Spectral Stability Monitoring of an Imaging Spectrometer by means of Onboard Characterization Sources

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ABSTRACT

In all disciplines, whose objective is a quantitative observation of nature, traceability, accuracy and comparability of measurements are key requirements. Thus, calibration, characterization and performance monitoring of the instruments employed to carry out such measurements are fundamental processes. Airborne imaging spectrometers are characterized and calibrated by means of time consuming and costly procedures aiming at assessing the radiometric, spectral and geometric performances of the instrument. This usually takes place at regular intervals and at certified calibration laboratories. To monitor the spectral stability of the instrument in-flight and understand when a re-characterization on the ground is necessary, a number of studies have investigated the use of spectral features occurring at known wavelength positions and observable in the acquired at-sensor radiances. Common features used for this purpose are atmospheric absorption lines (e.g. water vapor, oxygen lines, etc.) and solar Fraunhofer lines [1-3]. Nevertheless, a shortcoming of the latter approach is the dependency towards the quality of the acquired image data in terms of suitability of sensed targets and illumination and atmospheric conditions at the time of acquisition. To overcome this problem, onboard solutions, allowing the instrument characterization on-ground and in-flight by means of built-in characterization equipment, are preferred. What is more, the availability of internally stabilized light and appositely manufactured reference sources (e.g. coated diffusers, filters), grants the transferability of measurement standards from the laboratory to the flight environment.

In this paper we present the underlying concept of the In-Flight Characterization Facility (IFC) onboard the Airborne Prism Experiment (APEX). APEX is a pushbroom imaging spectrometer developed by a Swiss/Belgian consortium under the authority of ESA's PRODEX program. Operating between 380 and 2500 nm with 534 contiguous spectral bands in full spectral mode, it offers the possibility of application-specific binned band configurations. The field of view (FOV) is 28° with a total of 1000 spatial elements across-track. The IFC facility onboard APEX includes an internally stabilized 75 W Quartz Tungsten Halogen (QTH) lamp, a series of diffusers and a folding mirror, which is moved into the optical path to reflect the light beam through filter wheel openings into the spectrometer. Four spectral filters are mounted on the rotating filter wheel: a NIST Standard Reference Material (SRM) filter and three narrow bandpass filters at 700, 1000 and 2218 nm [4].

This paper shall provide insights in the methodology to be used for the retrieval of modifications in instrument spectral behavior, by means of IFC measurement acquisitions taking place before, during and after

a flight mission. The proposed method is based on spectral features, resulting when interposing to the IFC light beam one of the spectral filters, and on the implementation of spectrum-matching techniques able to identify changes in feature's shape or position over different data-takes. A number of spectrum-matching techniques have been reviewed and tested and their sensitivity towards changing measurement conditions assessed. As a result of the sensitivity analysis, an algorithm for APEX in-flight spectral stability monitoring based on IFC measurements is proposed.

The monitoring of APEX performance stability throughout operational phases, allowing the transferability of laboratory measurements standards to the operational flight environment, coupled with the flexibility in spectral binning, confers to this instrument the potential of a calibrator and simulator of current and upcoming airborne/spaceborne imaging spectrometers.

Keywords: APEX, in-flight calibration, spectral calibration, imaging spectroscopy

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