Report: 1350
Project title: Earth System Methods to Constrain the Atmospheres and Oceans of Jupiter's Icy Moons
Principal Investigator: Joachim Saur
Report period: 2023-01-01 to 2023-10-31

Report Summary

Period 2023-01-01 until 2023-12-31 was the first cycle of our program 1350. Our activities during this period are subdivided in (1) a first phase for basic software installment and testing, and (2) a second phase for scientific investigations.

First Phase

As the year 2023 was the first cycle in which we worked on HLRE-4, our first tasks were to install the Pluto code and to run basic checks for correct implementation. We also compared the results with those obtained from previous simulations at the computing facilities of the University of Cologne. We additionally investigated the performance and scalability of the Pluto code on HLRE-4. The results of these investigations are included in the proposal for cycle 2024 and are therefore not repeated in this report.

Scientific Investigation

The simulations for scientific investigations executed on HLRE-4 during the time period 2023-01-01 until 2023-10-31 are summarized in the following subsections.

Subproject Ganymede: For Jupiter's moon Ganymede we started with a low dimensional inversion of basic quantities, i.e., upstream plasma conditions, internal magnetic field and ocean and atmosphere properties. In Figure 1, we show the results of the inversion of two parameters only, i.e., upstream plasma density ρ_0 and the main moment of Ganymede's magnetic internal field g_1^0. The study is at the moment continued for 7 free parameters. A publication for 2024 is in planning.

Subproject Callisto: We modeled Callisto's time-variable plasma interaction and investigated how effects of its possible ocean and its ionosphere propagate away from the moon. We compared the results with magnetic fields observed by the Galileo spacecraft. A manuscript on the results is currently written up for publication. The results will be presented at the Fall meeting of the American Geophysical Union: SM43D-3132 Callisto's Space Plasma Environment within Jupiter's Time-Variable Magnetosphere.

Subproject Europa: We modeled Europa's plasma interaction in order to understand the measurements taken by NASA's Juno spacecraft which flew by

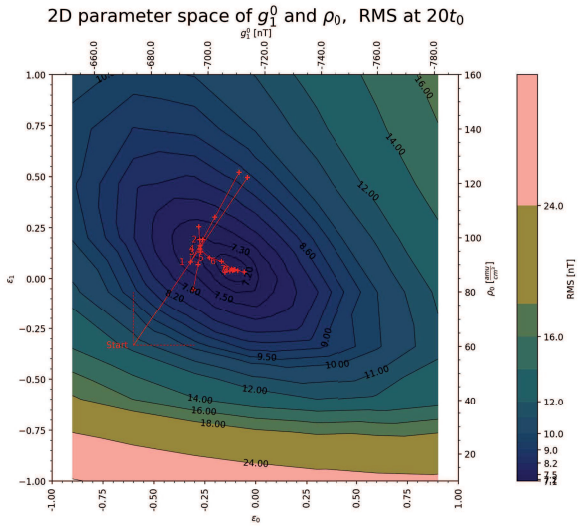

Figure 1: Cost function from the inversion of magnetic field measurements for Jupiter's moon Ganymede. The figure shows the results of the inversion of two parameters only, i.e., upstream plasma density ρ_0 and the main moment of Ganymede's magnetic field g_1^0.

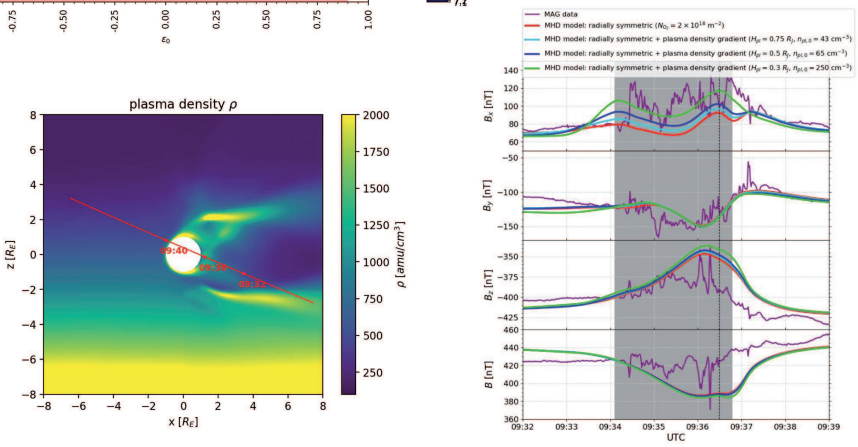

Figure 2: Europa's plasma interaction. Left: plasma density near the moon for inhomogeneous upstream conditions. Right: First model results compared to measurements by the Juno spacecraft.

the moon in September 2022. First results are shown in Figure 2. On the left side we show plasma densities for inhomogeneous upstream conditions and on the right hand side we show magnetic field measurements by Juno compared with modeling results. We are in the processes of writing up the results for a first publication in 2024. Results of this study are also presented at the Fall meeting of the American Geophysical Union.

Subproject magnetized planets and moons: We simulated the response of magnetized planets or moons to time-variable external fields. We calculated heating rates due to electromagnetic induction in the interior. We apply this for a generic understanding of a moon's response to solar or magnetospheric storms. This heating mechanism contributes to maintaining oceans within icy moons. A publication is planned for in 2024.