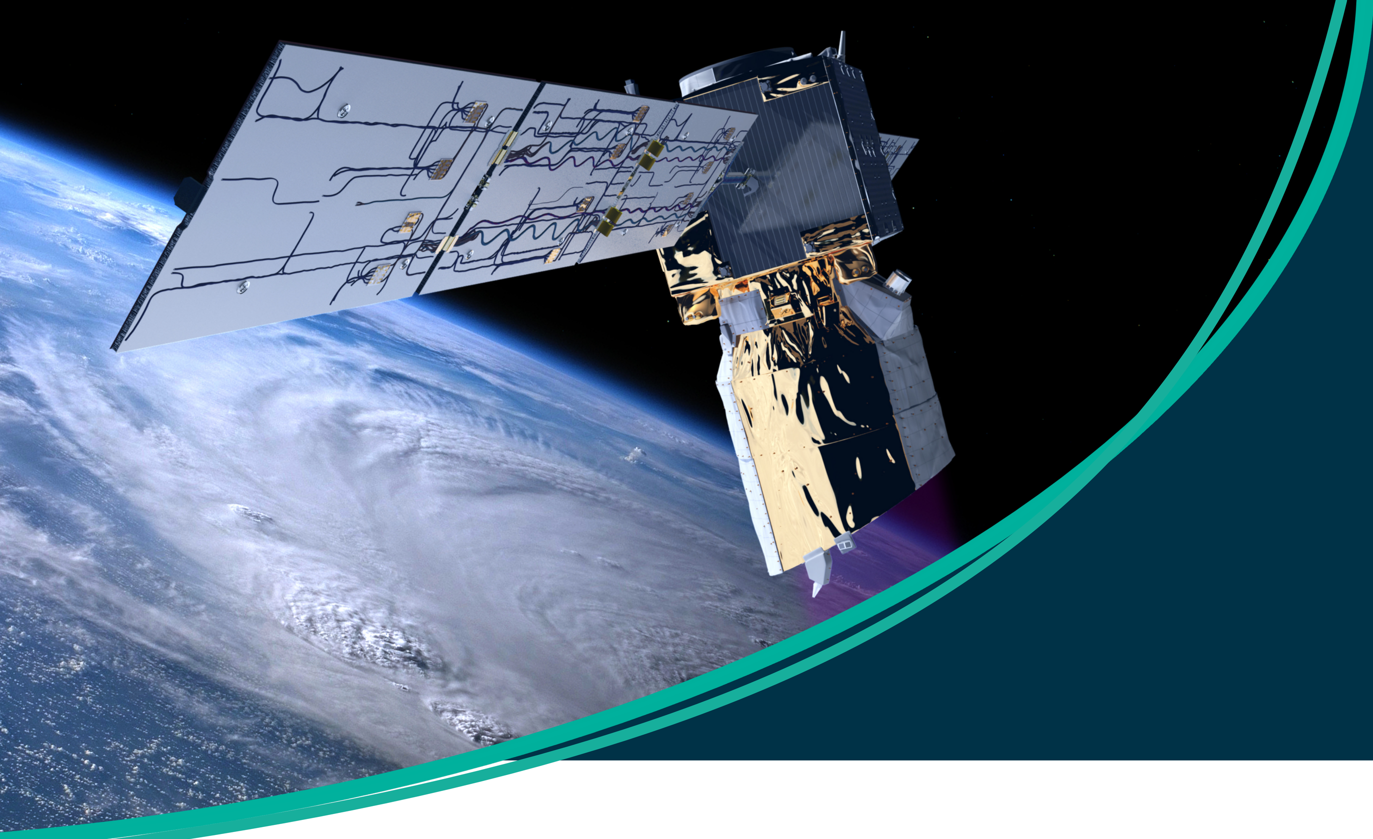

L2A+

Enhancing Aeolus L2A for depolarizing targets and impact on aerosol research and NWP

