UPDATING THE SPATIAL EXTENT AND TIMING OF SEASONAL FROSTS AND SNOWFALL IN THE NORTHERN MID-LATITUDE REGION OF MARS. J. M. Widmer[1], S. Diniega[2], P. O. Hayne[3], C. E. Gary-Bicas[4]. [1]University of Maryland (jwidmer@terpmail.umd.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, [3]University of Colorado, Boulder, [4]Stony Brook University.

Introduction: The martian atmosphere is composed of ~ 95% CO_2 gas and as surface and atmospheric temperatures drop, CO_2 forms solids on the surface as frost [1] and snowfall [2]. The deposition and removal of these seasonal volatiles (i.e. frosts and snowfall) have been proposed as geomorphic agents contributing to a variety of present-day activity on Mars [3]. Previous investigations with coarse-resolution data have shown seasonal expansion of the north polar cap during the fall and winter to extend as far south as 50-55° N [4-5]. Other studies using higher resolution data have identified seasonal frosts at 48° N with the Viking 2 Lander [6] and as far south as 32° N [7]. This makes the northern mid-latitude region (MLR) of Mars, defined as 30-65° N, an ideal location for understanding the spatial extent and timing of seasonal volatiles.

Preliminary results from a multi-instrument seasonal frost investigation in the MLR have been previously reported [8]. That investigation focused on the spatial extent and timing of local-scale seasonal frost observations. This was accomplished by monitoring 6 dune field study sites with data from the High Resolution Imaging Science Experiment (HiRISE), Context Camera (CTX), Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), and Mars Climate Sounder (MCS) instruments.

Updated Framework: This study builds on the preliminary results of [8] and provides updated results for the appearance of seasonal volatiles in the MLR.

In this study, we monitor local-scale seasonal frost behavior with 81 MLR dune fields, including the original 6 dune fields presented in [8]. This study also includes the results from our first imaging campaign which took place during the MY 34-35 winter.

New additions to the project framework include: 1) seasonal frost monitoring on a regional scale, 2) the addition of mid-latitude snowfall monitoring, and 3) the creation of seasonal volatile maps for the MLR. Utilizing larger datasets from the HiRISE, CTX, CRISM, and MCS instruments, we are able to extend the area of coverage beyond individual dune fields to the rest of the MLR. Daytime snowfall events have been identified in the MLR with MCS surface brightness temperature (SBT) observations, for the first time. Although snowfall differs from seasonal frost in its formation mechanism, combining both types of observations enhances our understanding of the mid-latitude thermal environment, thus contributing to the overall goal of the study. To record the spatial extent of the study results and allow for the comparison against present-day surface processes, we have created seasonal volatile maps (see Figure 1).

Preliminary Target Region in Chryse Planitia: With the inclusion of several major updates to the project framework and the expansion into the rest of the MLR, a smaller, targeted region was chosen to display our preliminary results. The region north of Chryse Planitia, covering 290-360° E and 30-65° N, was targeted to include high-priority dune fields identified in an ongoing, present-day surface processes investigation [9]. Extensive data coverage from the high-priority dune fields provides a detailed view of local-scale frost behavior over varying latitudes and helps serve as a check against our newly added regional, seasonal volatile survey.

Results and Discussion: Using the JMARS GIS software [10], we constructed seasonal volatile maps showing the extent of seasonal frost and snowfall in the Chryse Planitia region (see Figure 1). The foundation of both maps are built on a series of 1x1° white polygons, created in a JMARS custom shape layer. Other colored polygons correspond to the highest resolution data available in each polygon. For example, if HiRISE (0.25 m/pixel) and CTX (6 m/pixel) images both display frost at a single location, the polygon enclosing that location will be colored purple, corresponding to HiRISE coverage since it has the higher resolution. It is important to note that these maps ignore interannual variations and we resample data of various spatial resolutions to a 1x1° scale. Figure 1 displays the highest available resolution for the spatial extent of seasonal frost (A) and snowfall (B) in the Chryse Planitia region.

Looking at the spatial extent of seasonal frost in Figure 1A for the Chryse Planitia region, two features are readily apparent. First, at 1x1° resolution, nearly uniform seasonal frost coverage exists between 53-65° N. And second, there appears to be a fairly consistent latitudinal frost boundary near 53° N +/- 1°. However, this interpretation is largely based off MCS SBT measurements which have a resolution equivalent to ~5 km/pixel. Higher-resolution datasets such as CTX and HiRISE may show a frost boundary at lower latitudes than what appears in Figure 1A. Alternatively, Figure 1B at the same map resolution shows an irregular pattern in the spatial extent of daytime snowfall events, potentially due to variations in seasonal conditions from year to year.

