IDENTIFICATION AND QUANTIFICATION OF MARTIAN FROST USING HIRISE IMAGERY. V. M. Karnes[1] C. M. Sands, J. R. Sandtorf-McDonald, R. A. Slank, and V. F. Chevrier. [1] University of Arkansas, Fayetteville, AR, 72701; vmkarnes@uark.edu

Introduction: Frost on Mars was first identified in 1979 by the Viking 2 lander, and its presence and implications were subsequently studied in depth in the 1970s and 1980s [1], [2], [3]. Frost has important implications into near-surface conditions including temperature and water relative humidity, which are useful for local weather, overall climate, and input into Global Circulation Models (GCMs). However, little study has been done focusing on frost on Mars since recent missions, most notably the Mars Reconnaissance Orbiter (MRO). The HiRISE camera aboard the MRO offers a more recent dataset with RGB image products that allow for identification of frost more easily than black and white images.

We focused on HiRISE observations in the Northern hemisphere to evaluate the extent of the presence of frost and to determine if 1) the HiRISE dataset is conducive to frost identification and 2) if there are any observable trends in the formation and stability of frost. In this abstract we detail the initial investigations at specific sites of interest as well as an initial method of quantification of frost.

Case study #1 - Northern Dunefield: The first in-depth analysis focuses on a dunefield in the Mars northern latitude (80°N, 122.5°E) with 63 repeat HiRISE observations spanning multiple Martian Years (MY 28-32). A qualitative scale (0-5) was assigned to each image as shown in Figure 1 with example images, based on the RGB product produced by the Arizona HiRISE team. From left to right, the scale is 1) visible but minimal frost, typically seen in ridges or crater walls, 2) frost present in small but consistent quantities across the majority or entirety of the image, 3) frost ubiquitous throughout image, with moderate coloring from regolith 4) frost covers most of image, with minimal coloring from underlying regolith, and 5) frost covers entire image and no coloring from underlying regolith.

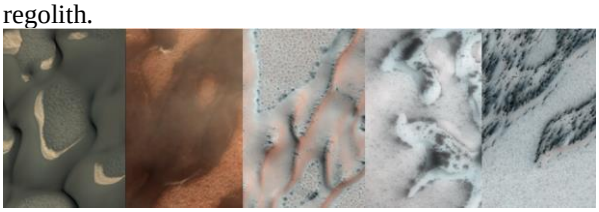

Figure 1: Examples of Qualitative Frost Scale used for initial analysis

Of note is that the 1st image only has frost in the very northern portion of the footprint, the 2nd image contains clouds as shown by the hazy appearance. The remaining images contain "spiders", a result of CO_2 venting and present throughout much of the frost observations [4].

This scale was used as an initial evaluation due to its simplicity, allowing the authors to coarsely identify any trends that might be present. A plot was then generated of the amount of frost vs solar longitude. Observations at this site were only made from beginning of spring through mid-summer.

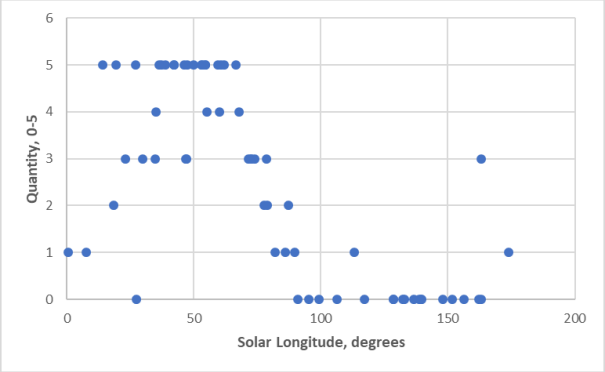

Figure 2: Presence of frost in northern dunefield as a function of solar longitude.

