MARTIAN SOUTH POLAR TERRAINS IN SPRING: II. MODELING OF RELEVANT PHYSICAL PROCESSES. G. Portyankina[1,4], N. Thomas[1], A. Pommerol[1], K.-M. Aye[1], C. J. Hansen[2], K. Herkenhoff[3], [1]Physikalisches Institut, Universität Bern, Switzerland, [2]Planetary Science Institute, Tucson, Arizona, [3]U. S. Geological Survey, Flagstaff, Arizona ([4]portyankina@space.unibe.ch)

Introduction: During local spring southern polar terrains of Mars exhibit fast and occasionally dramatic changes. It is commonly accepted now that most of these changes are related to phenomena of CO_2 ice sublimation, such as solid state green house effect, mobility of dark particles inside the ice, and ice cleaning from dust and sand [1, 2, 3].

As described in a related abstract [4], several instruments of the Mars Reconnaissance Orbiter spacecraft monitor the surface of Martian south polar terrains. Among the observed phenomena are general surface brightening at L_S = 190-220°, dark fans, bright halos. While related observations are described in details in [4] in this work we summarize our attempts to model various physical processes that shape the surface of southern polar terrains during spring.

Surface brightening: In the period L_S = 190-220° (with slight variations for different locations) the south polar terrains' surface progressively becomes brighter. At the same time CO_2 ice spectral features become stronger.

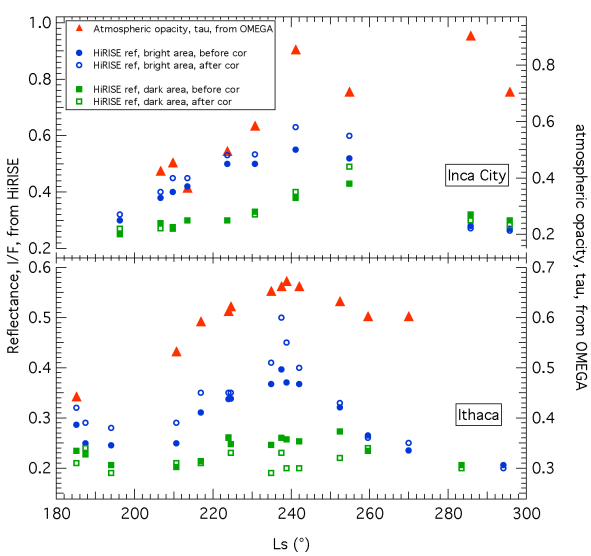

Figure 1: Spring evolution of the surface reflectance of dark fan and bright areas in two locations (Inca City and Ithaca) as observed by HiRISE. Surface reflectance is corrected for incidence angle and atmospheric scattering effects. Red triangles are atmospheric opacity over the same areas as estimated from OMEGA observations. Atmospheric opacity is in correlation with surface brightness.

Our favourite explanation for these observations is: in an environment that supports CO_2 ice sublimation, a top ice layer that is highly contaminated by dark polagonite particles (dust and sand) gets cleaned. Dust and sand that are imbedded in the ice migrate either upward and get carried away by an upward flux of subliming CO_2 or downward, becoming harder to be detected. The former case would also explain the increase of atmospheric opacities in south polar areas that happens simultaneously to the surface brightening. (Fig. 1)

Dark fans: Dark fans appear already on the very first spring images of south polar terrains [1, 2]. While spring progresses the number of fans increases [1]. It is commonly accepted that these fans are produced by jets of sublimed CO_2 coming from underneath the ice layer. This sublimation is enabled by the ice being transparent enough for the solar radiation to reach the dark substrate underneath the ice, starting the sublimation bottom up. While this CO_2 gas flows towards any fracture in the ice that allows it to escape to the atmosphere to form a jet, it collects substrate material and transports it to the top of the ice depositing the observed dark fans.

