CORRELATION OF RETREATING MARTIAN SOUTH POLAR CO2 ICE CAP WITH LOW ALTITUDE CLOUDS: A CONTROL ON ANNUAL ACCUMULATION. I. B. Smith[1] (isaac.smith@lmd.jussieu.fr), A. Spiga[1], John W. Holt[2], [1]Université Pierre et Marie Curie and Laboratoire de Météorologie Dynamique, [2]University of Texas Institute for Geophysics, Austin, Texas.

Introduction: Both Mars' north and south polar layered deposits (NPLD and SPLD) comprise the majority of surface ice on Mars and offer a historical record for understanding recent climate. Of importance, the deposits undergo seasonal variability, between winter (when CO_2 ice frost covers the polar regions) and summer (when the CO_2 ice has sublimed) [1].

Recent evidence has shown that winds and atmospheric deposition played major roles for forming the spiral troughs that cover the NPLD [2, 3]. Observations of low altitude clouds and atmospheric modeling [2], radar stratigraphy [3], and surface morphology [4] demonstrate that ice is transported across the NPLD by wind to form and modify the troughs. We find that the same processes occur on the SPLD and that seasonal retreat of high speed winds near the CO_2 seasonal ice cap boundary are responsible for where clouds manifest and where ice accumulates inter-annually.

Methods: We analyze ~10,000 Thermal Emission Imaging System (THEMIS) images from Mars years 26 - 31 to find ~500 near surface trough clouds (Fig. 1). The survey includes dates from L_s 190° to L_s 330°, temporally. Spatially, the entire SPLD is included.

To simulate atmospheric conditions on the SPLD, we use a mesoscale model developed at the Laboratoire de Meterologie Dynamique [5]. Comparable to simulations that have been conducted on the NPLD [2, 5], wind speed, wind direction, and temperature are output every hour for an equally divided "24 hour" Mars day. We simulate the conditions at several dates: L_s 230°, 260°, 290°, and 330°.

Our simulations cover the entire SPLD and surrounding regions: ~1800 km by 1800 km centered on 86° south and 173° east. The grid is 101 by 101 cells, yielding a resolution of ~18 km per cell. At this resolution the general topography of the SPLD is represented, but smaller features are not present.

It is particularly important to account for the evolution of the seasonal CO_2 ice deposit, which fixes the surface temperature to ~148 K. As was shown by [6, 7], near-surface regional winds over Martian polar caps are controlled by both topography and surface temperature, hence CO_2 (Fig. 2). We prescribe the CO_2 seasonal deposit that evolves by L_s date according to infrared measurements of the surface temperature [1].

Observations: Spatially, trough clouds are found at all latitudes of the SPLD, manifesting near topographic changes, *e.g.* where slopes decrease (Fig. 1). Trough clouds are observed as early as L_s 198°, and as late as L_s 318° (Fig. 2) over a range of ~120° L_s. Clouds at lower latitudes occur earlier in the spring, and clouds of higher latitudes appear later, revealing a southward progression of SPLD clouds (Fig. 2 m1-m4).

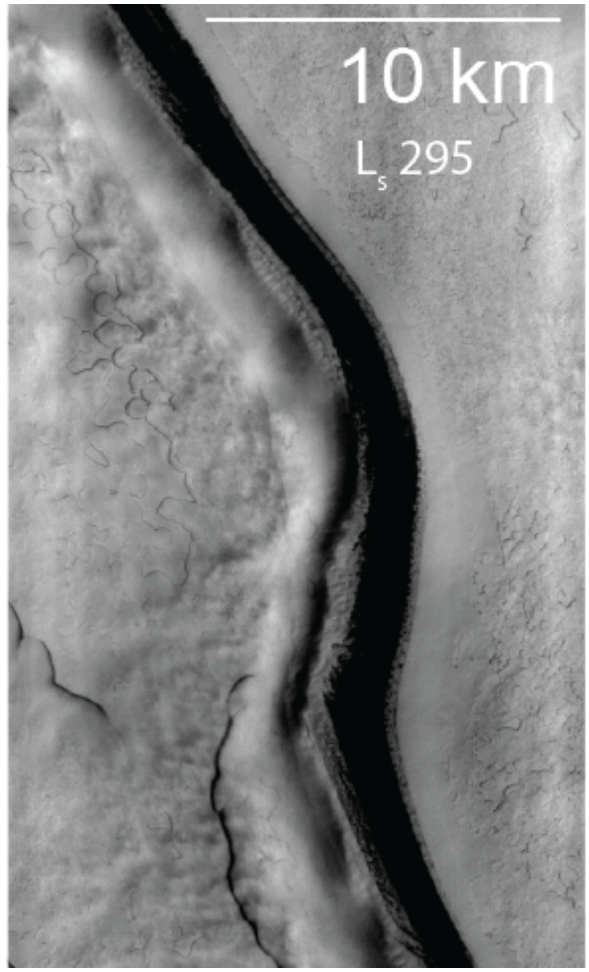

Fig. 1: *THEMIS VIS image V41808006 exhibiting a trough cloud near Australe Mensa. Clouds is found just above the lowest portion of the trough and later than clouds in other regions.*

Approximately half of all clouds, including all clouds between L_s 290° and 318° are found near Australe Mensa and the residual CO_2 ice cap. Clouds detected 50° after the local summer solstice are unexpected when compared to the NPLD, where clouds are only found until about 10° after the solstice [2].

Mesoscale model: We simulate the surface temperature and wind 20 m above SPLD the surface. Near-surface winds undergo a moderate daily cycle, so we focus our analysis on comparing winds at various seasons for a fixed local time, 23h. On a seasonal basis, the fastest winds on the SPLD are often found in the vicinity of the seasonal CO_2 ice boundary. As the season progresses the seasonal cap retreats towards the pole, along with the fastest winds (Fig. 2 t1-t4).

