In-flight Spectral Performance Monitoring of an Imaging Spectrometer

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Abstract

The spectral performance of airborne imaging spectrometers cannot be assumed to be stable over a whole flight season given the environmental stresses present during flight [1-4]. We present a new method for the assessment of instrument spectral performance in-flight, using as reference the performance characterized onground [5]. APEX, an airborne dispersive pushbroom imaging spectrometer, uses an onboard In-Flight Characterization (IFC) facility that allows monitoring the sensor's spectral performance stability on-ground and in-flight by tracking instrument-induced movements of spectral features. Spectral features are obtained by illuminating with an internal lamp a series of spectral filters. Performance deviations are investigated as a function of environmental parameters thanks to the acquisition of housekeeping information, co-registered on board with the image and calibration data. Correlations between instrument performances and environmental parameters provided the needed input for an additional engineering iteration aimed at minimizing these effects.

The In-Flight Characterization facility (IFC)

(1) QTH lamp
(2) Optical fiber
(3) Fiber output
(4) Calibration shutter
(5) Fixed folding mirror
(6) Diffusers
(7) Feedback loop sensor
(8) Sliding folding mirror
(9) Filter wheel with 3 band-pass filters and 1 NIST certified spectral filter
(10) Fixed folding mirror
(11) Global shutter
□,Δ,o temperature sensor

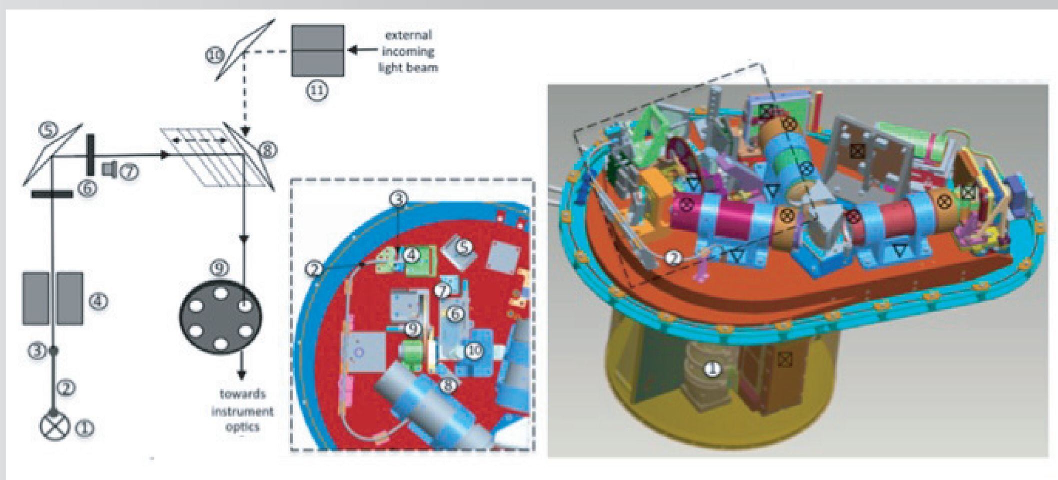

Fig. 1 In-Flight Characterization (IFC) facility onboard the APEX imaging spectrometer.

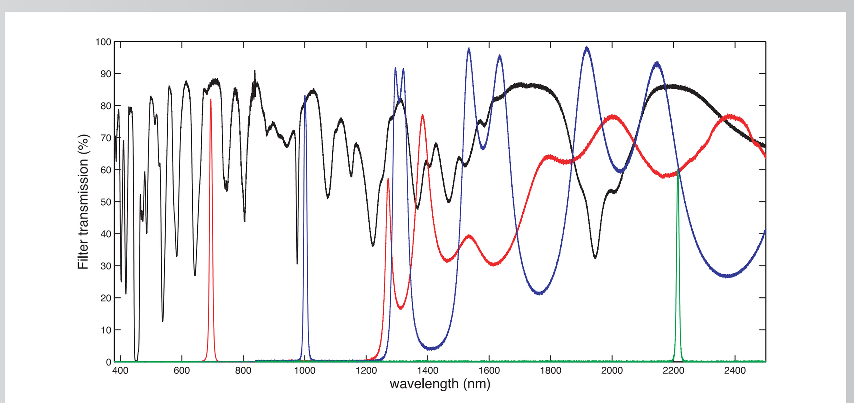

Fig. 2 Transmission of the spectral filters mounted on the In-Flight Characterization (IFC) facility onboard of the APEX imaging spectrometer (SRM NIST: black, BP700: red, BP1000: blue, BP2218: green).

