Classification of atmospheric structure on Mars with the UVIS instrument

1 Occultation Transmission Data

When the Sun passes behind Mars from the point of view of the orbiting TGO spacecraft there is a short period before setting/after rising when UVIS observes its light directly through the planet's atmosphere, as opposed to reflected from the surface (through the atmosphere). As the atmospheric density diminishes with greater altitude from the surface, more light in general is attenuated the lower the tangent altitude of the UVIS line of sight to the Sun, but the degree of attenuation is also affected by the content of the atmosphere in the path traversed by the light. This attenuation can be indicative of structural layers or features at different altitudes in the atmosphere.

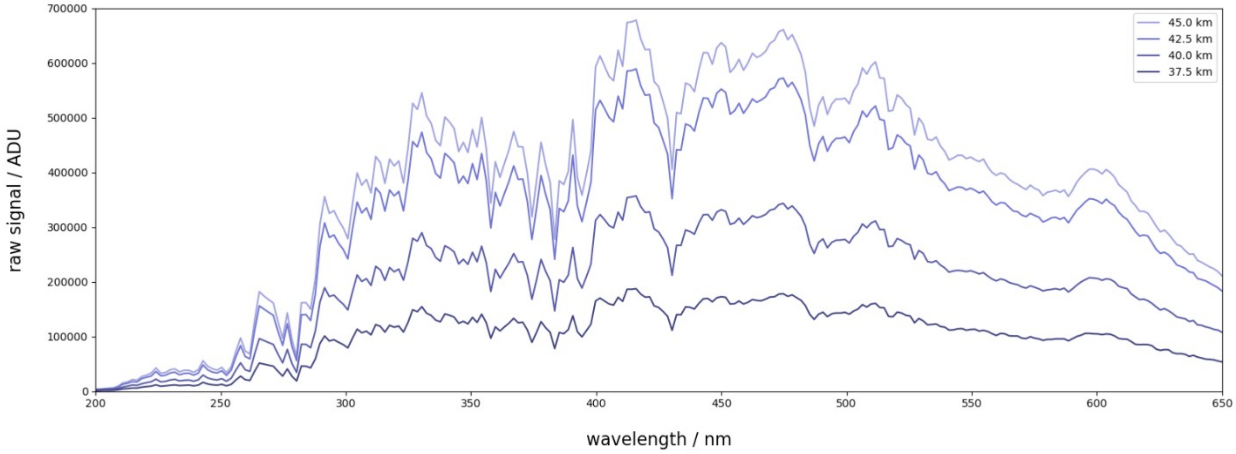


Figure 1: Attenuation of UVIS signal with decreasing TGO-Sun tangent altitude

The UVIS instrument conducts an observation approximately every second during one of these solar occultations, which corresponds to a vertical profile of the Mars atmosphere with approximately a one kilometre vertical resolution. After the raw data has been processed on the ground, each of the UVIS observations of one of these occultation events is stored as a time series of transmissions with each measurement defined as the ratio of the observed radiance at a given altitude to the radiance observed, during that occultation event, above the atmosphere.

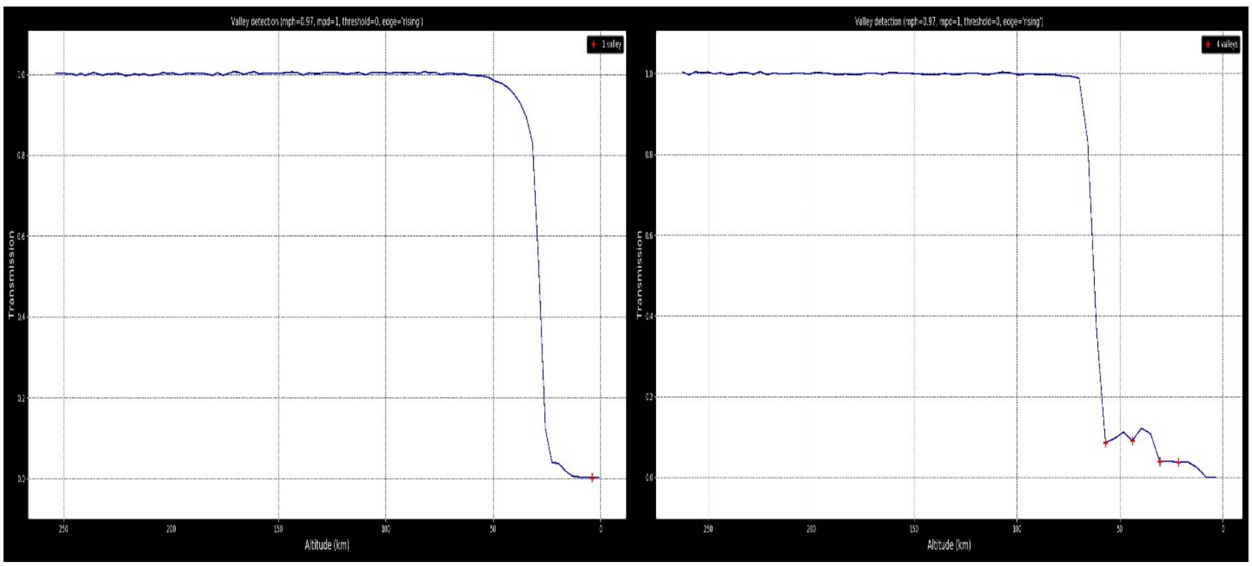
The aim of this SPIN project is to develop an algorithm to help categorise these transmission series, in both the high- and mid-altitude regions, using the following broadly defined features observed in the data:

