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Rayleigh-Bénard convection in the subsurface ocean of Ganymede.

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Introduction: Jupiter's icy moon Ganymede is widely known not only for its large dimensions, overcoming those of Mercury, but rather for its possible subsurface ocean that could be the greatest liquid water reservoir of the entire Solar System covering about the 50% of the whole satellite. The presence of liquid water is one of the main necessary conditions for life as we know making Ganymede one of the main targets for Solar System exploration [1,2]. The ocean that seems to be more than 100 km deep is confined by two ice layers with the upper one made by ice I and the lower one made by high pressure ice V or VI. In addition, Ganymede owes several characteristics such as a magnetic field, a complex internal structure, and a geologically interesting surface that make the satellite a primary target for the geosciences. It is thus important to investigate the possible geophysical and fluid dynamical processes ongoing in Ganymede’s putative ocean, such as convective motions that can lead to interactions between different interior layers and ocean mixing.

Methods: Icy moons’ oceans such that of Ganymede are known to be heated from below facilitating convection that could transport enough heat to melt the upper ice layer. In this perspective, we explored the (expectedly turbulent) convective dynamics of a portion of the hidden ocean. We considered a Newtonian fluid layer, set in a 3D box with thickness D and horizontal sides 2πD, subject to Rayleigh-Bénard convection. Periodic boundary conditions are used on the vertical boundaries at x=0, 2πD, and y=0,2πD while boundary conditions on temperature, salinity, and velocity on the horizontal boundaries are set with proper equations according to the case study. Gravity is aligned with the vertical direction, and it points opposite to the z axis. The model includes rotation that can be set at any direction in the y-z plane. The fluid density is a function of temperature and salinity; here we first use the Boussinesq approximation so that density becomes independent of pressure, and subsequently we consider a situation where the unperturbed state is compressible while density perturbations are kept incompressible. Once the theoretical model has been defined, simulations are carried out using RBSolve [3,4], a 3D Navier-Stokes Fortran code in the Boussinesq approximation.

Aims: This study will lead to a better understanding of planetary geophysics and comparative oceanography. In addition, investigating subsurface ocean circulation and its effects on the upper and lower layers of ice will lead us to astrobiological constraints on how a possible Ganymede’s environment could work.

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