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On-orbit cross-calibration of SIR-2 using Apollo landing sites

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Abstract

The near-infrared spectrometer, SIR-2 is a compact, monolithic grating, near-infrared point spectrometer for the Chandrayaan-1 spacecraft. The instrument covers a wavelength range from 900 to 2400 nm [1].

Despite careful laboratory calibrations, space-born remote sensing instrumentation usually requires an in-flight cross-calibration of their data set with compositional information from the ground. In this paper the Apollo landing sites have been chosen as locations for the “ground-truth“. Regolith samples returned from the Apollo mission have been analysed in great detail in the laboratory on Earth and can deliver the necessary information on their mineralogical and chemical composition.

Cross-calibrating the on-orbit instrument data to the information inferred from the “ground-truth” sites is a critical step, since the derived reflectance value at instrument wavelength range should correspond to the “ground-truth” sites. We investigate the observed uncertainties and systematic errors in the SIR-2 spectral response and discuss the found discrepancies between the SIR-2 and “ground-truth” data.

Data set used

The RELAB [2] spectral database has been used for the Apollo landing sites data. From the numerous samples collected during the Apollo mission a few have been carefully selected by considering the similar geological composition.

The SIR-2 data sets have been selected from at least three satellite orbits flying through/close to the Apollo landing sites and at least one hundred spectra (sample points) are considered from each orbit to cross-calibrate the SIR-2 response. To avoid any discrepancies between orbit coordinates and to have absolute coordinate points, it has been compared and corrected according to the Clementine coordinate system [3]. The SIR-2 observations are recorded in nadir point mode and phase angles for each orbit are between 20^0 and 57^0. We also consider spectra from the optically dark side at equivalent detector temperatures for dark and bias corrections. The in-flight recorded dark spectra are very similar to background spectra recorded by SIR-2 in pre-launch laboratory calibration. The SIR-2 absolute sensitivity response has been computed from pre-launch laboratory calibration.

Method and Results

The data reduction steps are followed in order to obtain qualitative reflectance spectra. Dark and bias are subtracted from the raw spectra based on in-flight dark measurements, as well as the absolute sensitivity of each pixel is corrected. In-flight measured SIR-2 reflectance spectra are dependent on observation geometry and in order to compare it with RELAB data it should be converted into standard geometry. The Semiemprical Shkuratov function [3] has been used for this purpose. The photometric function used for this analysis is described as: $F(\alpha,b,l) = H(\alpha)D(\alpha,b,l)$, where H is the phase function which depends on shadow-hiding and coherent backscattering, D describes the brightness distribution over the lunar disk and depends only on the observation geometry, α is the phase angle, b and l are the photometric latitude and longitude, and, derived from phase, emergence and incidence angles. The photometric corrected spectra are converted into reflectance spectra by dividing it by ASTM E-490 standard solar spectral irradiance.

The reflectance spectra measured by SIR-2 at Apollo landing sites and data from RELAB are compared. This comparison showed the same shape of the spectrum but the reflectance measured

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by the instrument is higher than the "ground-truth" spectrum measurement mainly for wavelength ranges: 1335-1420 nm, 1815-1965 nm and 2175-2390 nm. A correction factor is calculated for each pixel by dividing SIR-2 measured spectrum by "ground-truth" spectrum.

The analysis and results of the SIR-2 data sets provide an on-orbit assessment of the instrument's performance and demonstrates that pre-launch laboratory calibration is important but not sufficient, and a rigorous on-orbit cross-calibration is required for validation of in-flight data sets.

References

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