Objective

- Develop an independent method for the monitoring of instrument spectral characteristics in-flight.
- Study the system performance as a function of environmental parameters.

Methods

The spectral shift is estimated by performing a feature-wise matching of the IFC ground reference spectrum and IFC flight spectra and maximizing a cost function with respect to the position of a sliding window.

Feature-matching is repeated for all detector pixels in the across-track dimension so as to obtain an across-track shift profile (i.e. differential smile). Two indices derived from a linear LSM are used to synthesize instrument spectral performance as compared to the onground reference performance. These are the mean spectral shift (mss) and the rotation (angular coefficient) index.

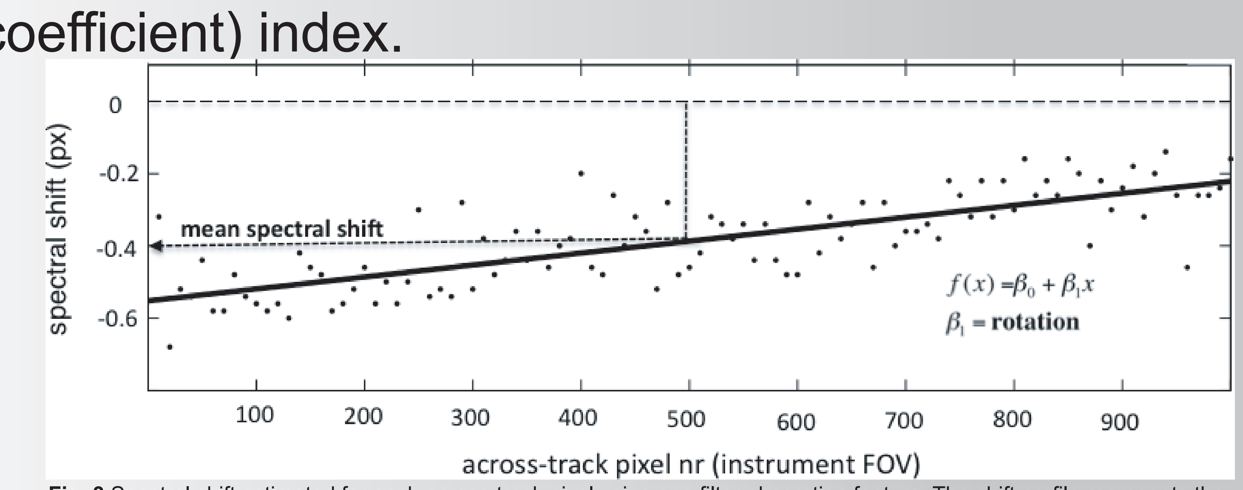

Fig. 3 Spectral shift estimated for each across-track pixel using one filter absorption feature. The shift profile represents the deviations of one acquisition in-flight compared to the reference acquisition onground.

Data were collected in-flight and as part of two ground experiments aimed at investigating the influence of individual environmental parameters. In the two ground experiments pressure and temperature conditions resembling those encountered in-flight were simulated, respectively.

Conclusions

Thanks to the onboard characterization facility, instrument spectral performance deviations could be quantified and traced back to their main causes, namely differential pressure and temperature variations. Instrument engineering iterations were carried out to counteract these effects.

Results

Differential pressure was found to explain the spectral performance deviations in time (mean spectral shift), in both the ground and the flight experiment.

Temperature in the baffle compartment was found to explain the spectral performance deviations across-track (rotation), in both the ground and the flight experiment.

Differences between the relation onground and in-flight can be attributed to the combined influence of parameters in-flight.