We investigated the behaviour of the jets from the point of view of fluid dynamics to determine the influence of several parameters (outflow mass and velocity, vent geometry, slope, and wind) on the structure of the gas jet and the resulting deposition pattern of dust. The expansion of the gas through a tube to a vent and into the ambient atmosphere has been calculated. We have included dust in the model (including a dust size distribution) with the drag being calculated including the feedback on the gas flow field. The simulations of the gas flow beneath the ice slab were run in a steady-state, i.e. if sub-surface sublimation were matched by outgassing from a vent without pressure build-up (the latter requires temporary sealing of the vent). An example of the deposition pattern produced by a jet in this model is shown in Fig. 2. The particle deposition pattern is shown to be size-dependent and being strongly affected by the relative influence of wind and slope. In the presence of a moderate wind (4-6 m/s), smaller particles are transported furthest from the vent because of their stronger coupling to the bulk flow of the atmosphere.

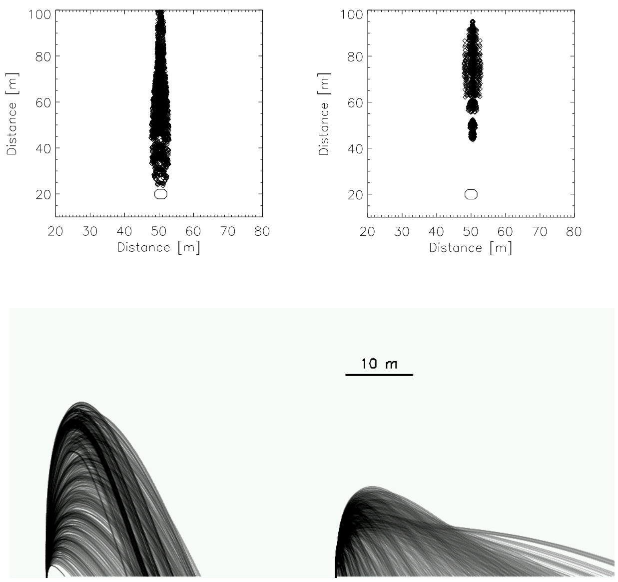

Figure 2 Ejected particles deposition pattern (top) and trajectories (bottom). Left: no wind on 20 degree slope. Right: no slope with a 6 m s^{-1} wind from the left. Other parameters of both jets (i.e. mass inflow flux, pressure and velocity of the gas in the bottom of the outflow vent, etc.) are identical. The wind modifies the particles heights and trajectories thereby influencing where particles of different size are deposited.

Bright halos: Bright halos are observed by HiRISE on the exactly same spots where dark fans appear first (see [4, 5] for the observational details). It is highly unlikely that re-condensation (or any other process that is not directly related to the surficial dust/sand cover) is responsible for such a precise substitution of dark material by the bright. Additionally, we need to explain the recently discovered re-appearance of the bright halos in Inca City during one single season [4].

We propose that the bright halos are the result of a process that is similar to the one responsible for surface brightening discussed above, i.e. particle migration inside CO_2 ice.

As was shown in [6], the speed with which a particle moves inside the ice depends on a variety of parameters, most importantly: solar radiation flux, ice and particle albedos, and thickness of the ice and dust layers. The same parameters control the CO_2 ice sublimation rates of the top layer. During spring these parameters gradually change and this leads to different ratios between ice sublimation rate and speed of particles sinking through the ice. When particles are sinking faster than the ice sublimes bright halos appear first in the areas where the layer of particles is thinnest (i.e. further from vents and thereby around fan deposits). Later, when the sublimation of ice becomes more efficient (for example, because of an increase in duration of solar exposure), the particle layer becomes exposed to the surface again, making the halo disappear. A repetition of this process would explain the reappearance of the halos later in the season.

References: [1] Thomas, N. et al. (2010) *Icarus* 10.1016/j.icarus.2009.05.030 [2] Hansen, C.J. et al (2010) *Icarus* 10.1016/j.icarus.2009.07.021 [3] Thomas, N. et al., (2011) *Icarus, in press.* [4] Aye, K-M. et al. (2011) *in these proceedings*. [5] Pommerol, A. et al (2011) *submitted to JGR.* [6] Portyankina, G. et al. (2010) *Icarus* 10.1016/j.icarus.2009.08.029.