ON THE EQUILIBRIUM STATE OF PLUTO’S SURFACE ICE. L. M. Trafton¹, S. Tan², J. A. Stansberry³. ¹University of Texas at Austin, Austin, TX, ²Planetary Science Institute, Tucson, AZ, ³Space Telescope Science Institute, Baltimore, MD

Pluto’s surface volatile inventory is dominated by the gaseous and solid phases of N₂ and CH₄. Simulation of the composition of these phases under 3-phase thermal equilibrium (i.e., between the gaseous and two solid phases) results in an atmospheric CH₄ mixing ratio far less than observed. For example, between 37K and 40K, the surface pressure under thermal equilibrium would vary from 11.5 to 62 µbar, and the atmospheric CH₄ mixing ratio from 0.0048% to 0.0102% [1]. This is compared to the observed values of 12.8 µbar and 0.3% [2, 3]. The equilibrium CH₄ mixing ratio is far less than observed over the plausible range of temperatures set by the global radiative balance of the N₂-rich ice with insolation [4, 2]. Under 2-phase equilibrium, in the case where the N₂-rich solid phase is absent, a temperature of 42.5 is required at the observed pressure of 12.8 µbar for the mixing ratio to reach the observed value. This would be 4-5K warmer than the regulated N₂-rich regions, [2]. However, the N₂-rich regions appear to be significantly undersaturated [5, 6], which is inconsistent with a surplus atmospheric CH₄ mixing ratio under thermal equilibrium.

The thermodynamics of these two ice regions are connected globally through interaction with the atmosphere. Unlike 3-phase equilibrium, which is fixed by just the temperature or pressure, 2-phase equilibrium requires two thermodynamic variables to fix the state of the ice, such as pressure and mole fraction [7, 1]. We investigate the contradiction between the excess atmospheric CH₄ concentration and the apparent lack of saturation in the N₂-rich ice in terms of the composition of a thin, CH₄-rich boundary layer on the N₂-rich ice surface near thermal equilibrium.

References: