The unusual electrodynamics of the ionosphere of Mars

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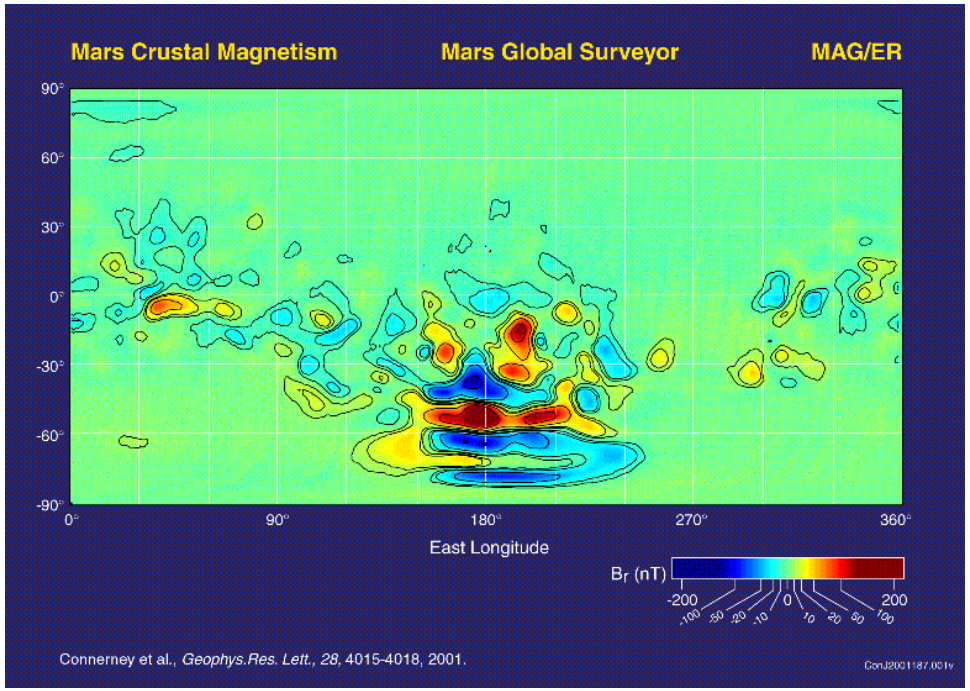
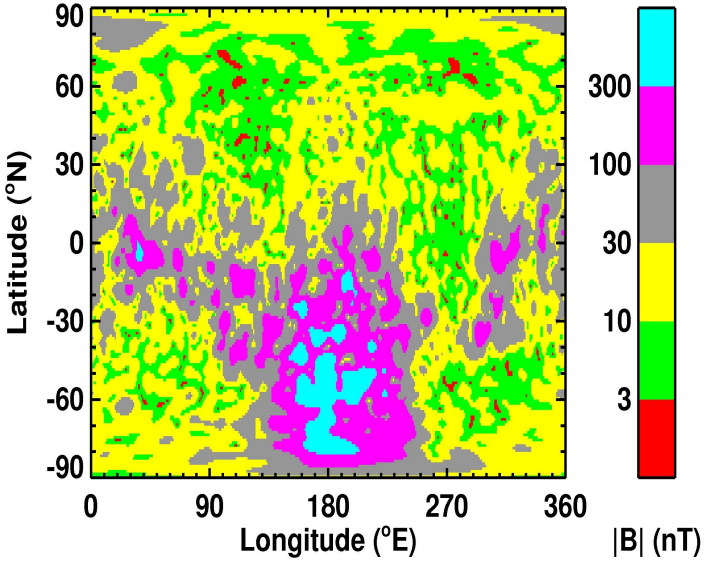
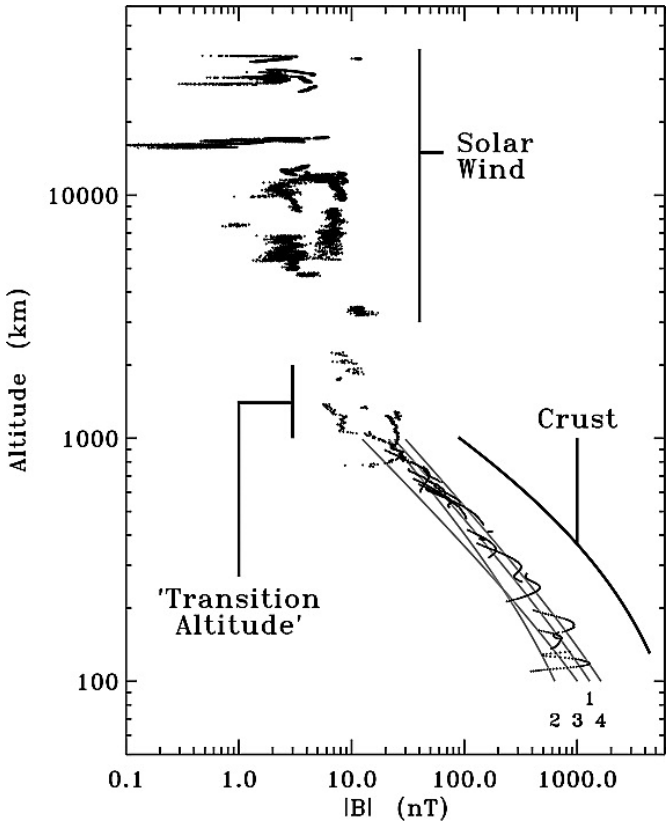
Martian Patchy Fields



