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To move or not to move: The thermal and dynamic state of Europa's ice shell

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Europa's hydro- and cryosphere is of primary interest in the quest for habitable environments in the solar system (e.g., Coustenis & Encrenaz et al., 2013). The ice shell, which connects the potential subsurface ocean to the surface, may itself provide niches for life if liquid brine pockets can form and exist for extended periods of time. It is thus crucial to understand the dynamics of the ice shell in order to characterize transport of liquid brines within the ice shell or between ocean and surface. Recent work by Carnahan et al. 2021 and Harel et al. 2020 investigated the effects of temperature dependent thermal conductivity (k) as well as heat capacity (cp) and a complex composite rheology on convection in the ice shell. In this work, we build upon these previous efforts by combining the influence of both - varying thermodynamic parameters and complex rheology - in geodynamic simulations performed with the convection code GAIA (Hüttig et al., 2013). Instead of a temperature-dependent heat capacity, we investigate the effect of a temperature- and depth-dependent thermal expansivity (α), which is a crucial term in determining the buoyancy induced by temperature differences. We study the dynamic state (Nu-Ra scaling), the mechanical state (elastic thickness, deformation maps), and the thermal state (bottom and top boundary heat flux) of the ice shell for various setups (using both constant and variable α and k) and input parameters (ice shell thickness and grain size). Future steps will include the calculation of radargrams (cf. Kalousova et al. 2017) and gravity anomalies (cf. Mazarico et al., 2023) from our modeled thermal and dynamic states of the ice shell. Both quantities will be measured by the upcoming JUICE and Europa Clipper mission and provide a unique opportunity to align models with observations.

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