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Spectral analysis via comparison of band characteristics

S. Erard

LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 6, Univ. Paris Diderot, Sorbonne Paris Cité, France (stephane.erard@obspm.fr)

Introduction

Study of the composition of planetary surfaces relies intensively on spectral observations and comparisons with laboratory data. However, spectroscopy data can be particularly difficult to compare because they consist in very correlated data sets where the relevant information only bears a small fraction of the overall variance. To go beyond the usual process of manually selecting samples and fitting spectra, both band extraction techniques and band lists of laboratory spectra must be available to support automated identification of spectral signatures.

Building on the Mulțumesc algorithm [1], the procedure presented here is an assessment of spectral matching based on band characteristics only, rather than fit of complete reflectance spectra. This procedure is expected to remove dependency on the spectral continuum and focus entirely on band location and shape, which carry the main compositional information.

Spectral fitting techniques are expected to benefit greatly from Virtual Observatory access to many laboratory data currently implemented by the VESPA activity in the Europlanet program [2]. In addition, this particular method will be tested in a VO context to provide analysis on demand.

1. Extraction of band parameters

The first step in the procedure is to analyze the observed spectrum and the possible matches using the Mulțumesc method [1]. This multiscale algorithm identifies absorption features that stand out of the noise level and are detected consistently at successive scales. The analysis returns a list of possible bands with their location, width, and depth, plus several confidence parameters. One of these consists in a comparison between the retrieved band depth and a composite noise level determined from several scales; others are related to detection near the edge of the spectral domain, especially when a shoulder of the band is not complete. Since the method analyses the spectral shape, correct spectral calibration is assumed at least in relative values (Fig. 1).

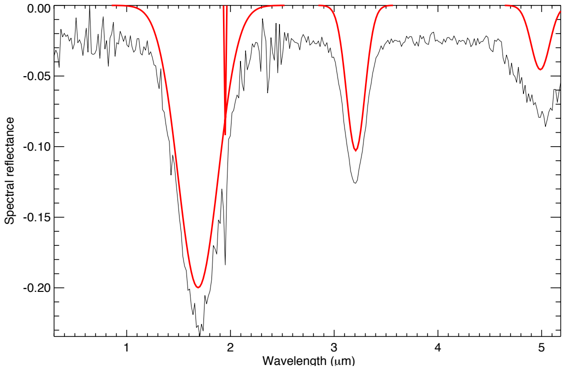


Figure 1: Simulated spectrum - overlapping Gaussians with different width and depth. Bands are reconstructed in red from estimated parameters.

A similar analysis is performed on available spectral libraries. In general, these have much higher spectral-to-noise ratio and therefore much lesser uncertainty on retrieved band characteristics. Reference libraries can be analyzed once for all, so that they are ready to use for this purpose.

2. Comparison of band parameters

Several strategies of spectral matching are being assessed and will be presented at the conference. As a general rule, a good match implies fitting the center/position of all detectable bands; the intrinsic continuum-correction involved in the multiscale analysis indeed minimizes band shifts related to continuum slopes. In contrast, band depths depend at least on a scaling parameter, and estimated widths may vary with signal-to-noise ratio.

The global matching procedure consists in testing the location of the major bands of the reference spectrum. If all are present in the observed data, depths and widths are compared using various correlation measurements. In some cases, the confidence parameter computed in the detection step can be used as a weight in the fits.

A specific problem may arise when several bands are superimposed – in this case the algorithm may detect the bands correctly but with part of the strength deported to a different scale (common "envelop" associated to several bands, see Fig. 2), so that the correlation is not longer linear.

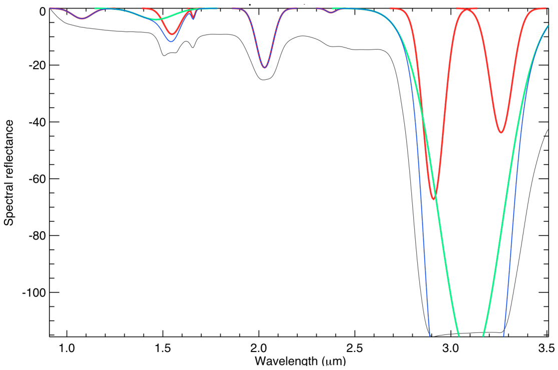
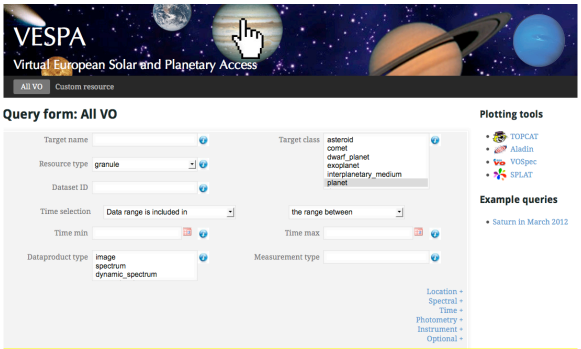


Figure 2: Ice spectrum from [3] - Individual bands are displayed in red, envelopes in green, their sum in blue.

3. Spectral match as a Virtual Observatory service

Although the band extraction algorithm is currently implemented under IDL, it can be embedded in a VO workflow and made available to process on-line data on demand. The results of the detection step will be transmitted via SAMP as a VOTable describing each detected band, for use in tools such as TOPCAT or CASSIS.

The Mulțumesc algorithm is also applied to large sets of laboratory reference data, starting with the PDS spectral library [4]. If deemed reliable, band descriptions will be distributed together with the data as an EPN-TAP data service, and will be searchable in the Virtual Observatory system set up by VESPA/Europlanet (Fig. 3). Finally, the detection tool will be enlarged to perform spectral matches with existing libraries on the basis of band characteristics.



Resource type: granule
Target class: asteroid, comet, dwarf_planet, exoplanet, interplanetary_medium, planet
Time selection: Data range is included in
the range between
Dataproduct type: image, spectrum, dynamic_spectrum

Figure 3: The VESPA user interface: http://vespa.obspm.fr

References

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[4] Murchie, S. et al (2007) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on Mars Reconnaissance Orbiter (MRO). *JGR (Planets)* 112, E05S03

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