profiles of wind vectors (horizontal components, u and v) It is considered important to receive the fully processed error information and product confidence data, as well as auxiliary information used

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Validation of Aeolus L2 aerosol and cloud product employing advanced ground-based lidar Measurements (VADAM)**
Link to full Proposal	27409
Team Leader name, affiliation and email	Dr. Vassilis Amiridis, NOA, vamoir@noa.gr
Support team-members names and emails	Dr. Volker Freudenthaler, volker.freudenthaler@meteo.physik.uni-muenchen.de Dr. Ulla Wandinger, ulla@tropos.de Dr. Mika Komppula, mika.komppula@fmi.fi Dr. Iwona Stachlewska, Iwona.Stachlewska@fuw.edu.pl Holger Baars, baars@tropos.de, Eleni Tetoni, eleni.tetoni@noa.gr, Eleni Marinou, elmarinou@noa.gr, Manolis Proestakis, proestakis@noa.gr Anna Gialitaki, togialitaki@noa.gr Mamouri Rodanthi-Elisavet, rodanthi.mamouri@cut.ac.cy Prof. Diofantos Hadjimitis, d.hadjimitsis@cut.ac.cy Dr. Argyro Nisantzi, argyro.nisantzi@cut.ac.cy
Summary of activity	The objective of this proposal is to validate the Aeolus L2A cloud and aerosol spin-off products (supplementary geophysical products) and the related instrument calibration modes and algorithms. The validation will be performed with ground-based Raman/polarization lidar instruments providing unbiased profiles of particle extinction, optical depth, backscatter, extinction-to-backscatter ratio and linear and circular depolarization ratios for clouds and aerosol at 355 nm. Simultaneous measurements will be performed during the ground campaign planned to be carried out at three different geo locations, namely Crete in Greece, Leipzig in Germany and Kuopio in Finland. The sites have been selected such as to cover different latitudinal zones and a variety of aerosol abundances/types. Specifically, the Finokalia site in Crete is mostly influenced by non-spherical dust particles including a marine background, Leipzig site in Germany is mostly affected by anthropogenic aerosols and Kuopio site in Finland is located in a region of biogenic and biomass burning organic emissions. All the selected sites are members of the ACTRIS European Infrastructure Network (www.actris.eu) and employ the advanced multi-wavelength Raman/polarization lidar system PollyXT. The ground campaign instrumentation will include two mobile lidar systems as well, namely the ESA's mobile Raman/polarization lidar EMORAL, operated by NOA, and the portable lidar POLIS, operated by LMU. The instrumentation will be coupled by sunphotometric measurements employing CIMEL instruments on the selected sites, which are all members of the AERONET network. Finally, wind-profile information will be available from wind lidars that will operate at the three selected sites. The deliverables will include collocated cloud, aerosol and wind observations during satellite overpasses and their analyses as well as conclusions on the Aeolus performance including calibration, correction schemes, and algorithms. The team is composed of well-experienced scientists in the field of cloud and aerosol lidar research and the performance of ground validation campaigns including pre-launch validation activities for Aeolus. After approval of the proposal by ESA, the responsible institutions at national and international level will be approached to obtain funding for the proposed activities.
Expected innovation for Aeolus	Advanced and high-sophisticated ground-based instrumentation is applied to provide unbiased aerosol and cloud products in terms of particle extinction, optical depth, backscatter, extinctionto-backscatter ratio and linear/circular depolarization ratio at 355 nm. In the Aladin retrievals, critical corrections schemes must be applied to derive the same kind of data. The schemes sensitively depend on the actual system parameters. In particular, the correction of cross-talk between the Mie and Rayleigh channels is expected to implicate uncertainties of Aladin's aerosol and cloud products. In addition, the coarse vertical resolution of the space-borne measurements and the lack of measuring the cross-polarized backscattered component of the circular-polarized emitted light may bias the retrievals. Therefore, the ground-based validation of Aladin's cloud and aerosol products with several independent instruments providing unbiased information on the optical parameters with high spatial resolution is of great importance.

<table>
<tr><td>Expected results for Aeolus</td><td colspan="3">The proposal contributes to the Aeolus Mission and to the AO Objectives (AE-OFESA-GS-002, p. 6) by
- validation of Aeolus atmospheric optical properties products (Level 2A) with ground-based experiments
- experiments to assess the accuracy, resolution and stability of Aladin with respect to cloud and aerosol retrievals
- assessment and validation of the Aladin aerosol and cloud retrieval algorithms

In particular the proposal contributes to the following objectives:
- assessment of L1B algorithm and instrument calibration, especially the cross-talk correction
- comparison of Level 2A products with aerosol and cloud products from ground-based observations including assessment of representativeness
- assessment of Aladin accuracy, including major error sources and error budgets with respect to polarization sensitivity, cross-talk correction, correction of the velocity-induced Doppler shift of the Rayleigh backscatter line, and correction of temperature-dependent Rayleigh line broadening for the retrieval of atmospheric optical properties.</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names

Level 1B data, AUX data, CAL data

Level 2A data

Overpass tables / Predicted orbit information</td><td>Data Coverage

Not specified</td><td>Specific Timeline of Validations

Not specified</td></tr>
<tr><td>Validation data to be collected</td><td colspan="3">Study area: Antikythera, Greece (PollyXT, CIMEL, windcube, POLIS), Leipzig, Germany (PollyXT, CIMEL, WiLi, EARLINET), Kuopio, Finland (PollyXT from Feb. 2019, CIMEL, windcube, EARLINET), Al Dhaid, UAE (autumn 2018 – Feb. 2019, PollyXT), Warsaw, Poland (PollyXT, CIMEL, windcube, EMORAL, EARLINET), Limassol, Cyprus (depol Raman lidar, PollyXT as of Feb2019, aeronet), mobile POLIS (LMU) could be employed at one of the stations Aeolus</td></tr>
<tr><td>Special data needs</td><td colspan="3">n.a.</td></tr>
</table>

<table>
<tr><th colspan="4">Status assessment</th></tr>
<tr><td></td><td>Pre-launch</td><td>Commissioning Phase</td><td>Phase E2</td></tr>
<tr><td>Schedule of proposed activities</td><td></td><td></td><td></td></tr>
<tr><td>Availability of funding</td><td></td><td></td><td></td></tr>
<tr><td>Availability of infrastructure</td><td></td><td></td><td></td></tr>
<tr><td>Availability of people</td><td></td><td></td><td></td></tr>
</table>

Validation Project Title	Validation and Calibration of Aeolus using ground-based lidars
Link to full Proposal	27411
Team Leader name, affiliation and email	Professor Songhua Wu, Ocean University of China, lidar2014@sina.com
Support team-members names and emails	Dr. Xiaoquan Song, songxq@ouc.edu.cn Dr. Bingyi Liu, liubingyi@ouc.edu.cn Xiaochun Zhai: zhaixiaochun@163.com Guangyao Dai: dgy1105@163.com Qichao Wang: 512565802@qq.com Rongzhong Li: rongzhongli@gmail.com Xiaoying Liu: jupiter985@163.com Xiaoye Wang: 2992496477@qq.com Kangwen Sun: sun474784304@qq.com
Summary of activity	We will provide an independent and credible measurement of radial wind speed, wind profile, 3D wind vector, aerosol-backscattering ratio (Rb), aerosol extinction coefficient, extinctionto-backscatter (Sa) ratio(limited in the atmospheric boundary layer and troposphere), sea surface wind vectors using the Mobile Doppler wind lidar / HSRL (High Spectral Resolution Lidar) with an iodine filter during Aeolus overpass the lidar site. Aerosol-backscattering ratio (Rb), aerosol extinction coefficient, extinction-to-backscatter (Sa) ratio and cloud base height is also available using Multi-wavelength Raman-Polarization lidar. The wind profile and sea surface wind vector can be provided by a coherent Doppler lidar if the voyage is available. In addition to the lidar observations, wind profiles and other relevant meteorological data from radiosonde could also be provided. These results can be compared with the data products of Aeolus, and we will analyze the comparison results and present assessment reports to ESA.
Expected innovation for Aeolus	1. The OUC/ORSI Doppler lidars are based on the direct-detect technique same as the Aladin but with the different laser wavelength and Doppler frequency discriminator which makes validation effective on the independent technological background. The validation lidars cover most of the data products of Aeolus such as LOS wind speed, aerosol extinction coefficient and backscattering. Moreover, aerosol backscattering ratio and lidar ratio can be provided which is essential to calibrate the atmospheric parameter used for aerosol extinction coefficient and wind velocity retrieval in the Aeolus algorithm. 2. Combined LOS wind velocity, wind profile and 3D wind vectors are the powerful tools to validate the Aeolus measurements. 3. The mobile Doppler lidar is a quasi-operational system qualified by the China Meteorological Administration. The data quality and quantity could be credible. Wind profile and other relevant meteorological data are also available from radiosonde of the Qingdao Meteorological Administration as the important reference for atmospheric model calibration. This system can be used to conduct experiments in Beijing. 4. The Coherent Doppler lidar includes a real time display of the light-of-sight wind velocity and wind profile. It is practical and efficient tool to characterize and monitor sea surface wind vectors. In particular, the compact design makes it easy to transport. If conditions permit, we will plan to carry out experiments at sea with the Coherent Doppler lidar. 5. Water vapour, Cloud and Aerosol Lidar is located at the Qingdao. Qingdao is the typical transition area between monsoon climate and marine climate. Both the validation and routine observations will play an important role in understanding and processing the lidar data to improve the numerical forecast model. 6. OUC/ORSI is developing an airborne Doppler lidar which could be a good optionfor calibration and validation if sources are available.
Expected results for Aeolus	With Mobile Doppler lidar system as the independent measuring method, we can validate Aeolus data products, such as wind profile, cloud and aerosol etc., and the assessment of Measurement accuracy and stability of both instruments. The mobile Doppler lidar validation is the only quasi-operational system in China qualified by China Meteorological Administration, which can obtain high resolution wind field with high update rate at present. Wind retrieval and calibration algorithms can be analyzed and improved if needed according to results of validation.

