



Royal Netherlands  
Meteorological Institute  
Ministry of Infrastructure and the  
Environment



# Aeolus L2A aerosol and cloud product validation using the European Aerosol Research Lidar Network EARLINET

A. Apituley<sup>1</sup>, G. Pappalardo<sup>2</sup>, U. Wandinger<sup>3</sup>, V. Amiridis<sup>4</sup>, L. Alados-Arboledas<sup>5</sup>, L. Mona<sup>2</sup>, D. Nicolae<sup>6</sup>

## Introduction

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 Aeolus will also use the High Spectral Resolution Lidar ALADIN to provide aerosol and cloud optical profiles.

The main product from Aeolus will be wind profiles. 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.

The success of EARLINET is based on a common measurement schedule, a rigorous quality assurance program for both instruments and evaluation algorithms, and a standardized data exchange format. In EARLINET 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 from multi-wavelength Raman lidar observations. Backscatter coefficients at three wavelengths (355, 532, 1064 nm) plus extinction coefficients at two wavelengths (355, 532 nm) are the minimum required for such inversion schemes. Presently, 17 EARLINET stations perform at this level.

## Goals and Approach

- 1) Validation of Aeolus L2A 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 EARLINET stations. For this, data will be used from:

- 1) The (historical) EARLINET database,
- 2) Correlative measurements performed by selected EARLINET stations during close proximity Aeolus overpasses.

EARLINET contributes to Aeolus Cal/Val through:

- Quantification of 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.

## Innovation

- 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 18 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 and through collaboration with Cloudnet.



Figure 1. EARLINET stations (status 2014)



Figure 3. Aeolus ground tracks over EARLINET stations (ESA km1 file).

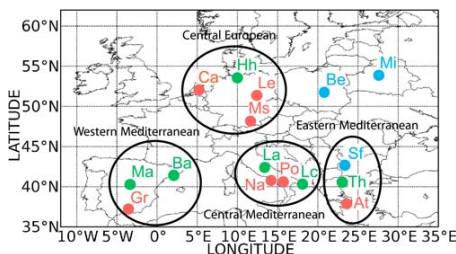


Figure 2. EARLINET stations as clustered for the CALIPSO validation. High- performance stations are reported as red dots, green dots represent contributing Raman lidar stations, and blue dots indicate contributing elastic-backscatter lidar stations. (Pappalardo et al., JGR, 2010)

An observation schedule is proposed according to overpasses related to clusters of lidar stations (see Fig. 2).

### Case 1 measurements:

Each station performs measurements as close as possible in time and space to the Aeolus overpasses. For validation studies, measurements made within 2 h and 40 km of the satellite overpass are preferred, but within 4 h and 100 km are acceptable.

### Case 2 measurements:

Additional correlative observations are suggested to be made at the lidar station which is closest to the station of the actual Aeolus overflight.

### Case 3 measurements:

If Aeolus passes over a multi-wavelength Raman lidar station (high-performance station) then also the neighbouring high-performance station performs a measurement.

## Workplan

WP01 – Measurement plan preparation (L-3 – L+18)

See Fig. 2 and adjacent text box.

WP02 – Database set-up and exchange (L-3 – L+18)

The data exchange between EARLINET and ESA will take into account QA4EO guidelines.

WP03 – Main correlative observational period (L+0 – L+18)

We estimate that 40 to 50 evaluated observational cases can be available at L+12 weeks and can serve for a very first quality check by the end of phase E1. The main focus of EARLINET is on the long-term validation (Phase E2).

WP04 – Data evaluation phase (L+3 – L+21)

Various Aeolus aspects will be taken into account. Experience gained in Calipso validation will be used.

WP05 – Reporting (L+3, L+21, L+24)

CalVal validation workshop attendance  
Symposium attendance  
Proceedings and peer reviewed publications