EPSC Abstracts
Vol. 9, EPSC2014-411, 2014
European Planetary Science Congress 2014

Is Enceladus Saturn's source of water?

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Abstract

Water in the atmospheres of the outer planets has both an internal and an external source (e.g., [1] and [2] for Jupiter). These sources are separated by a condensation layer, the tropopause cold trap, which acts as a transport barrier between the troposphere and the stratosphere. Thus, the water vapor observed by the Infrared Space Observatory (ISO) in the stratosphere of the giant planets has an external origin [3]. This external supply of water may have several sources: (i) a permanent flux from interplanetary dust particles produced from asteroid collisions and from comet activity [4], (ii) local sources from planetary environments (rings, satellites) [5, 6], (iii) cometary "Shoemaker-Levy 9 (SL9) type" impacts [7, 8].

Disentangling the various sources of externally supplied water in outer planet stratospheres was a key objective of the Herschel key program HssO (Herschel Solar System Observations) [9]. In this paper, we present observations of water in Saturn's stratosphere (see Fig.1) obtained with the Photodetector Array Camera and Spectrometer (PACS) [10] instrument onboard the ESA Herschel Space Observatory [11].

Previous observations of Saturn with Herschel led to the detection of a water torus at Enceladus orbit [12], fed by the geysers of this moon [13, 14, 15]. The fate of water from this torus is eventually to spread in Saturn's system [16] and a fraction of it is predicted to fall in Saturn's stratosphere (see Fig. 2). In this paper, we also test the validity of Enceladus as a source for Saturn's stratospheric water by comparing the horizontal distribution of water observed by Herschel with the results obtained from numerical simulations obtained with a new 2D photochemical model [17] that accounts for the predicted influx of Enceladus water in Saturn's stratosphere.

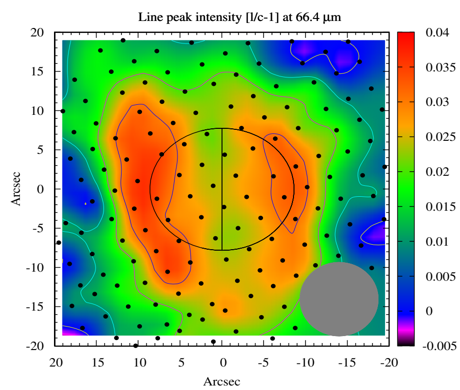

Figure 1: Line peak intensity of the H_2O line at 66.4 μm as observed with Herschel-PACS on January 2, 2011. The line peak intensity is expressed in terms of line-to-continuum minus one (=l/c-1, thus in % of the continuum). Saturn is represented by the black ellipse, and its rotation axis is also displayed. The H_2O emission was recorded across the disk of Saturn at each of the black dots, with a spatial resolution represented by Herschel's beam (grey filled circle).

References

[1] Larson, H. P., Fink, U., Treffers, R., and Gautier, III, T. N., 1975. Detection of water vapor on Jupiter. ApJ, 197, L137.

[2] Lellouch,E., Bézard,B., Moses,J.I. et al., 2002. The origin of water vapor and carbon dioxide in Jupiter's stratosphere. Icarus, 159, 112-131.

[3] Feuchtgruber, H., Lellouch, E., de Graauw, T. et al., 1997. External supply of oxygen to the atmospheres of giant planets. Nature, 389, 159-162.

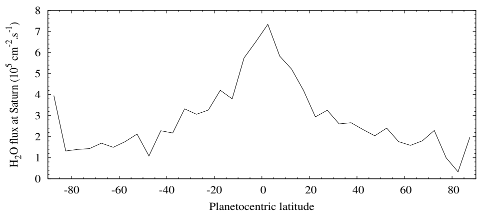

Figure 2: Flux of infalling H_2O in Saturn's stratosphere as predicted by [16], and expressed in terms of cm^{-2}·s^{-1} as a function of planetocentric latitude. The source of this flux is the Enceladus geysers.

[4] Prather, M.J., Logan, J.A., McElroy, M.B., 1978. Carbon monoxide in Jupiter's upper atmosphere-an extraplanetary source. ApJ, 223, 1072-1081.

[5] Strobel, D.F., Yung, Y.L., 1979. The Galilean satellites as a source of CO in the Jovian upper atmosphere. Icarus, 37, 256-263.

[6] Connerney, J. E. P., 1986. Magnetic connection for Saturn's rings and atmosphere. GRL 13, 773-776.

[7] Lellouch, E., Paubert, G., Moreno, R. et al., 1995. Chemical and thermal response of Jupiter's atmosphere following the impact of Comet Shoemaker-Levy-9. Nature, 373, 592-595.

[8] Cavalié, T., Feuchtgruber, H., Lellouch, E. et al., 2013. Spatial distribution of water in the stratosphere of Jupiter from Herschel HIFI and PACS observations. A&A, 553, A21.

[9] Hartogh, P., Lellouch, E., Crovisier, J. et al., 2009. Water and related chemistry in the solar system. A guaranteed time key program for Herschel. Planet. Space Sci. 57, 1596-1606.

[10] Poglitsch, A., Waelkens, C., Geis, N., et al., 2010. The Photodetector Array Camera and Spectrometer (PACS) on the Herschel Space Observatory. A&A, 518, L2.

[11] Pilbratt, G.L., Riedinger, J.R., Passvogel, T. et al., 2010. Herschel Space Observatory. An ESA facility for far-infrared and submillimetre astronomy. A&A, 518, L1.

[12] Hartogh, P., Lellouch, E., Moreno, R. et al., 2011. Direct detection of the Enceladus water torus with Herschel. A&A 532, L2.

[13] Hansen, C. J., Esposito, L., Stewart, A. I. F. et al. 2006. Enceladus' Water Vapor Plume. Science 311, 1422-1425.

[14] Porco, C. C., Helfenstein, P., Thomas, P. C. et al., 2006. Cassini Observes the Active South Pole of Enceladus. Science 311, 1393-1401.

[15] Waite, J. H., Combi, M. R., Ip, W.-H. et al., 2006. Cassini Ion and Neutral Mass Spectrometer: Enceladus Plume Composition and Structure. Science 311, 1419-1422.

[16] Cassidy, T. A. and Johnson, R. E., 2010. Collisional spreading of Enceladus' neutral cloud. Icarus 209, 696-703.

[17] Hue, V., Cavalié, T., Hersant, F., et al., 2014. A 2D seasonal photochemical model for giant planet atmospheres: application to Saturn. In preparation.