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Fogs and Clouds are a Potential Indicator of a Local Water Source in Valles Marineris

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Recurring slope lineae (RSL) are narrow, low-albedo seasonal flow features on present-day Mars that extend incrementally down warm, steep slopes, fade when inactive, and reappear annually over multiple Mars years [1,2]. Hypothesis for the sources of volatile by which RSL are recharged include seeping water, melting shallow ice, aquifers, and vapor from the atmosphere [1-5]. About 50% of the 250+ candidate and confirmed RSL sites appear in and around Valles Marineris [3], and coincide with regions where putative morning water ice fogs may appear as imaged by the High Resolution Stereo Camera on Mars Express [6]. The presence of fog may provide clues to the water cycle within the canyon, and could elucidate the processes related to the evolution of RSL.

Using a regional atmospheric model, we investigate the atmospheric dynamics in and around Valles Marineris. Our simulation results show a curious temperature structure, where the inside of the canyon appears warmer relative to the plateaus immediately outside at all times of day. Formation of fogs requires the atmosphere to be saturated. This can happen with the appropriate combination of cooling or addition of water vapor. The modeled temperature structure suggests that if water is well mixed and fog is present within the warmer canyon bottom, fog should be present on the cooler surrounding plateaus as well. This is generally not the case. Therefore, the only way to produce fog inside the canyon is to have a local water source. RSL may contribute to this atmospheric water through evaporation, or RSL may simply be a surface marker of a larger near-surface reservoir of water that can act as a source.

From the modeled temperatures, we calculated the corresponding saturation vapor pressures and saturation mixing ratios to determine the amount of water vapor in the air at saturation. The observed Martian atmospheric column abundance is $\sim$10 precipitable microns on average [7] and presents a major challenge for an atmospheric origin of volatiles.

If nocturnal clouds and fogs are present in Valles Marineris and not on the surrounding terrain, the modeled atmospheric thermal field points to an active source of water in the canyon. This source may be related to the water source for RSL and bolsters the hypothesis for a subsurface water reservoir. An atmospheric origin of water for RSL via deliquescence on salt requires an effective mechanism to trap water over small areas to support the estimated volumes of water in RSL. No such mechanism has been identified. However, there is evidence that the atmosphere still exerts control on the formation and activity of RSL through thermal effects.

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