INVESTIGATING THE TIMING AND EXTENT OF SEASONAL SURFACE WATER FROST ON MARS WITH MGS TES, HiRISE and THEMIS

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Summary

As seasons progress on Mars, surface temperatures may fall below the frost point of volatiles in the atmosphere (namely, carbon dioxide and water). Systematic mapping of the spatial and temporal occurrence of these volatiles in the Martian atmosphere, on the surface, and in the subsurface has shown their importance in understanding the climate of Mars. However, few studies have specifically investigated seasonal surface water frost and its role in the global water cycle. We examine zonally-averaged TES albedo, daytime temperatures, and water vapor abundance data [1] to map the presence of surface water frost on Mars. Surface water frost occurs in the polar and mid latitudes, in regions with surface temperatures between 170-220 K, and can significantly increase surface albedo relative to the bare surface. We show examples of this effect with multiple datasets and suggest that hemispherical asymmetry in the data is due to an water vapor abundance differences [1].

Hemispherical asymmetry?

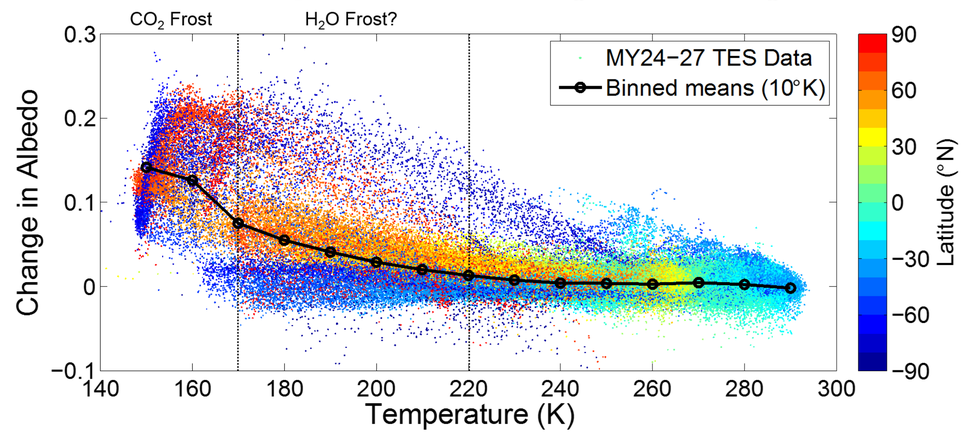

Figure 1. Scatter plot of our zonally-averaged TES data (~250,000 data points). The three variables include temperature, change in albedo (see Fig. 3 bottom), and latitude. A clear distinction can be made in the behavior of albedo and temperature between hemispheres on Mars. In the south (cooler colors), there is no dominant increase in albedo until the CO_2 frost point (~160 K) is met. The northern latitudes (warmer colors) show a clear trend, outside of CO_2 frost temperatures, with increasing albedo with decreasing temperature (e.g., 170-220 K range).

TES albedo and temperature (MY24-27)

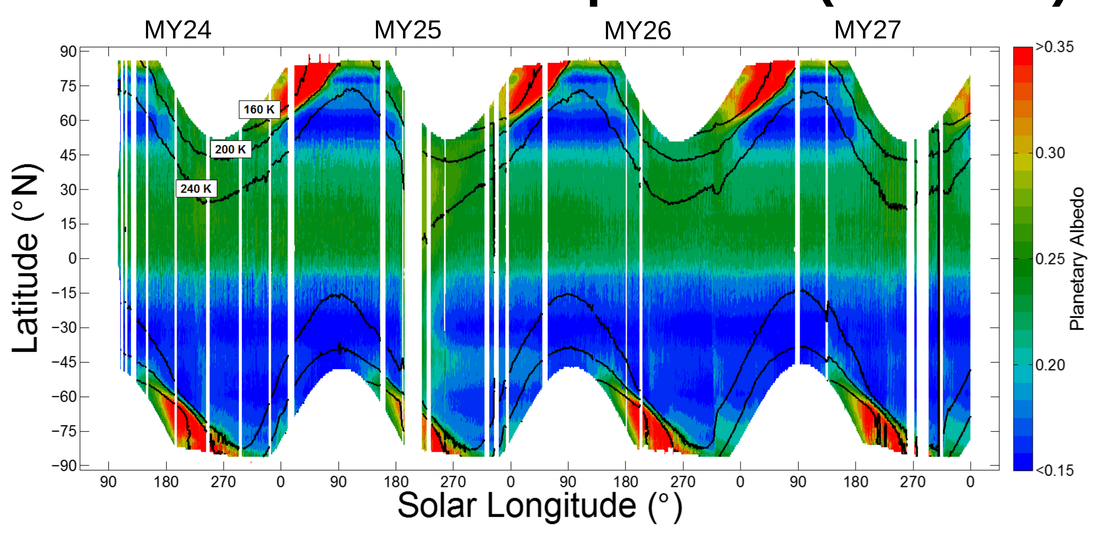

Figure 2. Zonally-averaged TES albedo and temperatures (three contours at 160, 200, and 240 K). Binned in 1°x1° latitude and L_s. Dominant features include seasonal polar caps, dust storms, and natural variability in the Martian surface albedo. Note the large gap in data in MY25 due to a global dust event.