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Introduction

Aeolus, ESA's space mission, provides vertical profiles of the HLOS wind component in the troposphere and lower stratosphere. In addition, Aeolus retrieves and provides extinction and backscatter coefficients of aerosol and clouds (known as the L2A products) at 355nm. However, Aeolus' design enables the detection only of the returned co-polar component of the transmitted light. This limitation causes Aeolus to produce **underestimated backscatter coefficient profiles** when **non-spherical particles** (e.g., dust, volcanic ash, cirrus ice crystals) are probed, with negative impacts on applications of Data Assimilation (DA) and Numerical Weather Prediction (NWP).

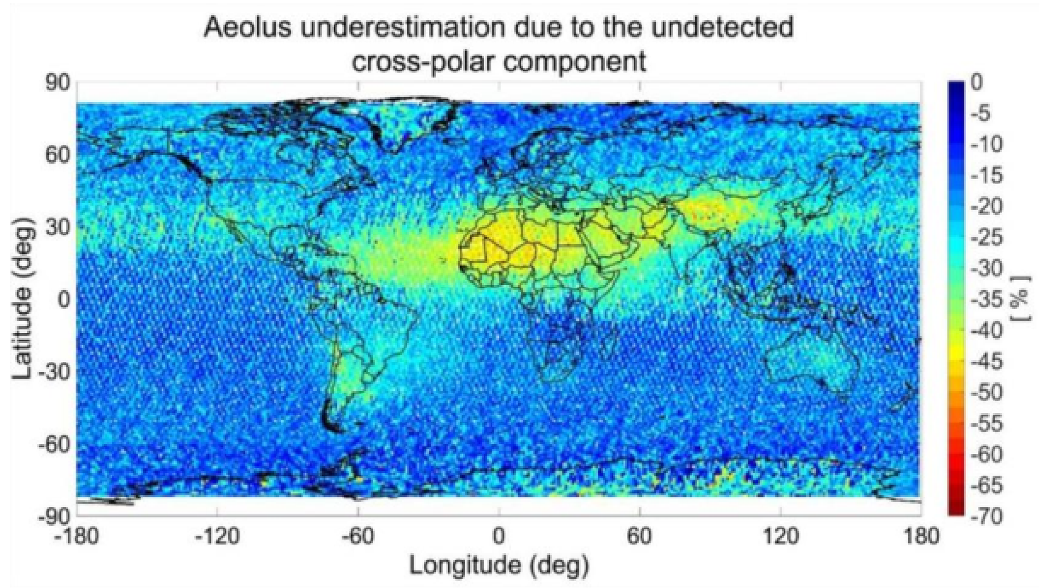

Figure 1: A measure of underestimation in terms of backscatter coefficient in AEOLUS' L2A product.

The ESA-L2A+ project, which kicked off in November 2022, aims to:

- Develop a **refined L2A+ aerosol product**
- Examine the impact of L2A and L2A+ on **aerosol assimilation and dust transport models**
- Highlight the benefit of Aeolus **joint aerosol and wind assimilation** on NWP and the associated impacts on the representation of the simulated dust fields.
- Access the climatological value of L2A+ for aerosol databases (e.g., ESA-LIVAS)

Methodology

The L2A+ project focuses on the N. Africa and the dust downwind areas across the Tropical Atlantic Ocean, in part due to the availability of ground-based observations from the ESA-ASKOS Tropical Campaign, as well as the NASA CPEX campaign. There are two time periods of interest, September of 2021 and September of 2022.