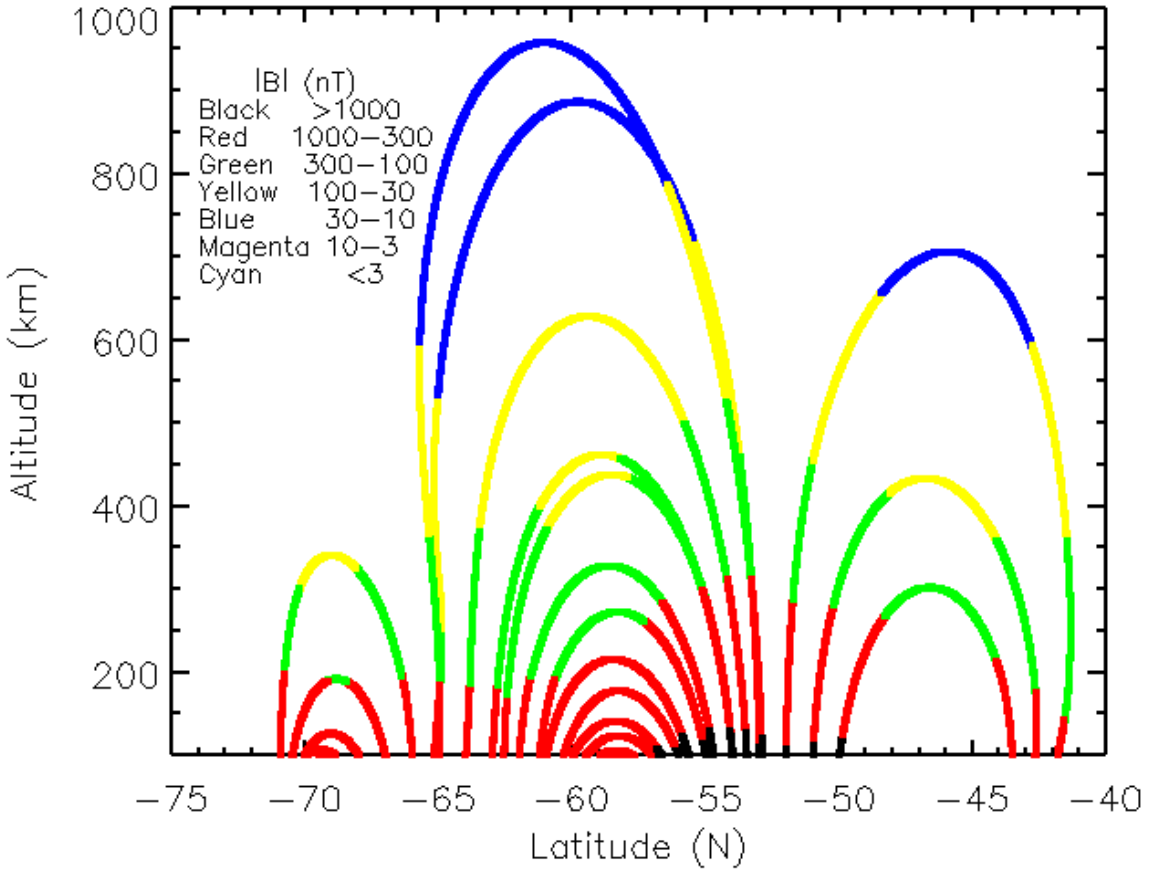


Arkani-Hamed model

Martian Field Lines

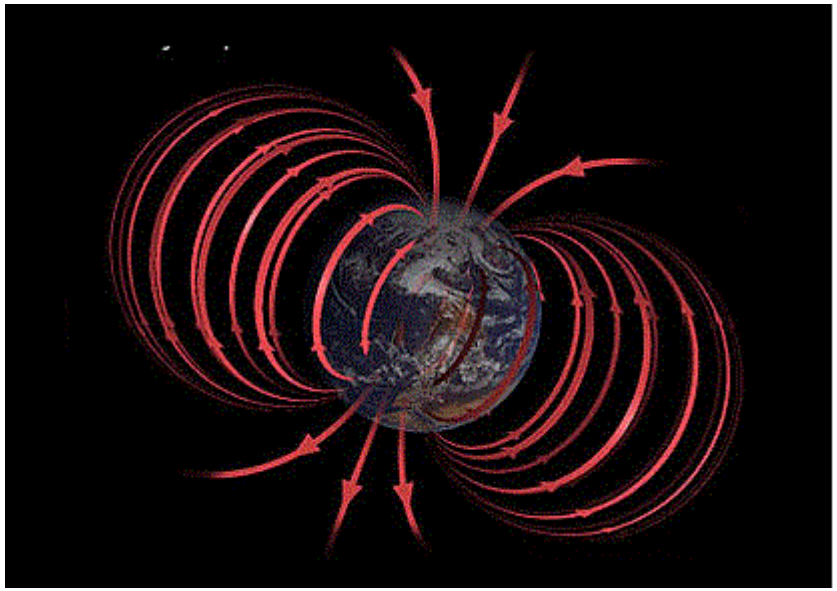


Brain et al. 2003

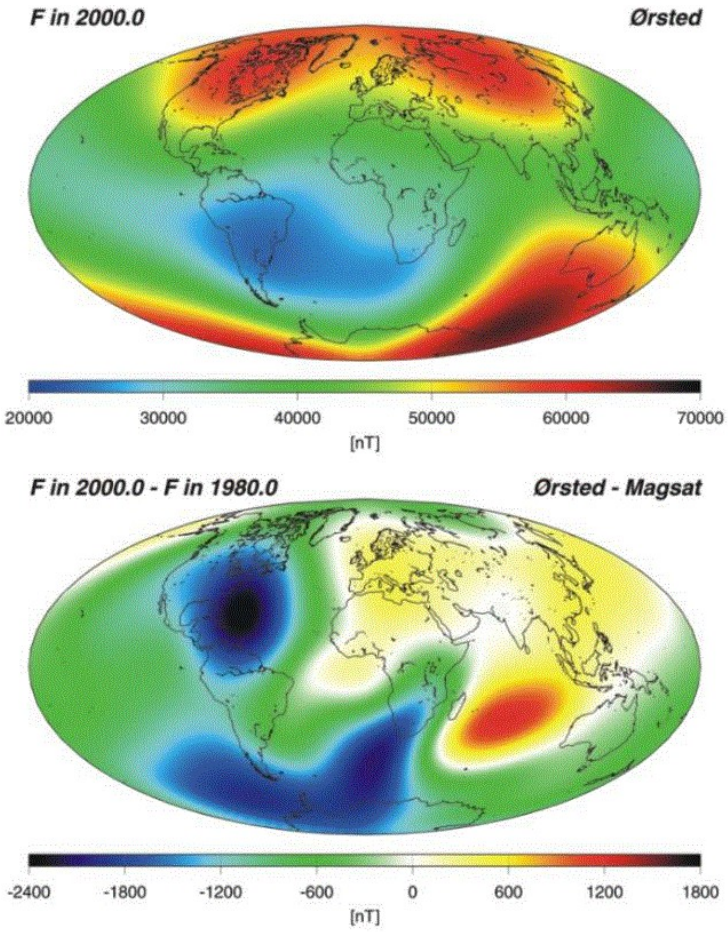


Mendillo and Withers, 2008

Earth's Field Lines

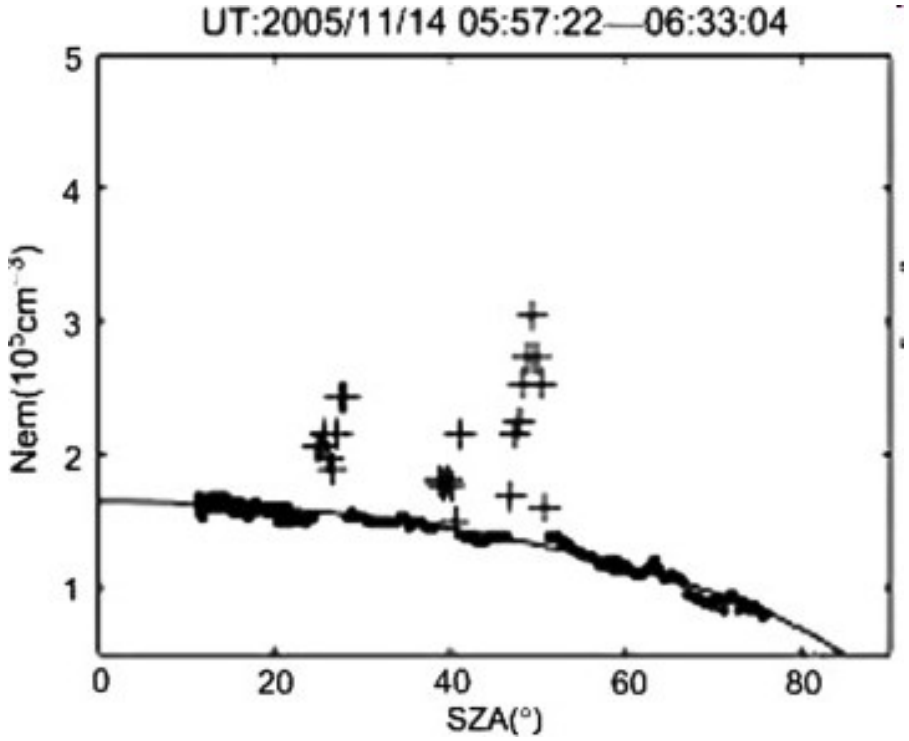


http://www.windows2universe.org/glossary/particle_motion.html

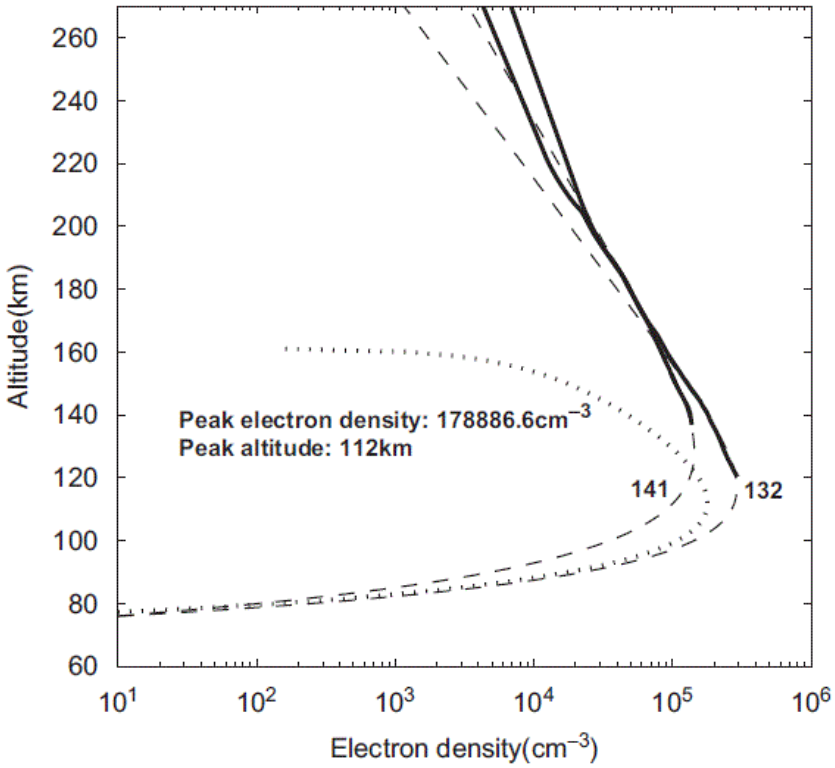


http://core2.gsfc.nasa.gov/terr_mag/core.html

Effect of Crustal B on Ionosphere



Nielson et al. 2007a, from Fig 1



Nielson et al. 2007a Fig 5

More effects of Crustal B

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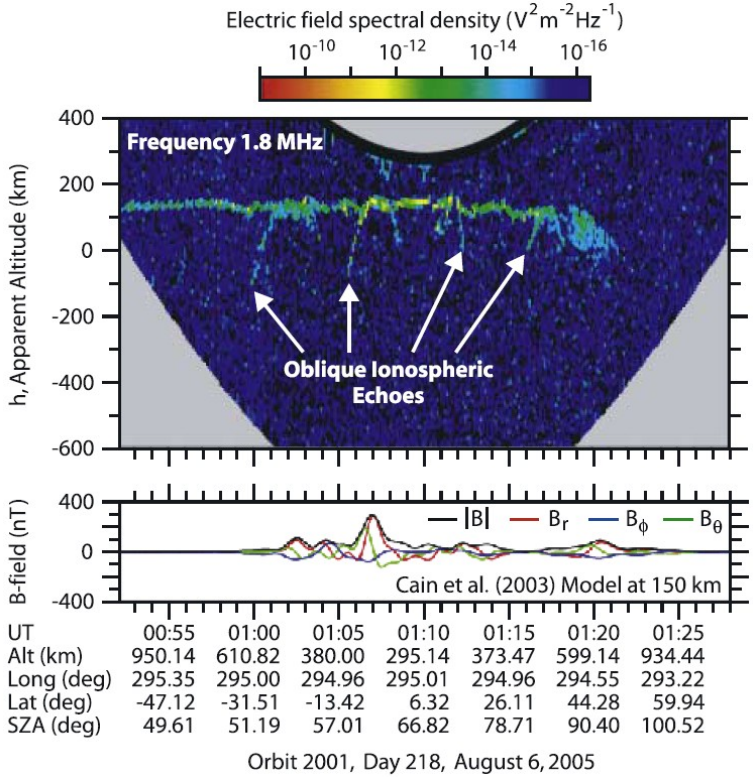
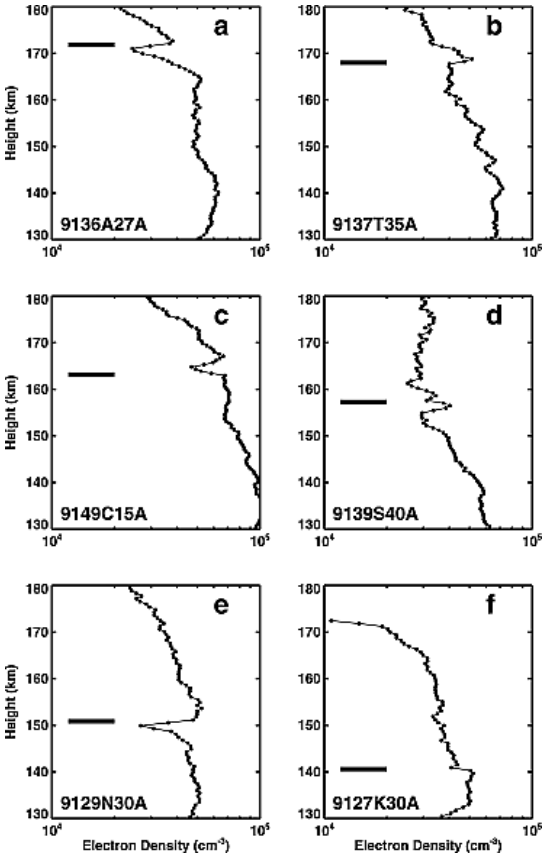


Duru et al., 2006, Fig 4



Withers 2005a, Fig 2