In addition to spatial extent, the timing of seasonal volatile appearance is crucial to understanding seasonal activity. Figure 2 incorporates all of the seasonal volatile data in the Chryse Planitia region to display the relationship between timing and latitude. Due to imaging constraints, most of the high resolution data falls during the end of the seasonal volatile period. However, the difference in spatial resolution is evident in the spring section of Figure 2 as MCS data no longer detects seasonal volatiles after Ls 15.2 but HiRISE and CTX data detect frost as far into spring as Ls 37.6. As part of the initial frost survey conducted in [8], 65 CRISM long wavelength, full resolution targeted (FRT-L) images were identified through visual inspection of their parameter maps as potential “frost positive” data points. Of those 65 images, 12 appear in the target region, many of which stand out as anomalous data points in Figure 1A and 2. These images are still under investigation but have been included for continuity with [8]. Once again, it is important to note that Figure 2 only shows data for a portion of the MLR but as work continues we will investigate how and if these initial results change.

Future Work: Moving forward, major updates in this study will include: 1) completion of the seasonal volatile maps for the remainder of the MLR, 2) completed analysis of the CRISM FRT-L images identified in [8], 3) implementation of a new method of frost detection with THEMIS IR data, and 3) development of a new, coordinated, multi-instrument imaging campaign for the MY 35-36 winter.

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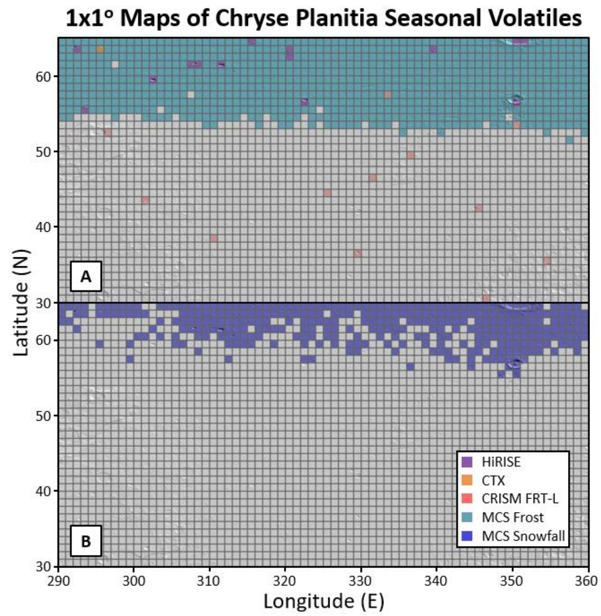

Figure 1: *Seasonal volatile maps of frost (A) and snowfall (B) have been created for the Chryse Planitia region (30-65° N, 290-360° E) at a 1x1° resolution. Differing colors in the frost map indicate the highest resolution instrument to detect seasonal volatiles within a given 1x1° box.*

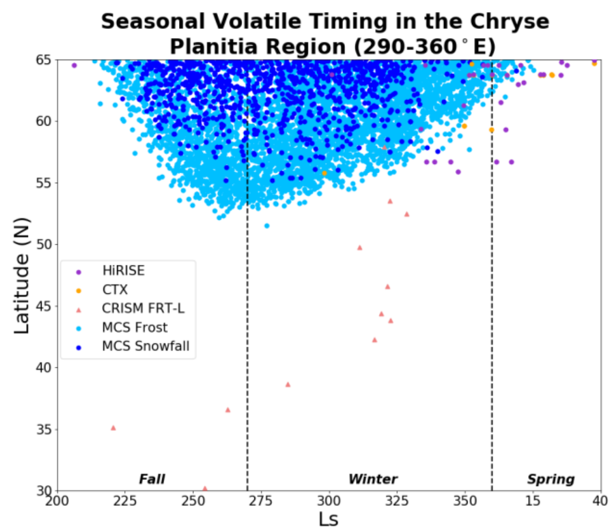

Figure 1: *Using all of the frost and snowfall observations from the Chryse Planitia region and ignoring interannual variations, this plot was generated to show the timing at which seasonal volatiles appear. Note that differing resolutions among the instruments used will affect the interpretation of the timing results.*