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Characterization of Titan surface scenarios combining Cassini SAR images and radiometric data

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A great amount of data and images was provided by the radar on Cassini probe, thus opening and suggesting new scenarios about Titan's formation and evolution. An important result was the detection, among the peculiar and heterogeneous Titan's surface features, of lakes most likely constituted by liquid hydrocarbons, thus supporting the hypothesis of a methane cycle similar to water cycle on Earth.These areas, which resemble terrestrial lakes, seem to be sprinkled all over the high latitudes surrounding Titan's pole. The abundant methane in Titan's atmosphere combined with the low temperature, 94 K, lead scientists to interpret them as lakes of liquid methane or ethane.

In this work, scattering models and a Bayesian inversion algorithm are applied in order to characterize lake and land surfaces. The possibility of combining the SAR data with radiometric ones on both lakes and neighboring land areas is also presented.

Radar backscattering from lakes is described in terms of a double layer model, consisting of Bragg or facets scattering for the upper liquid layer and the Integral Equation Model (IEM) model for the lower solid surface. Furthermore, by means of a gravity-capillary wave model (Donelan-Pierson), the wave spectra of liquid hydrocarbons surfaces are introduced as a function of wind speed and direction. Theoretical radar backscattering coefficient values are compared with the experimental ones collected by the radar in order to estimate physical and morphological surface parameters, and to evaluate their compatibility with the expected constituents for Titan surfaces.

This electromagnetic analysis is the starting point for a statistical inversion algorithm which allows determining limits on the parameters values, especially on the optical thickness and wind speed of the lakes. The physical surface parameters inferred by using the inversion algorithm are used as input for a forward radiative transfer model calculation to obtain simulated brightness temperatures.

The radiometric model has been introduced to further verify the values ranges for the different parameters. In fact the same parameters derived from the radar data analysis have been used as input for the radiometric model. The comparison between the observed and computed brightness temperatures has been performed in order to address the consistency of the observations from the two instruments and to determine the coarse characteristics of the surface parameters.

For both radar and radiometric data the soil medium is horizontally stratified into 2 layers. Each layer can be characterized by different absorption coefficients depending on the optical thickness, dielectric constant and physical temperature.

In this algorithm, the starting point is the map of optical thickness derived from the SAR images. The simulated brightness temperature is calculated by applying the forward radiative transfer model to the optical thickness map with the same hypotheses assumed to derive it.

The simulation is also carried out on the neighboring land areas by considering a double layer model including a contribution of volume scattering. Each layer is described in terms of dielectric constant values, albedo and roughness parameters with the hypothesis of water ice ammonia on layers of solid hydrocarbons and organic compounds like tholins. The analysis is applied to the areas detected on flybys 25 and 30.

One important result arises from the analysis of the inverted optical thickness on deep lakes. In this case, found values of optical thickness can be considered limit values because, beyond these values, a complete attenuation can be considered. This limit value is important as it is stable even if the other parameters vary. Starting from this point, posing the condition of a complete attenuation of the second layer, i.e. fixing the value of the optical thickness, the

algorithm can be used to estimate the wind speed. The retrieved values vary between 0.2 to 0.5 m/s.
The first results also show a good agreement between the simulated data and the measured brightness temperature for both the liquid surface and the surrounding areas. In the last case, a good agreement is obtained only if the contribution from volume scattering is included in the model