	The Coherent Doppler lidar includes a real time display of the light-of-sight wind velocity and wind profile. It is practical and efficient tool to characterize and monitor wind vectors. This system is easy to transport so that experiments with this system can be conducted both in Qingdao, Beijing and on the Tibetan Plateau. If conditions permit, we will plan to carry out experiments at the China sea with the Coherent Doppler lidar. Moreover with multi-wavelength Raman-Polarization lidar, we can continuously detect vertical profiles of water vapor (0.2 ~ 5km) and cloud (0.2 ~ 15km) in the troposphere. The data product Includes aerosol extinction coefficient, aerosol backscattering coefficient, Rb, Sa, depolarization ratio, backscatter color ratio and cloud base height. These meteorological coefficients retrieval and calibration algorithms can be also analyzed and improved if needed according to results of validation. We will conduct experiments on the Tibetan Plateau during July to August for the next three years. In that way, meteorological parameters of that region can be validated.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, L2B data	**Data Coverage** Not specified	**Specific Timeline of Validations** Not specified
Validation data to be collected	Coherent lidars for boundary layer wind measurements at Quingdao (Lat: 36.04 / Lon: 120.20) and Beijing (Lat: 40.10/Lon: 116.57) Additional CAL/VAL sites where data may be collected and used (coherent PBL lidars): Tianjin: 39.50/117.84, Yixian: 39.55/115.25, Zhangjiakou: 40.99/115.44, Henshui: 37.66/115.64, Jinan: 36.72/117.61 Shipborne lidar rout planning: TBD		
Special data needs	n.a.		

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Calibration and validation of Aeolus measurements by a mesoscale data assimilation system** **PROPOSAL WITHDRAWN**
Link to full Proposal	27449
Team Leader name, affiliation and email	Professor Nedjeljka Žagar, University of Ljubljana, nedjeljka.zagar@fmf.uni-lj.si
Support team-members names and emails	-
Summary of activity	The proposal is built on the existing expertize of the proposed project PI and her team member in data assimilation and the use of the retrieval software for Aeolus and challenges related to the assimilation of the horizontal line-of-sight (HLOS) winds in relation to the retrieval scheme, accumulation length of individual measurements within L2B software and properties of the background-error covariances for data assimilation. The goal of the proposed research is to analyse error characteristics of HLOS measurements with respect to background atmosphere properties, retrieval approach and weather situations focusing on their impact as a function of the accumulation length. The proposed research is the natural continuation of the ongoing PECS Slovenia project "Mesoscale wind profiles and data assimilation for numerical weather prediction" which will finish by the end of 2015. Within this project we have implemented the mesoscale numerical weather prediction model WRF with an ensemble Kalman filter (EnKF) data assimilation system DART coupled with the ECMWF ensemble 4D-Var analyses and forecasts as lateral boundary conditions. This unique framework for the mesoscale ensemble data assimilation is currently the only such system coupled with the chain of software E2S/L1B/L2B and we are using it to undertake mesoscale OSSE experiments associated with Aeolus. By the time of the launch, we shall have an expertize in the assimilation of HLOS by the EnKF system WRF/DART which will allow us to actively take a part in the validation of real measurements. The objectives of the proposed project are to implement the HLOS winds provided by the Aeolus mission in the mesoscale data assimilation and forecasting system WRF/DART in nearly real time upon the satellite launch, and to validate and calibrate the use of these observations in a mesoscale model with respect to the accumulation length (scale) applied for averaging individual DWL measurements within the Level-2B processor. The main data needed are thus the individual measurements as produced by the L1B software. Calibration efforts are related to the testing of the implemented retrieval procedure which is especially beneficial at smaller accumulation lengths where differences in accumulation algorithm can amplify due to smaller number of accumulated measurements. A separate validation with respect to distinct weather patterns should be provided for each of the four wind products (Ralyeigh-clear/cloud and Mie-clear/cloud) with focus on the comparison between Rayleigh-clear and other observation types. Another research component of the project would be definition of the forward operator that would appropriately account for the characteristics of the L2B retrieval scheme in relation to the accumulation procedure and comparison of the Rayleigh and Mie wind products. The project will not perform real-time data assimilation for operational NWP purposes and end users as it is based at the university and applies an NWP research model. It will however certainly provide useful understanding and results concerning the properties of HLOS observation errors and its data assimilation sensitivity which will be useful for operational NWP models, both global (ECMWF) and mesoscale (e.g. Aladin, AROME, HARMONIE). This proposal has been previously submitted to the 2013 call Programme for European cooperating states (PECS) in Slovenia. Upon its un-acceptance on the basis of no interest at ESA to support such projects, there was a discussion with the PECS office which brought an agreement that the funding to the project would be granted if the project proposal is positively evaluated on the Aeolus CAL/VAL call.
Expected innovation for Aeolus	There are several innovative components of this proposal. First we base the work on the application of a mesoscale NWP model with the ensemble Kalman filter assimilation methodology. The assimilation of HLOS with fully flow-dependent covariances has not been studied by the global models. Our work is thus complementary to what has been done at ECMWF and elsewhere. Second, we de four different wind profiles.

	We are interested in the formulation of the forward operator which takes into account characteristics of the L2B retrieval scheme (Mie and Rayleigh receiver, clear/cloud classification scheme, temperature and pressure of the background atmosphere).		
Expected results for Aeolus	Our work contributes specifically to the area of "the assessment and validation of the Aeolus retrieval and processing". Our research goals are complementary to the work carried out by the European Centre for Medium-Range Weather Forecasts (ECMWF) and its partners on the global scale. In particular, it has been shown that the main impact of Aeolus wind profiles should be expected in the tropics. The presented proposal is focusing on the mid-latitude mesoscale modelling by using an advanced data assimilation approach which is different from that used by ECMWF. Our effort would nevertheless be performed in close collaboration with the data assimilation section of ECMWF in relation to the use of L2B software and intercomparison of analysis increments due to HLOS. Our research focuses on the selection of accumulation length (L) which is a crucial choice as it defines the observation error of the retrieved HLOS winds (as inversely proportional to the number of individual laser shots or measurements available within the accumulation distance L). The default value of L used in L2B and by other projects have been set to around 90 km. The main question is the potential benefit of using a smaller value of L at the expense of a larger error in a mesoscale model and how this error depends on other factors important for the retrievals scheme. Within our ongoing project we are developing tools and performing studies perfectly suitable as preparatory steps for carrying out tests with real data in real time to calibrate to optimize the setup of the L2B software in relation to the model resolution, data assimilation modelling and above mentioned other sources of observation error.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B	**Data Coverage**	**Specific Timeline of Validations**
Validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Validation of Aeolus Level 2 products by comparison with global NWP and in-situ flight data**
Link to full Proposal	27529
Team Leader name, affiliation and email	Dr. Mary Forsythe, Met Office, mary.forsythe@metoffice.gov.uk
Support team-members names and emails	Mrs. Gemma Halloran, gemma.halloran@metoffice.gov.uk Dr. Franco Marenco, franco.marenco@metoffice.gov.uk Dr. Phil Brown, phil.brown@metoffice.gov.uk Dr. Francis Warrick, francis.warrick@metoffice.gov.uk
Summary of activity	Aeolus Level 2B - HLOS wind and optical (aerosol) properties - products will be validated by comparison with global NWP model short-range forecasts and ad-hoc in-situ flight data co-located with the Aeolus measurement tracks. Most of the work will be funded internally, the exact amount will depend on internal resources and availability of suitable flights. Dedicated airborne campaigns require a successful bid for external funding. Comparisons against Met Office global short-range forecasts will be undertaken to assess the quality of the data. An important part of this will be an initial analysis and follow-up in-depth investigations similar to those we undertake for the NWP SAF AMV analysis reports. We will produce an equivalent report for Aeolus HLOS winds, summarising the main features identified in the O-B statistics plots and results of investigations into possible dependencies or causes. Further work is expected to include comparisons to other wind observations and assimilation trials in the Met Office global model to assess where they provide most impact. We expect to undertake airborne cal/val activities with the Facility for Airborne Atmospheric Measurements (FAAM) aircraft. This will involve the direct comparison of wind and aerosol products, studies on scene classification and studies on how HLOS wind measurements are affected by atmospheric heterogeneities. Research flights will be executed on an opportunity basis, either in areas accessible from the United Kingdom or during previously planned campaigns in other areas of the world. Coordinated flights with the DLR Falcon 20 carrying the A2D demonstrator are also being contemplated.
Expected innovation for Aeolus	The Met Office global model numerical weather prediction (NWP) analyses provide a 3-dimensional, global coverage, optimal estimate of the state of the atmosphere every six hours. By comparing Aeolus HLOS winds to short-period forecasts interpolated in time and location to the Aeolus HLOS wind location it will be possible to validate all observations, enabling stable comparison statistics to be generated in a short period of time and covering a full range of geographic and atmospheric conditions. Thus the bulk characteristics of Aeolus HLOS winds can be assessed within a few weeks of first data availability during the cal/val phase, and problem areas identified and fed back to the suppliers very quickly. A key focus of our work will be the production of an analysis report summarising the main features identified in the O-B statistics plots and results of investigations into possible dependencies or causes. We can adapt existing software and learn from experience producing NWP SAF AMV analysis reports. The validation of HLOS against NWP model short-period forecasts will continue for the whole of the operational phase of the mission and could be considered as an extra activity within the EUMETSAT NWP Satellite Application Facility (SAF) monitoring (see http://nwpsaf.eu/index.html) enabling open display of the results. Ad-hoc flight data from a comprehensively instrumented aircraft underflying the Aeolus measurement tracks can provide more detailed in situ observations with the Aeolus HLOS and other derived parameters (aerosol and other lidar optical atmospheric properties) which will complement the NWP comparisons. Flight opportunities are necessarily limited in coverage; data from the near-UK and various other areas could be obtained, depending on missions and tasking diary of the FAAM aircraft during the actual cal/val phase (and depending on additional funding being obtained to cover such dedicated flights).
Expected results for Aeolus	This proposal contributes by providing a comparison (validation) of Aeolus Level 2 products (HLOS and atmospheric optical properties) against independent measurements of wind profiles, cloud and aerosols from global NWP model 3-D wind fields and in situ aircraft data.

