GLOBAL UV IMAGING BY MAVEN/IUVS: DIURNAL CLOUD FORMATION, DUST STORMS AND ATMOSPHERIC SCATTERING


Introduction:
A new UV spectral imaging dataset of Mars global images is being obtained by the Imaging UltraViolet Spectrograph (IUVS) on the Mars Atmosphere and Volatile Evolution mission (MAVEN). Of particular interest for atmospheric studies are spectrally-resolved mid-UV datacubes as shown in Figure 1. Clouds, haze, dust and ozone can all be detected and quantified through image analysis and retrieval. IUVS observations are the only MAVEN data capable of probing below the spacecraft altitude, and provide an important link between the denser atmosphere and escape processes which are MAVEN’s primary focus (Jakosky et al. 2015).

Observations:
The MAVEN spacecraft orbits Mars in a highly inclined elliptical orbit, with a periapsis that enters the upper atmosphere for in situ sampling and an apoapsis at nearly 3 Mars radii (6200 km above the surface) for remote sensing and solar wind measurement. IUVS is an imaging spectrograph which uses a long slit and a scan mirror to obtain spectrally-resolved datacubes of the atmosphere and planet (McClintock et al. 2014). Separate channels record spatially-resolved spectra in the Far-UV (110-190 nm) and Mid-UV (180-340 nm). Observation sequences are tailored to different science objectives and observing geometries along different segments of the orbit. The instrument is mounted on an Articulated Payload Platform which aligns the instrument’s fields-of-regard towards the planet and allows the scan mirror to the slit across the region of interest using exposures of a few seconds.

This presentation describes global images from apoapsis, as shown in Figure 1. The instrument is capable of spatial resolutions of 6 km at nadir and 9 km at the limb (farther from the spacecraft). Spectral resolutions up to 0.6 nm are possible with the instrument, but datarate considerations limit the spectral resolution to ~15 bins of 0.9 nm in the mid-UV when the highest spatial resolutions are employed. The relatively low spectral resolution is a substantial improvement over broadband filter imaging, and is fully capable of distinguishing all major spectroscopic components.

IUVS has collected global-scale images for more than one Mars year. Early in the mission, datarate allocations were low and images were obtained at coarse spatial resolution. During the recent Mars opposition, the close distance between Earth and Mars allowed higher spacecraft transmission rates and therefore the highest image resolutions listed above. Hundreds of comparable images were obtained over a period of several months. The orbit precesses on timescales of months, meaning the view from apoapsis between dayside to nightside viewing and between the northern and southern hemispheres.

MAVEN’s 4.5-hour elliptical orbit offers a unique observational perspective on the Mars atmosphere. While low circular orbits allow optimal resolution of the Mars surface, they do not allow global-scale imaging, and especially the wide range of local times that could be thereby sampled. From apoapsis,
MAVEN’s vantage point allows viewing of ~9 hours of local time, and ~4.5 hour sampling. Furthermore, a near-commensurability between 11 orbits and two sols allows interleaving of data from adjacent sols for and effective ~2.25 hour sampling for recurring phenomena (Figure 2).

Results

Multicomponent spectroscopic retrievals on dayside images (Lefevre et al., this conference) clearly distinguish the Mars surface, dust, clouds/ice, Rayleigh scattering, and ozone. The same features can readily be identified in the images. (Nightside imaging is capable of mapping nitric oxide nightglow (Stiepen et al., this conference). This presentation will focus on two notable phenomena visible in the IUVS images:

Diurnal cloud formation movies. As shown in Figure 2, IUVS images capture rapid orographic cloud formation over a span of ~7 hours. Cloud formation studies yield critical information about circulation patterns, condensate budgets, temperature structure and other atmospheric properties (both observationally, e.g., Clancy et al. 2007, and through global circulation models, e.g. Forget et al., 2014). Cloud formation movies will be shown for a variety of Ls values to identify stochastic variability and seasonal trends.

Topography and dust storm analysis through Rayleigh scattering studies. The altitude extremes of Valles Marineris and Olympus Mons can be clearly identified through the atmospheric scattering component, and additional features may be discernable (e.g., Hord et al.). Furthermore, high altitude dust storms can be distinguished by their low scattering spectral signature. We will report on potential uses of this aspect of the data, including seasonal variations in the features above. Spectra of these regions will be analyzed to determine whether Rayleigh scattering by CO₂ is a sufficient explanation or additional components such as haze or dust are required.

References:

C. Hord et al., Icarus 21, 292.