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Autumn at Titan's South Pole: The 220 cm^{-1} Cloud

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Abstract

Beginning in 2012 an atmospheric cloud known by its far-infrared emission has formed rapidly at Titan's South Pole [1, 2]. The build-up of this condensate is a result of deepening temperatures and a gathering of gases as Winter approaches. Emission from the cloud in the south has been doubling each year since 2012, in contrast to the north where it has halved every 3.8 years since 2004. The morphology of the cloud in the south is quite different from that in the north. In the north, the cloud has extended over the whole polar region beyond 55 N, whereas in the south the cloud has been confined to within about 10 degrees of the pole. The cloud in the north has had the form of a uniform hood, whereas the southern cloud has been much more complex. A map from December 2014, recorded by the Composite Infrared Spectrometer (CIRS) on Cassini, showed the 220 cm^{-1} emission coming from a distinct ring with a maximum at about 80 S. In contrast, emissions from the gases HC_3N, C_4H_2 and C_6H_6 peaked near the pole and had a ring at 70 S. The 220 cm^{-1} ring at 80 S coincided with the minimum in the gas emission pattern. The 80 S condensate ring encompassed the vortex cloud seen by the Cassini Imaging Science Subsystem (ISS) and Visible and Infrared Mapping Spectrometer (VIMS) [3, 4]. Both the 220 cm^{-1} ring and the gas "bull's-eye" pattern were centered on a point that was shifted from the geographic South Pole by 4 degrees in the direction of the Sun. This corresponds to the overall tilt of Titan's atmosphere discovered from temperature maps early in the Cassini mission by Achterberg et al. [5]. The tilt may be reinforced by the presumably twice-yearly (north and south) spin-up of the atmosphere at the autumnal pole.

The bull's-eye pattern of the gas emissions can be explained by the retrieved abundance distributions, which are maximum near the pole and decrease sharply toward lower latitudes, together with temperatures that are minimum at the pole and increase toward lower latitudes. The increasing temperatures overcome the decreasing gas abundances to produce emission in the narrow range around 70 S. This cannot, however, explain the maximum of emission at 80 S from the condensate ring. The coincidence at 80 S of the 220 cm^{-1} peak with the gas emission minimum may indicate where the condensation is taking place. The central, polar minimum in the cloud emission may be due to faster rain-out and smaller extinction cross-sections. Spectral maps from 2013-15 [6] show that the gas emission pattern has been evolving quickly, with noticeable changes from one flyby to the next (about one month). The bull's-eye structure appears to have been most prominent in early 2014 and by late 2014 the pattern was becoming more uniform. As Titan progresses through late southern Autumn we expect the morphology of the condensate cloud to take on a hood-like distribution similar to that in the north.

References:
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