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Recent Progress in Understanding Waves in Titan's Seas : Prospects for Cassini Observation

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Titan's hydrocarbon seas are an exotic and appealing aspect of that world. So far, however, no direct evidence of wind-driven waves has been identified - radar altimeter data and near-infrared specular glint observations show that on those occasions at least, Ontario Lacus, Kraken Mare and Jingpo Lacus have been as flat as a millpond. Yet there are some shoreline geomorphological indications of wave action. As we move into northern summer, Global Circulation Models predict winds in the north, home to the large seas Kraken and Ligeia, will freshen - increasing the probability and amplitude of waves. Furthermore, improving illumination, and the design of the Cassini trajectory, will improve observation opportunities. Motivated by these prospects, and by future missions, we have devoted some effort to understanding wave formation and growth.

First, an analysis of onset and growth mechanisms of capillary-gravity waves on Titan (Hayes et al., submitted) reveals liquid viscosity, surface tension, and density to be significant factors. Methane-rich liquids (as might form in transient lakes from rainfall) may begin growing with windspeeds U_{10}=0.4m/s. On the other hand, waves may not form at all in more viscous ethane-rich compositions (likely for the large seas) until U_{10}=0.7m/s, a much less frequent occurrence.

Once waves form, the dense Titan atmosphere causes them to grow in amplitude. A model of gravity wave growth (Lorenz and Hayes, submitted) shows that Titan's dense atmosphere causes growth rather faster than previously predicted by Ghafoor et al. (2000) but that the limiting ('fully-developed') significant wave height (SWH) is similar, and is $0.26U_{10}^2/g$ – thus 1m/s winds lead to 0.2m waves.

SWH is a statistical construct, the average of the highest one third of a series of wave observations (typically 20 minutes). In reality, the interaction of waves leads to a probability distribution, usually described by Rayleigh statistics, wherein larger waves occasionally occur – e.g. in a 3 month period one wave with a height of 2.7 times the SWH might be expected to appear. This distribution allows the estimation of wave effects on coastal geomorphology and on the design of future missions.

These wind-wave models suggest that even in the windy summer, observable waves might not always be present, and thus any interpretation of Cassini observations to refine or validate models should be done probabilistically. Our analysis (Hayes et al., submitted) suggests that the most sensitive tests of the presence of waves are radar altimetry and sunglint measurements in the near-IR by VIMS. Radar scatterometry can detect waves if performed at low altitudes where the beam footprint is smaller than the sea under study ; however backscatter from wave-ruffled surfaces may in some cases be below the noise-equivalent backscatter of SAR imaging.