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JOINT OBSERVATIONS OF MESOSPHERIC AEROSOLS ON MARS FROM MAVEN/IUVS AND MRO/MCS

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Introduction: Aerosols in the Martian mesosphere (40 – 100 km altitude), consisting of dust, water ice and CO_2 ice, act as tracers of both the water cycle and atmospheric dynamics [1,2,3], and are generated by the complex interplay of dust lofting with local perturbations in temperature and atmospheric circulation driven by zonal planetary waves (e.g. [4,5,6,7]). Although well-studied by various instruments on board Mars Express (e.g. [8,9,10,11]) and the ExoMars Trace Gas Orbiter (e.g. [12,13,14,15]), these instruments are unable to simultaneously probe the zonal and vertical structure of these layers for a given season and local time. This makes it difficult to distinguish mesospheric aerosol features driven by transient atmospheric instabilities from more persistent and predictable climatological phenomena.

Since 2015, the Mars Atmosphere and Volatile EvolutioN (MAVEN) probe's Imaging UltraViolet Spectrometer (IUVS) has conducted multiple targeted stellar occultations in close geographical and temporal proximity to limb observations made by the Mars Climate Sounder (MCS) instrument onboard the Mars Reconnaissance Orbiter (MRO). In this talk, we will present a climatology of these joint observations, identifying a) to what extent we detect mesospheric aerosol features that are consistent across both datasets and b) the lifetimes of these features. Our results will then be used to identify regional climatologies in aerosol features that can be distinguished from aerosol features generated by transient weather events.

Data: MCS joint observations began in March of 2015 and continued through January of 2022, corresponding to ~40 campaigns that targeted at least 1 IUVS occultation set each. We have available 140 MCS profiles that occurred within 60 minutes, and are within 10° of latitude, 15° of longitude, and 30 minutes of local time, of a single IUVS occultation.

IUVS and MCS are both sensitive to the vertical structure of both aerosols and temperature, while the longitudinal sampling of these observations at fixed latitudes and local times allows for zonal variations in aerosol structure to be extracted. From IUVS stellar occultation measurements [16], we can retrieve vertical profiles of two independent quantities: aerosol opacity up to ~110 km altitude, and an 'Ångström coefficient' [8,17] loosely correlated with particle size (with non-zero values indicating a submicron particle population). However, aerosol particle composition is difficult to determine with great accuracy. Conversely, MCS limb observations can easily distinguish vertical profiles of dust and water ice (in units of extinction coefficient, km^{-1}), but have little sensitivity to particle size or to aerosol opacity above approximately 60 km altitude. These measurements therefore complement each other.

Preliminary Results: Detections of detached aerosol layers below 60 km in IUVS data generally map well onto water ice cloud layers in joint MCS observations, with large densities of joint water ice cloud detections at equatorial and northern latitudes during the dusty season. Conversely, aerosol features at the lowest altitudes to which IUVS is sensitive mostly correlate with increases in dust opacity detected by MCS. The main exception is during winter and early spring at southern high latitudes, where detached aerosol layers are often retrieved by IUVS at approximately 50 km altitude but entirely absent from corresponding MCS data (with an example shown in Figure 1), even though they should be easily resolvable by both datasets.

Figure 1: Aerosol opacity and Ångström coefficient profiles retrieved from IUVS stellar occultations compared with dust and water ice extinction profiles retrieved from the closest three MCS observations. (top) in this observation, obtained in Southern winter at 63S latitude, IUVS observes a detached aerosol layer centred around 45 km altitude for which MCS failed to detect either a dust or a water ice layer, (bottom) in this observation, obtained in the northern tropics close to the autumn equinox, two detached layers are observed by IUVS at 40 km and 52 km altitude that are clearly determined to be water ice clouds by MCS.

As with [8,18] we also often observe regions of Ångström coefficient greater than 0 directly above either the level of detectable dust in MCS observations or just above water ice cloud layers, indicating layers of smaller aerosol particles – most likely dust - located just above the haze-tops and water ice clouds detected by MCS, and often undetected by MCS. However, we find as with [11] that this pattern is neither consistent nor usually correlated with the presence or absence of water ice clouds, and appears to be highly longitude-dependent.

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