Atmospheric Background Radiation Measured by the ALADIN Instrument of ESA's Aeolus Mission

Karsten Schmidt[1] and Oliver Reitebuch[2]

German Aerospace Center (DLR), Germany, [1] IMF Neustrelitz, [2] IPA Oberpfaffenhofen

1. Introduction

After each laser shot and the acquisition of the 24 atmospheric range gates, the acquisition of the atmospheric background radiation was started. The background radiation measurements were accumulated in each of the 20 pixels of row 24 (numbering of rows from 0 – 24) of the memory zones of the Mie and Rayleigh channel ACCDs with a nominal integration time of 3750 µs. Pixels 0 and 1 are pre-pixels, pixels 2 - 17 are the useful (illuminated) pixels, and pixels 18 and 19 are offset correction pixels (2-pixels DCO correction; DCO – detection chain offset). During the mission, also pixels (0,1,18,19) have been operationally used for the DCO correction (4-pixels DCO correction). The operational processors included also a correction of the dark currents in the memory zones.

This background radiation has been used to correct the acquired backscattered laser signals. Though this data has not been a nominal product of the mission, it can be e.g. used to compare with measurements of other EO instruments in the near UV, or for radiation simulations after a radiometric calibration.

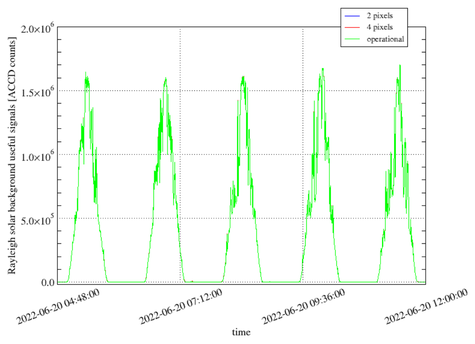
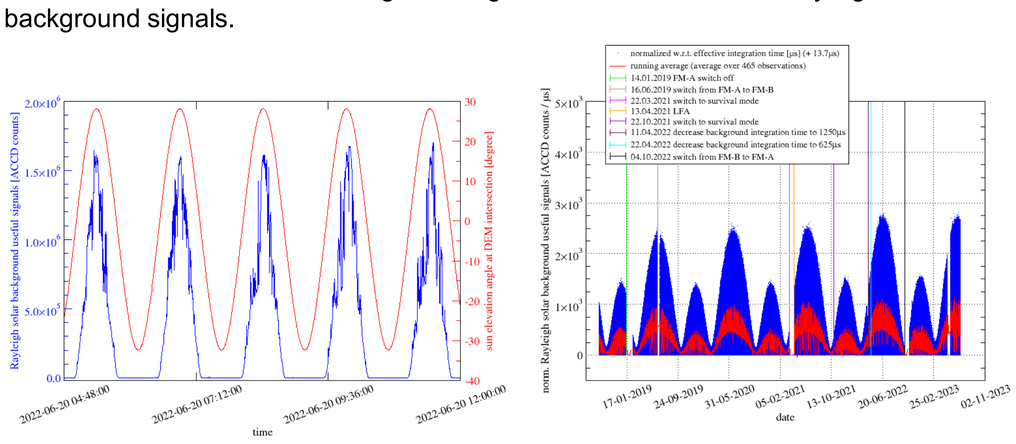


Figure: L1B Rayleigh solar background (SBG) useful signals on the observation level on 20.06.2022 with a 2-pixels DCO correction (blue line), a 4-pixels DCO correction (red line), and the operational observations (green line). The differences are small and noticeable only in the signal minima.