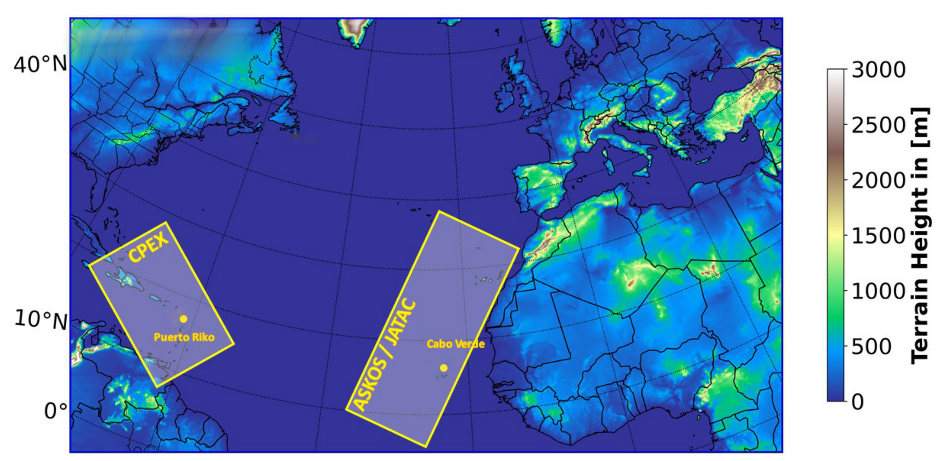

Figure 2: Region of interest for the L2A+ project, highlighted on the map.

The work plan of the project consists of creating the refined L2A+ product through processing of L2A and then assimilating it in NWP models to access the impact on aerosol transport. Observations from ASKOS are used throughout for validation both of the L2A+ product and of the forecasts.

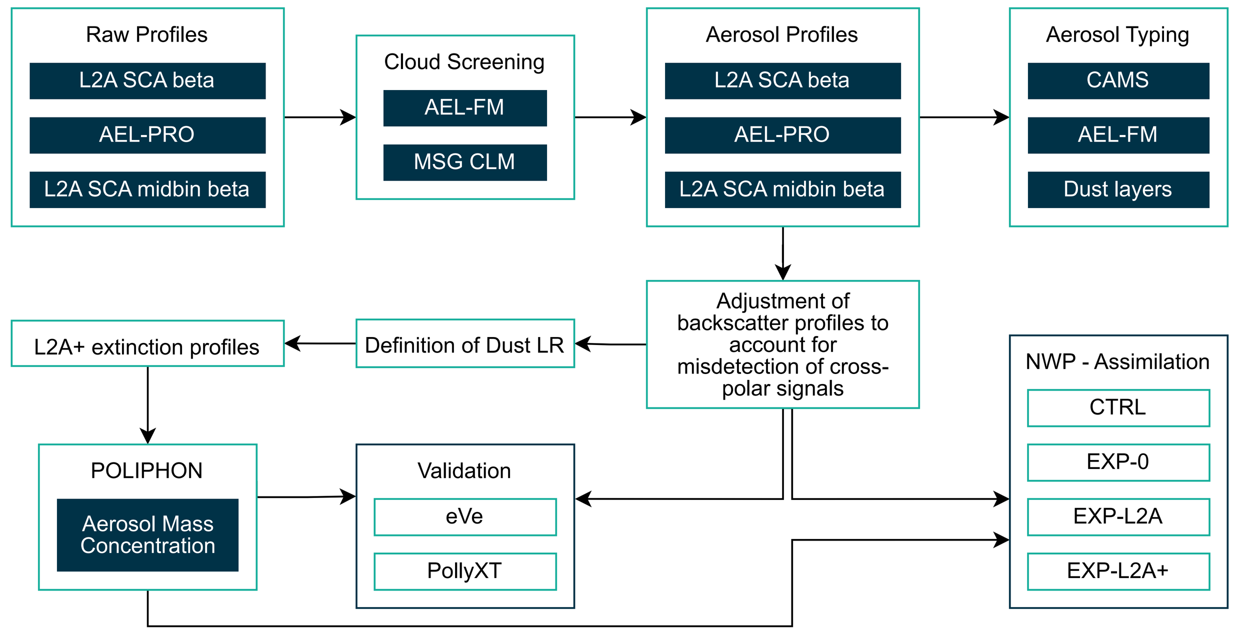

Figure 3: Methodology of the L2A+ project.

