# Sensitivity of Optical Searches for Liquid Hydrocarbons on Titan's Surface

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# Abstract and Conclusions

Liquid methane and ethane on the surface of Titan are thought to be present as a source and sink of atmospheric methane, a starting material for hydrocarbon and nitrile photochemistry. Radar studies recently provided observational support for significant aerial coverage of liquid on the surface (Campbell et al., *Science* **302**: 431-434, 2003). Specular reflection from a liquid surface at optical wavelengths can potentially provide a sensitive test for the presence of liquid because reflected I/F can be much higher than unity. Yet no such signatures have been noted in the literature thus far. We report here on empirical studies using Galileo images of earth, and radiative transfer models of Titan to better understand the visibility of the specular signature. The specular pattern in the Galileo images is not readily apparent in an individual image because of scene clutter from clouds, (which may not be a factor for Titan) but the pattern is much easier to see in a sequence of images. Our radiative transfer simulations for Titan include surface-atmosphere interaction in a hazy atmosphere for a variety of haze optical depths and scattering properties, and with a recently developed formalism to account for slopes of wind-driven capillary waves. It seems likely that a specular signature should be present in high-resolution adaptive-optics images already obtained if liquid was present near the specular point. High-resolution images from Cassini/Huygens instruments may see a signature even for haze optical depth as large as 2.

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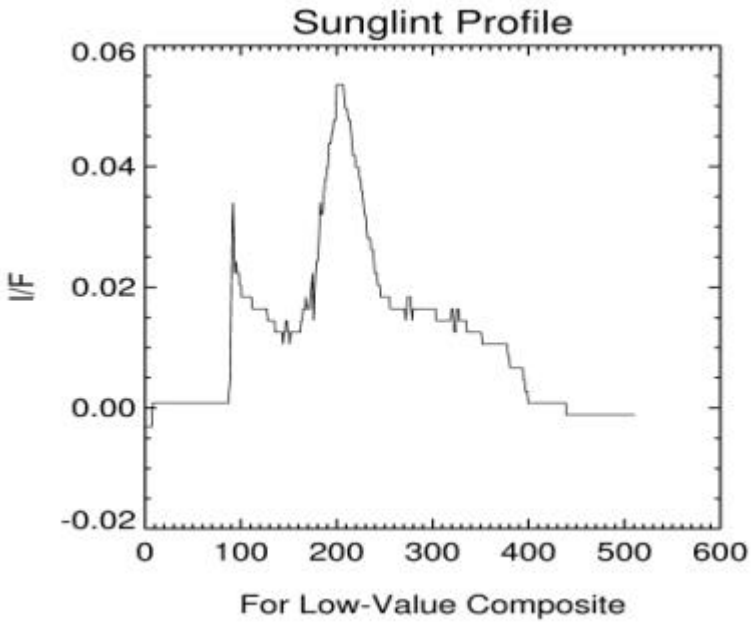
# Empirical Study with Galileo Images

- During Earth Flyby 2 Galileo obtained hundreds of images over more than two days of observations. We used 96 of these when the specular point traversed the south Atlantic and Pacific oceans
- Sun glint is often not apparent over oceans due to scene clutter or obscuration from bright clouds. We used a cloud-removal scheme by superimposing the images and taking the lowest value. This also removed reflectivity from continents, except for Antarctica where no dark ocean was available at any longitude

# Galileo Image Analysis, Continued

- The specular pattern is evident in the composite low-value image**.**
- The low values plotted filter out the significantly higher glints seen in some images.

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# Synthetic Images and Profiles from Doubling/Adding Calculations

- Intensity Doubling/Adding code includes multiple scattering for plane-parallel geometry and Fresnel reflection at the surface
- Haze particle phase functions from Mark Lemmon model (aggregates)
- Refractive index for liquid methane/ethane = (1.286, 1.14E-1), from Badoz et al., 1992
- Wave slopes vs. wind speed from Ghafoor et al. (2000) and Zhao and Toba (2003)
- RMS slope issues need to be resolved. Calculations not valid for emission angle less than 30 degrees

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# References


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