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Thermal Structure of Pluto's Lower Atmosphere

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Abstract

Prior to the New Horizons (NH) encounter with Pluto it was expected that the atmosphere was composed primarily of N2 with a significant abundance of CH4, that the atmospheric temperature rose rapidly from a surface temperature of ~36 K to ~105 K near ~0.1 Pa and that this high temperature powered an escape rate of 10^{27} s^{-1}. The composition and rapid temperature rise were confirmed but it was also discovered, through NH and Alma observations, that the atmospheric temperature dropped from its maximum of 105 K to a 70-80 K in the upper atmosphere and that, as a consequence, the atmospheric escape rate was orders of magnitude smaller than predicted. We investigate this problem by constructing non-LTE radiative-conduction models for the thermal structure of Pluto's atmosphere based on the observed CH4 abundance as well as species produced by photolysis of CH4 and N2, including C2H2, C2H4, C2H6, and HCN. We find that that temperature drop from 105 K to 70-80 K can be explained by radiative cooling by C2H2, C2H6, and HCN. Cooling by undetected species, such as H2O, is not required. We will also discuss the uncertainties in calculations of the radiative cooling rate and the implications for the escape rate at other phases of Pluto's eccentric orbit.