To create the refined L2A+ product, first a filter is applied to remove cloud-contaminated bins. The cloud screening methodology relies on the AEL-FM (Aeolus Feature Mask) product from the L2A processors II, which originated from the developments for the upcoming EarthCARE mission but was adapted to Aeolus.

Due to the absence of an aerosol classification scheme for L2A data, in order to identify the dust layers, we are utilising numerical outputs from the Copernicus Atmosphere Monitoring Service (CAMS) reanalysis. The CAMS aerosol model provides prognostic tracers for twelve distinct aerosol types. Through this information, the total aerosol load and the dust proportion of each layer will be determined. At this point, the backscatter profiles will be adjusted to account for the missing cross-polar component. Finally, the total backscatter (co-polar plus cross-polar) and an appropriate lidar ratio will be used to calculate the L2A+ extinction profiles.

Alternative ways of determining the dust composition of each layer will also be considered.

To examine the impact of L2A+ on NWP, four experiments will be conducted:

CTRL: No AEOLUS assimilation

EXP-0: AEOLUS wind assimilation

EXP-L2A: AEOLUS winds and L2A assimilation

EXP-L2A+: AEOLUS winds and L2A+ assimilation

The assimilation of **AEOLUS wind fields** in the regional NWP model will be approached in two ways:

1) Use IFS fields w/ AEOLUS assimilated as initial conditions.

2) Assimilate both wind fields and aerosol information directly in the regional NWP model.

The second way can directly demonstrate **the impact of joint aerosol/wind assimilation on emissions, dust transport, and deposition and highlight the unique value of AEOLUS.**

To conduct the assimilation experiments, the regional WRF model will be used alongside the Data Assimilation Research Testbed (DART). Work is in progress for developing an AEOLUS assimilation pipeline based on WRF/DART.

DART is a facility for ensemble assimilation, in which the model uncertainty is determined through a set of simulations, all starting with slightly perturbed initial fields. The spread of this ensemble is used to quantify the model error, which is then compared with the observation uncertainty in order to correct the model state. At the end of each assimilation cycle, the corrected fields are used to initiate the next ensemble of simulations.

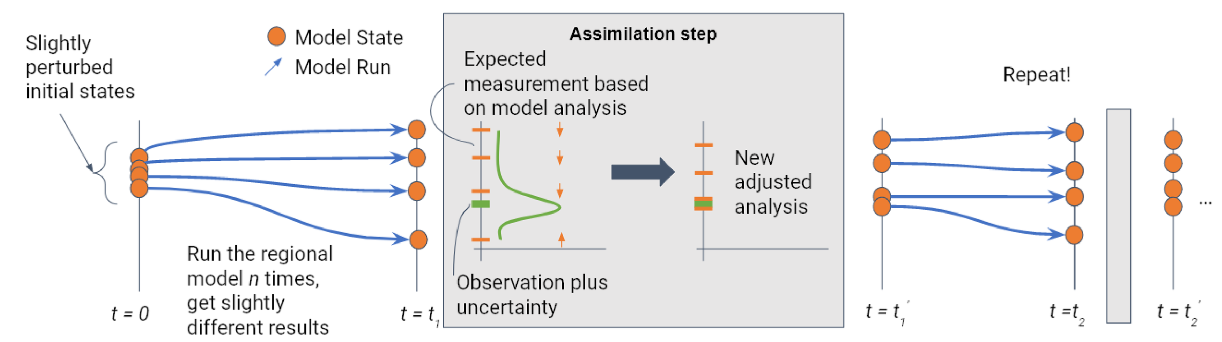

Figure 4: Overview of the ensemble assimilation method w/ Kalman Filters.