Data requirements, data coverage and timeline	**Aeolus Product Names** AUX and CAL files Level 2A and level 2b data Overpass tables	**Data Coverage**	**Specific Timeline of Validations**
Validation data to be collected	-		
Special data needs	Pre-launch: require some (several orbits) synthetic data in BUFR format for technical developments pre-launch. Initial cal/val: early access is desired as soon as possible post-launch and to continue at least to the end of the cal/val period. Availability of HLOS winds within 1-3 days is adequate for quasi-operational NWP validation. Operations: after the cal/val period, it is assumed that Level 2 HLOS wind data will be disseminated to users in BUFR via the GTS in near-real time. Data cut-offs vary from centre to centre, but we can make fullest use of the data if the majority of the data is available within 1-3 hours.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Validation of wind data for the Atmospheric Dynamic Mission-Aeolus in Japan**		
Link to full Proposal	27589		
Team Leader name, affiliation and email	Dr. Shoken Ishii, NICT, sishii@nict.go.jp		
Support team-members names and emails	Mr. Philippe Baron, baron@nict.go.jp Dr. Kohei Mizutani, mizutani@nict.go.jp Mr. Hironori Iwai, iwai@nict.go.jp Dr. Seiji Kawamura, s-kawamura@nict.go.jp Dr. Makoto Aoki, maoki@nict.go.jp Dr. Satoshi Ochial, ochiai@nict.go.jp Tomoaki Nishizawa, nisizawa@nies.go.jp Hajime Okamoto, okamoto@riam.kyushu-u.ac.jp Kaori Sato, sato@riam.kyushu-u.ac.jp Kozo Okamoto, kokamoto@mri-jma.go.jp Takuji Kubota, kubota.takuji@jaxa.jp		
Summary of activity	Aeolus is the first and unique Doppler Wind Lidar for wind measurement from space. The Aeolus uses a 355-nm single frequency laser and direct detection from space. The Aeolus measures a single line of sight (LOS) wind speed and provides profile of horizontal LOS (HLOS) wind speed. Continuous validation of HLOS wind speed after calibration processes is important in order to contribute to the numerical weather prediction. The purposes of the project are to contribute to reduce uncertainty (bias and precision) in the Aeolus wind measurement, to validation processes for improving HLOS wind speed measured by the Aeolus, and to assess wind data in the terms of data quality. NICT operates ground-based coherent Doppler lidars and wind profilers in Japan in 3 different sites: 2 mid-latitudes sites (Tokyo and Hyogo), and a sub-tropical site (Okinawa). Coincident LOS wind measurement with the Aeolus will be made from the surface to the troposphere (depending on the atmospheric conditions) during the 3 months of the commissioning phase (E1) and during operational phase (E2). Precision, accuracy and vertical resolution of the ground-based measurements are better than that of the Aeolus measurement. Statistical analysis will take into account the simultaneous observations of aerosols, clouds and temperature and pressure as well as coincident criteria and measurement sampling.		
Expected innovation for Aeolus	NICT coherent Doppler lidars are installed three different locations (Tokyo, Hyogo, and Okinawa). NICT coherent Doppler lidars are located in Tokyo, Hyogo (mid-latitudes, Japan), and Okinawa (sub-tropical region, Japan). Each lidar can measure LOS wind with very-low bias and high precision better than 0.5 m/sec and provide horizontal wind speed and direction, and vertical wind speed with the velocity-azimuth display scan. NICT can provide the profile of HLOS to match coincident the Aeolus HLOS direction. NICT coherent lidars are sensitive to large-sized particles. NICT coherent lidar will provide profile of coarse-mode aerosols and clouds.		
Expected results for Aeolus	NICT can provide profile of LOS and horizontal wind speeds and wind direction measured by the coherent Doppler lidar in the various location and weather conditions. NICT coherent Doppler lidars measure LOS wind speed with very low bias and high precision with a range resolution of better 100 m, and can measure the profile of HLOS measured in the similar direction to the Aeolus measurement direction. NICT windprofilers can measure wind profile in the atmosphere. NICT compare results obtained from coherent Doppler lidars and windprofilers with the Aeolus LOS wind data. Estimation of the uncertainty of the Aeolus LOS wind data can be inferred for various cloud and aerosols conditions in mid-latitude and sub-tropical latitudes. Uncertainties due to the horizontal resolution of the ADM wind products (50 km) and to the validation coincidence criteria will be studied, and also small temporal and spatial variations of wind field in the atmospheric boundary layer will be studied. NICT contributes to the validation of the wind data measured by the Aeolus through the atmospheric boundary layer and up to the middle and upper troposphere.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, L2B data, AUX_RBC, AUX_MET, AUX_PAR files for L2B processing	**Data Coverage** All phase E2, Japan	**Specific Timeline of Validations** Through-out phase E2

	Predicted orbit files / overpass tables		
Validation data to be collected	Tokyo: NICT coherent Doppler wind lidar, wind profiler, radiosonde, Kobe: Leosphere coherent doppler lidar (PBL), Okinawa: Leosphere coherent Doppler lidar (PBL)		
Special data needs	N/A		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**National Participation of Environment Canada in CAL/VAL Aeolus**
Link to full Proposal	27590
Team Leader name, affiliation and email	Dr. Paul Joe, Environment Canada, paul.joe@ec.gc.ca
Support team-members names and emails	Dr. Howard W. Barker, howard.barker@ec.gc.ca Dr. David Hudak, david.hudak@ec.gc.ca Dr. Alexei Korolev, alexei.korolev@ec.gc.ca Dr. Stephane Laroche, stephane.laroche@ec.gc.ca Dr. Louis Garand, louis.garand@ec.gc.ca Dr. Stella Melo, stella.melo@ec.gc.ca
Summary of activity	Aeolus (ADM-AEOLOUS) will be launched in late 2015/early 2016 and is designed to be a 3 years mission. It is an operational prototype for a space borne Doppler wind profiler for meteorological applications. It has been demonstrated that these wind profilers will benefit meteorological prediction (ADM-AEOLOUS Mission Report). Therefore, CAL/VAL and other NWP/Prediction investments will benefit Canada particularly in data sparse areas such as the Arctic. Canada is a vast country with a wide variety of weather conditions and climatic zones. This allows for the development of a meteorologically comprehensive CAL/VAL program and a demonstration of the utility of ADM-AEOLOUS data for meteorological prediction. ADM-AEOLOUS validation at high latitudes is envisioned to be of great benefit to Canada and the scientific community. European weather at similar latitudes is moderated by the Gulf Stream in the Atlantic. The weather at high latitudes in Canada is much colder and drier. Environment Canada operates weather monitoring and NWP models both for operations and research relevant to the calibration and validation of ADM-AEOLOUS. These could potentially include: • AMDAR winds, • extra release of operational radio-sondes • wind profilers (boundary layer, tropospheric* and stratospheric**), • Doppler lidars, • Doppler radars, • ceilometers, • 35 GHz Doppler cloud radar and research aircraft with cloud microphysics measurements, profiling lidar and aircraft winds. There are other specialized observational projects that may also contribute (e.g. PEARL). Of particular interest to Canada is high latitude CAL/VAL as it is a strategic area of interest. Canada has existing high latitude meteorological stations including Iqaliut, which is an operational and test site for meteorological observations, and the Canadian High Arctic Research Station (CHARS); a new site for deployment of research instruments. The Aeolus super-sites will piggy-back on current Environment Canada activities that include the Canadian Solid Precipitation Inter-comparison site at Iqaluit and the Canadian High Arctic Research Station at Cambridge Bay. There are existing research campaigns in Alert and Eureka as well. Capabilities include instrumented aircraft, ground based supersite, algorithm development and data assimilation with high resolution models. There are various ideas of validating or demonstrating the value of the Aeolus data. 1. Compute Doppler profiles from in-situ, ground based measurement with ADM-AEOLOUS measurements on surface site overpasses. 2. Direct comparison with ceilometer, 35 GHz cloud radar for occurrence 3. Direct comparison with NWP predicted cloud properties Potential EC Objectives 1. Improvement of NWP predictions with ingestion of Aeolus Doppler lidar data, in general but particularly at high latitudes. EC is responsible for forecasts for two new Metareas in the Arctic 2. Validate and understand the limitations of the Doppler Wind data from ADM-AEOLOUS: 3. Development of an Integrated Observing System concept for winds. 4. Contribute to the evolution of the Renewal of the upper air observing program. 5. Development of data assimilation for ADM-AEOLOUS Doppler lidar data for operational NWP. 6. Aid future developments of retrieval algorithms; especially in connection with cloud effects.
Expected innovation for Aeolus	Canadian Climate and Weather Canada is a vast country with a wide variety of weather conditions and climatic zones. This allows for the development of a meteorologically comprehensive CAL/VAL program and a demonstration of the utility of ADM-AEOLOUS data for meteorological prediction. ADM-AEOLOUS validation at high latitudes is envisioned to be of great benefit to Canada and the scientific community. European weather at similar latitudes is moderated by the Gulf Stream in the Atlantic. The weather at high latitudes in Canada is much colder and drier. Canadian CAL/VAL Data

