SEASONAL ATMOSPHERIC OBSCURATION IN VALLES MARINERIS. A. Shumway[1], L. Ojha[2], and M. Wolff[3], [1]School of Earth and Atmospheric Sciences, Georgia Institute of Technology (shumway@gatech.edu), [2]Deparment of Earth and Planetary Sciences, Johns Hopkins University, [3]Space Science Institute, Boulder, CO.

Introduction: While atmospheric obscuration has long been observed within the topography of Valles Marineris (VM), the composition of these atmospheric events (ice vs. dust) is not fully understood. The spectral data from the Planetary Fourier Spectrometer (PFS) on board the Mars Express spacecraft suggest the atmospheric obscurations in VM may be due to atmospheric fogs[1]. Fogs form when H_2O ice condenses around suspended dust particles in the atmosphere. The observations by the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activite (OMEGA) instrument onboard the Mars Express spacecraft, however, did not find any evidence for water fog in VM, and instead suggested that the atmospheric obscurations in VM are due to dry dust particles (i.e. haze)[2]. The surface obscuration in atmospheric haze is caused by dust particulates, which exhibit little albedo contrast from the surrounding and are spectrally indistinct[3][4].

Here we report the seasonality of the atmospheric obscuration in VM using data from the Mars Color Imager (MARCI), a wide-angle camera aboard the Mars Reconnaissance Orbiter that captures daily images at 1500 ± 2 hours local solar time in five visible and two ultraviolet spectral bands[5]. We present the spatial and temporal features of atmospheric obscuration to better understand the climate dynamics within VM and more broadly the Martian atmospheric cycle. We also constrain the composition of the atmospheric obscuration in VM using the MARCI UV bands which are sensitive to atmospheric ice[5].

Methods: We manually inspect all the MARCI visible-band images acquired between Mars Years (MY) 30-33 to look for atmospheric obscurations within VM. For more detailed observations, we divide VM into three sections: western, central, and eastern. For each day the atmospheric condition of each section of VM is recorded and from this information we compile a database spanning four MY. On days that images in the visible bands show bright atmospheric obscuration (e.g. October 23-25, 2015 in Fig. 1), the corresponding images from the UV bands—which are most sensitive to atmospheric water ice—are also inspected to distinguish between dust and ice clouds.

Results: Observations reveal a pattern in which the atmospheric obscuration is first observed in the west or center of VM. Over the course of multiple days, the obscuration is observed to progressively move towards eastern VM (Fig. 1). Occasionally the cycle will begin again with obscuration appearing in the west or center before the previous cycle of obscuration leaves the eastern section of the canyon.

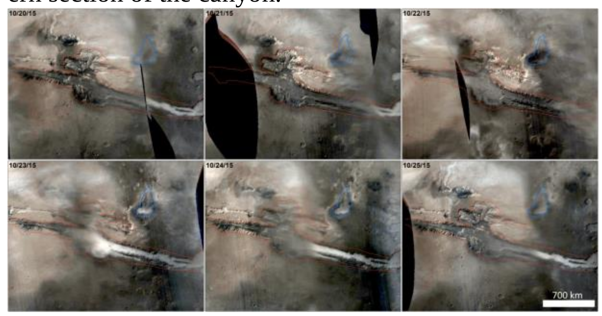

Fig. 1 [1] *MARCI observations of the progression of bright atmospheric obscuration in central and eastern VM over six days in MY 33 (L_s=57.0°-59.2°, Earth dates October 20-25, 2015). The corresponding UV image for October 23, 2015 (panel 4) is presented in Fig. 3. The geographical extent of VM is outlined in red.*

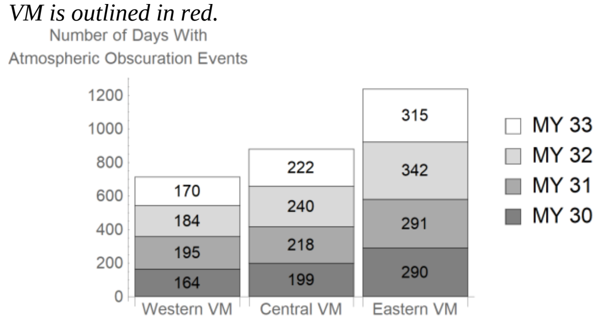

Fig. 2 *Chart showing the number of days when atmospheric obscuration was observed in each region of Valles Marineris. The occurrences in each region are separated into the years in which the occurrences were observed.*

Regardless of the MY in question, eastern VM shows the highest number of atmospheric obscurations followed by central and western VM (Fig. 2). The number of observations of obscuration in VM increase by 8.0% between MY 30 and MY 31, 33 (which have nearly equal number of total occurrences of atmospheric obscuration). MY 32 has the most occurrences, with 8.6% more than MY 31, 33 and 17.3% more than what is observed in MY 30. While there are periods where obscuration events are numerous and periods where they are less frequent, we observe no discernable seasonal trends in its occurrence between MY.

