A GENERAL CIRCULATIO MODEL OF TRITON'S ATMOSPHERE. A. M. Zaclucha[1] and T. I. Michaels[2], [1,2] SETI Institute. Corresponding author email azalucha@seti.org.

Introduction: Triton's atmospheric composition is primarily N_2, with trace amounts of, CH_4, CO, and CO_2 [1–3]. It has a rotation rate of about 6 Earth days and a surface pressure of order microbars [4]. Additionally, Triton receives weak insolation and is thought to have a condensation cycle like Mars [5]. Triton appears to be quite similar to Pluto, which is gaining attention due to the New Horizons flyby in July of 2015; thus both bodies should be studied in tandem.

A great deal of information was learned about Triton during the Voyager 2 flyby in 1989: two plumes that sheared off at 8 km altitude [6], a terminator cloud at 5 km altitude [7], crescent streaks at 1–3 km altitude [7], and surface (<1 km altitude) streaks that potentially indicate wind direction at these altitudes [7]. Subsequent analysis was performed on the surface wind streaks by [7] to determine wind direction, and a variety of dynamical features were analyzed using “back of envelope” calculations by [8].

Several stellar occultations were observed in the 1990's [9], but most notably the occultation observed 4 November 1997 [10] had the best signal to noise. To further explain the Voyager 2 observations and the 1997 stellar occultation, we have developed a 3D general circulation model (GCM) of Triton's atmosphere.

Model: The Triton GCM (TrGCM) is based on the Massachusetts Institute of Technology (MIT) GCM dynamical core [11]. The MIT GCM solves the primitive equations of geophysical fluid dynamics under the assumptions of conservation of mass, the ideal gas law, and conservation of energy (in the presence of an external source and sink term) on a sphere using the finite volume method. The model is hydrostatic in the vertical and compressible. The vertical grid is based on an eta coordinate and the surface topography is flat. Boundary layer friction is represented by a simple drag law (linearly dependent on the horizontal velocity) that decreases with height, reaches zero at the top of the boundary layer, and is zero at all levels above. The composition of the atmosphere is assumed to be primarily N_2, with trace amounts of CH_4 that is radiatively active but not advected. In this version of the model, mass is not permitted to be exchanged between the surface and the atmosphere. When the atmospheric temperature is diagnosed to fall below the N_2 freezing temperature, it is instantaneously reset back to the freezing temperature. Surface thermal inertia and albedo are globally and temporally constant. Surface temperature is held at the N_2 freezing temperature. We use the radiative-conductive scheme of [12] to calculate the external heating and cooling terms due to CH_4 at 3.3 and 7.6μm, respectively, and molecular conduction. This scheme captures non-local thermodynamic equilibrium effects and the sharp stratospheric temperature inversion, while being computationally practical in a GCM.

Results: Figure 1 shows the TrGCM results for the zonally averaged zonal wind on Triton on 4 November 1997. The TrGCM shows that the lowest ~5 km of Triton's equatorial atmosphere is characterized by relatively weak zonal winds, before a sharp increase in wind speed above this altitude. This behavior is very similar to the Voyager 2 observation of plumes on Triton that extended to 8 km altitude before being blown downstream [6]. At the time of the Voyager 2 encounter, [8] used Ekman layer theory to predict an anticyclone at the south pole. Anticyclonic flow corresponds to flow opposite to the body's rotation, or in this case westerly. Our TrGCM results do show westerly flow at the south pole (poleward of ~60°), but the wind speed is less (<0.5 m/s) than the [8] estimate of 5 to 15 m/s.

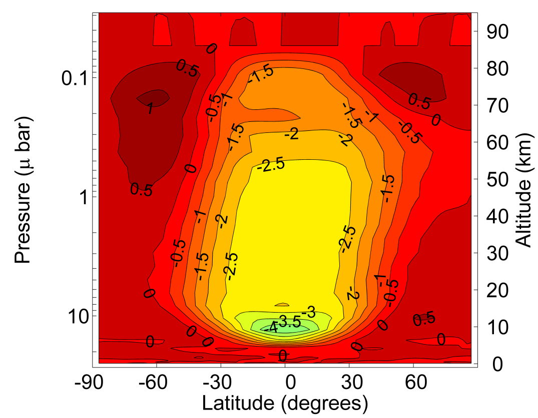

Figure 1: Zonally averaged zonal winds on Triton

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