	Environment Canada operates weather monitoring and NWP models both for operations and research relevant to the calibration and validation of ADM-AEOLOUS. These could potentially include: • AMDAR winds, • extra release of operational radio-sondes • wind profilers (boundary layer, tropospheric* and stratospheric**), • Doppler lidars, • Doppler radars, • ceilometers, • 35 GHz Doppler cloud radar and research aircraft with cloud microphysics measurements, profiling lidar and aircraft winds. There are other specialized observational projects that may also contribute (e.g. PEARL). CAL/VAL Sites Of particular interest to Canada is high latitude CAL/VAL as it is a strategic area of interest. Canada has existing high latitude meteorological stations including Iqaliut, which is an operational and test site for meteorological observations, and the Canadian High Arctic Research Station (CHARS); a new site for deployment of research instruments. The Aeolus super-sites will piggy-back on current Environment Canada activities that include the Canadian Solid Precipitation Inter-comparison site at Iqaluit and the Canadian High Arctic Research Station at Cambridge Bay. There are existing research campaigns in Alert and Eureka as well.		
Expected results for Aeolus	Contribution CAL/VAL Concepts There are various ideas of validating or demonstrating the value of the Aeolus data. 1. Compute Doppler profiles from in-situ, ground based measurement with ADM-AEOLOUS measurements on surface site overpasses. 2. Direct comparison with ceilometer, 35 GHz cloud radar for occurrence 3. Direct comparison with NWP predicted cloud properties including assimilating data experiments. Data Quality Issues The ADM-AEOLOUS Doppler wind measurement may be affected by many processes related to cloudy environment and local turbulence. The issues include:. • The measurements in optically dense clouds will result in attenuation of the lidar signal, blocking wind measurements inside and underneath the cloud • The Rayleigh and Mie scattered Doppler signals may experience separation in cloudy environment due to different velocity of hydrometeors and air • The effect of clouds may depend on their type due to difference in cloud particles and may be a function of altitude due to the dependence of the particle fall velocity on pressure. • A special attention should be dedicated to understand the effect of cloud coverage on the accuracy of the Doppler wind measurements. • In Doppler measurements the ground return is used as a reference. How will the absence of the reference signal affect the accuracy of the Doppler wind measurements? • The consequences and potential biases of the proposed averaging over 0.5km in the boundary layer need a better understanding and verification. • The same refers to the free troposphere averaging over 1km depth, specifically when strong wind shear is present		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, Canada	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	Operational data is available on GTS, other data will be internally collected and archived, including radar, lidar, aircraft, field campaign data. "Canada" - from east of newfoundland (-50W) to west of British Columbia (-142W); from Point Pelee (40N) to the North Pole (90N). "Global" - we run a global model.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Validation of ADM/Aeolus winds by examination of their statistical characteristics, for hemispheric scales and for the Arctic region.**
Link to full Proposal	28295
Team Leader name, affiliation and email	Prof. Paul Kushner, University of Toronto, paul.kushner@utoronto.ca
Support team-members names and emails	Mrs. Chih-Chun Chou, gina.chou@mail.utoronto.ca Mr. Alex Cabaj, alex.cabaj@mail.utoronto.ca
Summary of activity	Statistical properties of atmospheric winds such as turbulent spectral slopes and shape statistics of probability distribution functions could potentially provide important checks on the physical realism of the wind measurements of the Aeolus mission. For example, horizontal spectra of horizontal winds have over the last several decades been extremely well characterized from airborne high-resolution in situ measurements, and the skewed distribution of surface wind stresses have been well characterized in scatterometer data. Such statistical quantities could help assess the overall quality and accuracy of both the raw line-of-sight winds and the assimilated vector wind ADM products. This calibration/validation project involves objectives on the hemispheric scale and for the region of the Arctic. 1. HEMISPHERIC SCALE FOCUS: The project will first develop validation tools for horizontal spectra of horizontal winds from the lower troposphere to the lower stratosphere. First the feasibility of inferring spatial spectra in atmospheric data from the profiling information that will be provided by the Aladin sampling algorithm will be investigated. Monte Carlo simulations will be employed to generate an ensemble of sample wind fields consistent with observed gross spectral properties of the lower stratosphere, upper troposphere, and, to some extent, the lower to mid troposphere. (The latter region is less well characterized spectrally and therefore provides a region that will require a broader parameter range for full characterization.) These pseudo wind fields will be sampled to mimic the Aladin profiling approach. Benchmark diagnostics for validation will include metrics to characterize spectral slopes and spatial correlation functions on a range of scales, both larger than and smaller than the 50 km Aladin profile sampling limit. In addition, the confounding effect of clouds on the analysis will be tested for, and the extent to which heterogeneous observations interfere with the characterization will be assessed. 2. HEMISPHERIC SCALE: Following the Monte Carlo simulation study, analysis of the ADM products themselves will be carried out in comparison with published or otherwise available spectral characteristics. Because the ADM products will include unprecedented resolution of the mid-to-lower tropospheric winds (albeit under clear sky conditions), a particular focus on these regions will be undertaken. 3. ARCTIC FOCUS: The Arctic component of this project aims to examine Aeolus derived wind statistics over the Arctic region, in particular in relation to high quality sonde and reanalysis products. A particular focus will be on high latitude extreme wind events that have been shown to be responsible for forcing strong driving of clear-sky condition variability at the Toolik Lake site in Alaska, and on strong wind events that might influence sea ice processes over the course of the winter season. The vertical profile of the winds under extreme surface conditions will be examined for connections to boundary layer structure, synoptic conditions, and the broader scale pattern of tropospheric circulation. The PI leads important funded projects under NSERC, including the Canadian Sea Ice and Snow Evolution Network (CanSISE) which focuses on Arctic climate and cryospheric prediction, and a basic research Discovery Grant focussing on atmospheric processes. In support of these projects, the analysis of ADM will generate process oriented diagnostics that can be brought to bear on leading US and Canadian Earth System Models and seasonal to interannual prediction systems. Should this application be successful the PI will seek additional support to carry out this analysis.
Expected innovation for Aeolus	The project will focus on developing new insights into large-scale dynamical properties of the hemispheric circulation and the Arctic region, which will provide first-order characterization of the ADM wind products that are process oriented and hence do not rely on measurements coincident with the Aladin samples.

Expected results for Aeolus	The updated proposal described in the executive summary includes characterization of horizontal spectra as in the 2007 proposal but also a focus on polar processes, which is an area where he has received funding and has recognized leadership within Canada.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2B data	**Data Coverage** Global	**Specific Timeline of Validations** Phase E2
Validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Supporting Aeolus with lidar measurements from Korea and Britain (SALMON)**		
Link to full Proposal	41467		
Team Leader name, affiliation and email	Dr. Matthias Tesche (PI), University of Hertfordshire, Hatfield, Hertfordshire, United Kingdom, m.tesche@herts.ac.uk		
Support team-members names and emails	Youngmin Noh, nym@gist.ac.kr Boyan Tatarov, b.tatarov@herts.ac.uk Detlef Müller, d.mueller@herts.ac.uk		
Summary of activity	Measurements with two unique spectrometric aerosol Raman lidars located in the United Kingdom (51.75N; 0.24W) and the Republic of Korea (35.23N;126.84E) will be conducted during ADM-Aeolus overpasses to validate the aerosol and cloud profile products obtained from ALADIN observations. Both instruments are equipped with quarter wave plates that enable the emission of circularly polarised laser light at 355 nm and will allow for aerosol depolarisation measurements analogous to ALADIN. The Lidar Spectroscopy Instrument (LiSsI, Tesche et al., 2017) at the University of Hertfordshire (UH), Hatfield, UK, and the Multiwavelength Raman Spectrometer Lidar in East Asia (MRS.LEA, Noh et al., 2008; 2014; 2017), at the Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea are two of only three instruments worldwide that allow for carrying out multiwavelength spectrometric profiling of Raman scattering and depolarisation of atmospheric constituents. LiSsI and MRS.LEA are designed for measurements of gaseous and particulate pollution, while a third lidar with spectrometric capabilities, RAMSES of the German Met Service (Reichardt et al., 2016), focuses on the detection of the Raman spectrum of water molecules in the atmosphere.		
Expected innovation for Aeolus	The proposed work includes three innovative aspects: i) The LiSsI instrument based at the University of Hertfordshire in Hatfield, UK, features one of the most powerful Nd:YAG lasers ever implemented in an aerosol lidar system. With a repetition rate of 10 Hz and a power of 2.5 J at 355 nm, LiSsI is capable of performing measurements to a height of 40 km and above. ii) MRS.LEA at Gwangju, South Korea is the most advanced aerosol lidar in East Asia and enables measurements of both anthropogenic pollution and natural aerosols (mineral dust) in the Asian outflow regime. iii) The focus on performing measurements of the particle linear depolarisation ratio from the emission of circularly polarised laser light allows us to closely emulate the measurement capabilities of ALADIN and provides additional depth to the assessment of the accuracy of the co- and cross-polarised signals provided in the ADM-Aeolus level 2a particle products.		
Expected results for Aeolus	This proposal aims to validate ALADIN aerosol and cloud profile observations using independent ground-based measurements of clouds and aerosols over Hatfield, United Kingdom and Gwangju, South Korea. From these co-located measurements we will assess accuracy, resolution, and stability of the ALADIN instrument as well as the ADM-Aeolus data retrieval and processing. This proposal focusses on the evaluation of clouds and aerosols represented in the ADM-Aeolus level 2a particle spin-off products. Particular emphasis will be put on performing measurements of the particle linear depolarisation ratio from the emission of circularly polarised laser light in the same way as done by ALADIN. This procedure emulates the measurement capabilities and allows for assessing the accuracy of the co- and cross-polarised signals provided in the ADM-Aeolus level 2a particle products. The collocation of observations with ADM-Aeolus and the statistical evaluation of results within SALMON will adopt the strategy developed within EARLINET (Pappalardo et al., 2010) and use the trajectory matching approach of Tesche et al. (2013) to assure that the ground-based lidars sample the same air mass as ADM-Aeolus (see colocation criteria for full details).		
Data requirements,	**Aeolus Product Names** Level 1B, Level 2A data	**Data Coverage** Phase E2, UK	**Specific Timeline of Validations**

data coverage and timeline			Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**LALINET Aeolus CAL/VAL**
Link to full Proposal	44100
Team Leader name, affiliation and email	Dr. Eduardo Landulfo (PI), IPEN, So Paulo, Brazil, elandulf@ipen.br
Support team-members names and emails	Ivo Fustos, ivo.fustos@ufrontera.cl Dr. Fabio Lopes, fabioslopes@gmail.com Judith Hoelzemann, judith.hoelzemann@gmail.com Prof. Henrique Barbosa, hbarbosa@if.usp.br Dr. Boris Barja, bbarja@gmail.com Dr. Pablo Ristori, pablo.ristori@gmail.com Dr. Ricardo Forno, rforno@chacaltaya.edu.bo Dr. Lidia Otero, lotero@citefa.gov.ar Prof. Felix Zamorano, felix.zamorano@umag.cl Prof. Antonieta Silva, antonieta.silva@ufrontera.cl Maria Fernanda Sanchez, mafer.sb@chacaltaya.edu.bo Dr. Sebastian Papandrea, papandreasebastian@gmail.com Dr. Maria Alejandra Salles, marialesalles@yahoo.com.ar Dr. Estela Collini, estela.collini@gmail.com Dr. Yoshitaka Jin, jin.yoshitaka@nies.go.jp
Summary of activity	LALINET is a leading network in quantitative aerosol profiling performing a schedule of routine measurements and presently consists of 07-09 stations distributed over South America. The construction of an un-biased spatio-temporal database of vertical profiles of aerosol optical properties on a regional scale for climate and air quality research is the main objective of LALINET and is accomplished by the application of Raman lidars. Raman lidars, like HSRL, are capable of providing vertically resolved aerosol and cloud backscatter and extinction profiles as well as the lidar ratio without critical assumptions. The perspectives from space observations and ground based measurements are complementary: from space a global overview is obtained, built up from snap-shot like observations over different locations, while a temporal development over one place is obtained from a ground based station. A network of ground-based stations, therefore, has the ability to provide spatio-temporal development of aerosol fields and offers a unique opportunity for validation of observations from space. These notions are the basis for this proposal. The main objectives of this proposal are: 1) Validation of AELOUS products of aerosol and cloud profiles of backscatter, extinction and lidar-ratio, 2) Assessment of spatio-temporal representativeness of AEOLUS aerosol and cloud products. The objectives will be accomplished through correlation between ground based lidar data from LALINET stations. For this, data will be used from: 1) The (historical) LALINET database, 2) Correlative measurements performed by selected LALINET stations during close proximity AEOLUS overpasses. LALINET stations perform regular lidar measurements simultaneously at three fixed instances a week, guaranteeing unbiased data collection: one daytime measurement around noon, when the boundary layer is well developed, and two night-time measurements per week, in low background-light conditions, to perform Raman extinction measurements. Since the launch of CALIPSO in April 2006, LALINET maintains a correlative measurement schedule that takes advantage of the network structure. This is done so that close overpasses are captured by a particular station and also by its nearest-neighbour stations to capture the spatio-temporal variability. It is proposed to use a similar strategy for the validation of AEOLUS. Deliverables are: 1) Vertical profiles of aerosol optical properties (backscatter, extinction and lidar ratio) obtained from routine network observations, 2) Vertical profiles of aerosol optical properties obtained from correlative observations. 3) Report