-Ion densities
-Electron Densities
-Temperatures
-Neutral Atmosphere

Theory (Withers, 2008)

$$\frac{\partial N_j}{\partial t} + \underline{\nabla} \cdot \left(N_j \underline{v_j} \right) = P_j - L_j$$

$$0 = m_j \underline{g} - \frac{1}{N_j} \underline{\nabla} \left(N_j k T_j \right) + q_j \underline{E'} + q_j B \underline{\underline{\Lambda}} \, \underline{w_j} - m_j \nu_{jn} \underline{w_j}$$

$$\underline{w_j} = \left(m_j \nu_{jn} \underline{\underline{I}} - q_j B \underline{\underline{\Lambda}} \right)^{-1} \left(m_j \underline{g} - \frac{1}{N_j} \underline{\nabla} \left(N_j k T_j \right) + q_j \underline{E'} \right)$$

$$\underline{w_j} = \frac{1}{m_j \nu_{jn}} \left(\underline{\underline{I}} - \kappa_j \underline{\underline{\Lambda}} \right)^{-1} \left(m_j \underline{g} - \frac{1}{N_j} \underline{\nabla} \left(N_j k T_j \right) + q_j \underline{E'} \right)$$

$$\underline{w_j} = \frac{1}{N_j q_j} \left(\underline{Q_j} + \underline{\underline{S_j}} \, \underline{E'} \right)$$

$$\underline{J} = \sum_j N_j q_j \underline{w_j} \longrightarrow \underline{J} = \underline{Q} + \underline{\underline{S}} \, \underline{E'}$$

Traditional Conductivity Tensor

$$\underline{J} = \underline{\underline{\sigma}}\,\underline{E}' \quad \text{, where} \quad \underline{\underline{\sigma}} = \begin{pmatrix} \sigma_P & -\sigma_H & 0 \\ \sigma_H & \sigma_P & 0 \\ 0 & 0 & \sigma_0 \end{pmatrix}$$

$$\sigma_P = \sum_{j=1}^{M} \frac{N q_j}{B} \frac{\nu_j/\omega_j}{1 + (\nu_j/\omega_j)^2}$$

