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High altitude plumes at Mars morning terminator

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Abstract

In March and April 2012 two extremely high altitude plumes were observed at the Martian terminator reaching 200 - 250 km or more above the surface [1]. They were located at about 195º West longitude and 45º South latitude (at Terra Cimmeria) and extended ~ 500 – 1,000 km in both North-South and East-West, and lasted for about 10 days. Both plumes exhibited day-to-day variability, and were seen at the morning terminator but not at the evening limb. Another large plume was captured on Hubble Space Telescope images in May 1997 at 99º West longitude and 3º South latitude, but its altitude cannot be precisely determined. Broad-band photometry was performed of both events in the spectral range 255 nm – 1052 nm. Based on the observed properties, we discuss different possible scenarios for the mechanism responsible for the formation of these plumes.

1. Mars terminator plumes

The Martian thin, cold and dusty atmosphere allows condensed clouds to form at ~ 100 km and surface dust to reach ~ 50 km altitudes [2, 3]. In 2012 a high altitude Martian plume was imaged for the first time on March 12 using telescopes with apertures 25-40 cm diameter and CCD cameras working in the "lucky imaging" mode [1]. Its emergence and evolution at terminator was tracked by 19 independent observers between 12 and 23 de March at Terra Cimmeria showing great variability (Figures 1 and 2). A second plume was observed between 6 and 16 April showing properties similar to the previous event. These events occurred in early winter in the southern hemisphere at a solar longitude Ls = 85-90º.

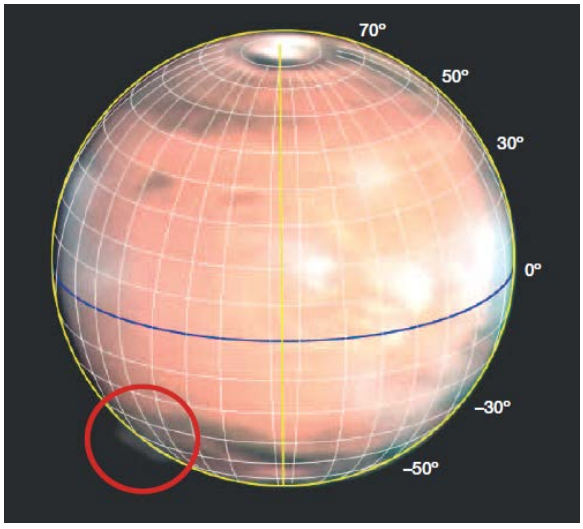

Figure 1: Mars plume location at terminator on 21 March 2012 (image by D. Parker).

The second limb protrusion we report here was observed in a single broad-band image series obtained Wide Field Planetary Camera onboard the Hubble Space Telescope at Ls = 119º (Figure 3). Its horizontal extent was similar to the 2012 events.

The 2012 March and April plumes were observed at different times rotating from the night side into view, allowing determination of its top altitude located between ~ 200 and 250 km from the surface, much higher than previously reported clouds [1].

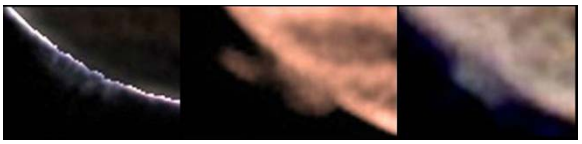

Figure 2: Morphology changes on the Martian plume on 21 March 2012 (from left to right images by W. Jaeschke, D. Parker, J. Phillips).

The 1997 event was above 50 km but its top altitude cannot be determined because of the lack of a rotating sequence.

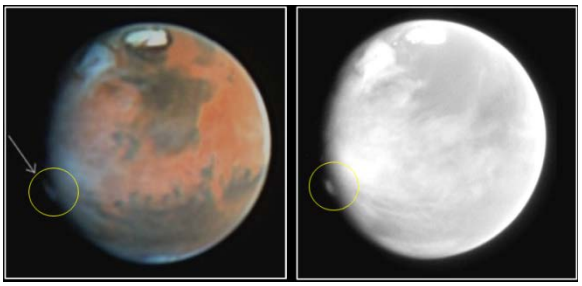

Figure 3: A Martian plume observed on 17 May 1997 using HST (left color composite, right ultraviolet filter).

2. Analysis and discussion

The measured plumes reflectivity curves for both 1997 and 2012 events have been used to perform a radiative transfer analysis of the solar reflected radiation at terminator by a volume a spherical particles. The model assumes three possible plume composition: icy condensates of CO_2 and H_2O, and Martian dust. Only for small icy condensates of 0.1 μm in radii and densities 0.01 particles per cm^3 the model fits the observations. Under such scenario and for the 2012 plumes, using the vertical temperature profiles provided by a GCM at Terra Cimmeria and for the epoch of the year [4,5], water icy condensation is favored [1]. In such a case, rapid particle transport by the intense winds predicted by the GCM should be involved.

Alternatively, since the Cimmeria region shows a crustal magnetic anomaly, the plume could be the result of an emission aurora phenomenon. However the observed emission intensity would be so high that this explanation is highly unlikely. We finally comment on other possible mechanisms .

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