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# Evolution of Titan’s Fall and Winter Polar Hood Cloud

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Fall and winter on Titan are marked by the formation and persistence of a vast polar “hood” cloud, covering the cold pole and extending equatorward as far as 40° latitude [e.g., 1]. Extending from the upper troposphere into the lower stratosphere, a polar hood cloud was present in the northern hemisphere during the Voyager I flyby and then again when Cassini arrived during the next northern winter in 2004 ($L_s$ ~ 290°) [2]. Although the full lifecycle of Titan’s polar hood cloud has not been observed, the Cassini mission provided observations of the north polar hood from mid-winter through northern spring, as well as observations of south polar clouds that started forming early in southern fall. In 2012 ($L_s$ ~ 32°), near-infrared imagery from early southern fall revealed the formation of a vast south polar cloud near the top of the stratosphere, over 150 km higher than any previously observed cloud [3,4]. By combining observations of south polar fall with observations of north polar winter and spring, others have started to construct a story of the formation, evolution, and dissipation of Titan’s polar hood [1]. Despite the polar hood cloud’s optical thickness, details of the cloud composition remain vague. While signs of HCN, benzene, and cyanoacetylene ices have been identified in this fall south polar cloud, and radiative transfer retrievals indicate the presence of mixed ices, the abundances of less radiatively active species like methane or ethane is not as well constrained [2]. We contribute to the story of the polar hood lifecycle using a combination of cloud microphysical modeling and image analysis [5,6]. Through careful analysis of imagery, we track south polar cloud’s spatial evolution and find that it descends from an altitude of about 300 km in 2012 to below 230 km by 2016 ($L_s$ = 79°), while expanding equatorward following the terminator [6]. We show using microphysical modeling that a pure HCN cloud with the observed characteristics [3,4] requires temperatures below 110 K at an altitude of 300 km over the pole [5]. Finally, using simulations of several additional volatile species, we trace the evolving chemical composition, and estimate the impact of condensation and precipitation on the stratospheric volatile budget.

[1] Le Mouelic et al. 2018, Icarus, 311, 371–383. [2] Anderson et al. 2018, Space Sci Rev, 214, 125. [3] West et al. 2016, Icarus, 270, 399. [4] de Kok et al. 2014, Nature, 514, 65. [5] Hanson et al. 2023, Planetary Sci J, 4, 237. [6] Hanson et al. 2025, Geophys Res Lett, 52, e2024GL113415.