A watched ocean world never boils: Inspecting the geochemical impact on ocean worlds from their thermal evolution. E.M. Spiers[1] and B. E. Schmidt[1], [1]Georgia Institute of Technology (311 Ferst Dr NW, Atlanta, GA 30332)

Introduction: Ocean worlds pose novel questions regarding astrobiology and habitability. However, liquid water is not the only component required for the perseverance of life. A complex system of feedbacks with energy inputs from thermal or geochemical sources, such as those operating on Earth, would provide a more viable environment for life. Therefore, understanding the temporal evolution of coupled thermal and geochemical systems within an ocean world are a crucial concern in discussions of habitability.

While many theories and models exist for plausible ocean world geochemical processes and interactions, few incorporate the non-static nature of heat flux to an ocean world system throughout its evolutionary history. On Earth, arguably our best understood model of an 'ocean world', variations in luminosity from our sun in the past 4.6 By have had significant effects on the geochemical systems and cycles. Understanding and defining the nature of geochemical fluxes of an ocean world should, therefore, be considered in the context of the thermal evolution of that ocean. For instance, work on the thermal-orbital history of Europa[1] show periods of extreme heating and cooling due to tidal forces may have existed due to variations in orbital resonances with Jupiter's other moons Ganymede and Io. These extreme thermal oscillations could have non-negligible effects on the geochemistry within the interior of an ocean world.

Box Model for Ocean Worlds: I aim to create a first order, one-dimensional coupled systems model to be applied to ocean world evolutionary pathways. Due to the many complexities of planetary evolution, this will be realized through a box model system, which has been successfully used in oceanography for modeling of Earth's ocean cycling [2] [3]. The utility of a box model is division of the system into plainer elements with realistically-solvable, dynamic equations enabling a focus on fundamental, long-term interactions.

The model consists of five boxes (upper and lower ice shells, ocean, silicate interior, and iron core) and calculates the thermal fluxes and chemical mass balance of the evolving system. The basis for heat input to the system will be the previously mentioned tidal heating, as well as consideration of the radiogenic and solar heat inputs.

Carbon, oxygen and hydrogen will be the first species that will be implemented within this box model. Understanding the production and circulation of carbon dioxide, carbon monoxide, methane, and oxygen will be the primary objective of modeling these elements. They are important participants in water-rock reactions at varying temperatures, and have likely played an important part in the evolution of the biosphere on Earth. Tracking sources and sinks of these species will assist in constraining geothermal processes, H2 outgassing, and ocean pH. Geothermal processes, such as serpentinization, hydro-thermalism, and H2 outgassing would create an effect on the long-term heat production in the interior. They would also provide geothermal energy sources for a putative biosphere.

By tracking the thermal and geochemical energy flux history of an ocean world until present time, this first order model targets general, long term energy distributions for an ocean world system. In addition, due to the low computationally intensive nature of the model, these given inputs and parameters can be varied. The resulting evolutionary pathways can give insights into feasibility of the inputs, and the initial conditions required for modern-day can be better constrained. Results can additionally constrain time scales and requirements for an energy rich system within ocean worlds that could support life.

References: *[1] Hussmann, H., & Spohn, T. (2004). Icarus, 171(2), 391-410.* [2] *Toggweiler, J. R., et al. Global biogeochemical cycles 17.1 (2003).[3] Sarmiento, J. L., and J. R. Toggweiler. Nature 308.5960 (1984): 621.*