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Detection of Body-wave Reverberations on Titan and Implications for the Ice Shell Structure Constraint

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NASA's upcoming space mission, Dragonfly, selected as the 4th mission under the New Frontiers Program, is set to explore Saturn's icy moon, Titan, in the mid-2030s. The mission's goal is to assess Titan's potential habitability. The rotorcraft lander, designed like a drone, will be equipped with the DraGMet instrument package, enabling comprehensive geochemical, climatic, meteorological, and geophysical analyses across multiple sites on Titan's surface. A key instrument in this package is the DraGMet SEIS short-period vertical seismometer, developed by JAXA, which will play a crucial role in investigating Titan's internal structure.

For successful seismic observations, it is essential to first anticipate the type of events and seismic phases that are likely to be observed in the data, with their detection conditions. Titan's surface exhibits a variety of potentially endogenous geological formations, many of which were identified through SAR data from the Cassini-Huygens mission (2004-2017), and some further analyzed with global tidal stress field models. As a first step, we focus on one of the primary sources of seismic activity in icy ocean worlds, "ice cracking events" , caused by Saturn's tidal forces. We model the broadband seismic waveforms produced by such events, considering several internal structure models and anelastic attenuation scenarios.

These results are then incorporated into noise models—considering both atmospheric turbulence and experimentally evaluated instrumental noise—to derive constraints on the detectability of these signals. We will also discuss methods for constraining a homogeneous upper internal structure case based on observations—particularly in estimating the thickness of Titan's ice shell.

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