A New Global Core Plasma Model of the Plasmasphere

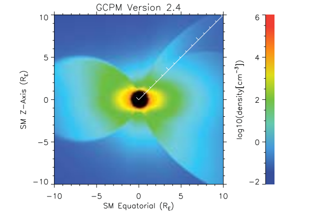
NASA Marshall Space Flight Center

D.L. Gallagher[1], R.H. Comfort[2], P.D. Craven[1]

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

Abstract

The Global Core Plasma Model (GCPM) is the first empirical model for thermal inner magnetospheric plasma designed to integrate previous models and observations into a continuous in value and gradient representation of typical total densities. New information about the plasmasphere, in particular, make possible significant improvement. The IMAGE Mission Radio Plasma Imager (RPI) has obtained the first observations of total plasma densities along magnetic field lines in the plasmasphere and polar cap. Dynamics Explorer 1 Retarding Ion Mass Spectrometer (RIMS) has provided densities in temperatures in the plasmasphere for 5 ion species. These and other works enable a new more detailed empirical model of thermal in the inner magnetosphere that will be presented. Specifically shown here are the inner-plasmasphere RIMS measurements, radial fits to densities and temperatures for H+, He+, He++, O+, and O+ and the error associated with these initial simple fits. Also shown are more subtle dependencies on the $f_{10.7}$ P-value (see Richards et al. [1994]).



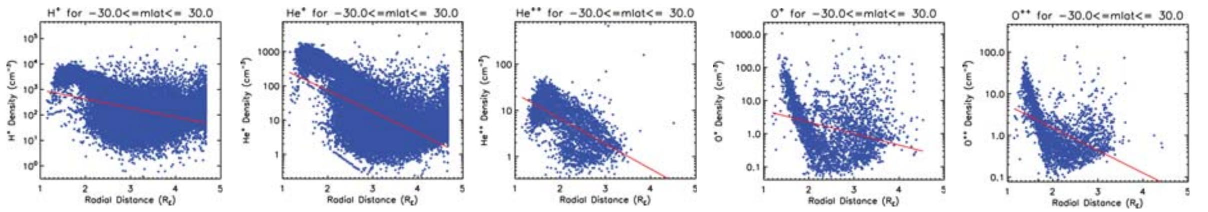
Ion Density Dependence On Radial Distance

Ion densities in the inner plasmasphere are included for all radial distances out to $r=5R_E$. In what follows only the inner plasmasphere is considered where the line between inner and outer depends on the ion density behavior. The distinction is made, because of the clear variation in behavior and in order to focus on one pattern of behavior at a time. The inner plasmasphere may in fact be expected to behave differently as it is less directly impacted by magnetic activity. Other potential dependences of plasmaspheric densities and temperatures will continue to be explored. Meanwhile expansion of GCPM can be provided for broad use. That is the intended application of these results.

Fit equation: ion moment = 10^((A + B*r) for all MLT

Densities

	A	B	std-A	std-B	std-% error
H+	3.338e+000	-3.546e-001	1.581e-002	4.715e-003	7.420e+002
He+	3.110e+000	-6.230e-001	1.594e-002	4.833e-003	4.004e+002
He++	1.908e+000	-5.433e-001	2.910e-002	1.306e-002	1.479e+002
O+	1.047e+000	-3.480e-001	5.313e-002	2.062e-002	4.480e+002
O++	1.264e+000	-5.419e-001	4.032e-002	1.853e-002	1.709e+002



Inner Plasmasphere Ion Dependence On Radial Distance

Ion densities in the inner plasmasphere and all available temperatures are plotted against radial distance. The scattered values are fit with a linear function; the fit parameters are shown below. Also shown below are the standard deviations in the fit parameters and the standard deviation of the percentage error between the linear fit and the parameter values. Error is obtained from the difference between data and model normalized by the data. Quite a lot of scatter remains. The dependence on other spacial parameters is small. The dependence on magnetic latitude previously discussed is attributed to a dependence on radial distance.

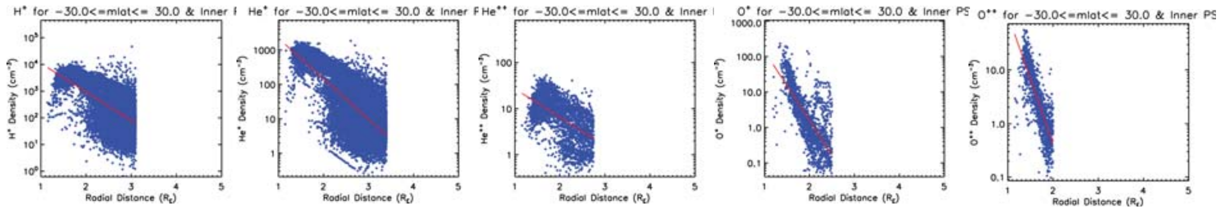
Fit equation: ion moment = 10^(A + B*r) for all MLT

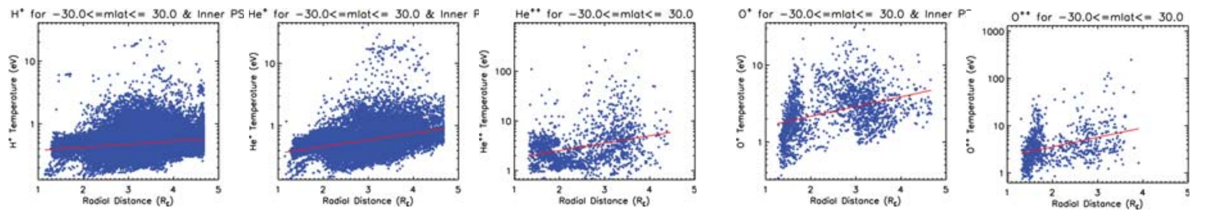
Densities

	A	B	std-A	std-B	std-% error
H+	5.115e+000	-1.072e+000	2.950e-002	1.174e-002	8.117e+002
He+	4.518e+000	-1.176e+000	2.335e-002	8.548e-003	5.613e+002
He++	2.042e+000	-6.140e-001	3.799e-002	1.848e-002	1.529e+002
O+	4.103e+000	-1.950e+000	8.936e-002	4.554e-002	4.184e+002
O++	4.441e+000	-2.408e+000	8.250e-002	4.902e-002	3.413e+002

