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SIR-2 Data Normalization and Integration with M^3 Data

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1. Introduction

The point spectrometer SIR-2 on Chandrayaan-1 provided radiance spectra integrated over circular footprints of 200 m diameter in the wavelength range 934–2410.8 nm in 256 channels [1]. To analyze SIR-2 reflectance spectra in their spatial context, a coregistration to Chandrayaan-1 M³ hyperspectral images [2] as well as a correction for topography and thermal emission are inevitable. The thermal and topographic correction procedure is based on the surface temperature and a digital elevation model (DEM) inferred from M³ data. The corrected reflectance spectra are then normalized to a standard illumination and viewing geometry.

2. Coregistration of SIR-2 to M³

Due to the footprint nature of the SIR-2 data and the image nature of the M³ data, a coregistration method is required. To account for the different spectral resolution, we integrate the measured spectral radiances in the interval 950–2000 nm and compare the radiance profile along the track with that of a simultaneously acquired M³ image. The normalized cross-correlation along the track is maximized for deviations of up to 10 km in horizontal and vertical direction from the original selenographic coordinates of the SIR-2 data set (cf. [3]). Fig. 1 shows the result of the coregistration method. The best-matching radiance profile along the track is shown in Fig. 2.

3. Surface temperature

The spectral range of the SIR-2 measurements does not extend far enough into the infrared domain to estimate the surface temperature. Hence, we apply the method presented in [4] to infer the surface temperature by minimizing the squared difference between the M³ radiance data and the superposition of a scaled standard surface radiance spectrum and a black body emission spectrum. The thermally corrected M³ and SIR-2 radiance spectra are obtained by subtracting the estimated black body emission spectrum.

4. Normalized reflectance

Division of the thermally corrected radiance spectrum by the solar irradiance spectrum yields the reflectance spectrum. The single-scattering albedo is computed for each channel and footprint, respectively, by minimizing the squared difference between the measured reflectance and the full Hapke model [5, 6] using the illumination and viewing directions provided by the M³ data set and the surface normal derived from a DEM of high lateral resolution. This DEM is inferred from GLD100 topographic data and M³ image data using the photometric method presented in [4, 7]. Finally, the normalized reflectance is obtained by inserting the estimated single-scattering albedo into the Hapke model, assuming a standard geometry of 30° incidence angle, 0° emission angle and 30° phase angle [3]. Fig. 3 shows the reflectance spectrum and the continuum-removed reflectance spectrum before and after the normalization procedure. The normalized reflectance values exceed the original ones due to the large phase angle at acquisition. The depths of the absorption troughs are overestimated without thermal and topographic correction.

5. Outlook

Due to the limited spectral range of the SIR-2 data, the ferrous absorption trough at 1000 nm is only partially visible, and the continuum is therefore estimated inaccurately. Thus, we will integrate the SIR-2 and M³ reflectance data and compute the continuum and the parameters of the 1000 nm absorption trough using M³ data. Finally, a nonlinear unmixing algorithm for the integrated dataset is being developed, a preliminary SIR-2 only based version of which is presented in [8].

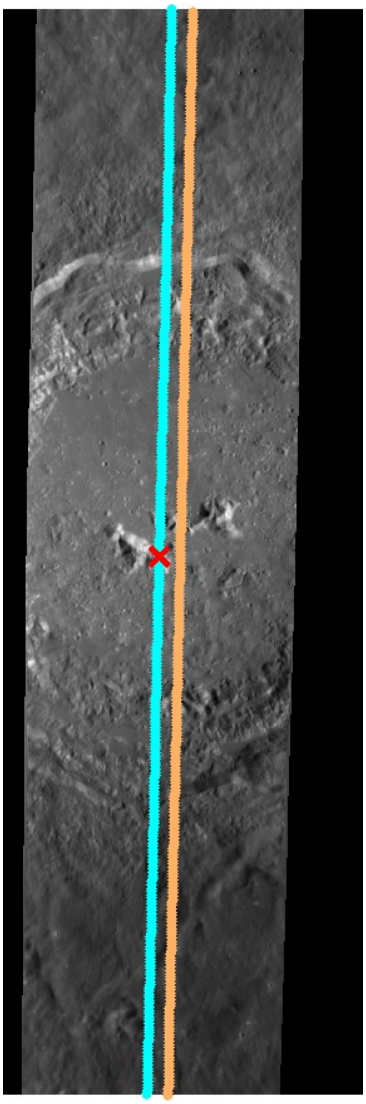

Figure 1: M^3 image of the crater Copernicus and the original (orange) and coregistered (cyan) SIR-2 tracks.

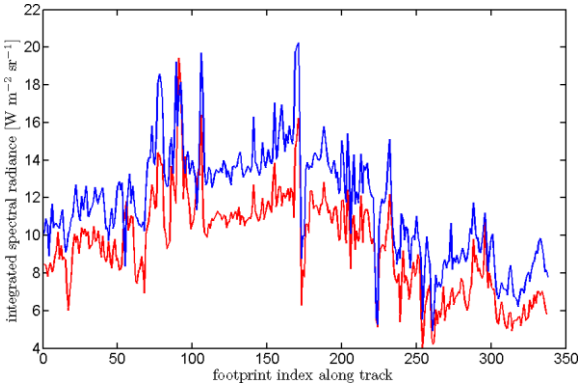

Figure 2: Integrated SIR-2 (blue) and M^3 (red) radiances along the 338 track points after coregistration.

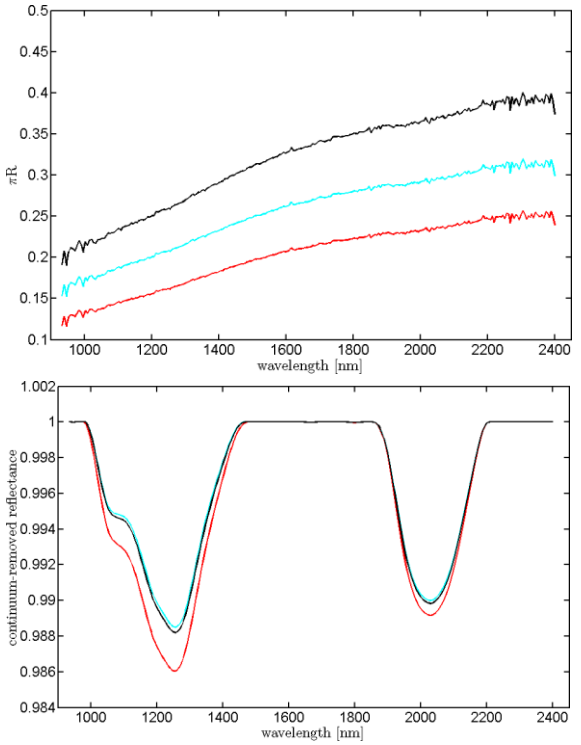

Figure 3: Absolute (top) and continuum-removed (bottom, smoothed) SIR-2 reflectance of the spot marked by a red cross in Fig. 1. Red curve: Original apparent reflectance spectrum. Black curve: Thermal correction, normalization to (30°, 0°, 30°) standard geometry assuming a spherical surface. Cyan curve: Thermal correction, normalization to standard geometry based on DEM.

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