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Principle component analysis of data from the near infrared spectrometer SIR-2 aboard the Chandrayaan-1 spacecraft

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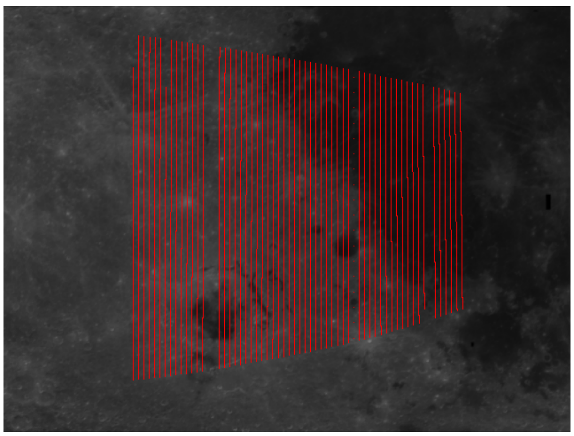

Figure 1: The ground tracks of the selected subset of spectra on top of the Clementine basemap. The spectra were selected according to the conditions that the emission angle is smaller than $15°$ and that the incidence angle is between $45°$ and $60°$. Additionally, they were taken in sequential orbits, so that the solar azimuth is also similar. The covered area is centered at the equator at $80°$W and $60°$ wide in longitude. The map is in simple cylindrical equidistant projection.

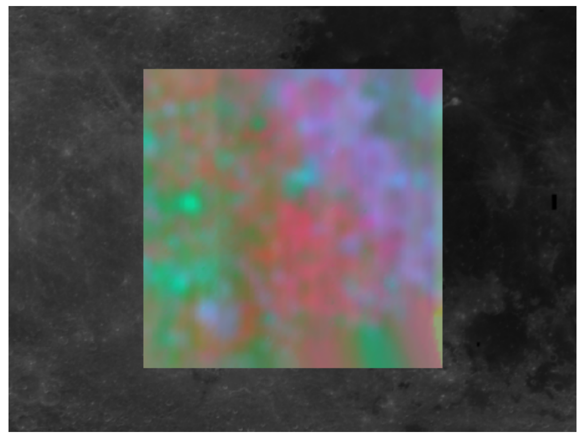

Figure 2: The coefficients of the principle components 2–4 (cf. Fig. 3) shown as red, green, and blue brightness, respectively, resampled onto an evenly spaced 121×121 grid. Location and projection is the same as in Fig. 1.

Abstract

As of May 2009, the near infrared spectrometer SIR-2 aboard the Chandrayaan-1 spacecraft has acquired about four million spectra of the lunar surface. The spectra have not yet been calibrated. In order to make a first assessment of the collected data, we have applied a principle component analysis to the complete data set and to different subsets. The results confirm that the instrument works well and that we can distinguish different surface types as expected.

Introduction

The SIR-2 near infrared spectrometer aboard the Chandrayaan-1 spacecraft is the successor of the SIR instrument, which flew on the SMART-1 spacecraft. The spectral range and resolution of 0.9–2.4 μm and 256 channels, respectively, is the same for both instruments. One main advantage of SIR-2 is that the sensor is temperature stabilized, which makes the calibration much easier and allows us in particular to remove any dark current contribution by a simple normalization which is the first step of a principle component analysis anyway.

Herein, we present just one example of a principle component analysis which was applied to a subset of 187 000 spectra which were acquired under similar illumination conditions. The ground tracks of all spectra of this subset are illustrated in Fig. 1. All these spectra were taken with the same exposure time of 300 ms.

Principle component analysis

The principle component analysis is straight forward. First, for each spectral channel, the mean and the variance over the data is computed and each channel is normalized to zero mean and unity variance. Because the instrument sensor is temperature stabilized and all spectra of the subset were taken with the same expo-

