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Tidal Distortion of Titan: Implications for Surface Features and Tidal Measurements

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Titan is unique due to its similarity to the Earth and terrestrial planets in spite of the satellite's ice-rich bulk composition. Gravitational field data acquired by the Cassini spacecraft suggest that Titan's interior is composed of a mixture of rock and ice and is only partly differentiated. Titan is tidally locked with respect to Saturn and thereby subject to periodic tidal forcing of its interior and surface. Based on interior structure models and assumptions on rheological properties of planetary materials (i.e. ice, rock, water-ammonia ocean), we compute the elastic body tide Love numbers h_2, k_2, and l_2 in order to describe Titan's tidal response. Key parameters, e.g., tidally-induced changes of local gravity, tilt relative to the direction of gravity, and areal strain are then given by linear combinations of h_2, k_2, and l_2. We find peak-to-peak amplitudes of tidally-induced surface displacement and tilt variation on the order of up to a few tens of metres and a few arc seconds, respectively. Based on the obtained variations of tidal parameters, we will address possible implications for morphotectonic surface features and compositional heterogeneity on Titan. In addition, we will address possible measurements of global tidal distortion by using a network of several small landed stations. Each of those would have to carry an instrument suite to monitor tidally-induced changes of local gravity, tilt relative to the direction of gravity, and areal strain at the surface of Titan. Furthermore, tidal stresses are expected to induce significant seismic activity comparable to tidally-induced quakes on the Moon, and possibly along with seismicity induced by localized cryovolcanic activity.