The initial examination at this site showed a couple of trends. First, there is an aggregate trend in a rise in frost at the beginning of the year (Ls = 0), and a linear-like dropoff at the transition from spring to summer (~Ls = 90). Additionally, there is a clear trend across the 4 MY as shown in . MY 29 shows no frost, and the quantity of frost present increased over each of the subsequent three years; MY 32 shows a maximum amount of frost coverage throughout the spring season.

Case Study #2 - Windy City The second analysis examined the Windy City polar erg located at 73°N, 355°E. This location was observed on 24 occasions across multiple Martian Years (MY 30 – MY 33) The scale shown in Figure 1 was used to evaluate the images in this location for frost coverage.

Case Study #2 shows a similar seasonal frost trend to Case Study #1. Frost is most prevalent at the beginning of the Martian year, from Ls = 0 to Ls = 100. The frost begins to form again at the end of the year, approximately Ls = 330. In addition, the overall quantities of frost are lower than those shown in Figure *2*, and appear to drop off a bit sooner as well. This is likely due to the more southernmost location of case study #2 at 73°N vs 80°N.

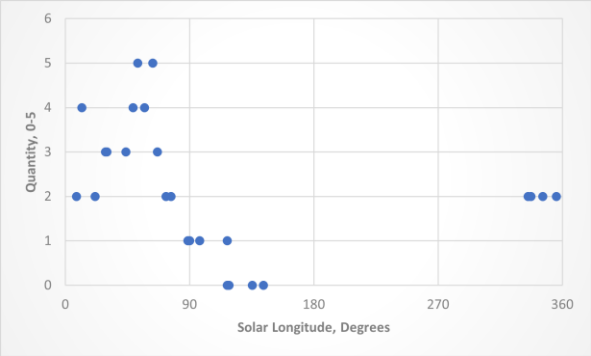

Figure 3: Frost presence in polar erg Windy City, as a function of solar longitude.

Quantification of frost using QGIS:

To identify and quantify frost within HiRISE imagery, a rudimentary process was established using QGIS, which will be further developed and analyzed.

This process begins by downloading the HiRISE imagery in a non-map projected format. For this project, the RGB color non-map projected JPEG imagery is used, as it is readily available for download through the University of Arizona Lunar and Planetary Laboratory. This imagery is then opened in QGIS version 3.16.

Within QGIS, the JPEG is then assigned a map projection and is exported and converted into geoTIFF format to allow for extractions and conversions of the imagery. This projection does not need to be the correct projection for the image, as the purpose of the quantification process does not require correct spatial coordinates.

The raster imagery is then polygonised, creating individual polygons for each pixel within the raster. Each pixel keeps the blue value from the raster image, creating a polygon shapefile of all blue values within the raster. These blue values were analyzed over a series of images to create a baseline value for frost in the blue band. This value was further determined when comparing the lowest white value across the imagery to RGB color codes, which show that a blue value of 125 is indicative of the color white and therefore of frost in HiRISE imagery. The example image below, for example, was found to have 93% frost coverage.

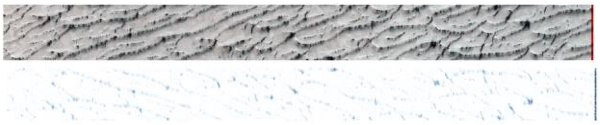

Figure 6: An original JPEG HiRISE image with a high frost coverage (top) compared to the brighter polygonised version created in the quantification process (bottom).

This process will be further refined to include the red and green bands present in the JPEG files and will be automated once the process is refined and determined to be satisfactory. The proper Experimental Data Records (EDR's) or Reduced Data Records (RDR's) will also be determined and sourced to provide the most accurate representation of the data, and any artifacts will be identified and removed from the imagery as needed.

Conclusion: Initial evaluation of HiRISE imagery in the Martian northern hemisphere indicates that frost can be identified in RGB image products, as well as the presence of both seasonal and yearly trends. Furthermore, a process to quantify frost coverage has been developed and assessed using the blue filter in QGIS. Future automation of this process, as well as the addition of other color filters, will allow for further study of frost presence and changes over time in the northern hemisphere of Mars.

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References:

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