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Analysis of a collection of planetary hyperspectral images through non-negative source separation

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In typical hyperspectral images encountered in Earth and Planetary Sciences, the spatial extent of a pixel is usually large enough to contain a mixture of various surface/atmospheric constituents which contribute to a single pixel spectrum. Unsupervised spectral unmixing aims at identifying the spectral signatures of materials present in an image and at estimating their abundances in each pixel. Bayesian Prior Source Separation (BPSS) [1] is an interesting way to deal with this unmixing challenge under linearity constraints. Notably, it ensures the non-negativity of both the unmixed component spectra and their abundances, such a constraint being crucial to the physical interpretability of the results. A sum-to-one constraint can also be imposed on the estimated abundances [2] (its relevance depends on the nature of the dataset under consideration). Thanks to adequate implementation strategies [3], computational issues (due to the nature of the algorithm and to the large size of the data) have been overcome, and a pixel selection method, performed as a pre-processing step, also allowed to reach significantly lower computation times without inducing a strong loss of quality as regards the estimation of the sources. As this selection aims at extracting a few especially relevant pixels among all the image pixels, it also contributes to the identification of the most interesting sources present in the analyzed image.

After performing tests on synthetic datasets (generated by linear mixing of known mineral endmembers) in order to better understand the limitations of this approach [3], the method has been applied on real planetary datasets. Pertinent results have been obtained for data coming from instruments onboard planetary spacecrafts such as OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité, onboard Mars Express) [3], VIRTIS (Visible and Infrared Thermal Imaging Spectrometer, onboard Venus Express) [4] and CRISM (Compact Reconnaissance Imaging Spectrometer for Mars, onboard Mars Reconnaissance Orbiter) [5]. Overall, results gathered in those different cases proved the ability of the BPSS approaches to provide a pertinent insight in the analysis of different planetary hyperspectral datasets. A possible next step is the processing of a collection of images coming from the same dataset, acquired in sufficiently similar conditions and covering similar or contiguous areas of the planetary body under consideration. We will investigate if and how the sources estimated by analyzing these hyperspectral images can be related to each other and if this could contribute to a better interpretation of the results and help to obtain a synthetic view of the spectral diversity within the collection of images.

Ref.: [1] Moussaoui et al. (2008), Neurocomputing 71/10. [2] Dobigeon et al. (2009), Signal Processing 89/12. [3] Schmidt et al. (2010), IEEE Trans. Geos. Rem. Sens., 48/11. [4] Tréguier et al. (2010), AGU Fall Meeting. [5] Ceamanos et al., submitted to IEEE Trans. Geos. Rem. Sens.