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Unsupervised classification of Mercury'S Visible–Near-Infrared MASCS/MESSENGER reflectance spectra for automated surface mapping.

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The surface of Mercury has been mapped in the 400–1145 nm wavelength range by the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) instrument during orbital observations by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft.

Under the hypothesis that surface compositional information can be efficiently derived from spectral reflectance measurements with the use of machine learning techniques, we have conducted unsupervised hierarchical clustering analyses to identify and characterize spectral units from MASCS observations.

We apply our analysis on the latest MESENGER data delivery to PDS including the new spectral photometric correction , finding result consistent with our previous analysis based on our custom photometric effect removal.

The input is a global hyperspectral data cube image of normalized MASCS visible (VIS) detector spectra, from the first Earth year of the orbital mission. Data coverage varies from region to region, but global maps at 1 degree/pixel can be obtained with a high signal-to-noise ratio (SNR). The resultant hyperspectral map was then visually inspected to search for anomalies that originated mainly in regions of low coverage or from high levels of spectral variation within a single pixel.

Our approach consist of several steps:
1. Data cleaning step: remove data artifact.
2. Independent Component Analysis (ICA): features compression and undelyng signal demixing.
3. Manifold learning : embedding of data in a low dimensional space via UMAP.
4. Hierarchical clustering : creation of spectrally similar partition and projection on the surface with comparison to existing human generated classifications.

We found the existence of two large and spectrally distinct regions, which we call the polar spectral unit (PSU) and the equatorial spectral unit (ESU).
The spatial extent of the polar unit in the northern hemisphere generally correlates well with that of the northern volcanic plains.

Further analysis indicates the presence of smaller sub-units that lie near the boundaries of these large regions and may be transitional areas of intermediate spectral characters.