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In-flight estimation of the MicroCarb Instrument Spectral Response Functions

Christelle Pittet (1), Vincent Crombez (2), Denis Jouglet (1), Laurent Georges (2), Elodie Cansot (1), and Aurélien Albert-Aguilar (2)

(1) Centre National d'Etudes Spatiales, TOULOUSE, France (christelle.pittet@cnes.fr), (2) Airbus Defence and Space, TOULOUSE, FRANCE

The scientific objectives of the CNES MicroCarb remote sensing mission are to monitor the fluxes of CO_2 at the surface between atmosphere, oceans and vegetation. A specific target of MicroCarb is to achieve this objective from a relatively small and cost-effective instrument based on passive sounding.

The payload of MicroCarb measures the radiance spectrum made of the sun light passing through the atmosphere and reflected by the earth in the Short Wave InfraRed. By observing specific narrow bands at high resolution corresponding to carbon dioxide and dioxygen absorptions, one can estimate the carbon column integrated volume mixing ratio in the atmosphere.

The main element of the payload designed by Airbus Defence and Space is an echelle grating spectrometer following the entrance slit. It allows the acquisition of the radiance of the reflected light in four spectral bands centered at known absorption wavelengths of CO_2 (1.61μm and 2.06μm) and O_2 (0.76μm and 1.27μm). The footprint of the slit associated to each spectral band corresponds to 13.5km across-track (nadir pointing). Taking satellite along track motion into account, the resulting footprint size is 13.5 km x 8.9km. It is arbitrarily divided in three identical field of views in across-track direction, each of them covering 4.5km x 8.9km.

To meet the very stringent mission precision of 1 ppm, it is necessary to characterize the measurement errors introduced by the payload itself as precisely as possible. In particular, an accurate knowledge of the Instrument Spectral Response Function (ISRF) is a pre-requisite for CO_2 retrievals. The payload design trade-offs lead to a partial sensitivity of the ISRF to the scene radiance non-uniformity during acquisition. As this sensitivity impacts the performances on the CO_2 retrievals, efforts have been put on estimating the ISRF distortion generated by the scene radiance evolution during time integration.

This paper aims at presenting an innovative algorithm developed by Airbus Defence and Space and CNES for in-flight ISRF estimation, which takes advantage of an optional acquisition mode (called "multi-reading") allowing several intermediate readings of the Next Generation Panchromatic detector matrix within an integration period. From these additional data a piecewise linear model of the scene radiance evolution along the track is estimated. The impact on the corresponding ISRF is then computed using several reference ISRF characterized on ground for given uniform and non-uniform scenes. Two types of linear models will be detailed and compared and their sensitivity to ground characterization data, tuning parameters and in flight measurement errors and noise will be analyzed. The performance of the algorithm with respect to the "real" ISRF computed by an optical model will be finally provided.