Dynamic Global Atmosphere Simulations of N_2 Condensation Flows on Triton from Equinox to the Voyager 2 Fly-by

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Triton's atmosphere is cold enough for molecular nitrogen (N_2) to condense out and freeze on its surface. Triton's tenuous, predominately N_2 atmosphere is in vapor pressure equilibrium with frozen N_2 on its surface with a surface pressure in the range of 10 -20 μbar or 1 to 2 Pa [1,2]. The transport of volatile N_2 along Triton's surface is both affected by atmosphere dynamics and in turn drives global circulation patterns. Global variations in the distribution of N_2 frosts lead to condensation flows, which are flows arising from the uneven spatial distribution of N_2 frost sublimation and condensation. In general, N_2 frosts sublime away on the sunlit hemisphere and condense on the darkened hemisphere and this pattern changes with changing seasons. Voyager 2 images of active geysers on Triton during its August 1989 fly-by provide direct evidence of wind speed and direction of Triton's atmosphere as a function of height [3,4]. These winds have been interpreted as caused by condensation flow of N_2 away from Triton's illuminated southern hemisphere during late southern spring [5].

We modeled condensation flows on Triton at several points along its orbit between the 1952 equinox and the 1989 Voyager 2 fly-by with a modified version of the NASA Ames Mars General Circulation Model, version 2.0. The Ames GCM incorporates several physical processes critical to modeling the atmosphere of Triton, including condensation and sublimation of the main atmospheric constituent gas as well as subsurface storage and release of heat. We altered the Ames GCM to simulate conditions found on Triton. These alterations included changing the size, rotation rate, orbital inclination, surface gravity, and distance to the Sun of the parent body to model the appropriate insolation over time. We also changed the gas properties from those of a CO_2 atmosphere in the original Ames GCM to those of an N_2 atmosphere, including appropriate values for latent heat, specific heat, and the proper vapor pressure-temperature relationship for N_2 frosts. We chose albedo and emissivity values for N_2 frost from published values based on global thermal simulations of Triton [6] and established a stable average surface pressure of 18 μbars over 300 Triton days given an initial global covering of 20 cm of N_2 frost. Our simulations did not include atmospheric radiative heat transfer, but did include conduction, convection, and surface-boundary layer heating. We ran simulations both with and without a Newtonian heating/cooling code using latitudinally varying pressure-temperature profiles. We present simulation results of averaged zonal and meridional winds and temperature profiles up to three scale heights, or approximately 50 km, above Triton's surface. This study was funded by a NASA Earth and Space Science Fellowship through grant number NNX09AQ96H.

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