HiRISE DETECTS NEW DENDRITIC TROUGHS IN SOUTHERN POLAR REGIONS. G. Portyankina[1] and C. J. Hansen[2], [1]LASP, 3665 Discovery Dr., Boulder, CO 80303, USA (Ganna.Portyankina@lasp.colorado.edu), [2]Planetary Science Institute, Tucson, AZ, USA.

Introduction: The High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter (MRO) has imaged seasonal activity for five martian years. The HiRISE seasonal observation campaign has multiple objectives; one of them is to identify changes in the surface over many martian years in order to estimate current erosion rates in the polar areas. HiRISE is particularly well equipped for this purpose: it has the highest spatial ground resolution of all the instruments orbiting Mars, up to 25 cm per pixel. It can use the capability of the MRO spacecraft to roll off-nadir in order to image a location with the same illumination geometry that was used in the initial observations. Multiple cases of surface changes in polar and circumpolar latitudes have been identified with the help of HiRISE data, such as seasonal frost-dust avalanches on the north polar scarp, expansion of the pits called swiss cheese on the permanent southern CO_2 cap, currently forming gullies and other morphological changes on martian dunes, etc.

Although HiRISE has proven to be a good tool for detecting surface changes, we have not yet detected clear visible changes in araneiform terrains. Araneiform terrains are probably the most seasonally active areas in the Martian polar regions. These areas are extensively monitored every spring to study dark and bright seasonal fan deposits that are believed to result from eruptions of cold CO_2 jets. The current general understanding is that the jets are the result of sublimation of CO_2 ice under the seasonal ice caps due to a solid-state greenhouse effect. The model that explains cold CO_2 jets' formation was developed by H. Kieffer [1]. According to this model both seasonal deposits and permanent araneiform features ("spiders") are the result of cold jet eruptions. It takes multiple repetitions of a spring jet eruption to erode the substrate and create araneiform troughs [1].

There are several possible explanations for the absence of visible changes of topography in the troughs of araneiforms. The changes might happen but be below the ability of HiRISE to resolve them. This would mean that their horizontal extent does not exceed 25 cm over 5 martian years. It is possible that the araneiforms in the southern polar areas do not currently erode. Despite the fact that we observe very active seasonal changes in these areas, the substrate material might be too stiff for the current erosive forces of the CO_2 gas flow to destabilize it. This would imply that seasonal CO_2 jets currently only recycle the dust layer that gets deposited during summer. Araneiforms then must be ancient features created during a period (or periods) of different climate.

The above reasons might explain the observed steadiness of the araneiform troughs over the last 5 martian years. However, away from the largest araneiforms and the most active areas, we have detected new shallow dendritic troughs that being created and modified at the present time.

Detections of new dendritic troughs: New troughs arranged in dendritic patterns were detected in several locations in southern polar areas. There are in total 6 different examples in 5 locations. The locations with detected changes tend to be at lower latitudes compared to the very active locations with seasonal blotches and fans that HiRISE routinely monitors. All the examples detected so far are at latitudes between -81° and -68° while most of seasonally active targets of HiRISE are between southern pole and -80◦. All the examples are in the direct vicinity of dunes. Below we discuss one case of new dendritic troughs in detail. Other examples of new dendritic troughs from different locations will be discussed in the presentation.

Figure 1 shows high-resolution close-ups of dendritic troughs that develop and evolve at (-70.4°, 178.2°). HiRISE is routinely monitoring this location to detect dune gullies' formation. The location is inside a dune field nested in a degraded crater. The location is seasonally active: it exhibits seasonal fans and blotches in early spring and multiple dust devils tracks appear during late spring. One can see albedo patches of different brightness on the frames a) - d) that are attributed to those.

Dendritic troughs shown in Figure 1 first became visible between summers of MY 30 and MY 31. Figure 1 shows the appearance and development of the structure. Panel a) shows no signs of the troughs that are visible on the panel b) and traced on the panel e). From MY 31 to MY 32 the dendritic troughs developed a more complex shape with several new tributaries: panels c) and f) show the troughs visible during the late local spring of MY 32. We show here an image taken in local summer of MY 32 to insure that the observed troughs are visible in the ice-free season and they are indeed carved in the substrate and not in the seasonal layer that might have still been present on the surface when images b) and c) were taken.

