CHARACTERIZATION OF HIGH ALTITUDE CLOUDS AT THE MARTIAN LIMB AND TERMINATOR USING MAVEN IUVS OBSERVATIONS

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Introduction:

Clouds are perhaps the most readily visible metric for investigating the Martian atmosphere. These clouds may be composed of either water or CO_2 ice, with the latter confined to high altitudes (> 60 km) where very cold temperatures permit condensation. Determination of cloud altitude is possible through observations at the planetary limb and near the terminator. Images in these geometries capable of unambiguously discriminating dust and clouds were first made by the Viking orbiters (Jaquin et al. 1986), and later by other spacecraft such as Mars Global Surveyor (Clancy et al. 2007). Observations from Earth can also distinguish terminator clouds near Martian opposition when the phase angle is not too small (James et al. 1996).

Putting observations of clouds in the context of geography, local time, and season gives insight into atmospheric dynamics and volatile transport. However, previous images of clouds on the limb and terminator have been limited in coverage of these conditions, or had inconsistent sampling. Hence, synthesis of data from multiple sources is necessary to obtain a complete understanding of the characteristics of Martian clouds.

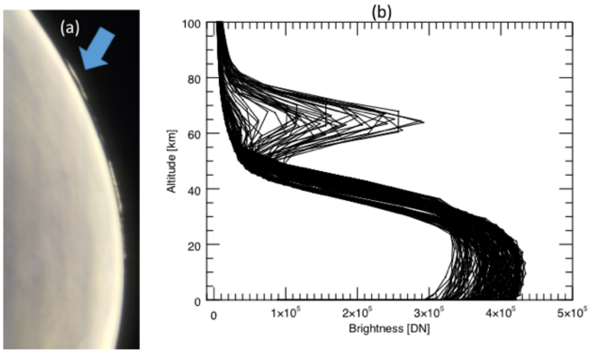

Figure 1: (a) Subsection of a MAVEN IUVS disk image acquired at apoapsis on orbit 2898, showing equatorial high altitude clouds on the limb at L_s=128. (b) Tangent altitude profiles of brightness at 290 nm sampled from the same image. Similar profiles are acquired in periapsis limb scans.

The MAVEN spacecraft, now in its extended mission at Mars, occupies a 4.5 hour orbit which allows limb observations to be performed at periapsis and semi-global synoptic views of the planet at an apoapsis of 6200 km altitude (Jakosky et al. 2015). The limb profiles and disk images acquired by the Imaging Ultraviolet Spectrograph (IUVS) provide a new and valuable data set for tracking Martian clouds (McClintock et al. 2015). Here, we focus on studying clouds at high altitudes (> 60 km), which can be composed of CO_2 ice.

Observations:

The IUVS instrument is most sensitive to scattered sunlight from clouds with its MUV channel (180-340 nm). From apoapsis it is capable of imaging the disk with a spatial resolution of approximately 6 km nadir viewing and 9 km limb viewing. Near periapsis limb scans targeting airglow are taken with a vertical resolution of 5 km and line of sight tangent altitudes ranging from the spacecraft altitude (≥150 km) down to about 50 km. This altitude range was chosen to allow the identification of high altitude clouds. The spectrum is sampled at < 6 nm, which resolves the spectral slope of the scattering aerosols.

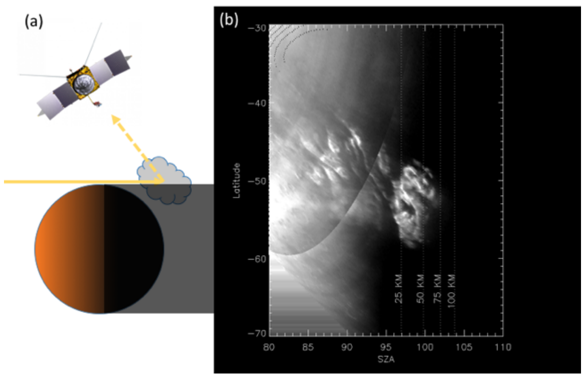

Figure 2: (a) Cartoon of MAVEN observing geometry for terminator clouds. (b) Image of high altitude terminator cloud mapped in solar zenith angle versus latitude, with vertical dotted lines indicating the minimum cloud altitude required for illumination. Orbit 2862, L_s=125.

An example disk image and sub-sampled vertical profiles for limb viewing geometry from apoapsis are shown in Figure 1. While periapsis observations do not produce such images, limb scans provide similar profile information subtending > 70 deg around the planet geographically. Figure 2 provides an example of a high altitude cloud observed near the terminator. Solar illumination of the cloud indicates that it lies outside of the shadow of Mars, which provides constraints on its altitude, as illustrated. The diffuse scattering confined to SZA = 90-97 deg (altitudes of approximately 0-25 km) is due to topography and ubiquitous dust and haze in the lower atmosphere.

Such MAVEN IUVS observations of high altitude clouds have now been acquired over thousands of orbits. The data are being analyzed for patterns and trends in geography and seasonality in the context of previous observations by other spacecraft. Results of this analysis and preliminary interpretation of driving dynamics will be presented.

References:

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