Expected innovation for Aeolus	LALINET is a "young" network and has a lot of potential scientific and regional coverage potential. The involvement with Calibration and Validation projects such as AEOLUS and EARTHCARE (already approved) will benefit all parties carrying measurement campaigns in routine and sporadic concepts. Also this effort will attract more researchers experienced and new ones to carry joint campaigns in Latin America which needs increase in more frequent measurement with good area coverage since the overall area of the continent is over 50 M Km2. Also this will bring together the interest of local space agencies to cooperate with this enterprise of coordinated measurements in different platforms on ground, airborne and satellite ones. Summarizing: - LALINET network covers Latin America offering a good the spatio-temporal variability of the aerosol fields on a regional scale. - LALINET is able to provide extinction, backscatter, and lidar ratio at 355 nm which can be directly compared to Aeolus aerosol and cloud profiles. - LALINET stations in majority can produce extinction, backscatter, and lidar ratio at 532 nm in addition to the UV wavelength. This information could be useful to better characterise the aerosol fields observed by the platform and provides an expansion to Aeolus dataset. - Separate treatment of aerosols and clouds is warranted, which can be provided by the lidar network.		
Expected results for Aeolus	- Improve the accuracy of aerosol and cloud geometrical and optical parameters using a ground based network of quantitative aerosol and cloud lidars. - Characterise deviations of the Aeolus -L2A products from ground truth established by the lidar stations in the network. - Parallel follow-up to processing algorithms based on intercomparison between observations from space and ground. - Monitoring of product stability over the observational period foreseen in the proposal.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, South America	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Plan for Validation of Aeolus Level 2A Aerosol and Cloud Retrievals Using CALIPSO**
Link to full Proposal	44512
Team Leader name, affiliation and email	Jason Tackett (PI), NASA / SSAI, Hampton, United States, jason.l.tackett@nasa.gov
Support team-members names and emails	Dr. David Winker (co-PI), david.m.winker@nasa.gov Mark Vaughan, mark.a.vaughan@nasa.gov Roman S. Kowch, roman.s.kowch@nasa.gov
Summary of activity	With over 12 years of space-based observations, CALIOP (the Cloud-Aerosol Lidar with Orthogonal Polarization) provides a valuable asset to the scientific community for understanding the three-dimensional distribution and properties of aerosols and clouds. The climate science community is eager to continue these observations onto multi-decadal time scales. The launch of Aeolus in 2018 and the forthcoming EarthCARE launch in the early 2020's make it possible to advance this goal. The purpose of this proposal is thereby to assess the Aeolus level 2A spin-off products, which will report aerosol and cloud properties, by comparing them with CALIOP observations. Information gleaned from this activity will serve to bridge the CALIOP-Aeolus-EarthCARE data record and will support the Aeolus Calibration Validation Team (ACVT) objectives. Namely, it will provide validation information for level 2A aerosol retrievals based on independent space-borne observations and it will help to assess Aeolus atmospheric corrections, which are required for accurate wind retrievals. CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) is expected to continue operations during the nominal 3-year mission phase of Aeolus, allowing a temporal match between the instruments. Aeolus and CALIPSO orbits are different, however, with equatorial crossing times for Aeolus near dusk/dawn and CALIPSO at 1:30 a.m./p.m. Because of these differences, comparisons will be based on seasonal and annual averages, using one full year of observations. Meaningful statistics can be derived from CALIOP information on these time scales, allowing robust comparisons. Six components of the Aeolus level 2A retrieval algorithms will be evaluated: aerosol detection frequency, cloud-aerosol discrimination capability, aerosol extinction, aerosol lidar ratio, cloud detection frequency, and cloud ice/water phase classification. The CALIOP cloud-aerosol discrimination and ice-water phase algorithms are considered mature, thereby providing ideal bases of comparison for characterizing the three-dimensional distribution of cloud occurrence, cloud ice/water phase, and aerosol detection frequency. Aeolus feature detection sensitivity and cloud contamination frequency will be assessed. The proposed analysis will also compare Aeolus and CALIOP aerosol extinction profiles by using ngstrm exponents, based on CALIOP retrieved aerosol types, to convert between CALIOP and Aeolus extinction wavelengths. CALIOP aerosol typing information will be used to assess lidar ratios reported by Aeolus. Given that lidar ratios are associated with particular aerosol types, consistency is expected between Aeolus lidar ratios and CALIOP aerosol types. A two-year effort is envisioned, beginning three months after launch. Initial analysis will begin once the Aeolus level 2A data files are made available to the ACVT. Preliminary analysis and results based on one year of Aeolus observations will be presented at the ACVT meetings in 2019 and 2020, respectively. Results will also be presented at the European Geosciences Union General Assembly and published in a peer-reviewed scientific journal paper in 2020.
Expected innovation for Aeolus	The proposed analysis compares aerosol and cloud observations by two independent spaceborne lidars that are operating at the same time. This is only the second time in the history of satellite-based measurements of Earth's atmosphere that such observations can be compared. The first pairing of space-borne lidars capable of observing aerosol and clouds was that of CALIOP and the Cloud Aerosol Transport System (CATS) which operated from 2015-2017 on board the International Space Station. The CALIPSO team has already prepared comparisons between CALIOP and CATS observations to assess their consistency (Rodier et al., 2017). The measurement techniques between the backscatter lidar CALIOP and that of Aeolus, the first operational HSRL in orbit, are quite different. Comparisons between these sets of retrievals will

	allow characterization of observational differences between two very different lidar instruments. Given that CALIOP will be the only space-borne lidar in operation during the beginning of the Aeolus mission, it will be the only opportunity for co-temporal lidar profile measurements on a near-global scale until EarthCARE. It is also the only opportunity to characterize retrieval differences due to the differing wavelengths between the instruments (CALIOP at 532 & 1064 nm and Aeolus at 355 nm). This proposed analysis will provide innovative methods to compare cotemporal aerosol observations acquired at these wavelengths. Because CALIOP will not likely be operating when the EarthCARE mission begins, such methods are required for connecting the record of aerosol observations from CALIOP to Aeolus, and then finally to EarthCARE (also operating at 355 nm). The analysis of Aeolus lidar ratio measurements relative to CALIOP aerosol typing is also innovative, given that CALIOP is also the only instrument that provides information on the vertical distribution of aerosol types on a near-global scale.		
Expected results for Aeolus	This proposed analysis will contribute to several objectives of the Aeolus Calibration Validation Team (ACVT). Namely, the analysis: - Provides a global comparison data set of independently acquired space-borne observations for validation of Aeolus aerosol and cloud retrievals. - Characterizes the ability of Aeolus to detect aerosol and cloud layers, thereby assessing the effectiveness of atmospheric geophysical corrections that are required for wind retrievals in the Rayleigh regime. - Validates Aeolus retrieval algorithms for cloud-aerosol discrimination and cloud ice/water phase. - Assesses Aeolus aerosol extinction and lidar ratio measurements. - Works toward bridging the observation record between Aeolus and EarthCARE by developing methods to assess the consistency of aerosol and cloud observations between two lidar systems that employ different retrieval algorithms.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A data	**Data Coverage** Phase E2, Global	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Correlative / Comparative measurements of Troposphere / Stratosphere Winds and other Atmospheric Parameters between Aeolus and a Ground-Based Direct Detection Doppler Wind LIdar System**		
Link to full Proposal	44812		
Team Leader name, affiliation and email	Prof. David Rees (PI), The Paradigm Factor Ltd, Robertsbridge, United Kingdom, walnut1@easynet.co.uk		
Support team-members names and emails	-		
Summary of activity	A ground-based Direct Detection System is available, based in SE UK that has been previously used for Validation of the Direct Detection technique exploited by Aeolus / ALADIN at Haute Provence Obs, France in 1999. A number of technological and S/W and Analysis improvements have been made since 1999. This includes the use of much-improved detectors for the Spectral Imaging approach, contrasting with the double-edge approach exploited by Aeolus / ALADIN. The spectral imaging (full fringe) approach is not, for example, in any way susceptible to the Rayleigh- Brillouin effect. In addition, the spectral imaging (full fringe) approach is able to work continuously and without disturbance under atmospheric conditions from a pure Rayleigh Atmosphere to one where Mie Scattering dominates. This study will therefore be of great value to the calibration / validation Team.		
Expected innovation for Aeolus	The Direct Detection Doppler Wind Lidar System proposed for use is one of very few such systems available globally. In particular, we will exploit "Fringe Imaging" - obtaining the full high-resolution back-scattered spectrum - rather than the Double-Edge technique exploited by Aeolus. Double-Edge certainly provides a subtle sensitivity advantage entirely necessary for middle stratospheric wind measurements. Fringe Imaging - by providing the full Spectral Analysis – can work equally well with pure Rayleigh and heavily Mie-contaminated signals from the boundary layer. The Fringe-Imaging technique thus provides a unique link between the two separate detection systems exploited by Aeolus.		
Expected results for Aeolus	A Fringe Imaging Doppler Wind Lidar - by providing the full Spectral Analysis - works equally well with pure Rayleigh and heavily Mie-contaminated signals from the boundary layer. The Fringe-Imaging technique thus provides a unique link between the two separate detection systems exploited by Aeolus. (Double-Edge for the Rayleigh Signal in the "free" troposphere and the Fizeau interferometer used for boundary layer wind measurements (i.e. where the Mie scattering component is large or dominates the back-scattered signal. These Direct Detection wind measurements should thus be of great value to the inter-comparison and validation campaigns.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, UK	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2

Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Support for Aeolus Calibration & Validation at the NASA Global Modeling and Assimilation Office**
Link to full Proposal	44648
Team Leader name, affiliation and email	Dr. Will McCarty (PI), NASA, Goddard Space Flight Center, Greenbelt, MD, United States, will.mccarty@nasa.gov
Support team-members names and emails	
Summary of activity	Through this proposal, the Global Modeling and Assimilation Office (GMAO) at NASA Goddard Space Flight Center aims to contribute to Aeolus Cal/Val through the implementation of Aeolus L2B horizontal line of sight winds* in the Goddard Earth Observing System (GEOS) atmospheric data assimilation system. As the system has been extended to use these observations, the goal is to acquire preliminary data and process it within the system with the aim of initially validating the retrieved winds in the context of an assimilation system*. This effort will be coordinated with other modeling and assimilation centers participating in the Aeolus Cal/Val, extending the ensemble of systems being used to perform this task. This will lead towards the accelerated implementation of the Aeolus measurements once they have been deemed of acceptable quality for routine scientific use. At this point, the GMAO will perform a full suite of tests within the modeling and assimilation framework with the unique focus that the GMAO can provide relative to other international NWP centers. This will result in documentation, both informal via scientific discussions and presentations and formal via peer reviewed publication, that will assist the Aeolus team in meeting its mission scientific objectives. This work will be funded by GMAO core funding provided by NASA headquarters. This effort is in line with the scientific goals of the GMAO and NASA HQ, and the use of GMAO funds is further justified in the attached letter of support. This work has been coordinated with Dr. Tsengdar Lee of NASA HQ and other scientists under the NASA umbrella with respect to NASAs contributions to Aeolus Cal/Val beyond data assimilation specifically in terms of aircraft Doppler wind lidar measurements and satellite underflights. This work is also being coordinated with other modelling and assimilation centers in the United States via the Joint Center for Satellite Data Assimilation.
Expected innovation for Aeolus	This work aims to extend the suite of global assimilation centers investigating the preliminary L2B wind retrievals with the aim of calibration and validation. While this is fundamentally not innovative, the non-operational nature of the GMAO allows a level of flexibility for accelerated implementation and monitoring of observations in routine, near real time production systems. Furthermore, as the goals of the GMAO extend beyond numerical weather prediction, scientific results are ultimately broader in an earth system context. Cal/Val and scientific goals are laid out within this document with the aim of illustrating how the GMAO can contribute to both.
Expected results for Aeolus	Explicitly, as a data assimilation-centered effort, this proposed effort readily contributes to the Aeolus mission scientific objectives aiming to: -Improving NWP analyses and forecasts of the 3D vector wind field -Improving medium-range forecasts for the extratropical region through a better definition of planetary-scale wave, and -Improved modeling and forecasting of tropical dynamics through the provision of direct wind observation profiles. These all fall in line with the standard metrics analyzed as part of a standard suite of observing system experiments. Furthermore, any development within the context of the GMAO is performed with the aim of improving the next earth system reanalysis. As such, this effort will also fundamentally achieve the scientific goal of 'providing data sets suitable for the evaluation of climate models' by becoming a part of the standard global observing system that will constrain the next major reanalysis. In this case, the reanalysis can serve as a gridded, assimilated product by which global climate models are frequently baselined against. Ultimately, this effort aims to assist in the Cal/Val procedures from a data assimilation perspective, while ultimately leveraging this effort to produce a set of scientific results (e.g. publication) and products (GMAO near real time forecasts and reanalyses via integration into their

	ongoing and future production systems) that assist ESA in achieving the scientific mission objectives listed here.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2B data	**Data Coverage** Phase E2, Global	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment

	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Intercomparison of wind accuracy between Aeolus and CMA geostationary satellite wind**		
Link to full Proposal	46032		
Team Leader name, affiliation and email	Dr. Feng Lu (PI), China Meteorological Administration, Beijing, China, lufeng@cma.gov.cn		
Support team-members names and emails	Shou Yixuan, shouyx@cma.gov.cn Dr. Xiaohu Zhang, zhangxiaohu@cma.gov.cn Cui Peng, cuipeng@cma.gov.cn		
Summary of activity	Objective and methods 1) Validation for operational IR/WV AMV, CMA will provide updated operational Geostationary AMV based on CMAs new geostationary satellite over Indian Ocean since Nov. 2018. With the new data, it will provide AMVs every 30 minutes for Northern hemisphere. Such new products could provide more coinciding observation to Aeolus satellite in compared with the heritage system, which only provide AMV every 6 hours. 2) Validation the AMV from stereo view. A prototype new system has been developed in CMA by my research group. In this new system, wind information is derived by using multi-geostationary satellite stereoscopic observations. And the wind height information is derived by parallax technique. With this method, motion information of dust/smoke can be obtained. This can to some extent solve the problems of the cloudless target height assignment in the current operational AMV which is only based on IR/WV two bands information. 3) Attempt s of data fusion of geostationary wind and Aeolus wind For the very complex terrain in west china around Tibet plateau and Taklimakan dust areas, there are quite a few RAOB observations. My research group would like to use Aeolus wind products as "anchor" observations to do data fusion on GEO AMVs, and make weather analysis after finishing the first and second objections in this proposal.		
Expected innovation for Aeolus	1) Validation Aeolus wind using CMA high temporal resolution AMV, CMA will provide updated operational Geostationary AMV based on CMA's new geostationary satellite over Indian Ocean since Nov. 2018. With the new data, it will provide AMVs every 30 minutes for Northern hemisphere. Such new products could provide more coinciding observation to Aeolus satellite in compared with the heritage system, which only provide AMV every 6 hours. 2) Validation the AMV from Geo stereo view. A prototype new system has been developed in CMA by my research group. In this new system, wind information is derived by using multi-geostationary satellite stereoscopic observations. And the wind height information is derived by parallax technique. With this method, motion information of dust/smoke can be obtained. This can to some extent solve the problems of the cloudless target height assignment in the current operational AMV which is only based on IR/WV two bands information.		
Expected results for Aeolus	For the very complex terrain in west china around Tibet plateau and Taklimakan dust areas, there are quite a few RAOB observations. My research group would like to use Aeolus wind products as "anchor" observations to do data fusion on GEO AMVs, and make weather analysis after finishing the first and second objections in this proposal.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, Global, China, specifically Gobi desert, Tibet	**Specific Timeline of Validations** Phase E2

In situ validation data to be collected	RAOBS over China, specifically Gobi desert, Tibet
Special data needs	n.a.

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Validating Aeolus Low Altitude WINd measurements using ground-based Doppler wind lidars (VALAWIN)**
Link to full Proposal	46417
Team Leader name, affiliation and email	Dr. Ioanna Karagali (PI), DTU Wind Energy, DENMARK, ioka@dtu.dk
Support team-members names and emails	Dr. Merete Badger, mebc@risoe.dtu.dk Dr. Charlotte Bay Hasager, cbha@dtu.dk Dr. Alfredo Pea, aldi@dtu.dk Nikolas Angelou, nang@dtu.dk Pedro Santos, paas@dtu.dk
Summary of activity	The objective of VALAWIN is to use the research infrastructure and expertise available at DTU Wind Energy to perform validation of the Aeolus low altitude wind retrievals using data from an on-going measurement campaign. DTU Wind Energy is currently participating in a campaign at the Alaiz mountain range, near the city of Pamplona, Spain. A WindCube 70 (WLS70) lidar profiler is installed in the valley and has been obtaining measurements since November 2017. Furthermore, five scanning lidar systems (WindScanners) are measuring with different scanning patterns since June 2018; two Virtual Met Masts (VMM) extend from 100 meters to 1000 meters above ground level. A major advantage of VALAWIN is that data are currently being collected simultaneously with the Aeolus commissioning phase and are available with unrestricted access. Furthermore, after finalising the ongoing measurement campaign, the vertical wind profiling instrument will be moved to a different, not yet defined location, to continue measuring and thus, can provide more data for validation purposes at a different site. Finally, meso-scale model simulations are also available for the Alaiz site and this dataset can be compare to Aeolus retrievals of higher altitude winds where ground-based systems cannot obtain measurements. The methodology will utilise the WindCube (WLS70) instrument, located at 42.79 N, 1.63 W near Pamplona, Spain at less than 400 meters above sea level. It has been measuring since November 17th, 2017 and it is foreseen to continue well into 2019. The instrument scans with a range of 100 meters and a probe volume of approximately 30 meters. Profiles are available every 6 seconds and as 10-minute averages, i.e. 144 profiles per day at best. Currently, data recovery rates from the profiling instrument at Alaiz range from approximately 65% at the height of 500 meters to 10% at 2 km above the ground. The two VMM scanning patterns are available from June 2018 and will continue measuring, every 20 seconds, profiles from 100 meters up to 1000 meters above ground level. The profiles will be available as 10-minute averages and the estimated recovery rate is expected to range between 30% and 50% depending on the location and height. This unique set of readily available measurements can be ideal for validation purposes of the lower altitude Aeolus horizontal line of sight (HLOS) winds from L1B and L2B products. Furthermore, VALAWIN aims to validate the L2A estimated backscatter coefficient of the low altitude atmosphere using measured Carrier-to-Noise Ratio (CNR) values from the ground-based WindCube profiler and the WindScanners scanning the VMM patterns. Finally, it is envisaged that the ground-based measurements can also contribute to the characterisation of cloud parameters (i.e cloud depth) through the concurrent measurements of the vertical profile of the backscatter coefficients. The deliverables of the VALAWIN project will consist of two reports and one manuscript. The reports will summarise the data availability to perform the Cal/Val activity (D1) and the findings from the validation activities (D2). A manuscript submitted to a peer-review journal (D3) is also foreseen. Please see attached Gantt chart for further details.
Expected innovation for Aeolus	The proposed project aims at supporting the Aeolus Cal/Val activities using ground-based measurements concurrent with the Aeolus launch and commissioning phase.
Expected results for Aeolus	The proposed project aims to contribute to the Aeolus Cal/Val activities by using ground-based Doppler wind lidars to perform a validation of the Aeolus low altitude retrievals. Thus, it is directly contributing to the “comparison of the wind products with ground-based measurements also considering scale issues (‘representativity’)” objective of the Cal/Val activity.

Data requirements, data coverage and timeline	Aeolus Product Names Level 1B, Level 2A, Level 2B data	Data Coverage Phase E2 Pamplona, Spain (42.79 N, 1.63 W)	Specific Timeline of Validations Phase E2, 2019
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

<table>
<tr><td>Validation Project Title</td><td colspan="3">Validation of Aeolus winds using radar measurements in Arctic Sweden and Antarctica, and optimal use of wind data in numerical weather prediction</td></tr>
<tr><td>Link to full Proposal</td><td colspan="3">47571</td></tr>
<tr><td>Team Leader name, affiliation and email</td><td colspan="3">Dr. Heiner Kornich (PI), Swedish Meteorological and Hydrological Institute, Sweden, heiner.kornich@smhi.se</td></tr>
<tr><td>Support team-members names and emails</td><td colspan="3">Prof. Sheila Kirkwood, sheila.kirkwood@irf.se
Dr. Evgenia Belova, belova@irf.se
Dr. Peter Voelger, peter.voelger@irf.se
Dr. Magnus Lindskog, magnus.lindskog@smhi.se
Dr. Susanna Hagelin, susanna.hagelin@smhi.se</td></tr>
<tr><td>Summary of activity</td><td colspan="3">The proposed project aims at: 1) validation of Aeolus winds and 2) optimal usage for wind observations in convective-scale NWP systems. The work will be done in a close collaboration between the Swedish Institute of Space Physics (IRF) and the Swedish Meteorological and Hydrological Institute (SMHI).
Aeolus winds will be validated by comparison with winds measured by two atmospheric radars, located at Esrange in Arctic Sweden and at Antarctic station Maitri. Scarcity of data at high latitudes makes our radar observations very valuable for validation of Aeolus wind products in these regions. Validation will be done for one year of satellite operation, and, as a result, Aeolus wind errors will be evaluated. For certain cases (e.g. high likelihood for significant vertical winds, jet streams, broken clouds) the comparison will be done in more detail using a NWP model. This comparison will allow examining spatially correlated observational errors for Aeolus that are known to have detrimental influence on the performance of a NWP system. The second part will focus on optimal implementation of Aeolus and ESRAD wind data into convective-scale NWP system for Fenno-Scandinavia. Different assumptions and formulations for the data assimilation will be examined. Also, the handling of correlated observational errors will be addressed for Aeolus.</td></tr>
<tr><td>Expected innovation for Aeolus</td><td colspan="3">The project will analyse the performance of Aeolus in high latitudes. This is especially challenging due to few observational stations in these latitudes. As impact studies have shown potential impact in high latitudes, the validation done in the project is of importance. Furthermore, the project will examine the usage of Aeolus in a meso-scale NWP system.</td></tr>
<tr><td>Expected results for Aeolus</td><td colspan="3">The project will contribute to the mission objectives by:
- validating Aeolus in high latitudes where observations are scarce.
- validating Aeolus with a meso-scale NWP model for certain cases such as significant vertical winds due to mountain waves, jet streams and under broken cloud conditions.
- examining the optimal usage of Aeolus winds in a meso-scale NWP system</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names

