EPSC Abstracts
Vol. 12, EPSC2018-655, 2018
European Planetary Science Congress 2018

Rhea's thermal properties and regional anomalies revealed by Cassini's Radar/radiometer

Léa E. Bonnefoy (1,2), Alice Le Gall (2), Emmanuel Lellouch (1), Cédric Leyrat (1), Michael A. Janssen (3) and the Cassini Radar team
(1) Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique (LESIA), Observatoire de Paris-Meudon, LESIA (Bât. 18), 5, place Jules Janssen, 92195 Meudon Cedex, France (2) Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), UVSQ /CNRS/Paris VI, UMR 8190, 78280 Guyancourt, France (3) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA
(lea.bonnefoy@latmos.ipsl.fr)

1. Introduction

The Cassini Radar/radiometer was primarily designed to study Titan's surface, but also observed other Saturn satellites on multiple occasions. Operating at a wavelength of 2.2 cm, the Radar/radiometer is able to probe up to several meters into the subsurface, deeper than any other instrument on board Cassini, and thus provides a unique insight into the composition and structure of the subsurface. On Enceladus and Iapetus, this dataset allowed the identification of thermal [1], structural [2], and compositional [3] anomalies. Spatially-resolved Radar and passive radiometry data were also acquired over Rhea: we perform a similar analysis as on Iapetus and Enceladus. Rhea is Saturn's largest icy satellite, and is the furthest of Saturn's satellites thought to have formed from the rings, which may be very young [4,5]. We use a thermal model described in Le Gall et al. (2014, 2017) to simulate the brightness temperature, which we compare to observations to constrain thermophysical properties and anomalies [1, 3]. Understanding the origin of such anomalies can help us to investigate the formation and evolution of Rhea, and to place new constraints on its age.

2. Dataset and Methods

Microwave radiometry scans were conducted on 11 instances, during 7 different flybys, as reported in Table 1. On March 2nd, 2010, concurrent active Radar and passive radiometry data were taken at resolutions of down to 0.11 times the diameter of Rhea (~85 km). This Radar observation was calibrated and corrected to an incidence angle of 32° by Wye (2011); the resulting Real Aperture Radar (RAR) image is shown in Fig. 1B [6]. We calibrate the radiometry data using the method described in [7], and map it using an iterative deconvolution method as described in [8].

Table 1: Cassini radiometry data of Rhea

Observation ID	Beam size (diameter)	Sub-spacecraft point (°)	Sub-solar point (°)
RH11	0.79	(-48, -75)	(175,-20)
RH18	0.74	(-22, 0)	(157, -19)
RH22-1	0.51	(-136, 1)	(52, -18)
RH22-2	0.64	(-153, 1)	(46, -18)
RH45	0.84	(-58, -44)	(-158,-12)
RH49	0.51	(15, 0)	(-114,-11)
RH127-1	0.47	(-160, 0)	(19, 3)
RH127-2	0.35	(-162, 0)	(17, 3)
RH127-4	0.11-0.24	(-167, 1)	(12, 3)
RH177-1	0.40	(-102, -76)	(-12, 17)
RH177-2	0.33	(-92, -77)	(13, 17)

While studying the deconvolved maps of the brightness temperature can help us identify anomalies, a thermal model is necessary to determine whether they are due to compositional or structural variations or to diurnal and seasonal temperature variations. We therefore simulate brightness temperatures by using a combination of a thermal model, a radiative transfer model, and an emissivity model, as described in Le Gall et al. (2014) [3].

3. Preliminary results

The thermal model assumes uniform properties over the surface, and therefore highlights anomalies that cannot be explained simply with diurnal or seasonal temperature variations. All resolved radiometry data (RH22, RH49, RH127, and RH177) covering the Inktomi crater region were taken during the night and consistently show the Inktomi crater ejecta region as colder than its surroundings (e.g. Fig. 1D), a pattern which the model is unable to duplicate (Fig. 1C). Using Cassini's Composite and Infrared

Spectrometer (CIRS), Howett et al. (2014) found an anomalously high thermal inertia in this region, which should lead to higher temperatures during the night [9]. This contradiction can be resolved by the existence of a lower emissivity anomaly, which is consistent with the high Radar return (Fig. 1B). A low emissivity in Inktomi crater and its ejecta blanket can be explained by a high water ice purity at depth, as detected on the surface by VIMS [10], and/or by increased volume scattering, due likely to the cm-scale structure of the fresh ice. Preliminary results also point to a lower emissivity in the leading hemisphere as opposed to the trailing hemisphere, and to possible differences between the poles, maybe indicative of regional variations in the degree of compaction of Rhea’s regolith.

