MARS LOW ALTITUDE POLAR CLOUDS AS A DIAGNOSTIC TO POLAR PROCESSES. T. N. Titus¹, K. E. Williams¹, and G. E. Cushing¹. ¹U.S. Geological Survey Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86004, US.

Introduction: Mars polar processes are dominated by the exchange of the predominately CO₂ atmosphere and the seasonal CO₂ ice caps (e.g. [1-4]). This process is generally referred to as the CO₂ cycle. H₂O, even though it only comprises ~100 ppmv, also cycles in and out of the seasonal polar caps. The H₂O is cycled between the surface as ice and the atmosphere as both vapor and ice. Ice clouds are observed over the spring-time seasonal cap. This presentation will focus on these observations over the northern cap.

Background: The CO₂ and H₂O cycles are intimately coupled as H₂O can be cold trapped on top of colder seasonal CO₂ and the H₂O ice can modify the CO₂ ice sublimation rates, primarily by changing the effective surface emissivity (e.g. [5-6] and references within).

Observations of the receding seasonal northern CO₂ cap have shown an annulus of H₂O ice that surrounds the CO₂ cap throughout much of the northern spring [7-10]. As the annulus of H₂O ice sublimes, the H₂O vapor can be transported over the CO₂ cap edge where it is cold trapped as a layer of H₂O ice [11-13]. This layer can be optically thick, thus hiding the spectral signature of the underlying CO₂ ice. This layer of H₂O ice has been observed to extend across much of the interior CO₂ cap [9-10], thus raising the question – is the H₂O delivered to the interior of the cap by the same process as near the edges?

Data: The Mars Odyssey spacecraft is currently in an orbit that allows for early morning observations. Onboard Odyssey is the THERmal Emission Imaging System (THEMIS) [14] which contains both a multiband thermal infrared imager and a multiband visible imager. These instruments enable us to look for morning clouds over the seasonal cap. Lee clouds are clouds that form near the surface and have a wave-like structure that is caused by winds blowing over a topographical obstacle. Thus, lee waves can be used to determine wind direction. The lee clouds are also composed of H₂O ice (based on THEMIS IR observations). Therefore, the lee clouds are a tracer of H₂O circulation above the seasonal polar caps. Examples of lee clouds observed by the Odyssey THEMIS VIS camera are shown in Fig. 1.

![Figure 1: Topographically induced atmospheric lee waves. Each panel shown is ~ 18 km wide. Left panel shows waves in H₂O clouds south of Escorial crater. Right panel shows waves in possible CO₂ ice clouds northeast of Koralev crater. Credit: [15] Fig 3.](image)

Results: THEMIS observations of clouds were categorized by type. The lee clouds were used to identify wind direction. Figs. 2 & 3 show the clouds observed by THEMIS during the northern spring of Mars Year (MY) 33. The location of the CO₂ seasonal cap edge and the H₂O annulus edge are shown for reference. Near surface fog and ice-clouds are wide spread suggesting the H₂O vapor source is regional and not local.

Morning observations. Fig. 2 summarizes the morning observations. Wind directions, as indicated by the lee clouds show a general southward flow, which is...
consistent with polar sublimation winds. The clouds are not only along the cap edge but also deep in the interior. Since the clouds indicate a southward flow, what was the source of the H$_2$O that formed the clouds? CO$_2$ seasonal ice is still on the ground at a temperature ~148 K. H$_2$O ice surface layer temperatures would be buffered by the underlying CO$_2$ ice, which makes vigorous sublimation of the H$_2$O ice unlikely. If the H$_2$O source is not from below and the winds are blowing outward towards the cap edge, not from the cap edge, then the source is mostly likely atmospheric. A polar cell (similar to the Hadley or Farrell cells but focused in the polar regions) could be bringing H$_2$O vapor from the lower latitudes (e.g. seasonal cap edge) and depositing that vapor over the interior of the cap where the atmosphere is sufficiently cold to form new ice-clouds.

_Afternoon observations._ Fig. 3 shows the afternoon observations. Far fewer lee clouds are observed suggesting that the afternoon atmosphere is not conducive for lee cloud formation but that other near surface clouds and ice-fog can still form.

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**References:**