Numerical radar simulation for the explorations of the ionosphere and plume at Jupiter's icy moons

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Jupiter's icy moons such as Europa and Ganymede may harbor subsurface liquid water oceans and have ionospheres and plumes created from the water oceanic materials. While only Earth has the ocean on the surface in our solar system, multiple icy bodies like the icy moons of giant planets have subsurface oceans. The icy body's ocean is potentially more universal habitable environment than the Earth-type surface ocean. Evolution of the subsurface ocean is the most important problem for understanding of the universality of habitable environment. Current structures of the ocean, ionosphere, and plume of the icy moon are essential information for the evolution. In-situ observation of surface and interior with landers is the most effective method for estimation of the structures. However, the structures have been unknown because the lander exploration is still in the technically conceptional level at present. Here we are going to uncover the structures of the oceans, ionospheres, and plumes of Jupiter's icy moons by the radar exploration with the Radio & Plasma Wave Investigation (RPWI) and the Radar for Icy Moon Exploration (RIME) onboard the JUpiter ICy moons Explorer (JUICE) launched in 2022. We are now developing the numerical simulation code for the radar explorations with RPWI and RIME that model propagation of electromagnetic (EM) wave in the ionospheres and plumes of the icy moons. From our preliminary simulations, we confirmed that rays of the EM wave are significantly refracted in the ionosphere and plume with dependences on their frequencies. This result demonstrates that the structures of ionospheres and plumes are detectable with the JUICE instruments. We are going to simulate reflection and transmission of the EM waves in the ice crust and underlying ocean to explore their structures. After completion of this study, we will be able to estimate the structures of icy moons by combining our model with the JUICE radar explorations. The combination will constrain pressure and temperature of the subsurface ocean as well as the structures, which finally lead to deep understanding of the icy moon's habitability.

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