Level 2A, Level 2B data</td><td>Data Coverage

Phase E2, Sweden, Europe and North Atlantic, Antarctica</td><td>Specific Timeline of Validations

Phase E2</td></tr>
<tr><td>In situ validation data to be collected</td><td colspan="3">n.a.</td></tr>
<tr><td>Special data needs</td><td colspan="3">n.a.</td></tr>
</table>

<table>
<tr><td colspan="4">Status assessment</td></tr>
<tr><td></td><td>Pre-launch</td><td>Commissioning Phase</td><td>Phase E2</td></tr>
</table>

Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Analysis of remotely sensed, aerosol cloud interaction over the Arctic: Aeolus validation activities**		
Link to full Proposal	47692		
Team Leader name, affiliation and email	Prof. Norman ONeill (PI), Universit de Sherbrooke, Canada, norm.oneill@usherbrooke.ca		
Support team-members names and emails	JeanPierre Blanchet, blanchet.jeanpierre@uqam.ca Patrick Hayes, patrick.hayes@umontreal.ca Rachel Chang, Rachel.Chang@dal.ca		
Summary of activity	The Aeolus wind speed product will be used to analyze wind properties in order to better characterize aerosol - cloud (AC) dynamics in the neighbourhood of AC transition regions. Inasmuch as Aeolus also acts as an AC profiling lidar we will employ those profiles as redundant and complementary information relative to CALIOP profiles. The TROPOMI imager products will specifically include cloud height, cloud fraction and cloud optical thickness, aerosol layer height and aerosol absorbing Index (AI). The planned NPP - VIIRS products include cloud classification, particle type and size. The satellite lidars yield vertically - resolved AC interaction information during the polar winter and synergistic vertical information in combination with the passive sensor products for polar spring analyses. In our previous Polar winter work with CALIOP we carried out comprehensive comparisons between starphotometer - derived fine and coarse mode (sub – and super - micron) aerosol optical depths (AODs), ground based CRL (CANDAC Raman Lidar) profiles of depolarization ratio and derived extinction coefficient as well as GEOS – Chem (chemical / aerosol transport model) simulations of fine and coarse mode AOD over Eureka and Ny Alesund. These comparisons allowed us to, on the one hand, better understand the physical optical dynamics over Eureka and Ny Alesund but as well, to validate the quality of the CALIOP AODs. We seek to carry on the same type of analysis with Aeolus data (including CALIOP comparisons as long as the latter continues to be operational). The interpretation of our empirical findings will be supported by event - level and climatological - scale simulations.		
Expected innovation for Aeolus	The interaction with the teams developing the various retrieval algorithms, will provide insight into ways for improving / adapting the ALADIN and TROPOMI products over the Arctic where RS validation (particularly during the polar winter) is at a premium. Being part of the TROPOMI as well as the Aeolus validation teams should prove mutually beneficial to the satellite product team and our group of ground-based RS experts.		
Expected results for Aeolus	We will employ our PEARL CRL and sunphotometers and starphotometer to help validate Aeolus AC (L2a and L2b) products of aerosol typing, lidar ratios, optical depths, AC top and bottom heights and cloud cover during the Polar winter and summer. Our experience has also shown that context is important and thus L1b products are essential in the interpretation phase. The CloudSat / CALIOP profiles along with CRL / MMCR retrievals will assist in terms of the interpretation of Aeolus backscatter profiles and achieving a better physical understanding of the Doppler wind profiles. These comparisons will allow us to better understand the physical optical dynamics over Eureka but as well while validating the quality of the Aeolus AODs as well as infer the quality of aerosol typing products.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, NH/Arctic	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		

Special data needs	n.a.

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

<table>
<tr><td>Validation Project Title</td><td colspan="3">Validation of ADM-Aeolus L2 aerosol and cloud product employing advanced ground-based lidar measurements</td></tr>
<tr><td>Link to full Proposal</td><td colspan="3">48932</td></tr>
<tr><td>Team Leader name, affiliation and email</td><td colspan="3">Dr. George Avdikos (PI), Raymetrics, Greece, gavdikos@raymetrics.com</td></tr>
<tr><td>Support team-members names and emails</td><td colspan="3">Dr. King Kheong, mah_king_kheong@nea.gov.sg
Dr. Gavin Yeao, gavin_yeap@nea.gov.sg
Dr. Ivan Lock, ivan_lock@nea.gov.sg
Dr. Ioannis Binietoglou, ioannis@inoe.ro</td></tr>
<tr><td>Summary of activity</td><td colspan="3">The objective of this proposal is to validate the ADM-Aeolus L2A cloud and aerosol spin-off products (supplementary geophysical products) and the related instrument calibration modes and algorithms.
The validation will be performed with ground-based Raman/polarization lidar instruments providing unbiased profiles of particle extinction, optical depth, backscatter, extinction-to-backscatter ratio and linear and circular depolarization ratios for clouds and aerosol at 355 nm. Measurements will be performed by Raymetrics lidar system operating in Singapore.
The sites have been selected such as to cover different latitudinal zones and a variety of aerosol abundances / types. The deliverables will include collocated cloud and aerosol observations during satellite overpasses and their analyses as well as conclusions on the ADM-Aeolus performance including calibration, correction schemes, and algorithms. The team is composed of well-experienced scientists in the field of cloud and aerosol lidar research and the performance of ground validation campaigns including pre-launch validation activities for ADM-Aeolus.</td></tr>
<tr><td>Expected innovation for Aeolus</td><td colspan="3">Advanced and high-sophisticated ground-based instrumentation is applied to provide unbiased aerosol and cloud products in terms of particle extinction, optical depth, backscatter, extinction to backscatter ratio and linear/circular depolarization ratio at 355 nm. In the ALADIN retrievals, critical corrections schemes must be applied to derive the same kind of data. The schemes sensitively depend on the actual system parameters. In particular, the correction of cross-talk between the Mie and Rayleigh channels is expected to implicate uncertainties of ALADIN's aerosol and cloud products. In addition, the coarse vertical resolution of the space-borne measurements and the lack of measuring the cross-polarized backscattered component of the circular-polarized emitted light may bias the retrievals. Therefore, the ground-based validation of ALADIN's cloud and aerosol products with several independent instruments providing unbiased information on the optical parameters with high spatial resolution is of great importance.</td></tr>
<tr><td>Expected results for Aeolus</td><td colspan="3">The proposal contributes to the ADM-Aeolus Mission and to the AO Objectives (AE-OFESAGS-002, p. 6) by
- validation of ADM-Aeolus atmospheric optical properties products (Level 2a) with ground-based experiments
- experiments to assess the accuracy, resolution and stability of ALADIN with respect to cloud And aerosol retrievals
- assessment and validation of the ALADIN aerosol and cloud retrieval algorithms
In particular the proposal contributes to the following objectives:
- assessment of L1B algorithm and instrument calibration, especially the cross-talk correction
- comparison of Level 2a products with aerosol and cloud products from ground-based observations including assessment of representativity
- assessment of ALADIN accuracy, including major error sources and error budgets with respect to polarization sensitivity, cross-talk correction, correction of the velocity-induced Doppler shift of the Rayleigh backscatter line, and correction of temperature-dependent Rayleigh line broadening for the retrieval of atmospheric optical properties.</td></tr>
<tr><td>Data requirements, data coverage and timeline</td><td>Aeolus Product Names
Level 2A data</td><td>Data Coverage
Phase E2, Singapore</td><td>Specific Timeline of Validations
Phase E2</td></tr>
</table>

In situ validation data to be collected	n.a.
Special data needs	n.a.

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Characterization of ALADIN HLOS data over Korean peninsula using the radiosonde and dropsonde data**		
Link to full Proposal	49937		
Team Leader name, affiliation and email	Dr. ChuYong Chung (PI), KMA, Republic of Korea, cychung@kma.go.kr		
Support team-members names and emails	Prof. MH Ahn, terryahn65@gmail.com Dr. Young Cheol Kwon, yc.kwon@kiaps.org		
Summary of activity	A team of satellite operators (Dr. Chuyong Chung from National Meteorological Satellite Center), model developers (Dr. Young Cheol Kwon from Korea Institute of Atmospheric Prediction Center), and a university professor (MH Ahn from Ewha Womans Univ.) interested in the ALADIN data plans to start a project to utilize the ALADIN data into a global numerical prediction model which has been development for 7 years and is planned to open publicly in the later this year. To facilitate the utilization, characterization of ALADIN data using locally available reference data including radiosonde data (twice per day from 8 regular upper air weather stations over Korea), dropsonde data (infrequent launch over ocean area), and atmospheric motion vector (AMV) derived from the newly launched geostationary satellite of Korea (the main payload is similar to the GOES-16, 17/ABI). Through the inter-comparison, we would like to validate the ALADIN error characteristics, generate an error covariance matrix, and conduct sensitivity study with the new global nwp model.		
Expected innovation for Aeolus	We are going to use 1. local radiosonde data (some of data may not have been GTS communicated) with a careful quality control process (probably applying manual inspection of raw data) to do the comparison 2. Special observation of dropsondes by observation aircraft over the area surrounding Korean peninsula are planned in May and August. The flight schedule could be adjusted to coincide with the ALADIN observation track 3. About 8 ground based wind profiler operated by KMA would be used for the comparison (fixed but continuous observation) 4. KIM model output for comparison and assimilation experiment with ALADIN		
Expected results for Aeolus	We believe that our planned activities could 1) increase the number of data used for the validation 2) increase the coverage that ALADIN data is validated, 3) add more model sensitivity results.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A, Level 2B data	**Data Coverage** Phase E2, global	**Specific Timeline of Validations** Phase E2
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2

Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

Validation Project Title	**Statistically based calibration/validation control of ALADIN/ADM-Aeolus L1/L2A Data**
Link to full Proposal	49974
Team Leader name, affiliation and email	Dr. Artem Feofilov (PI), Ecole Pollytechnique / Laboratory of Dynamic Meteorology, France, artem.feofilov@lmd.Pollytechnique.fr
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Summary of activity	We propose a set of parameters, which would characterize the behavior of the ALADIN lidar system on a day-to-day basis using the L1/L2A data as an input. With the help of this set we will trace: a) the stability of the detection chain for ALADIN channels (Rayleigh, Mie); b) the stability of day- and nighttime noise; c) the stability of the radiation detection for all atmospheric scenarios and over the whole globe using a clustering algorithm applied to the scattering ratio (SR) histograms. Overall, we define 8 parameters: 2 related to surface reflection, 4 related to stratospheric day- and night time noise for 2 channels, and 2 related to the SR histogram analysis. We demonstrate the feasibility of the approach using CALIOP L1 data for polarized and cross-polarized attenuated backscatter (ATB) components in 2008-2015 and using a LMDZ general circulation model coupled with the COSP2 ATLID lidar simulator. (i) The stability control using surface backscatter takes advantage of a stable scattering scene providing thousands measurements per day, namely, a clear sky ocean surface at fixed surface temperature (3001 K). Using CALIOP data, we show that the ATB histograms built over this subset demonstrate a clear maximum, the behavior of which over the years is coherent with laser power degradation. Applied to the ALADIN channels, this approach will track the performance of laser, the absolute calibration for each channel, and the cross-talk coefficients. (ii) For the stratospheric noise analysis, we build histograms of day- and nighttime r.m.s. values of the stratospheric noise (35-40 km layer) and analyze them in the same manner as above. For ALADIN, this will help tracking issues in the detection path, in the signal treatment chain, and in the cross-talk estimates. (iii) To address the whole range of the detected molecular and particular ATBs, we use an advanced SR histogram approach based on our previous studies. We take advantage of the day-to-day similarity of physical processes in the atmosphere and quantify the deviation of the SR histograms built for typical scenes from the reference ones. To identify these scenes, we use a clustering approach. Using 8 years of CALIOP data, we show that the clustered SR histograms do not change dramatically over time for a well-calibrated instrument and that they are sensitive to calibration issues. This feasibility study is supplemented by the sensitivity study performed for the COSP2 ATLID simulator, which proves the concept for the HSR lidar operating at 355 nm. The proposed approaches directly relate to the validation requirements listed in Section 6 of the ADM-Aeolus Scientific Calibration and Validation Requirements document and indirectly to the performance of the instrument as a whole. The deliverables are the results of day-to-day quality control for 8 parameters.
Expected innovation for Aeolus	
Expected results for Aeolus	The proposed activity is aimed at quality control of the Aladin instrument. The HSRL part of the instrument is composed of two registration channels (Rayleigh and Mie, which are further split to the elements of the CCD matrix) which, being coupled with the sounding lidar and its optical system, represent a complex setup. In such a system, the degradation of Level 1 data quality can be caused by multiple reasons. We propose a quality control approach based on a set of 8 indicators of the “system health”, which we introduce in the proposal and which we suggest checking on a day-to-day basis. For each indicator, we define “safe limits” explained by natural

	atmospheric variability and estimated from the analysis of CALIOP data over the period of 2008-2015 and adapted to Aladin specifications. If any of the indicators crosses the safety threshold, a warning is issued. From the analysis of the indicators, one can make a conclusion regarding the issues in the optical path, or in signal treatment, or with the detector's efficiency, linearity or calibration including cross-talk estimates, or with electronics. The proposed activity will contribute to Aladin validation objectives, namely, to assessing the stability and calibration of the Aladin instrument. The proposed approaches directly relate to the validation requirements listed in Section 6 of the ADM-Aeolus Scientific Calibration and Validation Requirements document and indirectly – to the performance of the instrument as a whole.		
Data requirements, data coverage and timeline	**Aeolus Product Names** Level 1B, Level 2A data	**Data Coverage** Phase E2, Global	**Specific Timeline of Validations** Phase E2, 12 months
In situ validation data to be collected	n.a.		
Special data needs	n.a.		

Status assessment			
	Pre-launch	Commissioning Phase	Phase E2
Schedule of proposed activities			
Availability of funding			
Availability of infrastructure			
Availability of people			

13.4 Data requirements

The following data requirements have been defined based on [AD 1]:

1. The Aeolus data shall be provided in ESA Earth Explorer Binary format (EEE).
    a. To help users to read the data and to convert it into other common binary data formats such as NetCDF, the CODA software and library has been developed: https://atmospherictoolbox.org/, https://atmospherictoolbox.org/coda/

2. The Aeolus L2B wind data shall be available in BUFR format to allow operational assimilation into Numerical Weather Prediction Models
    a. A BUFR convertor tool and BUFR template has been developed and is available here: https://confluence.ecmwf.int//display/AEOL/Aeolus+Level-2B+Processor+Package

13.5 Aeolus data dissemination needs

The following requirements on data dissemination are issued by the ASCV IP:

1. FTP data access to the complete data archive is requested (not a limited rolling archive).
2. FTP or HTTP access is needed that allows searching and scripting functions, e.g. search for specific geographic coverage.
3. Test data sets (TDS) of scientific utility are required prior to launch, both for Level-1 and Level-2 products.
    a. Tests of data dissemination prior to launch was performed prior to the Aeolus CAL/VAL Rehearsal Workshop in 2017 (https://earth.esa.int/web/sppa/meetings-workshops/aeolus-2017)
4. The Aeolus L2B wind product shall be available to NWP users in Near Real Time (NRT)
    a. When the Aeolus L2B wind data are publically released, ECMWF will push Aeolus L2B wind data in BUFR format in near real time (NRT) to EUMETSAT, who will distribute it on EUMETCast. The Aeolus L2B BUFR data will hence be available to NWP users in NRT.

13.6 Central Database to store Aeolus Campaigns and collocated CAL/VAL data sets

The ASCV Team are requested to upload their collocated CAL/VAL data to a central database for sharing with ESA and the ASCV Team members. The selected service for the Aeolus collocated CAL/VAL data is the ESA atmospheric Validation Data Centre (EDVC), https://evdc.esa.int

The following shall be taken into account when uploading data to the EDVC:

- o The CAL/VAL Teams are expected to provide systematic and random error estimates for the collocation measurements
- o For model validation; model analysis and prediction errors shall be assessed, provided and included in the analysis in the validation reports.

The following information useful to the ASCV Team are available on the EDVC:

- Collocated dataset from other ASCV teams
- ECMWF predictions could
- Aeolus orbit prediction / station overpass tool

13.7 Information and tools

ESA shall provide ASCV Teams with overpass table tools to allow collocated observations and planning of campaigns. Overpass table tools from ESA prepared for Aeolus are:

- EVDC overpass table tool: https://evdc.esa.int/orbit/
- ESA EOP-CFI software: https://eop-cfi.esa.int/index.php/applications/tools

ESA shall provide ASCV Teams with easy and flexible data access:

- The Aeolus Data Dissemination Facility (ADDF) and software for the reading of Aeolus data, overpass table tools etc. are described in [RD 20], and on https://www.aeolus.esa.int/. The ADDF contains quick-browse images.

ESA shall provide ASCV Team member with data reading and browsing tools:

- The CODA software and library has been developed for ESA EE data reading into various programming software, and simple plotting routines: https://atmospherictoolbox.org/, https://atmospherictoolbox.org/coda/
- The VirES for Aeolus tool can be used for data browsing and plotting: https://aeolus.services/. VirES for Aeolus works best when using Google Chrome.

13.8 Reporting

The CAL/VAL teams are requested to perform short status reports every 6 months to ESA (see section 11.6.1), to report at the annual Aeolus CAL/VAL workshops (Table 13.1) and to deliver a final CAL/VAL report at L+36 months.

13.8.1 Template short CAL/VAL status reports

Six-monthly CAL/VAL status reports shall be prepared by the CAL/VAL team PIs, and uploaded to the Aeolus CAL/VAL wiki page described in section 11.8, at the 1st of April and 1st of October. The reports are requested to contain the following information:

1) Short summary containing one or two highlight plots, the main findings, statements about the Aeolus data quality (e.g. observed departures/biases with respect to reference measurements)
2) Bulleted list of new findings and open issues
3) A detailed report including:
    a. Number of collocated data collected and evaluated
    b. Instrument/variable of the validation measurement
    c. Baseline/time period of the Aeolus product
    d. Special case studies (if any)
    e. Additional measurements (Time period, location, instrument, product)
    f. Collocation criteria used other than the common one
    g. Quality filtering (QC) applied to the Aeolus data as well as the ground based data
    h. Statistics on the comparison of Aeolus with the collocated information, considering the CAL/VAL requirements listed in this document (section 6.2) and CAL/VAL requirements and techniques described in [AD 2]
    i. Discussion of potential differences in information content of the collocated and Aeolus observations
    j. Plots: e.g. scatter plots (with Aeolus products on y-axis including error characteristic related parameters (standard deviation etc.)) and selected profile plots down-sampled to Aeolus vertical resolution and fulfilling the common collocation criteria (100 km distance, +/- one hour). The CAL/VAL Teams are expected to report systematic and random error estimates for the collocation measurements.
    k. Datasets uploaded to the EVDC during the reporting period
    l. Open issues under investigation and next steps
4) Recommendations/Comments to ESA
5) Acknowledgements

13.9 Communication

All communications to and from the ASCV Teams shall be done on the

Aeolus CAL/VAL Portal: https://www.aeolus.esa.int/

The portal contains latest news on the Aeolus mission, instrument performance, algorithm and data quality, CAL/VAL team activities, links to PDGS site, CAL/VAL database, tools, discussion fora, etc. An overview of the Aeolus CAL/VAL teams and activities will also be kept up to date on the wiki page, and it is therefore not planned to update this plan regularly throughout the mission.

Communications are also provided on the

SPPA site for the Aeolus mission: https://earth.esa.int/web/sppa/home

14 SUMMARY AND CONCLUSIONS

This document presents the Aeolus Scientific Validation Implementation Plan (ASCV IP). It is a reference handbook for all those involved in scientific validation of the mission and interfacing to the activities that are planned within the ASCV. The ASCV IP is of course, a living document and will be updated on a regular basis as the Aeolus mission progresses.

15 APPENDIX A: CONTACT DETAILS OF ASCV TEAM MEMBERS

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