Whenever bright atmospheric obscurations were observed in the MARCI visible bands, we also examined the UV images to constrain the composition of the obscuration. We identified 30 events that show signatures in the visible and UV bands characteristic of water ice clouds (e.g. Fig. 3). These obscurations which resemble water ice clouds occur with a particular seasonality, occurring exclusively during the solar longitude L_s=35°-61° and L_s = 142°-161° (Fig. 4).

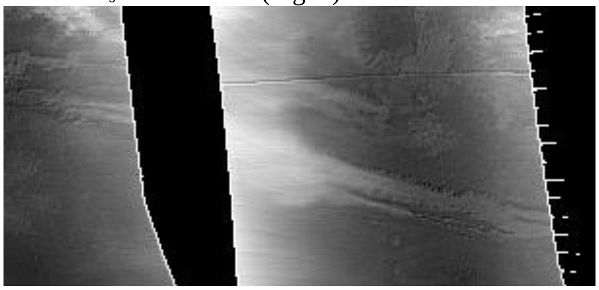

Fig. 3 *UV image of VM produced by MARCI's band 7 (320nm), which is most sensitive to the detection of water ice clouds[3]. This image was taken MY 33, L_s=58.3; Earth date: October 23, 2015; the corresponding visible image of VM for this date is seen in panel 4 of Fig. 1.*

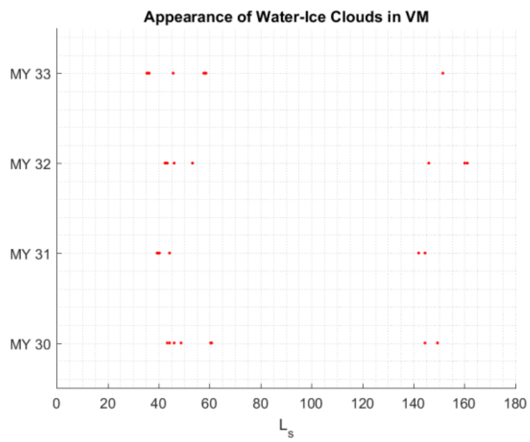

Fig. 4 *Chart showing all solar longitudes where potential water ice clouds are observed in any part of VM. We only display L_s=0°-180° as no such clouds are observed between L_s=180°-360° in any MY.*

Discussion: Our observations reveal an intriguing pattern where atmospheric obscuration always seem to initiate in the west or center of the canyon and then progressively move eastward. On average, this progressive movement of the obscuration lasts 6 days. Alternatively, because MARCI gathers data at the same local solar time every day, another possible explanation of the pattern is that the clouds form in western VM in the morning but tend to fade or move before MARCI images the canyon. This, however, does not explain why the clouds persist over multiple days and seem to move eastward over that timeframe.

Based on the surface temperature retrievals from the Mars Climate Database (MCD), the seasonality of the ice clouds coincides with the coldest season of the year in VM. On the same date that highly reflective atmospheric obscuration was observed in VM by MARCI, spectral signatures of water ice were detected by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). This CRISM data along with comparisons between our observations in VM and MARCI observations of known water ice clouds suggests that obscuration which appears bright in both visible and UV bands could be an indicator of atmospheric water ice. Water ice clouds were also observed in morning fogs of VM by the Planetary Fourier Spectrometer (PFS)[1], while observations by OMEGA suggest the presence dust rather than water ice clouds[2].

Ice nucleation in the Martian atmosphere results from the deposition of water vapor onto suspended dust particles. Ice nucleation for a thin layer (~100m) of ice cloud requires a water vapor column abundance of only a few 10s of pr. µm (precipitable microns). In contrast, an excess of 600 pr. µm would be required to explain ground hugging fog as suggested by the PFS data[6]. Therefore, we posit that the water ice cloud observed within VM are confined layers not exceeding more than 100 meters in thickness.

The presence of low lying H_2O ice clouds in VM suggest the possibility for an active volatile exchange between the surface and atmosphere. An increase in near-surface humidity by the presence of an ice cloud provides viable pathways for deliquescence, perhaps triggering the formation of active mass-wasting features such as recurring slope lineae (RSL)[7] or topographic slumps[6]. While there is no known connection between RSL and these bright atmospheric obscuration events, RSL are detected in higher densities on the slopes of eastern VM, particularly on Coprates and Nectaris Montes[8]. This is the same region of the canyon where we observe the potential ice clouds linger for several days before exiting and dissipating. The seasonality of the potential ice clouds also corresponds to that of topographic slump features (L_s=0°-120°) observed in Juventae Chasma with the High Resolution Imaging Science Experiment (HiRISE)[6].

The observations of low lying water clouds in locations with high concentrations of RSL and topographic slumps merits continued study of the region to understand any possible interactions between these surface and atmospheric processes.

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