The performance trend was found to be consistent for all analysed spectral regions.

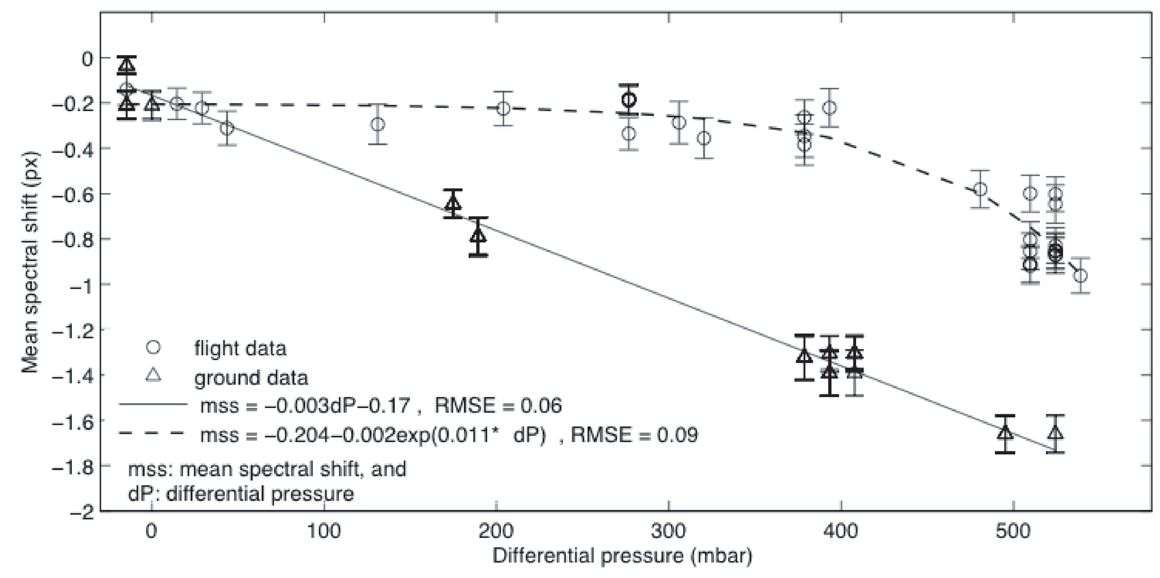

Fig. 4 Spectral mean shifts estimated for flight data (circle) and for on-ground data (triangle) acquired at different pressure regimes.