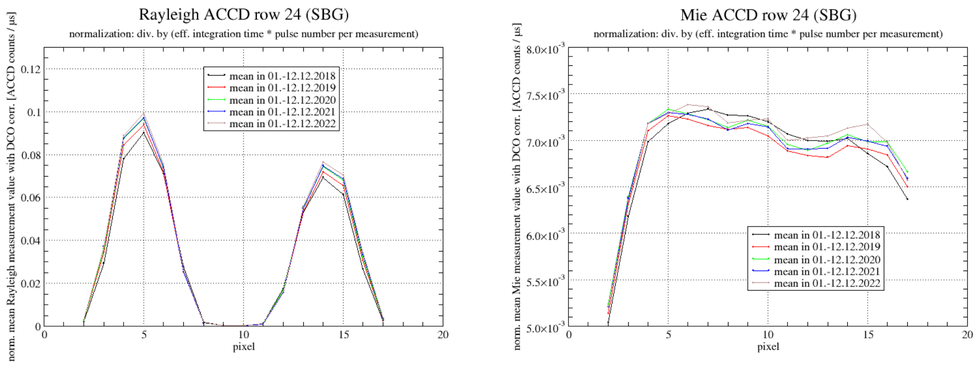
2. L1B Useful Signals for Solar Background on the Observation Level versus Time

Left figure: L1B Rayleigh SBG useful signals on the observation level on 20.06.2022 (blue line), and the sun elevation angle at the intersection of DEM and the line-of-sight (red line). The background signals follow the varying local sun elevation angle along the orbit. The same holds for the Mie background signals and the ratio of the Rayleigh to Mie background signals.



Right figure: L1B Rayleigh SBG useful signals on the observation level from 03.09.2018 to 05.07.2023, normalized w.r.t. the effective background integration time (= integration time + 13 µs) (blue line), and their running average, averaged over 465 observations (red line). Maxima are obtained in June (primary maximum) and December (secondary maximum). Minima appear in October and in March. This behaviour is mainly caused by the Earth orbit around the sun and the inclination of the Earth's rotational axis w.r.t. the ecliptic. A slight increase in the yearly maxima of the Rayleigh SBG signals is seen.

3. Mean L1A Solar Background Measurements versus ACCD Pixels

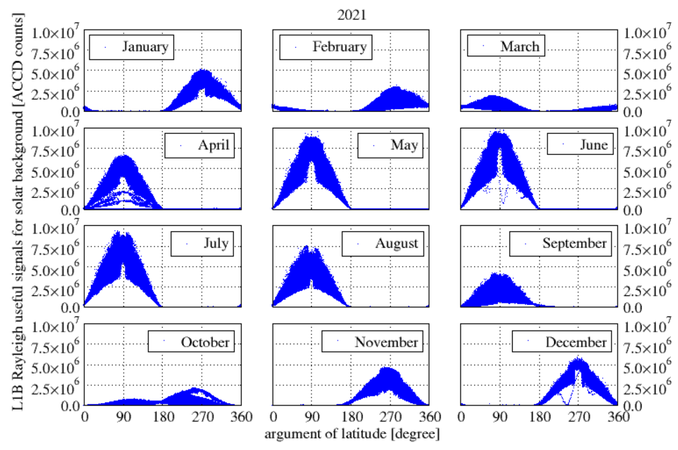


Mean L1A Rayleigh (left figure) and Mie (right figure) SBG measurements, averaged over all measurements in 01.-12.12.2018 to 01.-12.12.2022, normalized w.r.t. the effective background integration time and number of laser pulses per measurement, versus useful pixel.

In the **Rayleigh channel**, the signals are maximal in the illuminated pixels, in particular in pixels 5 and 14. The mean SBG signal level increased continuously from 2018 to 2022.

In the **Mie channel**, the signals are maximal in the pixels 5 – 7 and 14 – 15. No clear mean signal increase is seen from 2018 to 2022.

