EPSC Abstracts
Vol. 7 EPSC2012-889-1 2012
European Planetary Science Congress 2012

Magnetosphere-Atmosphere Coupling at Saturn: Response of Thermosphere and Ionosphere to Steady State and Time-Dependent Polar Forcing

I. C. F. Müller-Wodarg (1,2), **M. Galand (1,2)**, L. Moore (2), S. Miller (3) and M. Mendillo (2)
(1) Space and Atmospheric Physics Group, Imperial College London, UK
(2) Center for Space Physics, Boston University, USA
(3) Atmospheric Physics Laboratory, University College London, UK
(i.mueller-wodarg@imperial.ac.uk)

Abstract

We present comprehensive calculations of the response of Saturn's coupled thermosphere–ionosphere to forcing by solar radiation, magnetospheric energetic electron precipitation and high latitude electric fields caused by sub–corotation of magnetospheric plasma. Significant additions to the physical processes calculated in our Saturn Thermosphere Ionosphere General Circulation Model (STIM-GCM) include the comprehensive and self–consistent treatment of neutral–ion dynamical coupling and the use of self–consistently calculated rates of plasma production from incident energetic electrons.

Our simulations successfully reproduce the observed high latitude temperatures as well as the latitudinal variations of ionospheric peak electron densities that have been observed by the Cassini Radio Science Subsystem experiment (RSS). We find magnetospheric energy deposition to profoundly control the flow of mass and energy in the high and mid latitude thermosphere and thermospheric dynamics to play a crucial role in driving this flow.

By relating observed H_3^+ column emissions and temperatures to the same quantities inferred from simulated atmosphere profiles we validate our calculations and provide some constraints to the still unknown abundance of vibrationally excited H_2 which strongly affects the H_3^+ densities. Our calculations also demonstrate that most local time variability in H_3^+ column emission flux is driven by local time changes of H_3^+ densities rather than temperatures. By exploring the parameter space of possible high latitude electric field strengths and incident energetic electron fluxes, we determine the response of thermospheric polar temperatures to a range of these magnetospheric forcing parameters, illustrating that 10 keV electron fluxes of 0.1–1.2 mW/m^2 in combination with electric field strengths of 80–100 mV/m produce H_3^+ emissions consistent with observations.

In addition to examining the steady–state response of the atmosphere to polar forcing, we have introduced time–dependency in the auroral parameters, simulating "magnetic storm" scenarios for Saturn. These studies allow us to examine time constants in the atmosphere and the global propagation of waves, highlighting important differences in the responses of Saturn and Earth to space weather events.

Our simulations highlight the importance of including dynamics in any high latitude energy balance studies on Saturn and other Gas Giants and questions the validity of 1–D energy balance calculations in the auroral regions. Furthermore, we find thermospheric temperatures to be a key constraint for examining the state of Saturn's magnetosphere and its coupling to the upper atmosphere.