Plasmaspheric H⁺, He⁺, He++, O⁺, and O++ Densities and Temperatures

D. L. Gallagher1, P. D. Craven1, R. H. Comfort2

1 NASA/Marshall Space Flight Center
2 University of Alabama in Huntsville

ABSTRACT
Thermal plasmaspheric densities and temperatures for five ion species have recently become available, even though these quantities were derived some time ago from the Reversing Ion Mass Spectrometer onboard the Dynamics Explorer 1 satellite early in the years 1980-1986. Some of the quantitative properties are presented. Densities are found to have one behavior with lower statistical variation below about L=2 and another with much greater variability shows that L-shell. Temperature also have a behavior difference between low and higher L-values. The density ratio He⁺/H⁺ is the best behaved with values of about 0.2% even at L-values of L=3.5 and 4.5. The density ratios of the other ions are tightly centered around 1.0 except for the middle plasmasphere between L=3.5 and 4.5 where the temperature can be significantly higher. The temperature of He++, O+, and O++ are consistently higher than H⁺.

OBJECTIVE
The objective of this effort is to create a new, updated Global Coordinated Plasma Model (GCPM). First published by Gallagher et al., JGR, 197, 18035, 2008, GCPM is an empirical, global model of thermal plasma density intended to provide typical concentrations of H⁺ and He⁺ in the inner magnetosphere. The model design was initially based on 30 years of published regional models and intended to be smooth in value and gradient. Samples of the existing GCPM are shown below.

SOLUTION SET
The objective for a new GCPM, call it GCPM*, is to take advantage of extensive ion mass calculations performed with the Reversing Ion Mass Spectrometer (RIMS) data that provide densities and temperatures for five ion species: H⁺, He⁺, He++, O+, and O++. Further, it is intended that the new model take advantage of what has been learned from global plasmaspheric images obtained by the IMAGE Mission Extreme Ultraviolet (EUV) Instrument [Sandel, et al., Space Sci. Rev., 92, 197, 2000]. That knowledge is in a global morphology of the plasmasphere (plasmopause) that decreases with space weather conditions. The gaps in this solution set result from changing magnetospheric convection, whose recognition may enable new opportunities to achieve a more ordered assembly of in situ measurements for the model and other more recently published observations are also to be included in the new GCPM*.

DATASET
A Distinct Break in H⁺ Densities Distinguishes High Topside Ionosphere from Higher Altitudes

SUMMARY
Three areas are shown to the right. The first provides a quick look at an initial set of equations that can be used to describe some, but not all, of the densities and temperatures. This is a preliminary look at the problems sought through this investigation. Perhaps not unexpectedly there is a predominance of relatively ordered relationships between observable parameters. The gaps in this solution set result from greater than one order in magnitude scatter in ion density or temperature in these plots. Naturally it is expected that there will be a strong dependence on geophysical or space weather conditions, even when different ions respond similarly. As indicated by somewhat better behaved laws of nature it is clear that some simple trends are not sufficient.