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Correction of the CCD temperature dependency in the VIR/Dawn visible data

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Abstract

Data acquired by the visible channel of the Visible and InfraRed mapping spectrometer (VIR) on board the Dawn spacecraft, are affected by the temperature variations experienced by the CCD sensor. Here, we present the method used to correct the Ceres data.

1. Introduction

The VIR imaging spectrometer [1] has been in operation on board the Dawn spacecraft [2] from 2011 to 2018, first orbiting Vesta and then orbiting Ceres. A rich dataset has been produced thanks to the coverage of these two bodies at several resolutions.
However, the slope of spectra acquired by the visible channel of VIR directly are affected by the temperature variations of its CCD detector. As a consequence, the higher the temperature, the redder the spectral slope.

2. CCD temperature dependency

Acquisitions of the VIR data are organized in sequences made of several hyperspectral cubes acquired one after the other. During a given sequence (lasting several hours), the temperature of the CCD detector increases, and then cools down when the sensor is not operative. The range of temperatures may vary between 168K and 195K depending of the mission phase. In the Figure 1, the CCD temperature – ranging from 168K to 184K – is mapped for the data acquired during the Ceres HAMO phase (CSH).

The effect on the spectra of such temperature variation, as shown in the Figure 2, is a change in the spectral slope that could affect the correct interpretation of the data. A correction is therefore needed to retrieve the real shape of the Ceres spectra.
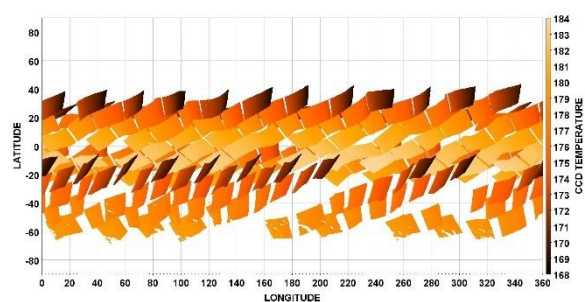
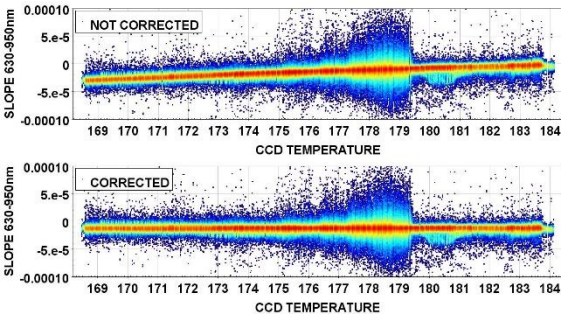**Figure 1** - Map of the CCD temperature for the CSH mission phase (Ceres).
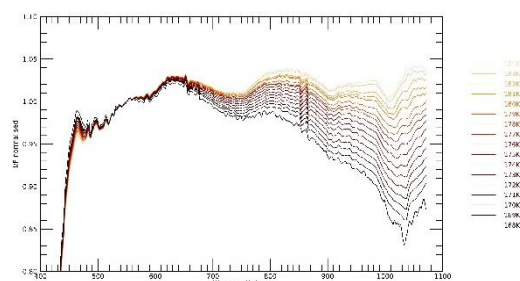
Figure 2 - Median spectra (normalized at 550 nm) for each bin of CCD temperature in the CSH dataset.

3. Spectral correction

The correction of the spectra requires to define references in terms of CCD temperature and wavelength. We normalized the correction at 550 nm and we use as a reference the CCD temperature at 177K as it corresponds to the temperature at which an observation of Arcturus has been made by VIR and present a good agreement with ground-based observations. Based on these hypotheses, we compute a correction factor (CF – equation (1)) that we apply on the dataset (see figure 3):

$$CF_{\lambda,T} = \frac{(^I/_F)_{\lambda,T}}{(^I/_F)_{\lambda,177K}} \qquad (1)$$

Where I/F are the reflectance normalized at 550 nm, λ the wavelength and T the CCD temperature.

Figure 3 - Distribution of the spectral slope between 630nm and 950nm against the CCD temperature for the CSH dataset before (top) and after (bottom) the application of the correction factor.

Such process allows to obtain a globally coherent dataset which is then usable – e.g. for mapping purpose as shown in Figure 4 – without instrumental effects.
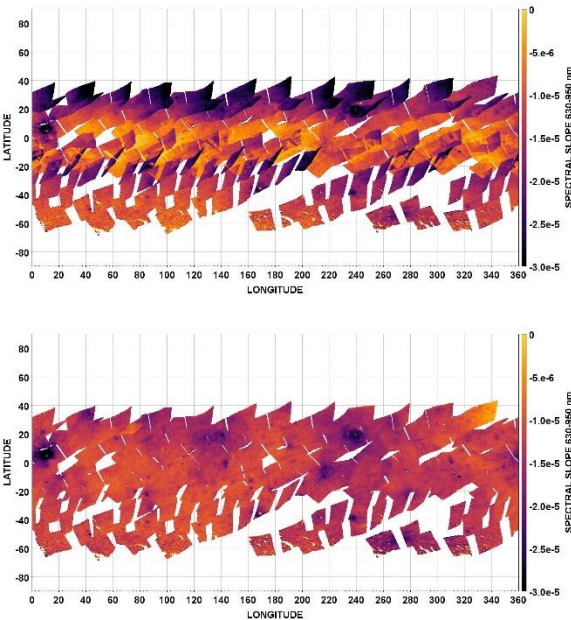
Figure 4 - Map of the spectral slope (630-950nm) for the CSH data. In the top panel the calibrated and photometrically corrected data, still suffering of the CCD temperature variations. In the bottom panel the same map after the correction.

4. Summary and Conclusions

We developed a method to correct the data acquired by the visible channel of the VIR imaging spectrometer which are all affected by the variations of the CCD temperature. Such a correction is mandatory prior to carry out any analysis at global or local scale. The same evaluation and correction of the data will be done for the Vesta data.

Acknowledgements

References

[1] De Sanctis, C. et al.: The VIR Spectrometer, Space Science Reviews, Vol. 163, pp. 329-369, 2011.

[2] Russell, C.T., Raymond, C.A.: The Dawn Mission to Vesta and Ceres. Space Science Reviews, Vol. 163, pp. 3-23, 2011

[3] Taylor, M. B. (2005). TOPCAT & STIL: Starlink Table/VOTable Processing Software. ASP Conf. Ser., Vol. 347, p.29