Albedo change from summer reference

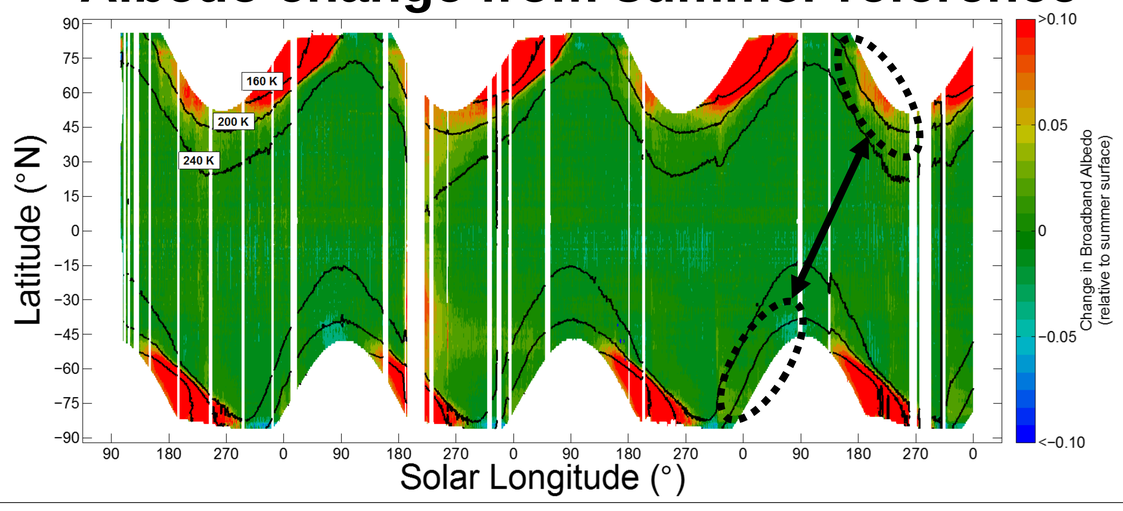

Figure 3. Raw bolometric albedo subtracted from a summertime mean (calculated independently for each hemisphere during their respective summers). Prominent features still include the spring retreat of seasonal CO_2 cap. However, a new feature becomes apparent: a northern autumn albedo anomaly (not seen in the south). We interpret this anomaly to be surface water frost.

HiRISE/THEMIS evidence for seasonal water frost

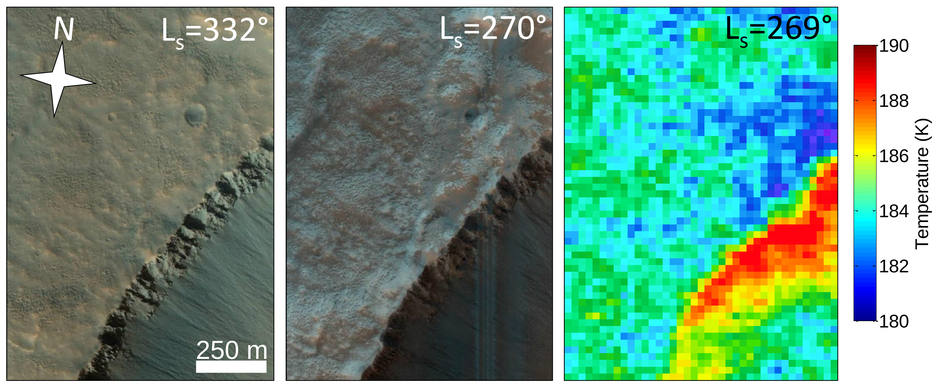

Figure 4. Example of seasonal water frost at 42.109°N, 312.031°E. HiRISE images (left) ESP_032192_2225_COLOR and (middle) ESP_030847_2225_COLOR and corresponding THEMIS I07941019 brightness temperatures (right). Temperatures are too warm for CO_2 ice. Few examples were found for seasonally-water-frosted surfaces that have THEMIS coverage for the appropriate time of year. No convincing southern hemisphere examples were found, however, due to small samples sizes, we are not able to exclude the possibility of southern seasonal water frost deposits that exhibit similar features.

References & Acknowledgments

[1] Smith, M. (2004), Interannual variability in TES atmospheric observations of Mars during 1999–2003, *Icarus, 167(1)*, 148–165.

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