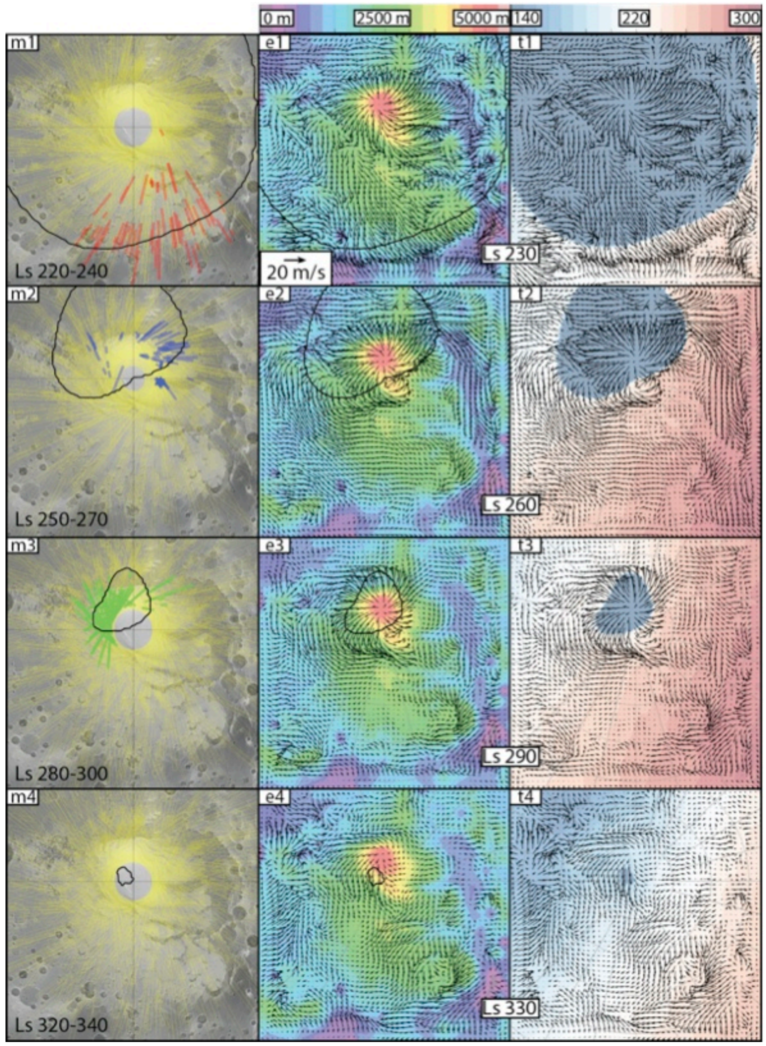

Fig. 2. *Maps of SPLD for cloud detections and wind speeds corresponding to topography and temperature. m1 – m4: Cloud detections (in red, blue, and green) overlaying available THEMIS image footprints (yellow). Cloud detection is not limited by coverage. A poleward progression of cloud detections is detected as date increases. Solid black line corresponds to the CO_2 seasonal ice extent. e1 – e4: Map of SPLD wind vectors 20 m above the surface overlying colorized topography. Winds generally have higher velocities near strong slopes. t1 – t4: Map of SPLD wind vectors 20 m above the surface and surface temperature. CO_2 seasonal ice (and ~148 K fixed surface temperature) retreats as the season progresses [1]. The highest wind speeds and clouds are detected where strong thermal contrasts meet with steep slopes and high water vapor content.*

Our mesoscale simulations reveal that topographic heights of the SPLD primarily drive slope-wind (katabatic) circulations, e.g. [5]. This existing circulation is reinforced by an additional thermally-direct circulation, explaining why enhanced winds are mostly found in the vicinity of the CO_2 seasonal ice boundary.

In the simulation for L_s 290° the ice line is located so that the slope winds produced by the SPLD topography are optimally enhanced (up to 20 ms^{-1}) by thermally-direct circulations caused by a nearly 100 K thermal contrast. Later in the season, at L_s 320°, the thermal contrast is significantly reduced, causing no near-surface winds to be predicted above 10 ms^{-1} in the model.

The relationship between strong winds and trough clouds at high latitudes is less clear at L_s 230°, when winds are modeled to be extremely fast, but no trough clouds are detected. We find that strong winds are necessary but not sufficient condition for trough clouds to form. The water vapor mixing ratio in the atmosphere must be higher, but the cold trap of ground water ice is very effective at L_s 230°, explaining low water vapor mixing ratios in the atmosphere, and consequently the absence of trough clouds near the pole.

Conclusions: Winds are very fast near the boundary between the seasonal CO_2 ice line and the exposed SPLD. As the ice line retreats poleward during warm months, so do the fast winds. Where the winds are fastest and water vapor availability is high, trough clouds are expected to form. Our observations of cloud appearances matches well with the location of the ice line and fastest modeled winds.

This work, in combination with detailed stratigraphic analysis from ground penetrating radar [9] indicates that sites of deposition and retention of ice on the pole coincide with where clouds form. Thus clouds influenced by the retreating CO_2 seasonal cap tell us where annual and long-term accumulation occurs. Regions with many clouds have thicker recent deposits, while those with no clouds have little or no recent accumulation. It is possible, and eventually testable with adequate modeling, that trough morphology is dependent on a seasonal CO_2 ice cap and that the troughs themselves may require a seasonal cap to initiate.

Acknowledgements: We thank NASA grants NNX10AT24H and NNX10AO26G, the Jackson School of Geosciences, the William J. Fulbright Foundation, and the JMARS and SHARAD science teams.

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