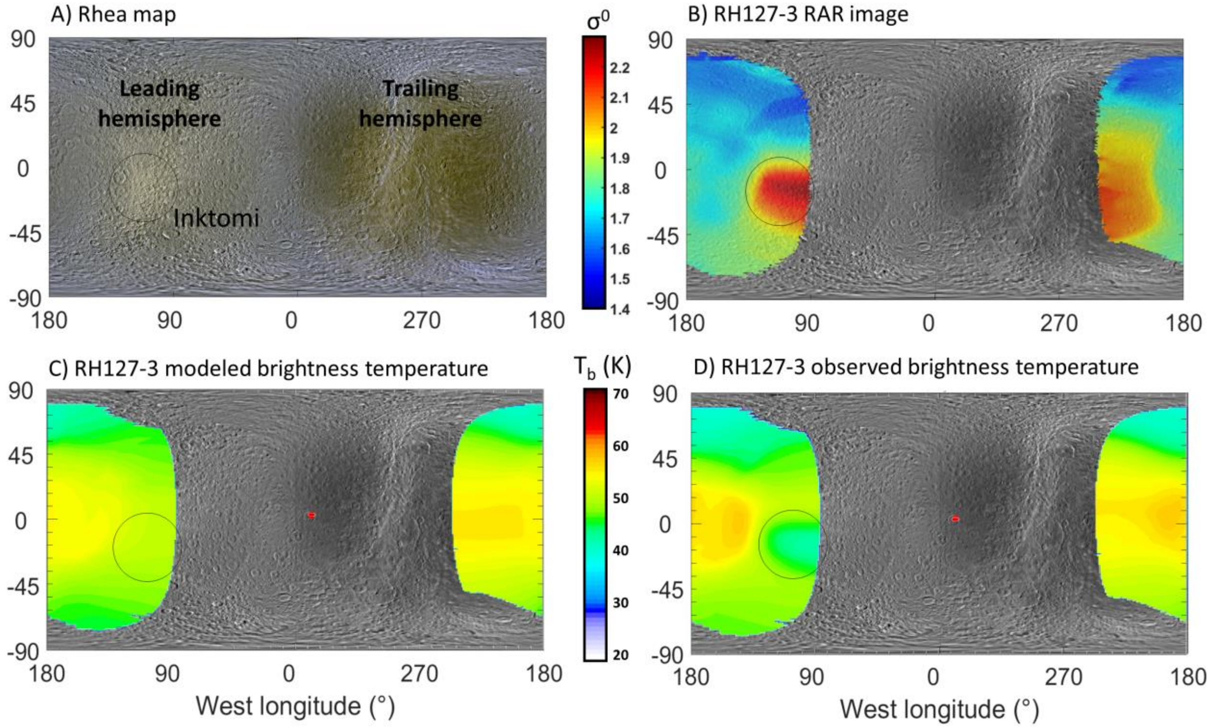

Figure 1: RH127-3 spatially-resolved Cassini Radar and radiometry data. A) Color mosaic made from Cassini IR, UV, and visible data (credit: NASA/JPL-Caltech/SSI/LPI). B) Real Aperture Radar (RAR) image [5]. C) Deconvolved map of the best fit model temperature. D) Deconvolved map of the observed brightness temperature. The sub-solar point is indicated in red, and the Inktomi crater ejecta region is circled. Note that the thermal model is unable to explain the low temperatures in Inktomi crater.

Acknowledgements

This work was funded by DIM-ACAV and CNES. The authors wish to thank the Cassini-Huygens (NASA/ESA/ASI) team for the design, development, and operation of the mission.

References

[1] A. Le Gall et al. (2017), *Nature Astronomy*, Vol. 1, 0063.
[2] P. Ries and M.A. Janssen (2015), *Icarus*, Vol. 257, pp. 88-102.
[3] A. Le Gall et al. (2014), *Icarus*, Vol. 241, pp.221-238.
[4] S. Charnoz et al. (2011), *Icarus*, Vol. 216, pp.535-550.
[5] J. Cuzzi (2018), LPSC #2083.
[6] L.C. Wye (2011), PhD thesis.
[7] M.A. Janssen et al. (2009), *Icarus*, Vol. 200, pp. 222- 239.
[8] Z. Zhang et al. (2017), *Icarus*, Vol. 281, pp. 297-321
[9] C.J.A. Howett et al. (2014), *Icarus*, Vol. 241, pp. 239-247.
[10] F. Scipioni et al. (2014), *Icarus*, Vol. 234, pp. 1-16.