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# Revisiting 13 cm-$\lambda$ Arecibo radar observations of Titan

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Titan, Saturn's largest satellite and the only moon in the solar system with a thick atmosphere, has long been an object of scientific investigation. Campbell *et al.* (*Science*, **302**, pp. 431–434, Oct. 2003) observed Titan on 16 nights in Nov–Dec. 2001, making use of the 13-cm wavelength radar capabilities of the Arecibo telescope. Based on observations of "specular echoes," they concluded that scattering from Titan's surface is consistent with the presence of large areas of liquid hydrocarbons covering much of the surface. The 'oceans' conclusion is in conflict with the absence of near-infrared specular reflection (West *et al.*, *Nature*, **436**, pp. 670–672, August 2005). Some aspects of the methodology employed in radar astronomy in which the Hagfors Law, representing quasi-specular scatter, is combined with a representation of a diffuse component, usually expressed as a power of cosine, may be flawed. We show that for Titan the oceans conclusion is not required by *i*) fitting the data with fractal-based scattering laws rather than the Hagfors model, and *ii*) investigating the validity of using the reflectivity parameter, $\rho$, to obtain the dielectric constant, $\epsilon$, of the surface via the formula: $\rho = [(\sqrt{\epsilon} - 1)/(\sqrt{\epsilon} + 1)]^2$. The inference of $\epsilon$ from $\rho$ is problematic due to the existence of significant diffuse scattering modeled using an *ad hoc* law, such as a cosine, which does not exhibit explicit dependence on either the composition or structure of the surface. On the other hand, the fractal-based scattering laws applied here yield higher values for $\epsilon$ than does the Hagfors model and, thus, produce results inconsistent with liquid hydrocarbon surfaces, even when the predominance of diffuse scattering is neglected. We thank D. B. Campbell and G. J. Black for access to the Arecibo-Titan data.