a function of temperature and strain rate (or stress), necessitating a precise definition of the Rayleigh number in terms of a reference temperature and strain rate (or stress). In this thesis, the Rayleigh number is always defined at the melting temperature of ice. A reference strain rate $\dot{\varepsilon}_o = \frac{\kappa}{D^2}$ is used in Chapter 2. In Chapters 3 through 5, a reference strain rate of $\dot{\varepsilon}_o = 10^{-13}$ s^{-1} is used, largely for algebraic convenience.

The definition of the reference strain rate, and thus, the reference Rayleigh number, is somewhat arbitrary, so the values of Rayleigh number used in simulations with a composite rheology for ice I may seem counterintuitive (for example, $Ra_o = 10^{-2}$) when the grain size of ice is large and the ice becomes strongly non-Newtonian. In a non-Newtonian fluid, as the fluid begins to flow and convection starts, the viscosities in the fluid layer decrease. The viscosity in the convecting sublayer may be several orders of magnitude lower than the reference viscosity. A more physically intuitive definition of Rayleigh number in the non-Newtonian case is the effective Rayleigh number:

$$Ra_{eff} = \frac{Ra_o \eta_o}{\langle \eta \rangle} \tag{1.24}$$

where the average viscosity in the convecting sublayer ($\langle \eta \rangle$) can be calculated after the convection simulation is run.

The temperature in the fluid layer is rephrased in non-dimensional coordinates (primed quantities) using the temperature difference between the base of the ice layer and the surface of the layer,

$$T' = \frac{T - T_s}{T_m - T_s}, \tag{1.25}$$

where T_m is the melting temperature of ice, and T_s is the surface temperature on the icy satellite. The warm base of the ice shell at $z = -D$ is held at a non-dimensional temperature $T' = 1$, and the surface is held at $T' = 0$. The spatial coordinates in the fluid layer are non-dimensionalized using the thickness of the ice shell,

$$x' = \frac{x}{D} \tag{1.26}$$

$$z' = \frac{z}{D}. \tag{1.27}$$