Analysis of the Cassini Bistatic Radar Data

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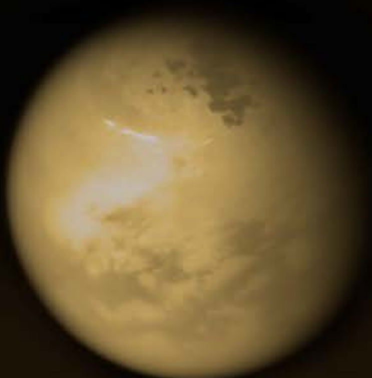
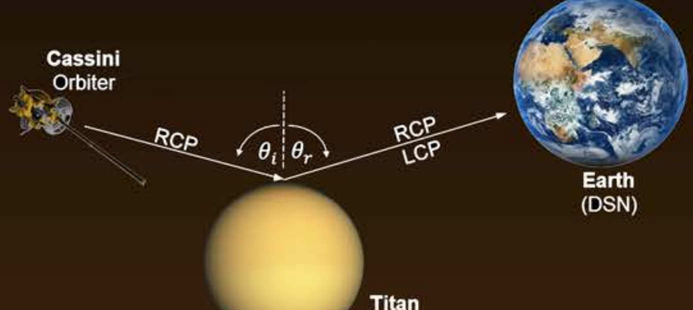
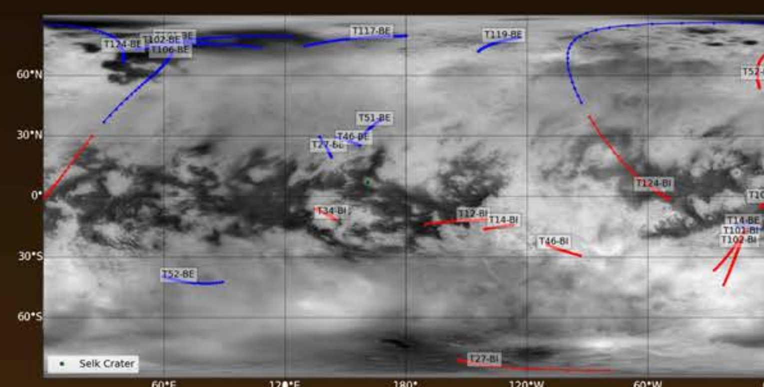
Introduction



The Cassini RSS bistatic radar observations acquired on Titan's solid surfaces, conducted between 2006 and 2016, represent a resource that holds immense potential for significant discoveries related to the dielectric and roughness properties of Titan's surfaces. Our research's focus is on analyzing the dataset spanning multiple wavelengths: S-, X-, and Ka-bands. The bistatic tracks cover a diverse range of landforms on Titan (see map), presenting a unique opportunity for comprehensive exploration.

The key advantage of these experiments is the utilization of polarimetric analysis. This methodology allows to discriminate the effects of local dielectric vs roughness properties through the analysis of their associated circular polarization ratio and backscatter. By leveraging this technique, we are providing independent microwave scattering information that will enhance our understanding of surface composition and terrain textures in regions previously observed by Cassini RADAR and ISS instruments.





Interpreting the bistatic radar data

The Cassini spacecraft transmits right circularly polarized (RCP) signals and during the interaction of the radar wave with the surface of Titan, this polarization is modified in such a way that a left circularly polarized component (LCP) is generated. The complete characterization of the signal is done on Earth by using two (coherent) receivers. The Cassini raw RSS data are initially in the form of IQ samples that must undergo absolute amplitude calibration. The relative dielectric constant ε_r of the reflecting surface can be derived from the ratio of the same sense and opposite sense received powers (CPR):

$$\varepsilon_r = \left(\frac{\tan^2\theta}{\mathrm{CPR}} + 1\right)\sin^2\theta$$

For gently-undulating surfaces, the effects of roughness and composition are separable.

There is a relation that quantifies the half-power bandwidth of the quasi-specular echo (or its spectral broadening) in terms of surface rms slope (ζ) and the velocity of the footprint across the surface (v):

$$\Delta f = 4(\ln\ 2)^{1/2}(v\zeta/\lambda)\cos\theta$$

Objectives of the research

The success of the preliminary analyses of the data acquired over Titan's seas and lakes motivates the exploration of the remaining observations, which cover a wide range of surface features on Titan. Powerful solid-surface returns were identified and isolated during flybys T14, T27, T34, and T124, which sample very diverse terrains including dunes, plains, mountains, south polar regions, and the Menrva crater, a radar analogue for Selk which could provide contextual constraints for Dragonfly's landing-site environment.

Acknowledgements

This research is supported by NASA CDAP grant NNH21ZDA001N-CDAP. We appreciate the efforts of the Cassini RSS (Radio Science Subsystem) Team in planning and executing these observations.

References

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Brighi G., et al., Geophysical Research Letters, 52 (2025).