The geometry of observations slightly differs between the frames: the incidence angle of incoming

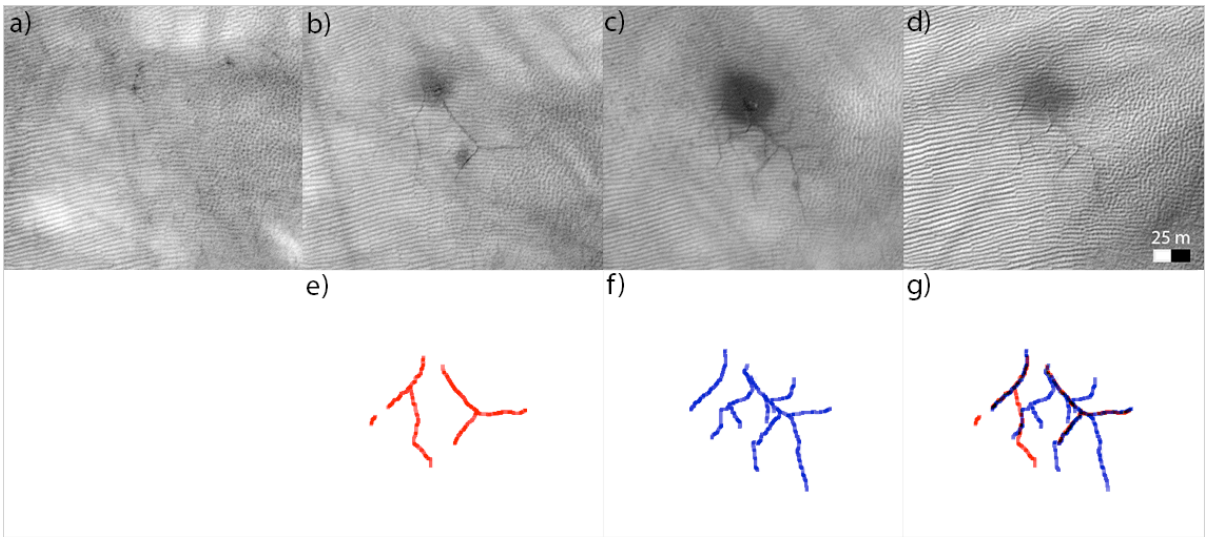

Figure 1: Development of dendritic troughs. Panels a) through d) show sub-frames of HiRISE images ESP_022255_1095, ESP_031024_1095, ESP_039912_1095, ESP_041402_1095 respectively. The images were taken at L_s =281.4° of MY 30, L_s =279.1° of MY 31, L_s =282.6° of MY 32, and L_s =348.8° of MY 32. Panels e) and f) show the new troughs traced from HiRISE sub-frames b) and c) accordingly, and panel g) is an overlap of the two.

solar light varies from 53.8° to 71.1°, phase angle from 47.7° to 68.5°. Phase functions of either dry Martian regolith or mix of Martian regolith with CO_2 ice or water ice are measured to be smooth in these ranges of phase angles [2]. The ripples visible in all frames provide additional justification that the small-scale surface features (1-10 m) must be recognizable on all images. In addition some of the troughs themselves are visible through the years as well.

A dark blotch marks the center where the troughs converge. It is first visible in MY 31 (panel b) and more extended in the following year (panel c). We interpret it as a deposit of the jet eruption that carved out the troughs. It will eventually fade away similar to other seasonal albedo features in this area.

Panel g) shows an overlay of the traced troughs from both years 31 and 32. Note that some troughs extended and new troughs developed as tributaries to the previously existing ones. Also a part of the trough from MY 31 has disappeared. This points to the partially random nature of the process acting here. This fits well with the observation that statistical variations of the physical processes lead to the development of the dendritic shapes in nature [3]. The paths taken more often create deeper troughs and become more pronounced and sometimes new path created by the statistical variation takes over to create new tributaries. In other cases new path completely exhausts some of the older ones and those degrade. The new dendritic trough is possibly an onset of a future complex and extended dendritic feature similar to araneiforms.

Discussion: Several locations in southern polar regions exhibited development of new troughs over recent Martian years. Their connection to the blotches and their fractal dendritic structure speak in favour of their relationship to the early spring jet activity. However, there are still some uncertainties. It is possible that the retreat of the dune exposes the underlying troughs that later might get active and accelerate the erosion. It is also not yet clear if the troughs are permanent features because of their proximity to the movable dune material. In the northern polar erg similar features (called furrows) were observed on top of the dunes [4]. In contrast to the northern furrows, southern dendritic troughs do not form on the main dune body, but rather in-between the dunes or on the dune boundary where the sand layer is the thinnest. In addition, dendritic troughs exhibit gradual development of their shape from one MY to the next while furrows get erased. Future observations will show with certainty if the troughs persist and expand or get erased by the next southern summer.

References: [1] H. H. Kieffer. Cold jets in the Martian polar caps. Journal of Geophysical Research, 112(E8): E08005, 2007. [2] A. Pommerol et al. Photometry and bulk physical properties of Solar System surfaces icy analogs. PSS, 59(13): 1601–1612, 2011. [3] T. C. Halsey. Diffusion-Limited Aggregation: A Model for Pattern Formation. Physics Today, pages 36–41, 2000. [4] M. Bourke. The formation of sand furrows by cryo-venting on martian dunes. 44th Lunar and Planetary Science Conference, 2013.