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The flight radiometric calibration of IRS/SuperCam onboard Perseverance: campaign follow up and performance assessment

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The Perseverance rover (Mars 2020 mission, NASA) is exploring the mineral diversity within Jezero, the host crater of a paleolake, and is searching for potential biosignatures and past habitability evidence. Amongst its science payload, the SuperCam instrument (LANL/USA and a consortium of French laboratories) plays a central role in the Mars habitability investigation by providing rapid, synergistic, fine-scale mineralogy, chemistry, and color imaging [1]. In particular, it carries the first near-infrared spectrometer, IRS, to be operated on the Martian surface. IRS is a miniaturized point spectrometer (~ 1.15 mrad field of view) located in the SuperCam's mast unit. Its spectral range (1.3 – 2.6 μm range) covers major silicate and hydrated mineral absorption features [2].

The instrument has been fully calibrated on ground before its launch [3] but flight measurements are necessary to check and refine its instrumental response after the cruise, entry, descent and landing. During the first 90 sols, observations of the SuperCam Calibration Targets (SCCT) were routinely performed in alternance with scientific targets.

An opportunistic observation of the Mastcam-Z calibration target has also been acquired. The IRS sensitivity, measured on the White SCCT, appears to be generally compliant with the ground measurements, except at short wavelengths (Fig. 1).

Flight calibrated measurements of the other SCCTs are compliant with their lab reference (Fig. 2) within 5 to 20 % for the Red and Cyan, but the evaluation of the absolute reflectance of the Black SCCT is far from expected, perhaps due to the ambient light misestimation. The calibration also consists in the removal of instrumental and environmental parasitic effects: CO₂ absorptions caused by the path of light through the Martian atmosphere are removed by dividing by a simulated spectrum of the gas; an EMI/EMC effect causing "glitches" in the AOTF's RF power supply as well as in acquired data is mitigated by a specific detection algorithm; and readout spikes are eliminated by

a statistical algorithm as well. Finally, datasets are cosmetically cleaned using higher level refinement algorithms (wavelets filtering and polynomial smoothing of the dark) to enhance band depth contrast without introducing significant biases. The remaining uncertainty on reflectance absolute level is mainly attributed to the error on the geometry of the illumination which requires a better modeling of local topography and the atmosphere diffusion. Some low frequency residuals are also miscalibrated by the current pipeline and still under investigation (e.g., RF power stability, thermal effects).

Notwithstanding these calibration uncertainties, the instrument signal to noise ratio (SNR) is high enough, and the relative (i.e., spectral channel to spectral channel) calibration is precise enough to be sensitive to faint spectral features (down to a few percent band depth) even if few parts of the spectral range show very faint but high frequency effects. Thus we will present the assessment of the radiometric in-flight performance of the instrument and the evaluation of the detection threshold for specific spectral signatures.