$$\sigma_H = \sum_{j=1}^{M} \frac{N q_j}{B} \frac{1}{1 + (\nu_j/\omega_j)^2}$$

$$\sigma_o = \sum_{j=1}^{M} \frac{N q_j}{B} \frac{\omega_j}{\nu_j}$$

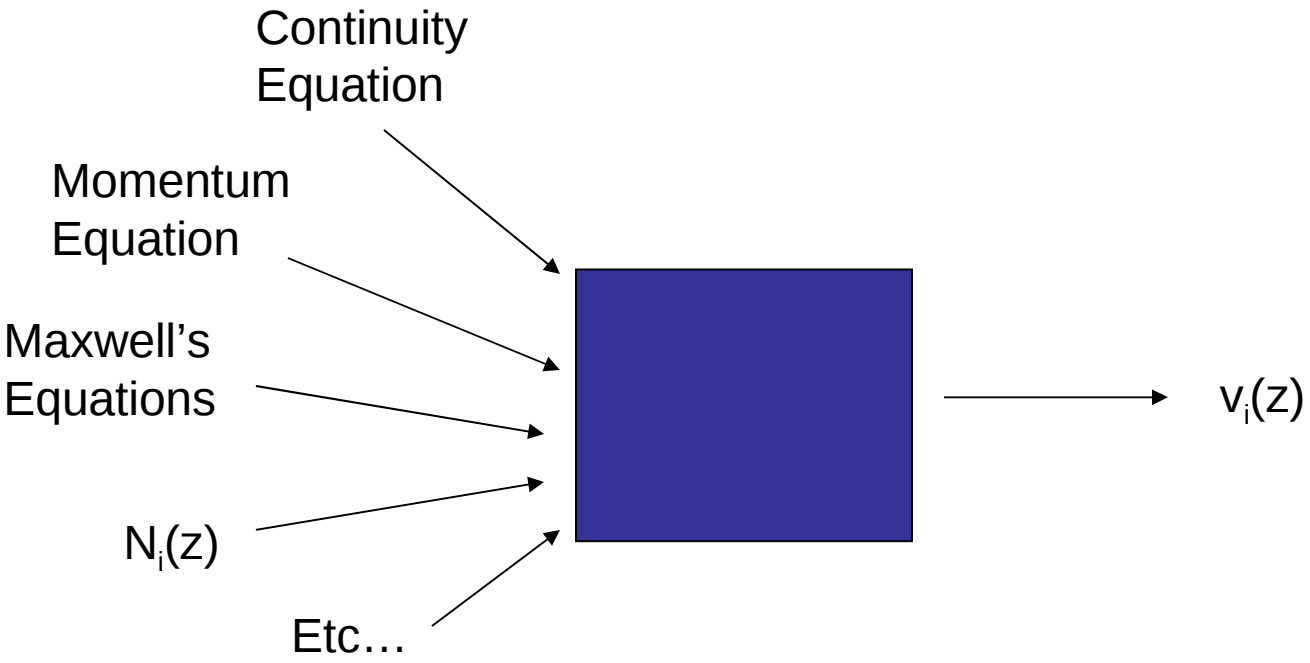
(Forbes, 1981)

General Conductivity Tensor:

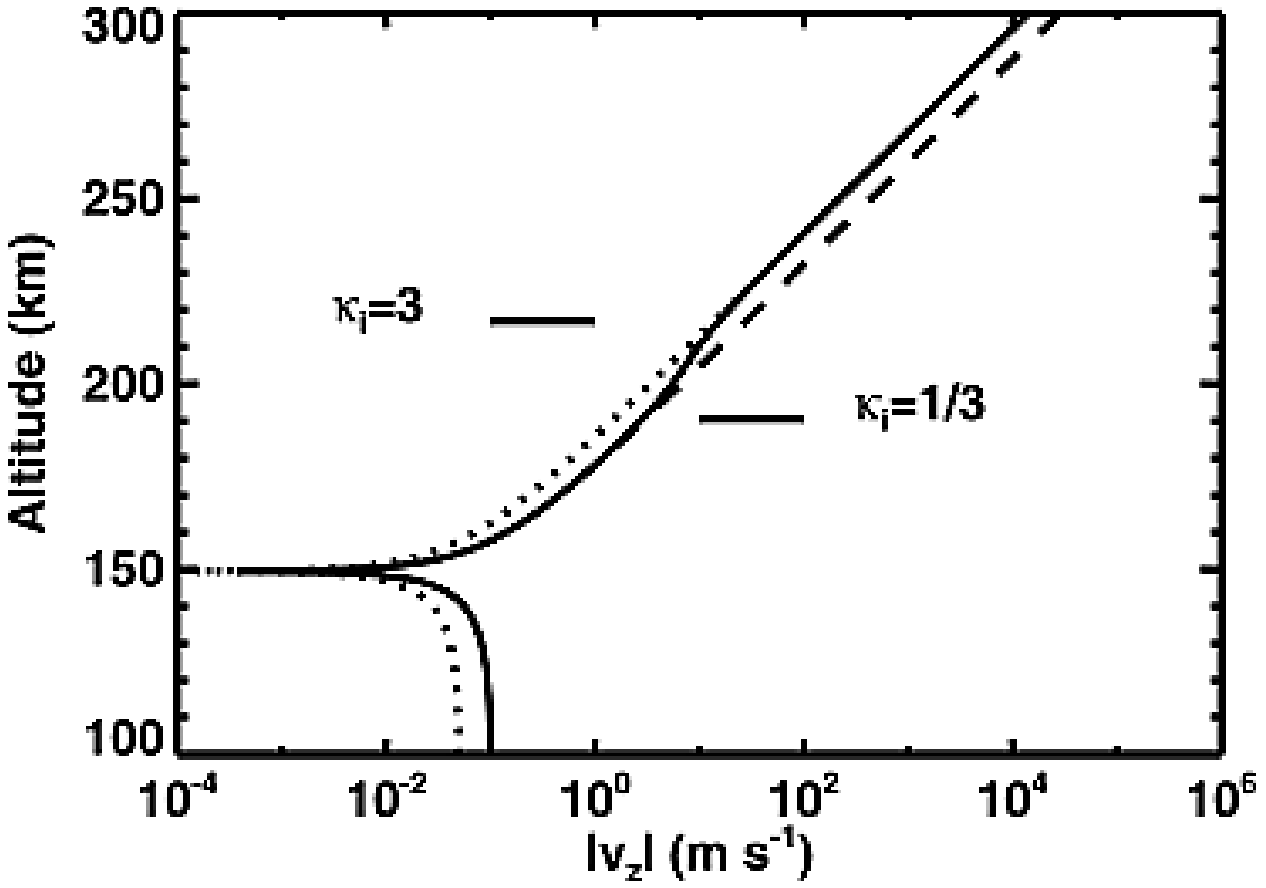
$$\underline{\underline{S}} = \sum_j \frac{N_j q_j^2}{m_j \nu_{jn}} \begin{pmatrix} \frac{1}{\left(1+\kappa_j^2\right)} & \frac{\kappa_j}{\left(1+\kappa_j^2\right)} & 0 \\ \frac{-\kappa_j}{\left(1+\kappa_j^2\right)} & \frac{1}{\left(1+\kappa_j^2\right)} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

