A GLOBAL LOOK AT MARTIAN CO_2 SNOWFALL USING OBSERVATIONS FROM THE MARS CLIMATE SOUNDER.

J. M. Widmer[1], S. Diniega[2], P. O. Hayne[3], [1]Univ. California, Los Angeles (jacob.m.widmer@gmail.com), [2]Jet Propulsion Lab., California Inst. of Tech., [3]Laboratory for Atmospheric and Space Physics, U. Colorado, Boulder.

Summary: Previous studies have identified CO_2 snowfall within the polar regions on Mars [1,2]. An earlier study using Surface Brightness Temperature (SBT) retrievals from the Mars Climate Sounder (MCS) found that CO_2 snowfall extends into the mid-latitudes in the northern hemisphere [3]. Here, we report a more extensive survey using the MCS retrievals, which indicates that significant amounts of CO_2 snowfall occurs in the mid-latitudes of both martian hemispheres (Figure 1). In both hemispheres, the majority of snowfall is within the contiguous seasonal cap however, there are key differences between the two hemispheres. The southern hemisphere exhibits a large amount of snowfall near the edge of the extending seasonal cap in the fall, and again along the edge of the retreating seasonal cap in the spring (Figure 1b). Additionally, both the contiguous seasonal cap and snowfall extend much farther equatorward in the south, with fall snowfall concentrated in Hellas Planitia and Argyre Planitia (Figure 2).

CO_2 Snowfall Detection: Based on previous work [4], CO_2 snowfall is identified using MCS SBT observations with values below a calculated CO_2 frost point (~140 – 150 K at typical Mars surface pressures). Extensive surface CO_2 frost is identified based on MCS SBTs that are at the CO_2 frost point. In contrast, freshly fallen snow exhibits an emissivity minimum near the MCS bandpass used here (B1 = 32 µm), due to the strong 20-30 µm transparency band of solid CO_2 [5]. Therefore, the MCS SBT is observed to be strongly depressed relative to the local CO_2 frost point when the surface is blanketed by snow. The footprint of an MCS SBT observation is ~6km wide and therefore, a frost or snowfall detection corresponds primarily to the contiguous seasonal frost cap, which extends in a roughly similar manner each Mars year (MY) [6].

Open Questions: An improved understanding of the CO_2 snowfall locations, timing, and amounts would help answer a number of important open questions about the global volatile budget and related processes on Mars, as well as how those volatile movements and phase changes affect the Martian climate. In particular, some initial open questions that this work will help answer (but not necessarily fully answer):

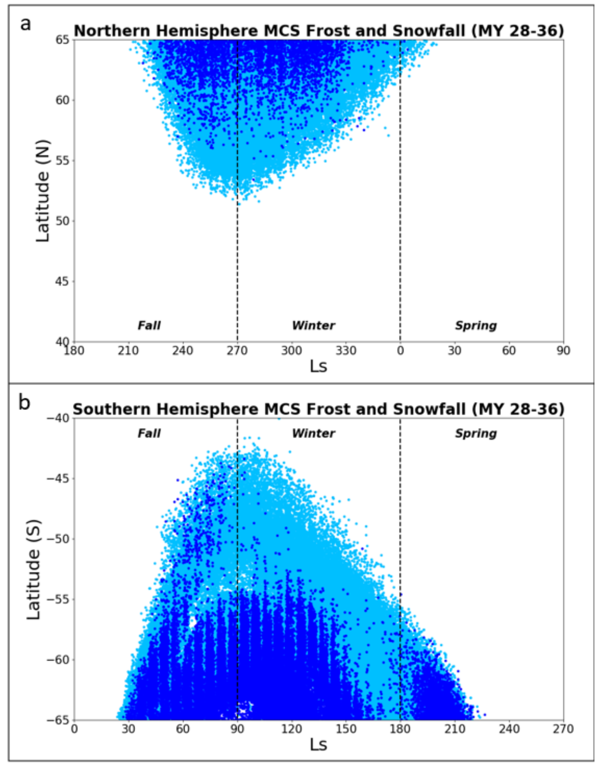

Figure 1: *Latitudinal coverage of the seasonal frost cap in the a) northern and b) southern mid-latitudes (equatorward of 65°), as a function of L_s, collated over Mars Years (MY) 28-36. Light blue indicates the presence of surficial seasonal frost, and dark blue indicates recent CO_2 snowfall. The northern hemisphere plot includes 41,555 frost detections and 4,215 snowfall detections while the southern hemisphere plot includes 125,887 frost detections and 46,227 snowfall detections.*

