National Aeronautics and Space Administration

Simulating Subsurface Oceans of Icy Moons in the Lab and in Global Models

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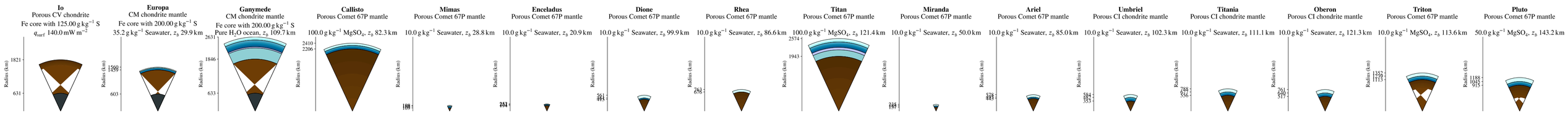
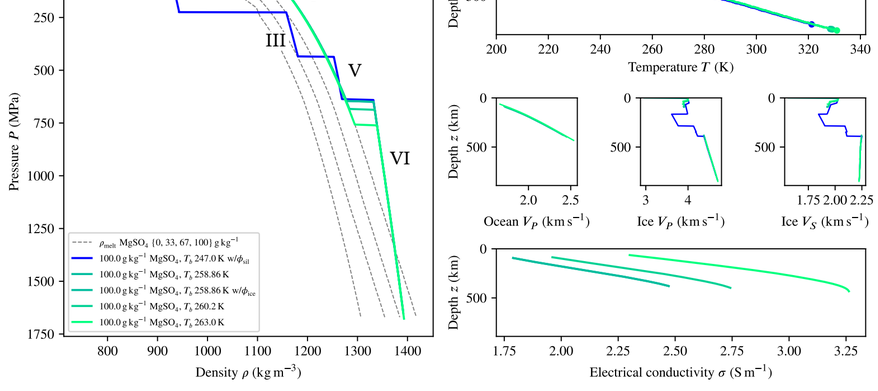


Research goals

Understand the habitability of the subsurface oceans of icy moons through spacecraft measurements.

Project objectives

1. Measure electrical conductivity of various ocean analog fluids at icy-moon-relevant *P*, *T*, and *w* conditions
2. Model global magnetic induction signal using interior geophysics



Interior geophysical models

PlanetProfile is an open-source software package for global modeling of interior geophysics. All figures have been created with the new Python version we have recently completed (scan the QR code!). These models are critical for connecting spacecraft observations of body properties to ocean conditions. Surface + bulk properties are used to determine self-consistent profiles from minimal assumptions.

Above: Ocean conditions for various models of Ganymede created with *PlanetProfile.* Note the range of *P* and *T* spanned, which requires high-pressure, low-temperature lab analogs.
Right: Wedge diagrams showing the warmest and coldest ocean conditions from the set of models displayed above.

Conductivity measurements →

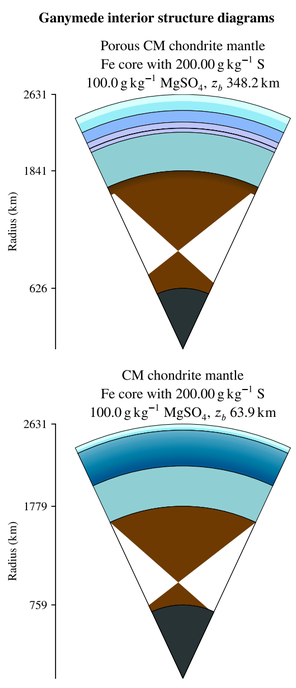
SIWI: Simulator for Icy World Interiors. SIWI is a hydraulic high-pressure, low-temperature system with a pressure vessel (PV) that compresses and cools ocean analog fluids to *P,T* conditions found inside icy moons: Up to 700 MPa and as low as –40°C.
Right: PV closure with sample chamber attached. Electrical connections end in Ti electrodes that extend into the sample fluid.
Far right: sample chamber inverted to show hydraulic barrier that moves to communicate pressure to the sample fluid.
Lower right: The SIWI setup. PV is wrapped in insulation in the back.

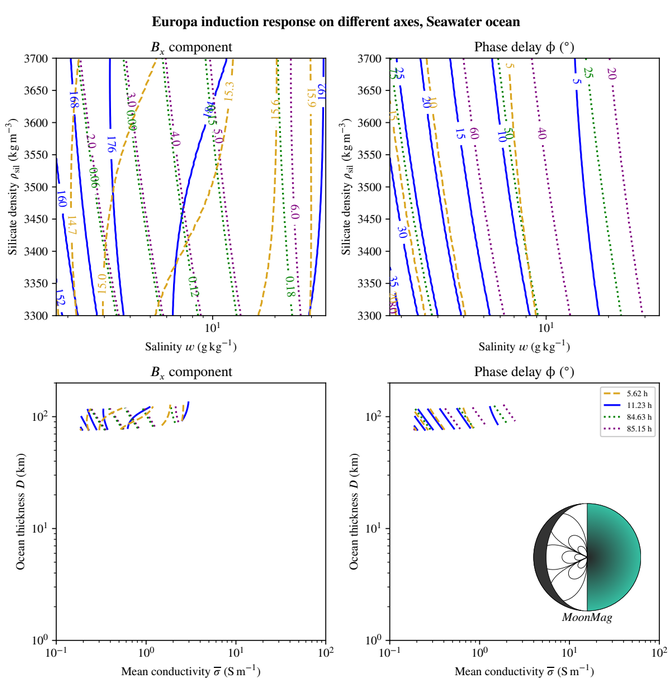
PlanetProfile

Motivation

Hardly any conductivity data exists for ocean fluids at low enough temperatures and high enough pressures. We need these measurements to inform induction models.

The *P, T* conditions of subsurface ocean waters affects their electrical conductivity, which in turn affects the induced magnetic field. We make thousands of geophysical forward models (with varying inputs) to compare against spacecraft data using sophisticated statistics.





Magnetic data

We can directly probe ocean conditions by measuring magnetic fields. This work lays the track for processing magnetic measurements from spacecraft to assess habitability inside of icy moons.
Left: Induced magnetic field for many Europa models with varying interior models. Each color is associated with the moments measured by a spacecraft with a specific period.

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Publications:
PlanetProfile: Self-consistent interior structure modeling for terrestrial bodies in Python (in prep)
Conductivity of subsurface ocean analog solutions from molecular dynamics simulations (in prep)

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