(Withers, 2008)

Determining Ion Velocities

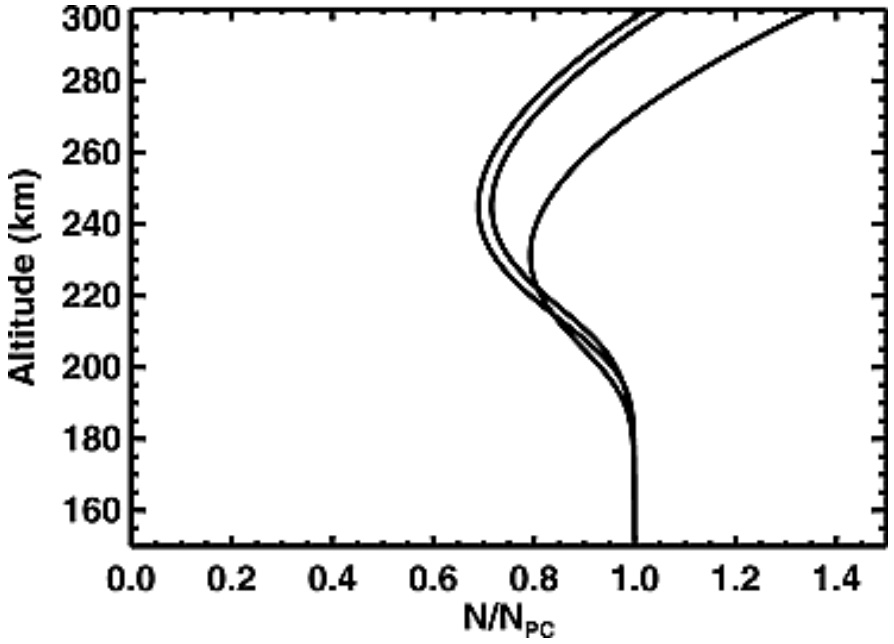


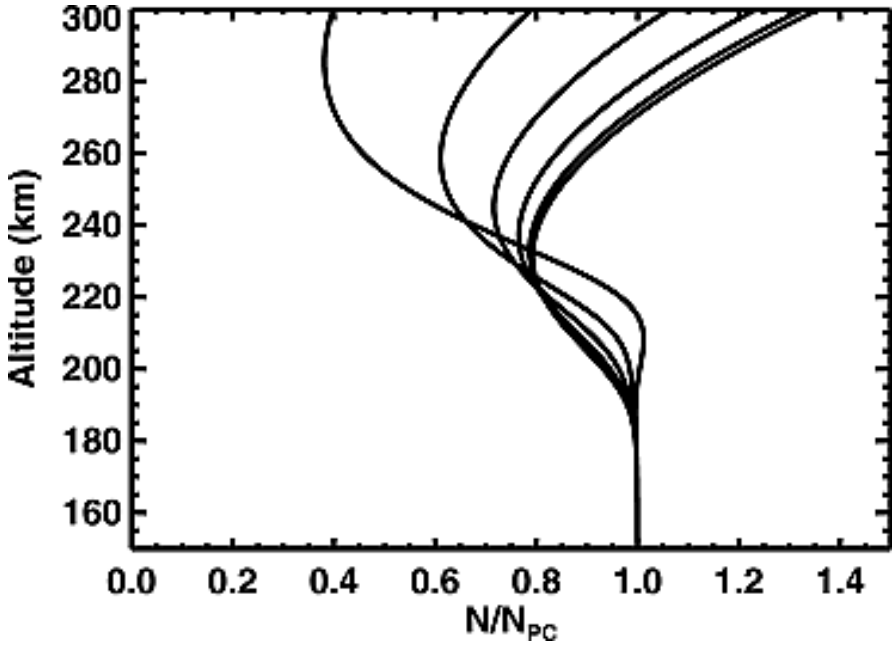
More Theory



(Withers, 2008)

Application of General Conductivity





(Withers, 2008: Figures 7 and 9)

Next, a 2D Model:

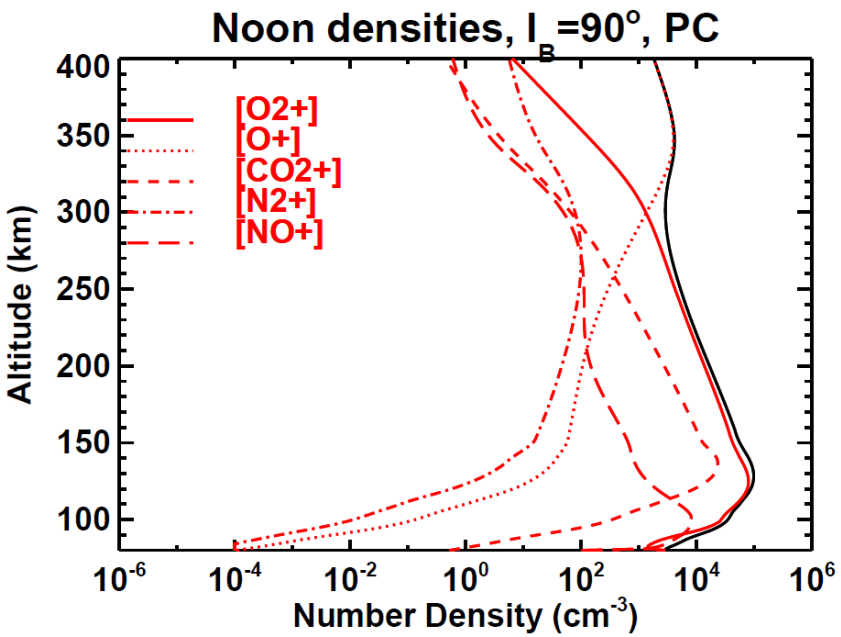
- Objective is to model, as accurately as possible, the generation of 5 major ions in the Martian ionosphere between 80-400 km.