- What is the fractional contribution of snowfall to the seasonal cap?
- Does this contribution change following a Global Dust Event, such as in MY34?
- Does CO_2 snowfall influence the formation of geomorphology, such has been proposed for dune avalanches [7-9]?
- What causes the differences in the snowfall distributions between the two hemispheres?
- Why does snowfall occur much further equatorward and later in the spring in the south? (Figure 1)

Next Steps: This first look hints at intriguing patterns, reflective of the present climate conditions and controls on Mars. To identify the main controls on when and where CO_2 snowfall occurs, we will investigate changes in snowfall locations throughout a martian winter, and between martian years, while normalizing against the number of MCS observations. We will also analyze retrieved aerosol profiles from MCS, to identify clouds and determine their opacity within regions of frequent snowfall.

For example, in the southern hemisphere, the majority of snowfall observations located equatorward of 50°S during the late fall comes from MY36 and are located in Hellas and Argyre Planitia (Figure 2). Similarly, the number of late winter snowfall detections from MY35 and MY36 are ~2-3x higher than any other MYs. We will confirm if this is due to observational bias or is a real change, potentially related to the 2018 Planet Encircling Dust Event [10].

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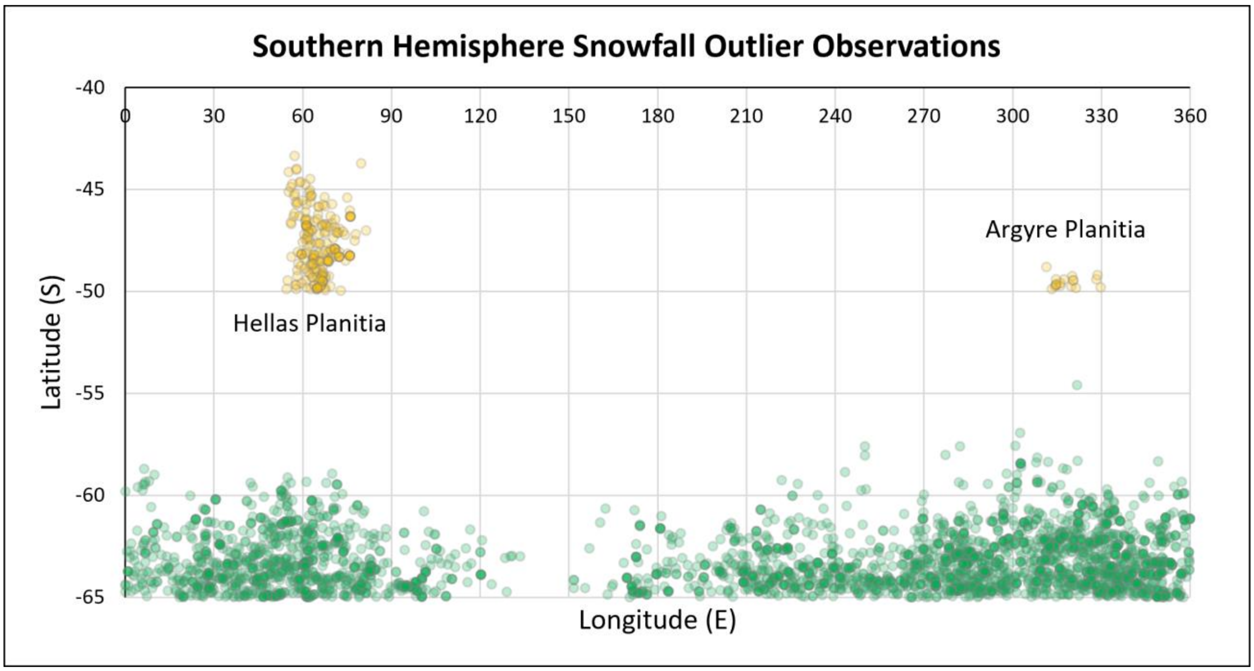

Figure 2: *Spatial distribution for two subsets of southern mid-latitude snowfall observations from Figure 1b. These "outlier" observations represent snowfall activity that is unique to the southern hemisphere and provides an opportunity to determine how the controls on snowfall differ from those in the north. Gold points show locations of autumnal (L_s 30-90) snowfall detections equatorward of 50°S, and green points indicate snowfall during L_s 180-230.*