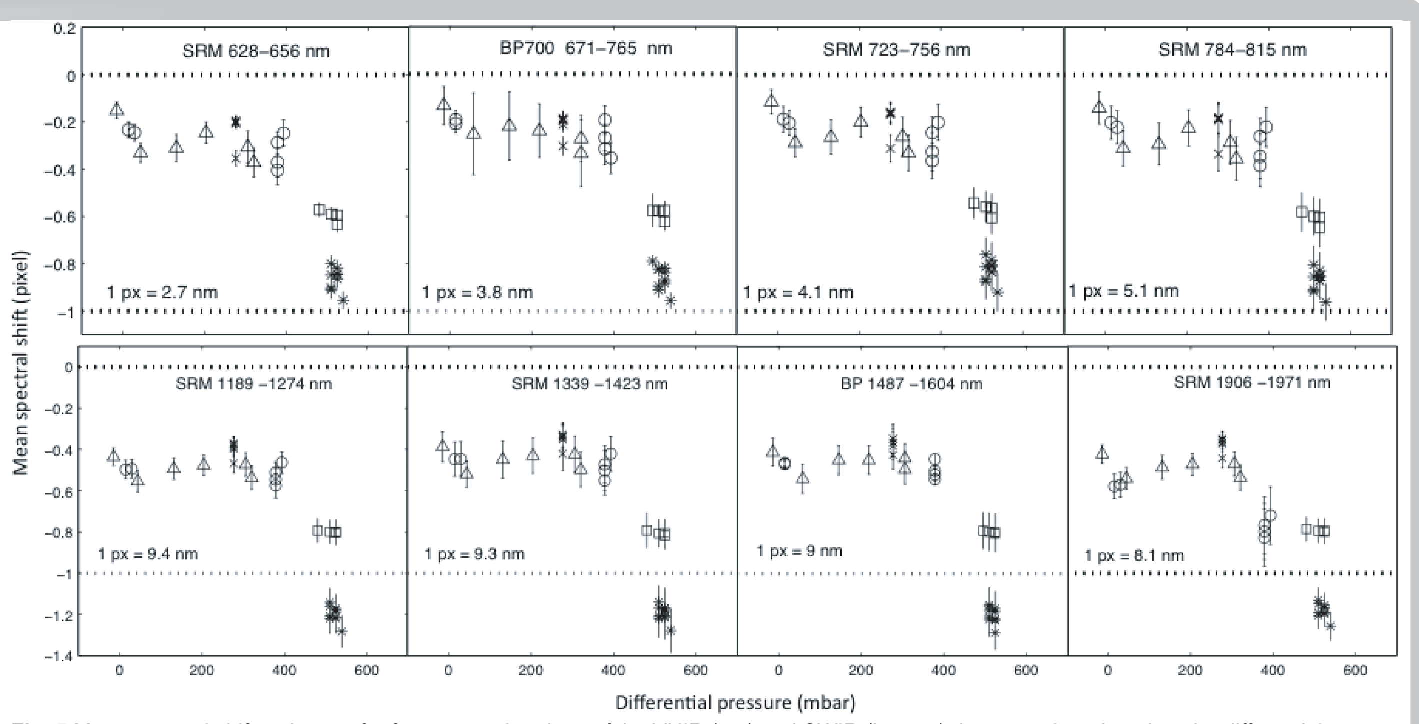

Fig. 5 Mean spectral shift estimates for four spectral regions of the VNIR (top) and SWIR (bottom) detector, plotted against the differential pressure trend. The different symbols represent different flight days.