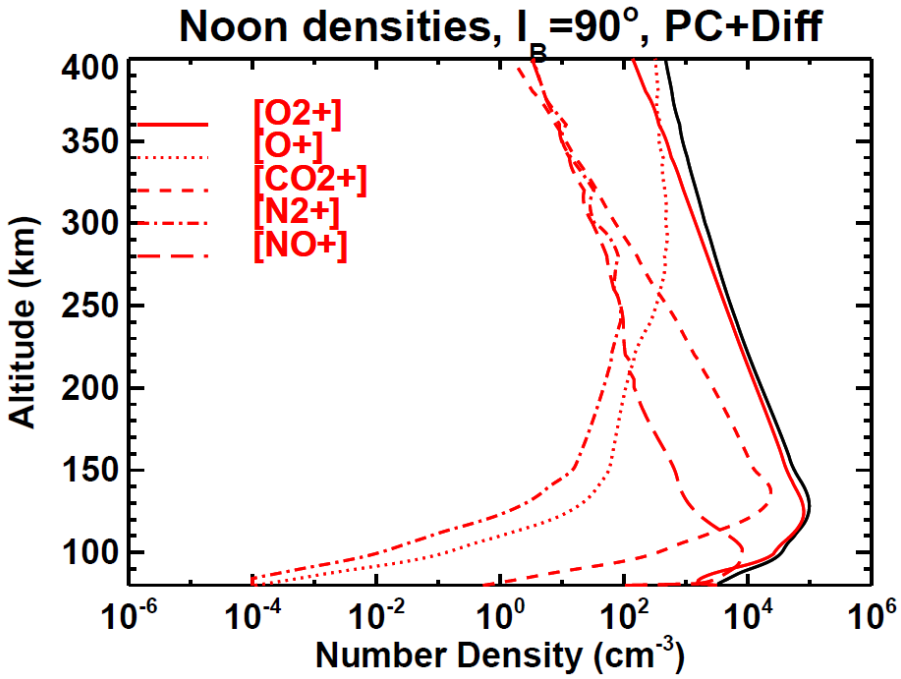
- Then to analyze this model as input parameters change (location over surface, surrounding magnetic environment, etc...)

2D Model Methodology

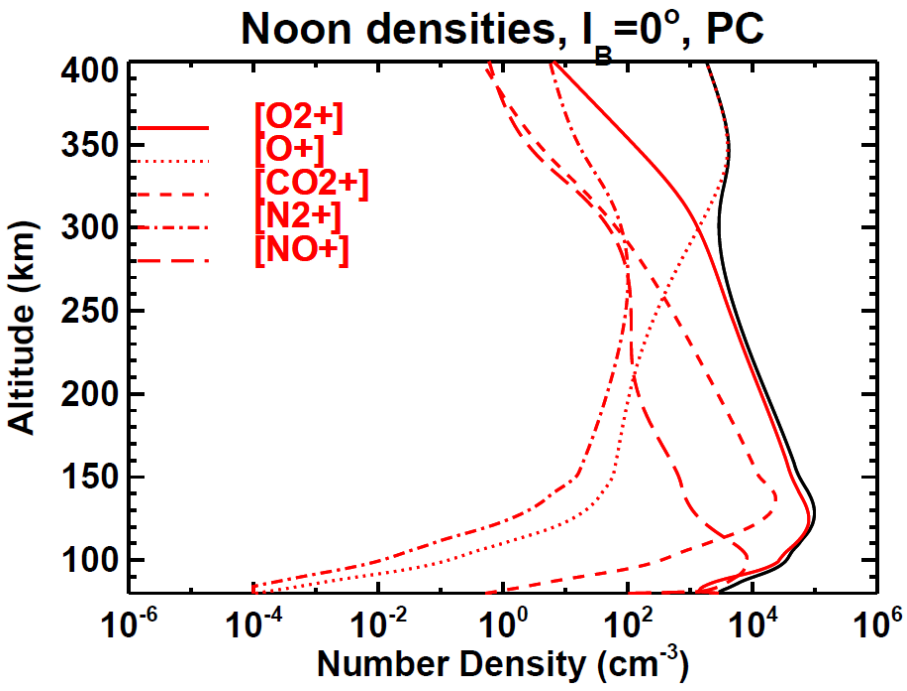
- PC Production
- PC Loss
- Transport
- Calculation of 2D ion velocities