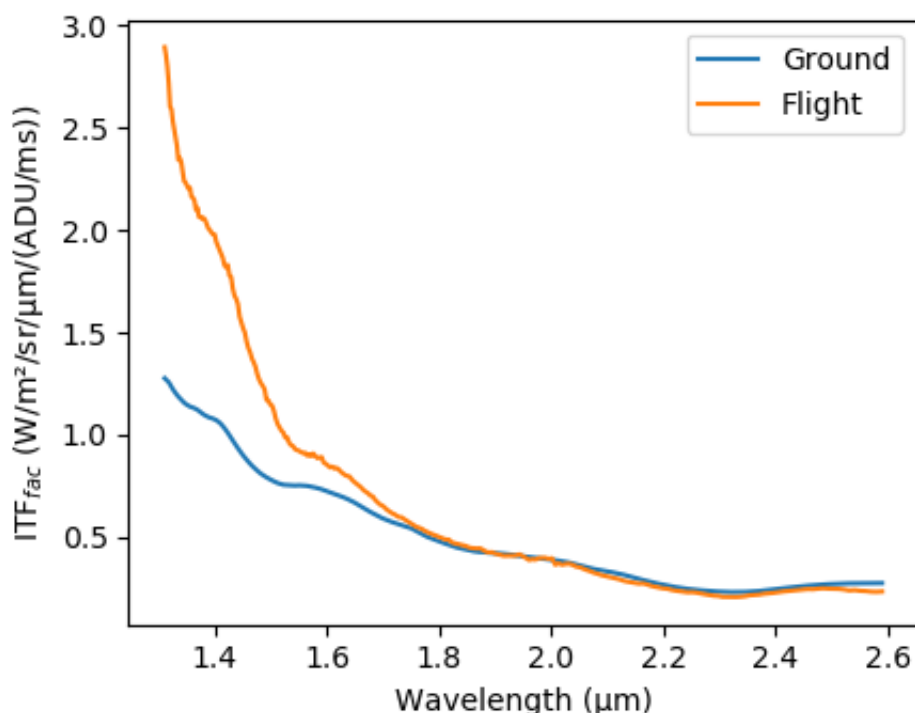


Figure 1: Radiometric instrument transfer function derived from ground calibration (blue) and flight measurements (orange), showing their divergence at short wavelength.

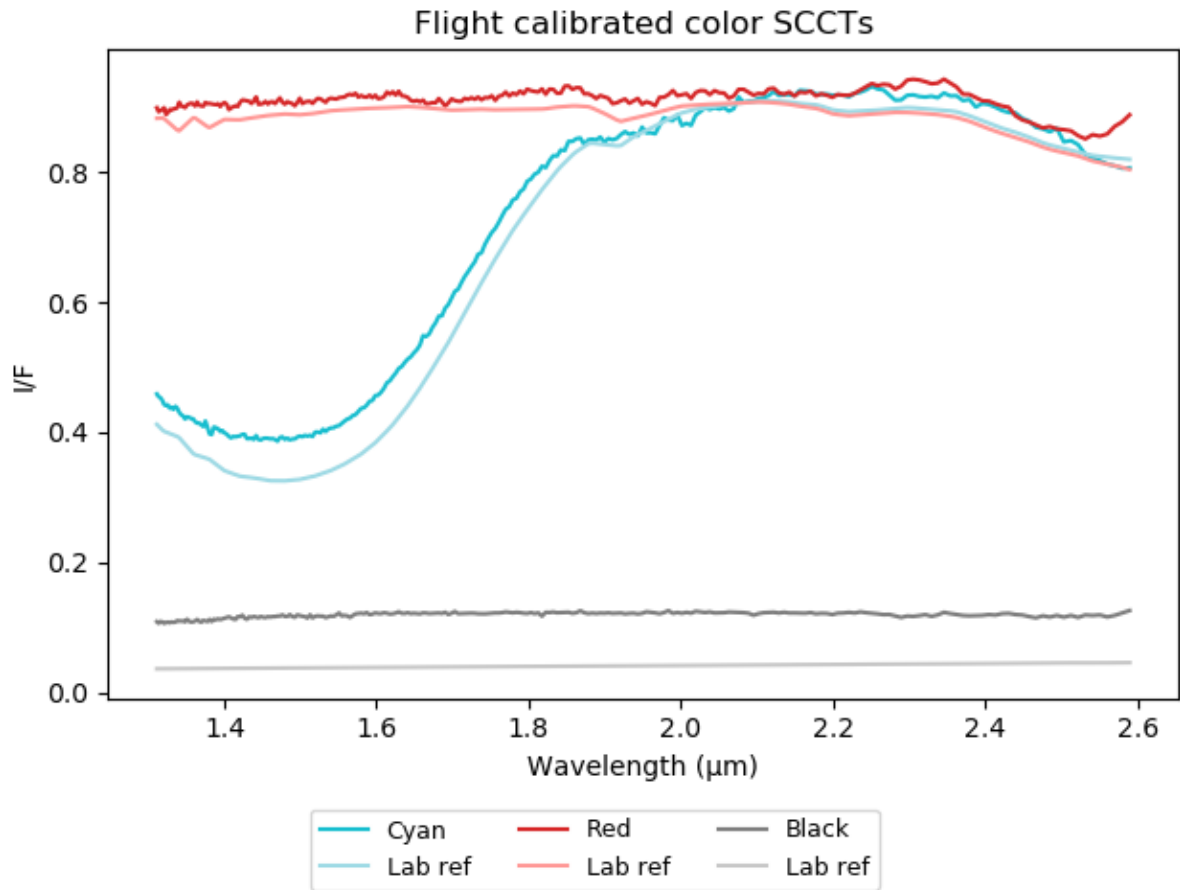


Figure 2: Color SCCTs measurement performed on Sol 77. The lighter lines correspond to the lab reference of these calibration targets.

References

- [1] Wiens, R.C. et al., 2017. Spectroscopy; [2] Fouchet et al., 2015, 46 th LPSC; [3] Royer et al., 2020, RScI;