To evaluate our results, observations from the tropical campaign ASKOS will be used. The availability of high quality ground-based lidar measurements (eVe, the Aeolus reference system and PollyXT), as well as a Doppler lidar and a radar will provide reference observations to evaluate both wind and aerosol assimilation experiments. To determine dust fraction, we will use both the established POLIPHON method but also HETEAC-Flex, an EarthCARE-like typing scheme.

Preliminary Results

Here we present an indicative overpass of Aeolus and the various L2A+ processing steps. This overpass occurred on the 17th of September, 2021.

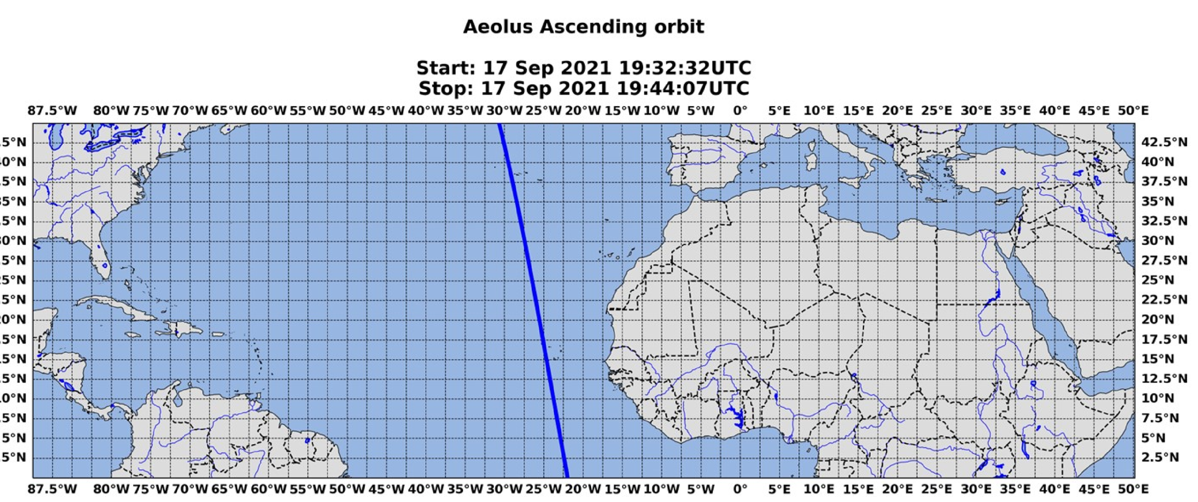

Figure 5: Aeolus overpass (orbit id 017790) on 2021-09-17.

The figure below shows the AEL-FM feature mask which is used to remove cloud-contaminated bins.

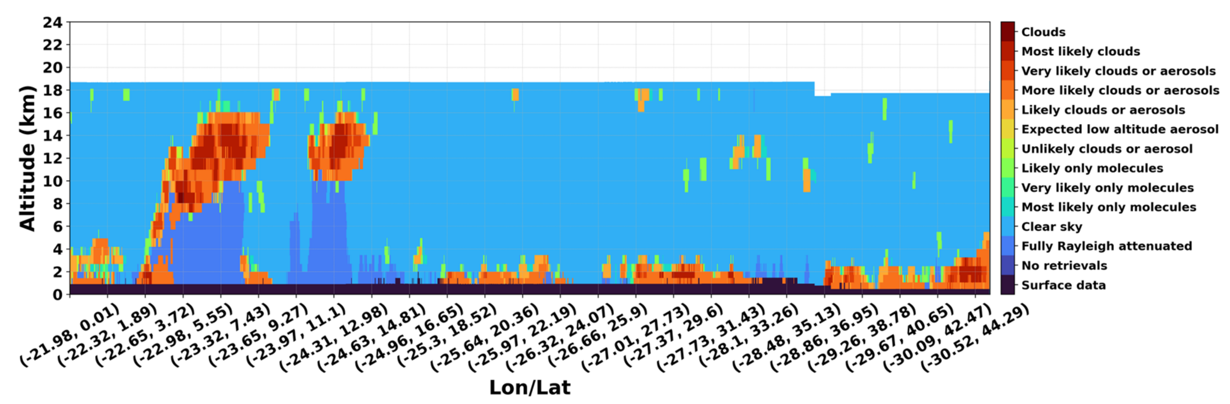

Figure 6: AEL-FM feature mask for the overpass of Figure 5.