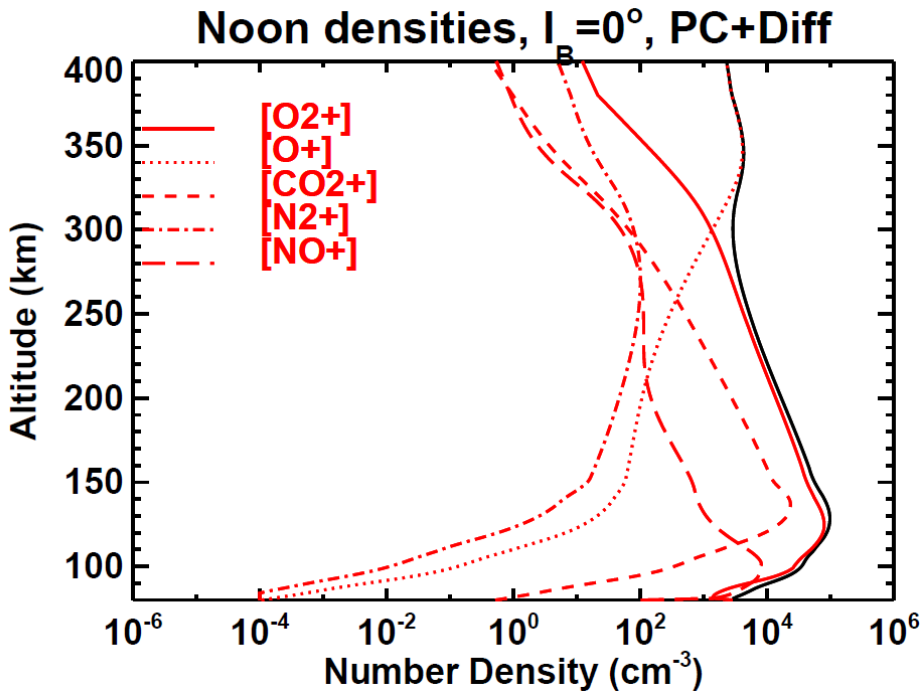
2D Model, Preliminary Results



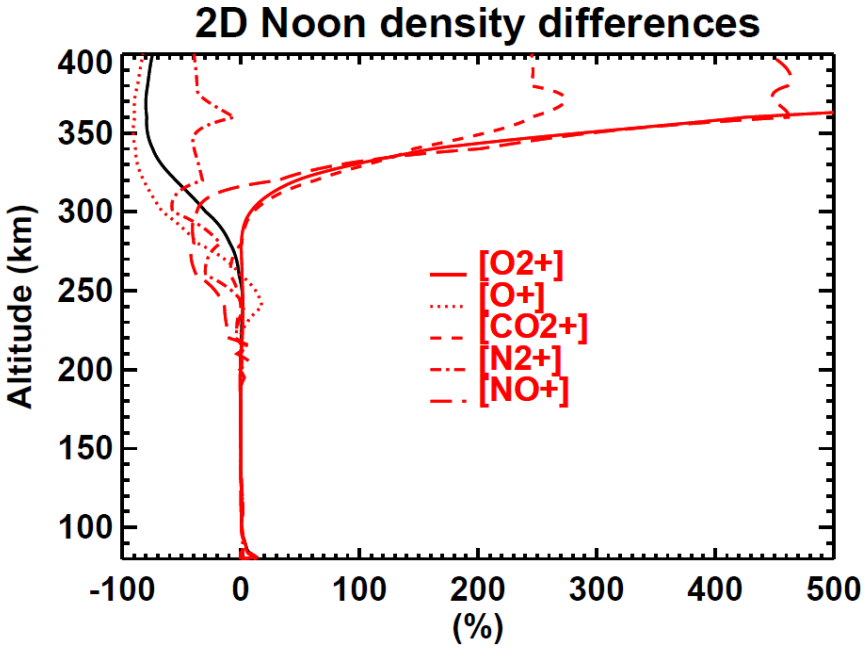


More Preliminaries

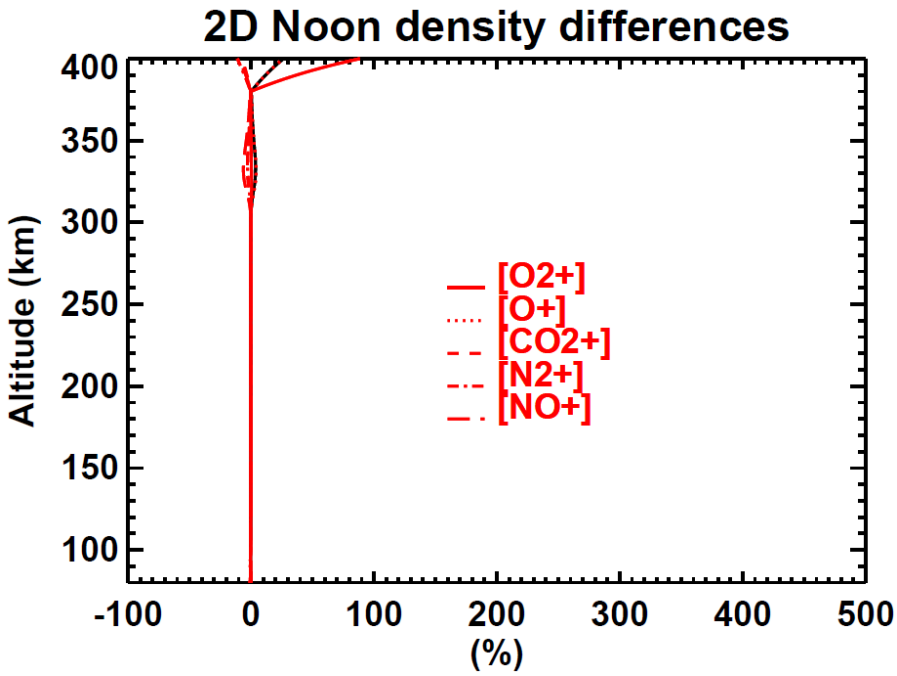




More 2D Model Preliminaries



Difference between PC only and PC with Diffusion densities for I_B=90º



Difference between PC only and PC with Diffusion densities for I_B=0º

Conclusions

- Martian crustal fields generate effects on the ionosphere that have been measured and modeled (1D).
- The most general representations of underlying physics apply to the regions of Martian ionospheres that should not be generalized for terrestrial-like cases.
- Further study and modeling (2D) is required to improve our understanding of the phenomena governing such regions.