

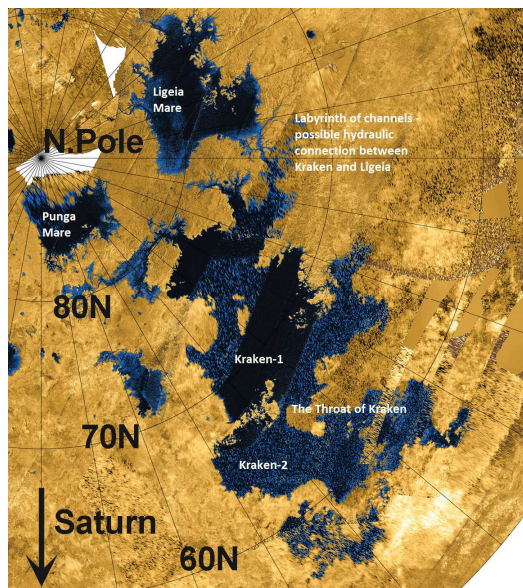
## PHYSICAL PROCESSES IN TITAN'S HYDROCARBON SEAS

R.D.Lorenz<sup>1</sup>

<sup>1</sup>*JHU Applied Physics Laboratory, Laurel, MD, USA.*

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Titan's hydrocarbon seas present a new laboratory for geophysical studies : oceanography is no longer just an Earth science. Air-sea exchange of heat, matter and momentum may take place under quite different conditions from Earth, challenging many empirical parameterizations of these processes which are critical in hurricane intensification, wave generation and erosion, climate evolution and so on. On a world at 94K with gravity similar to our Moon, but with a nitrogen atmosphere 4x denser than ours, methane takes the role of water. Ethane is likely present (although its apparent low abundance is a mystery) and acts somewhat analogously to salt on Earth, a relatively involatile tracer. Nitrogen dissolves significantly in methane, so the seas are principally a ternary mixture. It is possible that a latitude gradient in the amount of methane rainfall 'flushes' Ligeia Mare much like the Baltic or Black Seas on Earth, concentrating solutes in Kraken Mare. The extent to which this occurs depends on the tidal mixing between the seas. Analytic and numerical models have been applied to this problem. Remote sensing by the Cassini spacecraft has provided some constraints on sea-surface roughness, and on composition. Titan's seas are an attractive target for future exploration, e.g. by a floating capsule like the Titan Mare Explorer (TiME) Discovery Phase A study, or even by a submarine, a concept being explored by the NASA Innovative Advanced Concepts (NIAC) program. The interaction of such vehicles with their environment (e.g. the response of a capsule to waves, or the thermodynamic exsolution of nitrogen associated with heat rejection from a radioisotope heat source) poses new and interesting challenges to engineers.



**Figure 1.** Radar Map of Titan's Seas. Ligeia Mare is about 350km across and is linked to Kraken by a narrow channel, Trevize Fretum. Interesting tidal dynamics are also expected at Seddon Fretum (aka, The Throat of Kraken)

### References

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