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Dynamical Phenomena in Martian dust storms

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We present a study of the morphology, patterns, and dynamics of dust storms on Mars observed at the edge of the North Polar cap during the Northern Hemisphere Spring Equinox from May to June 2019 (MY35) [1] and of the onset of the Global Dust Storm in May to June 2018 (MY34) [2]. The analysis is based on images obtained by the Visual Monitoring Camera (VMC) [3] and the High Resolution Stereo Camera (HRSC) [4] onboard Mars Express, and MARCI camera onboard Mars Reconnaissance Orbiter (MRO) [5-6]. VMC images were analyzed with tools described in previous works [7-8], HRSC images were analyzed from map-projections, and MARCI were processed and projected using the Integrated Software for Imagers and Spectrometers (ISIS) of the USGS [9].

The dust activity at the edge on the North Polar cap in MY35 (Ls = 28°-35°) took place around latitude 60°N in the longitude range 140°E -240°E (along Acidalia, Arcadia and Amazonis planitias). These features exhibited a rich phenomenology typical of this season with different morphologies in form of filaments and fronts, flushing storms (large arc-shaped features), compact textured storms and well developed spiral systems, sometimes mixed with water-ice clouds [1]. Here we concentrate in these last two types of features.

The textured and spiral storms are of local type (areas < 1.6×10^6 km^2)and contained cellular patterns suggestive of organized active updrafts within the storms. The cells varied in size from one storm to other: 50x20 km, 135x60 km and 70x40 km. In all cases, the cell texture is anisotropic in the horizontal size (length/width, l/w~ 2) with values well above the atmospheric scale height (H ~ 8 km). Measured local winds reached velocities from 20 to 45 ms^{-1}. The presence of storms with such different overall structure, for example in the form of compact areas on the one hand and spiral systems on the other, indicates that the underlying mechanisms are different but that above a threshold velocity, all of them generate the dust storms. We explore the action of dry convection in the formation of these patterns driven by buoyancy generated by the radiative heating of atmospheric dust.

The onset of the last Global Dust Storm (GDS 2018) took place on 30 May 2018 (Ls = 182°) at latitude ~ 33°N and longitude 342°E, following a precursor storm on 26-27 May 2018 at latitude ~

58°N and longitude 325°E [2]. The MARCI high-resolution images reveal again the presence of cellular patterns at different scales (typically 40x20 km) with a well defined frontal line marking the storm advance. The storm morphology rapidly evolved in one day showing patterns of long wave trains with wavelengths ranging from 10 to 20 km. We interpret these as gravity waves formed by intense winds flowing over craters and other topographic structures.

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