Temperatures

	A	B	std-A	std-B	std-% error
H+	-4.702e-001	4.868e-002	5.390e-003	1.606e-003	2.681e+001
He+	-5.488e-001	1.069e-001	7.185e-003	2.358e-003	3.076e+001
He++	1.018e-001	1.496e-001	2.785e-002	1.087e-002	6.284e+001
O+	7.987e-002	1.269e-001	1.913e-002	7.244e-003	5.091e+001
O++	1.467e-001	2.023e-001	3.756e-002	1.773e-002	5.932e+001





Ion Dependence On F10.7 P-Parameter ($f_{10.7}$+$f_{10.7}$ 81day-ave)/2

The strongest dependent of either density or temperature on several indices is on the P-parameter. The quantities tested are Kp, Dst, F10.7, P, and trending values for each. Trends are determined by the slopes of linear fits to preceding values over customized time periods. For Kp the preceding 1-day and 3-days are considered. For Dst, the preceding 6-hours and 1-day, and for F10.7, the preceding 5-days. As previously found, noteworthy dependences are found for H+ and He+ densities. The trend in He++ density may also be significant. No dependence in the other two ions or any of the temperatures is considered significant at this time.

Fit equation: ion moment = 10^((A + B*r) * (C + D)*P) for all MLT

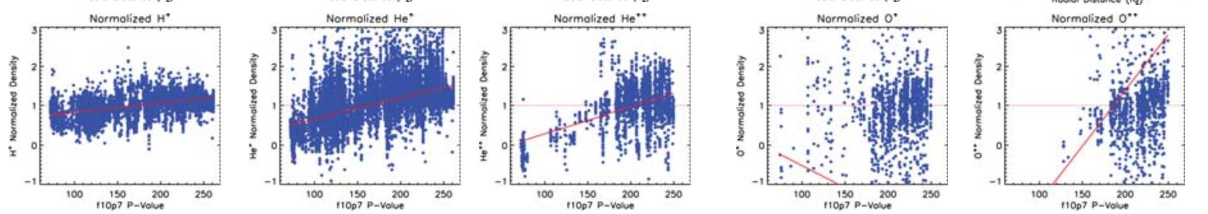
Densities

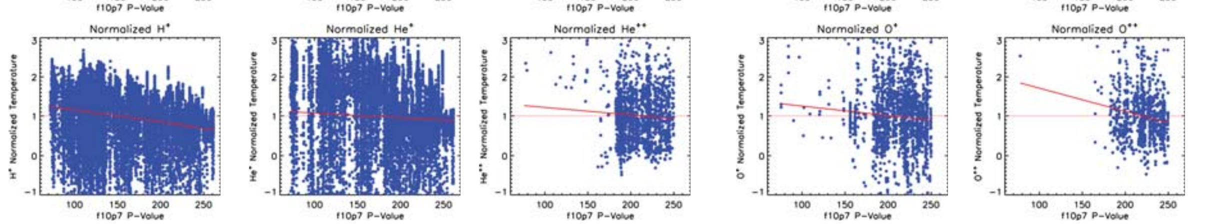
	C	D	std-C	std-D	std-% error
H+	5.881e-001	2.358e-003	7.166e-003	3.903e-005	6.562e+002
He+	1.309e-001	5.320e-003	1.211e-002	6.879e-005	6.370e+002
He++	-3.896e-001	6.811e-003	5.289e-002	2.550e-004	1.239e+002
O+	6.128e-001	-1.134e-002	8.320e+000	3.997e-002	2.882e+003
O++	-4.281e+000	2.837e-002	4.787e+001	2.215e-001	1.214e+003

Temperatures

	C	D	std-C	std-D	std-% error
H+	1.464e+000	-3.071e-003	1.307e-002	8.205e-005	2.543e+001
He+	1.194e+000	-1.192e-003	4.128e-002	2.239e-004	3.014e+001
He++	1.413e+000	-1.937e-003	1.683e-001	7.967e-004	6.653e+001
O+	1.497e+000	-2.431e-003	1.432e-001	6.742e-004	4.995e+001
O++	2.304e+000	-5.925e-003	2.366e-001	1.070e-003	6.570e+001

Questionable linear dependence





GCPM 2000

The interior plasmasphere density profile is given by:

$n_e = 10^{(-0.79L+5.3)}$

and the He+/H+ density ratio is given by:

$n_{He+}/n_{H+}=10^{(-1.541-0.176*r+8.557e-3*P-1.458e-5*P^2)}$

where the current treatment finds the density ratio as a function of radial distance to be:

$n_{He+}/n_{H+}=10^{(-0.248-0.2658*r)}$ with one standard deviation

errors for these two fit factors of: 0.0141 and 0.0052.

Summaries of Model Composition

While there remains considerable scatter, trends in densities and temperatures can be quantified using the linear fits. Using only the radial distance fits, the plots below provide a summary of the trends with radial distance for each ion density and temperature. He++ is of some interest given its average behavior. It would be expected to result from charge exchange with He+, just as O++ would arise from charge exchanged O+. Much is yet to be learned from the DE1 RIMS measurements.