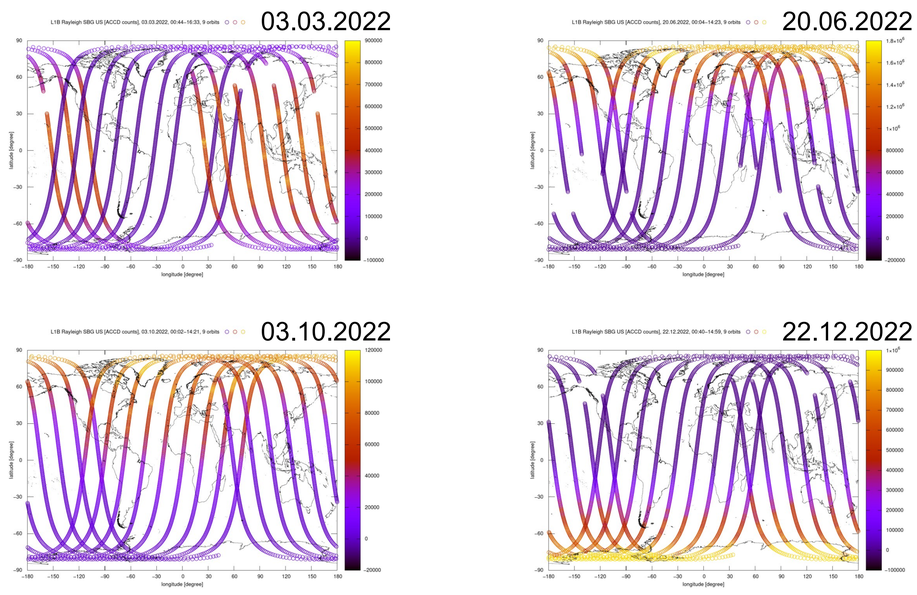
4. Evolution of the L1B Rayleigh Useful Signals for Solar Background on the Observation Level as a Function of the Argument of Latitude in 2021



Argument of latitude: 0° - equator, 90° - North Pole, 180° - equator, 270° - South Pole, 360° - equator

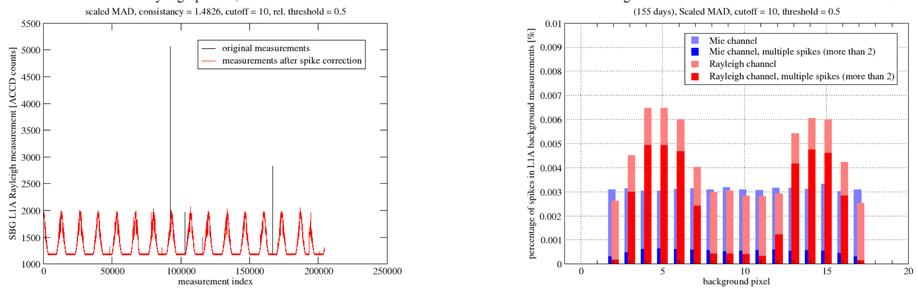
The SBG signals are maximal in the Arctic during the primary maximum in June. They are maximal in the Antarctic during the secondary maximum in December. During the yearly minima in March and October, the measured SBG maximum passes the equator. The same holds for the SBG Mie signals. The maximum of the annular solar eclipse in the Arctic on 10.06.2021 and the maximum of the total solar eclipse in Antarctica on 04.12.2021 are seen as low SBG signals.

5. L1B Rayleigh Useful Signals for Solar Background on the Observation Level during the Primary and Secondary Maxima, and Minima in 2022 versus Geolocation



Aeolus measured the largest signals during the primary SBG maximum (20.06.2022) in the Arctic. During the secondary maximum (22.12.2022), the largest signals were obtained in the Antarctic. The signal levels are determined by the background integration time, changed from 3750 µs to 625 µs in April 2022. The impact of the Earth albedo is seen.

6. Spikes in the Uncorrected L1A Solar Background Raw Measurement Data



Left figure: L1A Rayleigh background measurements on 01.12.2021 (30 measurements per observation) of pixel 2 (black line) and the same after a spike correction (outlier detection by scaled MAD with cutoff = 10; afterwards spike detection by using a relative threshold of 0.5). 3 spikes have been detected and corrected (replaced by their corresponding median values). It is assumed that the spikes are caused by cosmic radiation. They could degrade the Aeolus wind data for a few measurements per orbit.

Right figure: Percentage of spikes per pixel, determined by scaled MAD with cutoff = 10 and a relative spike threshold = 0.5, in the L1A Mie (blue bars) and Rayleigh (red bars) background measurements of all Decembers 2018 – 2022 of the mission lifetime. The dark blue and red bars show multiple spikes where more than 2 different pixels per measurement have spikes at the same time. Only few spikes have been detected and corrected.

The spike detection and correction scheme is currently implemented in the upcoming L1B processor, baseline B17, yielding spike corrected L1B data for the next reprocessed data products.

Deutsches Zentrum für Luft- und Raumfahrt

Institut für Methodik der Fernerkundung

http://www.dlr.de/eoc

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