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Plasma variations in Saturn's inner magnetosphere from the main rings to Enceladus

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Abstract

With the discovery of an oxygen atmosphere over Saturn's main rings by the Cassini spacecraft observation (Tokar et al., 2005; Johnson et al. 2006), as well a strong, but variable source from the plumes emanating from the southern polar region of the moon Enceladus (Porco et al., 2005; Smith et al., 2010) the physics of the inner magnetosphere from the main rings to inside the orbit of Enceladus has changed dramatically. This region contains O_2 produced by the ring atmosphere and water group ions from the plumes. During the Saturn Orbit Insertion (SOI), July 1, 2004, Cassini detected a significant density of O_2^+ ions over the main rings and between the F & G rings suggestive of an oxygen atmosphere produced from photochemistry of the ice particles in Saturn's ring system (Johnson et al., 2006, Tseng et al., 2009, Tseng & Ip 2010). We have produced a simple photochemistry model combining the water products from Enceladus and the seasonal effects on the ring atmosphere. The purpose of this study is to examine ion densities and composition from several periapses passes from 2004 to 2010 for the region in order to separate contributions from the seasonal effect on the ring atmosphere from any contribution from water products coming from Enceladus. Due to the high background of this region, the number of orbits used in this study with good pointing into the plasma is limited to 6 passes, SOI, 2005(Sept 5), 2007(June 11, June 27/28), and 2010 (Mar 3, June 19). Our analysis indicates a large variation in ion density and temperature between 2004 and 2010 and between the Voyager 2 data. Although the Enceladus plumes are variable, the very large variability in the ion density and the changing composition from 2004 to equinox appears to be more consistent with the seasonal variation estimated for the ring atmosphere.

1. Introduction

The photo-produced portion of the atmosphere that forms over the main rings is expected to vary seasonally as the source rates of the neutrals produced from the ring particles depend on the ring temperature and on the incident angle of the sun (Tseng et al., 2009). Since this atmosphere is a source of ions for the region studied, examination of plasma data from 2004, when the sun was near southern solstice, and later plasma data as the solar angle reduces toward equinox, might reflect the changing source rate. The source from Enceladus while variable (smith et al. 2010), however, has no known seasonal dependence, however, this same water source has been shown to influence the seasonal oxygen source from the A ring (Tseng et al 2010, Tseng & Ip, 2010). We found there was a significant drop in the density and temperatures of the ions between the Cassini SOI pass, the Voyager 2 pass and the Cassini passes examined between 2005 and 2010. The data also indicates a stronger O_2^+ peak closer to the rings and an enhanced water (W+) group ion peak containing: O^+, OH^+ and H_2O^+, peak closer to Enceladus.

The large variability observed in the density and temperature and compositional data in this study seems to correspond more closely to the seasonal effects modeled by Tseng et al (2009). However, solar activity levels and Enceladus plume variability can affect our results.

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