Figure 7 presents the raw Aeolus L2A backscatter coefficient profiles, as retrieved by the SCA algorithm. The cloud-screened profiles are shown in Figure 8. Notice how the clouds to the left of the figure are removed from the second plot.

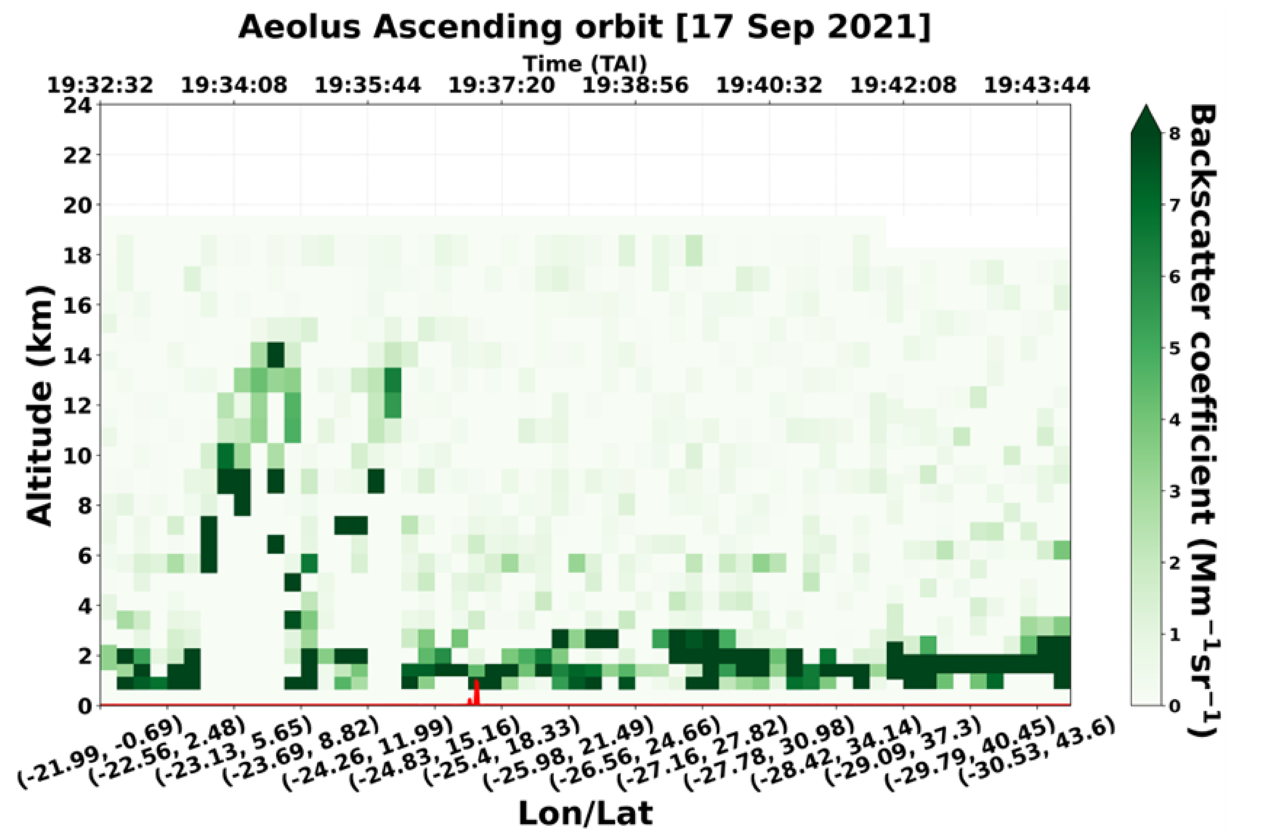

Figure 7: Raw Aeolus L2A SCA backscatter coefficient profiles.

