

Global Modeling of Planetary Ionospheres and Thermospheres

INGO C. F. MUELLER-WODARG¹, R. V. YELLE³, M. MENDILLO²

¹*Space and Atmospheric Physics Group, Imperial College London*

²*Center for Space Physics, Boston University*

³*Lunar and Planetary Laboratory, University of Arizona, Tucson*

Over the past decades our understanding of the outer regions of atmospheres (thermospheres/ionospheres), which interact directly with the space environment, has matured considerably. While many details remain poorly understood, we have a good first-order understanding of the basic principles, how energy from solar radiation or particle influx is absorbed in the atmosphere and redistributed internally. This generates global dynamics, which in turn affect the distribution of atmospheric constituents. Upper atmospheres are particularly complex since both plasma and neutral gases co-exist, which in the presence of magnetic and electrical fields potentially behave very differently. In addition, the upper atmosphere regions are often affected by waves propagating upwards from below and adding momentum and energy to the environment. Our understanding this complex non-linear system has greatly benefited from the development of global models which numerically solve the coupled equations of energy, continuity and momentum for neutrals and ions in 3 dimensions of space. While such General Circulation Models (GCMs) were initially applied to the Earth's thermosphere and ionosphere, they have since been adapted to other planets in our solar system and beyond, from Venus and Mars to Jupiter and Saturn, including moons Titan and Triton. Often, the initial disagreement between model predictions and observations and subsequent inclusion of additional physical processes in the models have led to a far deeper understanding of the processes than observations alone would have given us. Examples of this are the thermospheric winds on Venus, which are in reality far smaller than models had predicted, probably due to the deceleration by dissipating gravity waves. On Titan, GCM calculations predicted strong horizontal variations of composition, which were recently confirmed by the Cassini Ion Neutral Mass Spectrometer observations, but in the opposite sense, suggesting that dynamics on Titan are not solely controlled by solar EUV heating. My talk will give an overview of what GCMs are currently capable of capturing and what not. Amongst other, I will give examples of Titan and Saturn, whose thermospheres and ionospheres are currently being explored by the Cassini spacecraft.