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.

References


Figure 1: Line peak intensity of the H₂O 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 H₂O 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).
Figure 2: Flux of infalling H$_2$O 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.


