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Topic: Mission Status and Product Evolution

Improved Line Profile Characterization from the Mie Spectrometer of Aeolus for Enhanced Scattering Ratio and SNR Retrieval

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The Aeolus mission, launched on August 22, 2018, carried the Atmospheric Laser Doppler Instrument (ALADIN), the first Doppler wind lidar in space. During its operational period until 30 April 2023, ALADIN provided near real-time global wind profiles crucial for weather forecasting. With five years of global wind data now available, ongoing efforts by the Aeolus Data Innovation and Science Cluster (DISC) focus on improving data quality through successive reprocessing campaigns. Following the successful fourth reprocessing campaign covering the entire mission dataset, preparations for the fifth reprocessing campaign are underway, including significant enhancements to the L1B processor.

A critical component of the Mie channel data processing is the accurate determination of the Rayleigh scattering offset in the response signal on the Fizeau interferometer as part of the Mie spectrometer. The signal consists of a peaked contribution from Mie scattering superimposed on an approximately constant offset from Rayleigh scattering. Precise characterization of this offset is essential for calculating reliable scattering ratios and signal-to-noise ratios.

The previous algorithm (called MieCore 2) exhibited several limitations: the used Lorentz function did not accurately represent the actual line profile, and the fitting procedure frequently resulted in negative offsets, leading to non-physical negative scattering ratios. To address these issues, the processor employed an "initial offset" based on a Lorentz fit with constant FWHM of 1.61 pixels, determined using the center of gravity of 5 pixels around the maximum. When this linear fit still yielded negative values, the offset was artificially set to 1, resulting in non-physical estimates.

The new algorithm (called MieCore3) introduces a fundamentally improved approach based on line profiles extracted from Mie response calibrations. These profiles are accurately described by a pseudo-Voigt function—a weighted sum of Lorentzian and Gaussian components. The Gaussian contribution accounts for non-perfections of the Fizeau interferometer, particularly imperfect reflector plates and significant non-optimal angle. Both the Gaussian weight and the width of the pseudo-Voigt function are treated as free parameters and differ between the two flight model lasers FM-A and FM-B.

This pseudo-Voigt fitting approach provides superior characterization of the line profile, especially at the wings of the spectrum, enabling more accurate offset determination. Additional improvements include implementation of a maximum likelihood-based optimization algorithm and enhanced quality control procedures.

The MieCore3 processor demonstrates significant improvements over MieCore2:

- Substantially increased number of valid wind retrievals
- Better agreement with scattering ratio data at observation level from L2A aerosol product, which uses a different retrieval approach
- Elimination of the gap between scattering ratios of 5 and 9 present in MieCore2
- identification of "no signal" regions below ground level or beneath dense clouds, improving the reliability of valid data identification
- Reduced pixelation effect, which describes the periodic deviation from true pixel position with 1-pixel period

This contribution will present the scientific validation of the MieCore3 processor, which will be implemented in the upcoming baseline 17 (B17) L1B processor for the fifth reprocessing campaign, demonstrating the enhanced quality of Mie channel scattering ratio products.