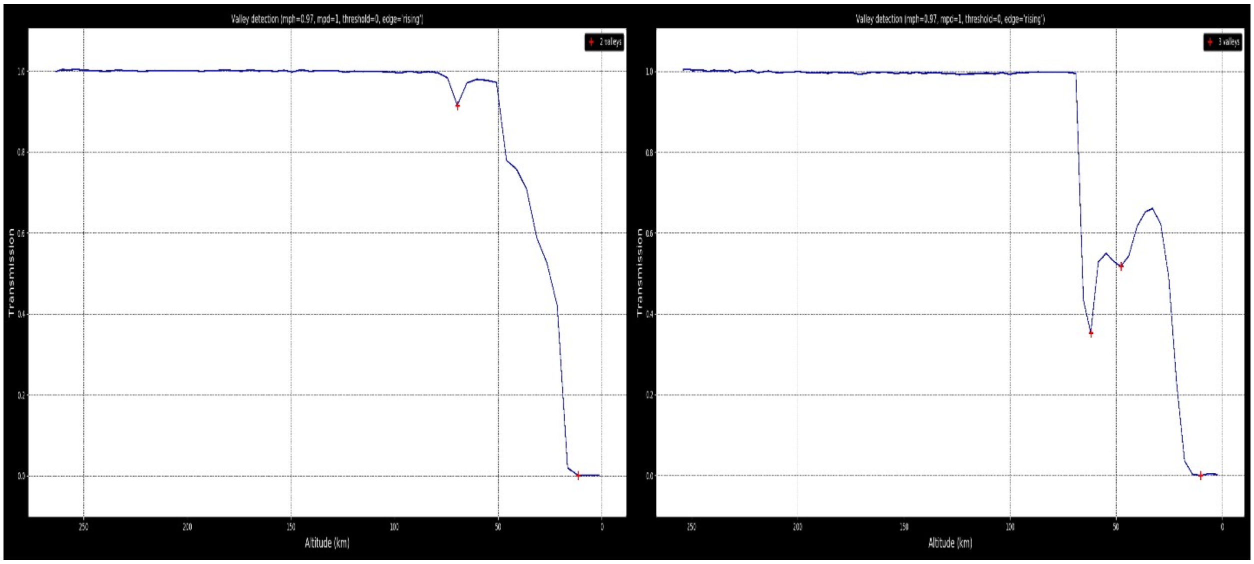
High-altitude features:

- Those with high altitude blips
- Clear atmospheric attenuation
- Sharp attenuation drop-offs
- Layered atmospheric structure

Mid-altitude features:

- Clear atmospheric attenuation
- Lower altitude sharp drop-offs
- Layered atmospheric structure





The outline of the first part of the project is as follows:

- Study and identify examples of all primary features that are present in the data
- Explore multiple methods for classifying spectral data
- Select optimal method
- Develop an algorithm for classifying UVIS data

The first stage of the project will involve determining a set of defined criteria that will be used to guide an appropriate algorithm, identifying all useful features of the transmission profiles (eg. gradients, feature altitudes, etc.), then selecting a path to follow and developing a method to meet the requirements.

2 Work plan

Week 1-2

- ➢ Introduction to TGO/NOMAD/UVIS
- ➢ Background reading (Instrument/Machine Learning)

Using UVIS data:

https://confluence.hdfgroup.org/display/HDF5/Introduction+to+HDF5
https://confluence.slac.stanford.edu/display/PSDM/How+to+access+HDF5+data+from+Python

- ➢ Introduction to UVIS data files
  - Types (observation type/level)
  - Data HDF5 structure (groups/datasets)
- ➢ Loading UVIS files
  - Load single HDF5 file
  - Load multiple files
- ➢ Inspecting and plotting UVIS data
  http://mars.aeronomie.be/en/exomars/observations/pages/EXM-NO-SNO-AER-00015-iss0rev30-CROSSDRIVE_HDF5_Data_Format_180528.htm
  - Housekeeping/TEMP_2_CCD & Housekeeping/TEMP_3_DETECTOR_BOARD
  - Channel/IntegrationTime
  - Channel/ReverseFlagAndDataTypeFlagRegister
  - Science/Y (CCD science data)
    - Nadir
    - Occultation
  - Geometry/Point0/Lat & Geometry/Point0/Lon
  - Geometry/Point0/TangentAlt

  Ground processed data:

  - level_0p2b/ElectronicNoise
  - level_0p2e/Science (Processed CCD science data)
  - level_0p2f/Radiance250nm

Introduction to the atmospheric structure project:

- ➢ Study examples of atmospheric transmission series from UVIS occultation data
- ➢ Understand different general categories of attenuation features
- ➢ Explore ways of categorising profiles based on common and distinguishing features

Week 2-4

- Literature review of machine learning methods used to classify spectral features
- Identify appropriate method to classify categories of transmission series
- Discuss with team to agree on method to employ

Week 5-8

- Produce prototype algorithm
    - Supervised learning algorithm with known input features
    - Unsupervised learning algorithm applied to all types of spectra
- Apply to a training dataset

Apply method to Mars transmission series:

- Generalise algorithm to account for any input profile/spectrum
- Allow for extraction of key information (eg. altitude of feature)
- Apply developed method to the full Mars occultation dataset

Additional development:

Development of a procedure for displaying relevant transmission profiles from a geographical map of archived observations.