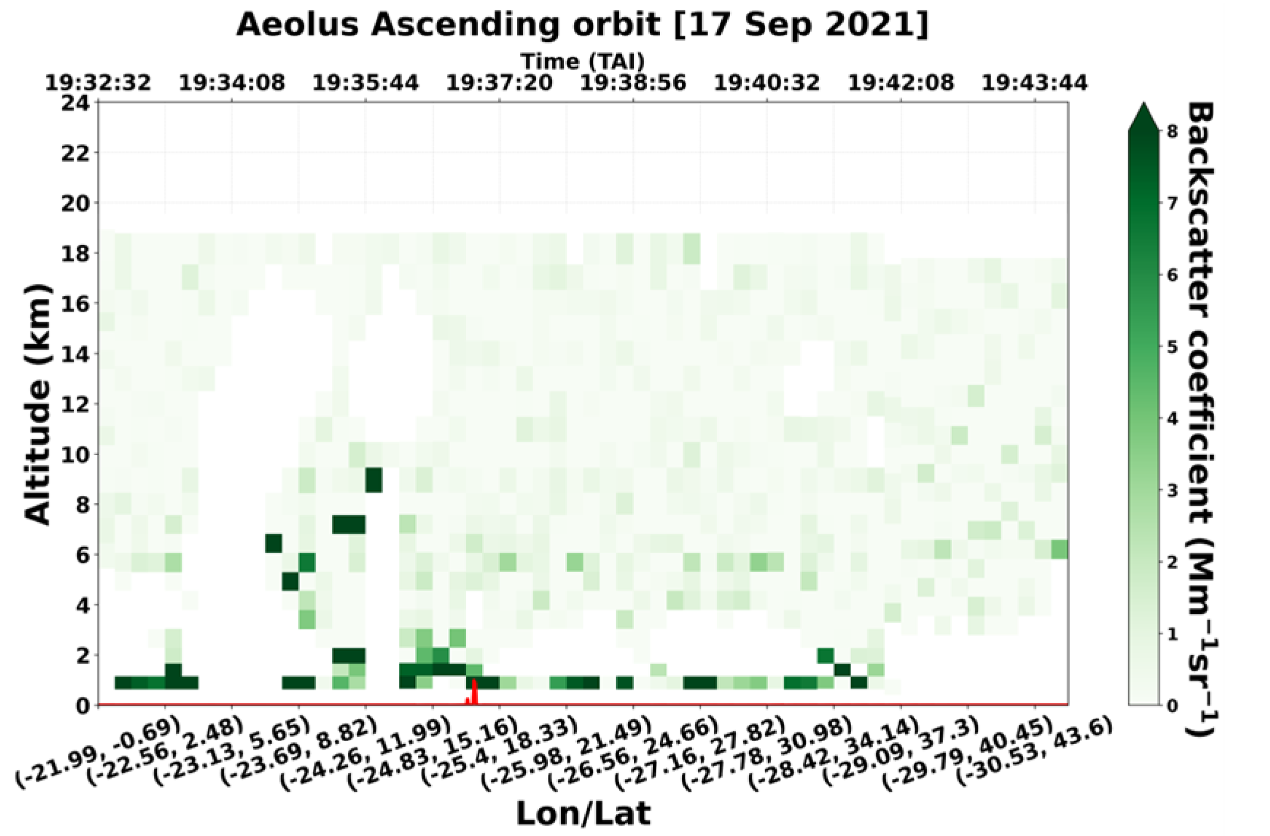

Figure 8: Raw Aeolus L2A SCA backscatter coefficient profiles.

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