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Changes in Ice Cloud and Gas Emission at Titan's South Pole as Winter Nears

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Abstract

As winter approaches in Titan's south, dramatic changes in atmospheric infrared emissions are taking place near the pole. An ice cloud seen only in the north by Voyager and Cassini [1-4] became visible near the South Pole in July 2012 [5]. In the north, emission from the ice cloud located at 220 cm^{-1} in far-infrared spectra from Cassini's Composite Infrared Spectrometer (CIRS) [6] has been gradually decreasing since the beginning of the mission [4]. In the northern winter shadow when the stratospheric temperature minimum was deepest the ice cloud resided at 100-150 km altitude. The onset of the ice cloud in the south was quite sudden and concurrent with the formation of a polar cloud at higher altitude (360 km) seen by the Imaging Science System (ISS) on Cassini [7]. After 2012 the southern ice cloud grew rapidly and at present has reached an emission intensity rivaling that seen in the winter north at the beginning of the Cassini mission. In mid-2013 the South Pole emission began to exhibit a distinct collar morphology. By early December 2013 the radius of this emission ring was about 10 degrees in latitude. The radius had expanded by 6 degrees between July and December 2013. The ring's center was shifted from the pole toward the Sun by 4 degrees. Minor stratospheric gases had a similar collar structure near the South Pole and also a central peak, again shifted 4 degrees from the pole.

At high southern latitudes the temperatures at 1 mbar drop steeply and reach a minimum at 80-90 S. The collar structure we see in the ice cloud and gases might be produced by material concentrated near the pole in combination with a steep drop in temperature toward the pole. The recent amassing of gases and condensables at the South Pole is probably the result of the seasonal reversal of atmospheric circulation. We find that the temperature field in the south as winter nears is also shifted from the pole toward the Sun by 4 degrees. The 4-degree shift of the ice cloud and gas collars, together with the temperature field, is consistent with the atmospheric tilt reported by Achterberg et al. [8]. Over the Titan year the atmospheric tilt axis appears to remain inertially fixed, i.e., stationary with respect to the stars, but its orientation is such that as solstice approaches the tilt at the winter pole is toward the Sun. Achterberg et al. conjectured that the tilt arises from a feedback between atmospheric circulation and solar heating. We further suggest that the feedback is strongest in advance of solstice, reinforcing the tilt at that time. CIRS will follow the evolution of the ice cloud and gas emission collars as Titan progresses toward winter in the south.

References

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