New Inflight Calibration of OCO-3's Oxygen A-Band for Build 11 Products

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Poster

The Orbiting Carbon Observatory-3 (OCO-3) instrument, operated from the International Space Station, was launched on May 4th, 2019. Its primary objective is to provide high-precision estimates (< 0.25% of background values) of the column averaged dry-air mole fraction of carbon dioxide (XCO2) and solar-induced chlorophyll fluorescence (SIF). It consists of three long slit imaging spectrometers that provide high resolution spectra in three infrared channels centered at 0.765 (O2 A-band), 1.61 (Weak CO2), and 2.06 µm (Strong CO2). The shortest wavelength channel is characterized by absorption lines from molecular oxygen and the other two channels show numerous carbon dioxide (CO2) absorption lines. While the Weak and Strong bands provide independent measurements of CO2 column abundance, the oxygen A-band is used to constrain optical path length and SIF, and is also used for cloud screening. All three bands are used in the determination of aerosol optical depth.

OCO-3 relies on three tungsten halogen lamps for relative inflight radiometric calibration, which is frequently updated (every three to seven days) through the delivery of gain degradation coefficients. Throughout the mission, OCO-3 has undergone important changes in instrument response. In the A-band, these are associated with the buildup of contaminants, which are removed by periodic decontamination procedures where the focal planes are allowed to warm. One way contaminant buildup affects the A-band in OCO-3 is by imparting a S-like shape to the spectra (something that has not been observed in OCO-2 data), which is inconsistent among observations of the different lamps and between lamps and science observations. In Build 11, we derive the spectral shape of inflight gain degradation in the A-band directly from observations of clear ocean scenes. The new calibration of the A-band drastically reduced the curvature of spectral residuals between model and science observations, which previously had a strong footprint dependence. In Build 10, this manifested itself in the form of a slow drift of XCO2, from February 2020 to January 2021, with respect to models, TCCON, and OCO-2, which was corrected during the post-processing step. This correction was necessary, despite the use of Empirical Orthogonal Functions (EOFs) to remove the artifact in Build 10. EOFs associated with curvature derived from Build 10 products explained up to 9 % of the variance. This dropped to less than 1 % in Build 11, where curvature related EOFs are no longer subtracted. The slow drift in XCO2 was significantly reduced from 2 ppm in Build 10 to less than 1 ppm in Build 11.

The work presented here underscores the value of incorporating built-in redundancy within on-board calibrator systems and the need to monitor for rapid changes in the response of instruments in real time. Additionally, it highlights the importance of developing techniques based on Earth data to access the relative in-band response for spectrographs.

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