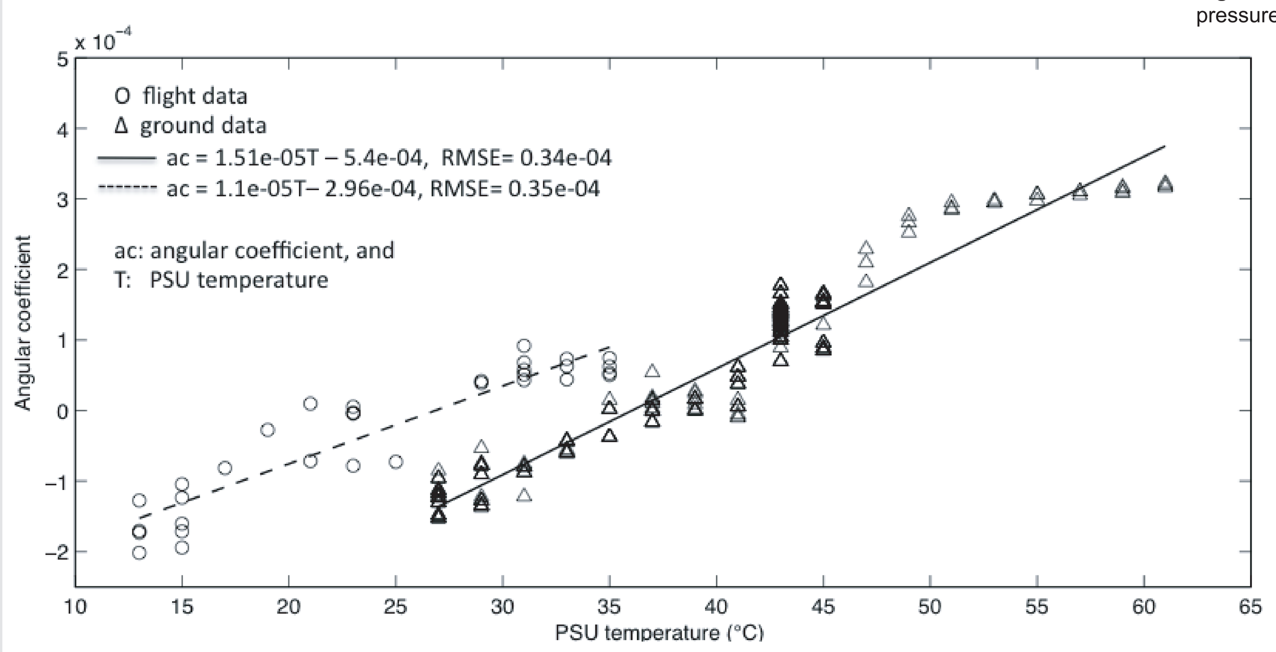

Fig. 6 Rotation estimated for flight data (circle) and for onground data (triangle) acquired at different PSU temperatures.

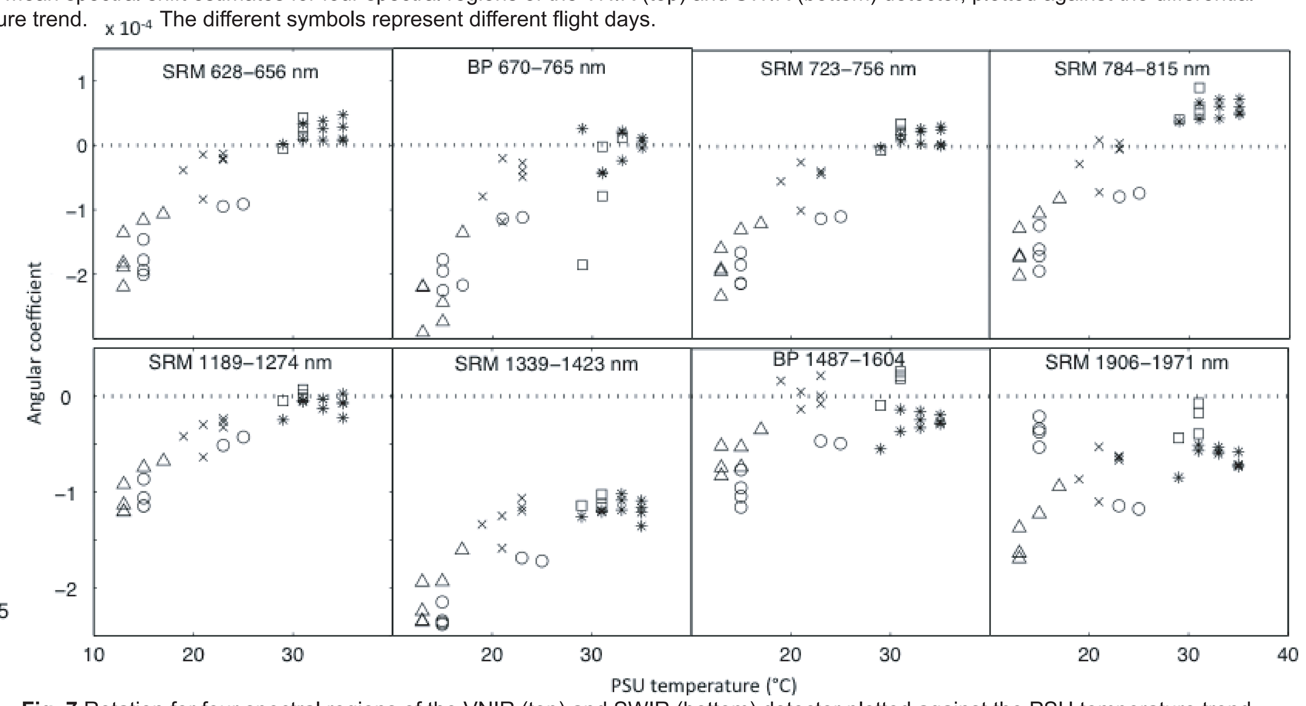

Fig. 7 Rotation for four spectral regions of the VNIR (top) and SWIR (bottom) detector plotted against the PSU temperature trend. The different symbols represent different flight days.

References

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