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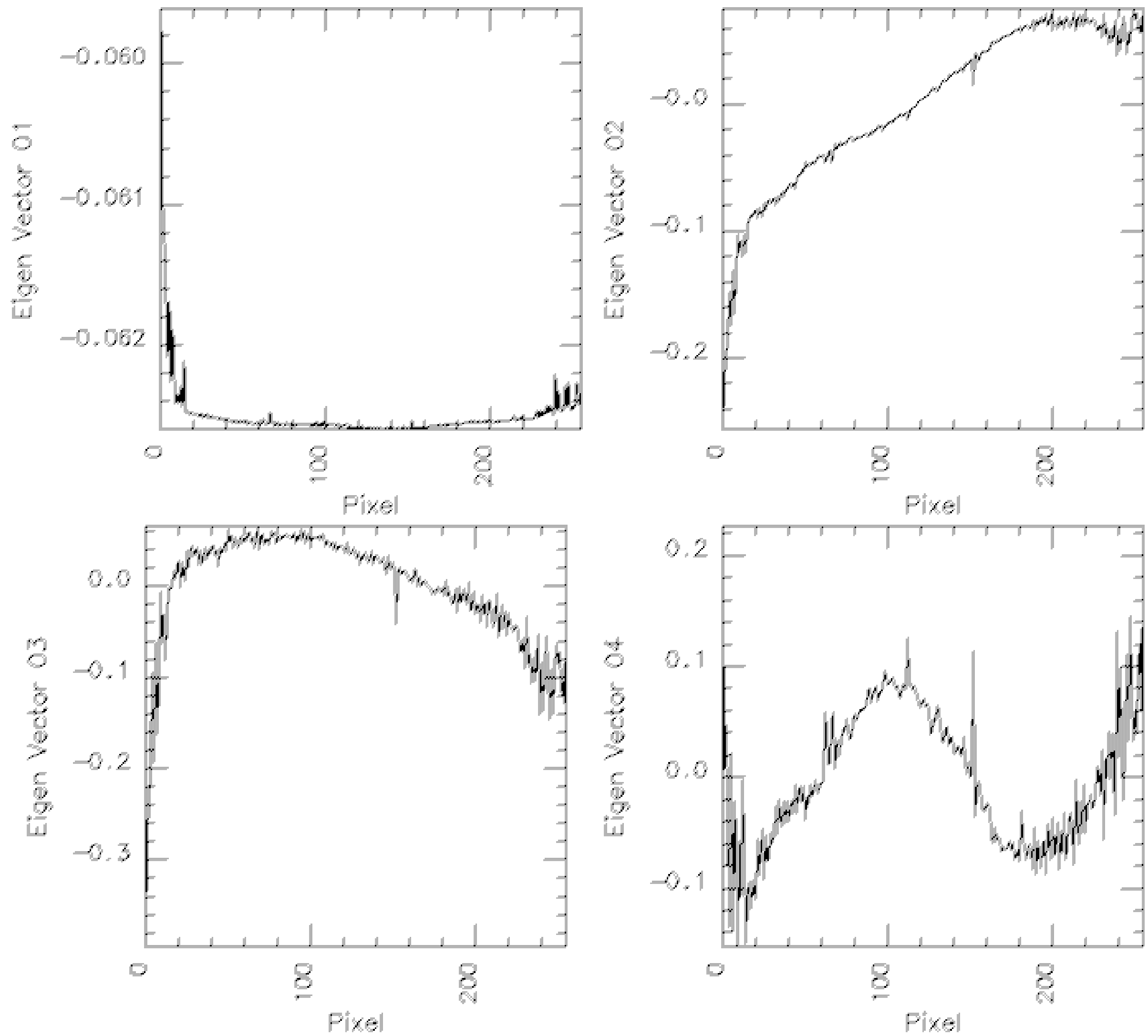

Figure 3: The first four principle components of a subset of the spectra which was acquired under similar illumination conditions. Their explained variances are 99.62 %, 0.17 %, 0.15 %, and 0.02 %, respectively.

sure time, the subtraction of the mean removes any dark current contribution.

After normalization the covariance matrix is computed. The eigen vectors of the covariance matrix are the principle components of the data. The first four principle components are shown in Fig. 3. Then the measured spectra are projected onto the principle components to obtain the respective coefficients. The spatial variation of some coefficients over the data subset is illustrated in Fig. 2 .

Results and discussion

The first principle component, see Fig. 3, explains by far most of the data variance. It represents just brightness changes which occur coherently in all spectral channels. The wavelength dependence reflects the responsiveness of the spectral channels.

While the other principle components have very small explained variance, they are the ones which reflect spectral variations in the data. The spatial variation of coefficients 2–4 is illustrated in Fig. 2. By comparison with Fig. 1, we note that the colors are clearly related to different surface types. We will try to relate the principle components to certain surface materials and possibly extend the principle component analysis to an end member analysis.