An Empirical Model of Oxygen Charge State Distributions in the Earth's Magnetosphere

Robert C. Allen (rallen@swri.edu)[1,2], S. A. Livi[2,1], and J. Goldstein[2,1]

[1] University of Texas at San Antonio, San Antonio, TX 78249, USA

[2]Space Science and Engineering Division, Southwest Research Institute, San Antonio, TX 78238-5166, USA

Southwest Research Institute

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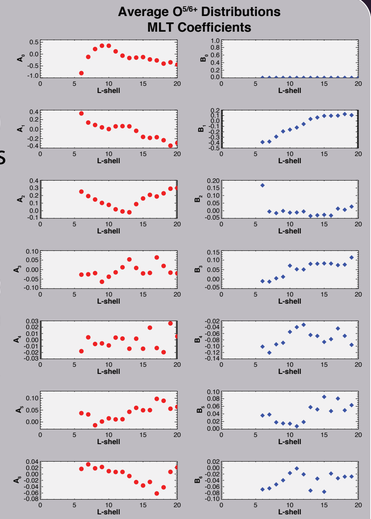
Motivation

- Oxygen ions near Earth originate from two sources:
  1) Ionospheric outflow (i.e., O^+)
  2) Solar wind penetration (i.e., $O^{5/6+}$)
- Most missions cannot measure the solar wind oxygen, so we need a reliable tool to have a a metric for solar wind penetration and subsequent dynamics.
- We present an empirical model of average oxygen charge state distributions based on Polar observations.

Methodology

- Using Polar observations from *Allen et al.* [submitted]
  - **Average O^+ through $O^{5/6+}$ distributions (top)**
  - O^+ and $O^{5/6+}$ distributions binned by:
    - **Dst (storm activity, bottom)**
    - Vsw*Bz (SW coupling)
    - AE (substorm activity)
- Conduct Fourier expansion of each L-shell as function of MLT following:



$$S_6(x) = \frac{a_0}{2} + \sum_{n=1}^{6}\left(a_n \cos\left(\frac{\pi n x}{12}\right) + b_n \sin\left(\frac{\pi n x}{12}\right)\right)$$

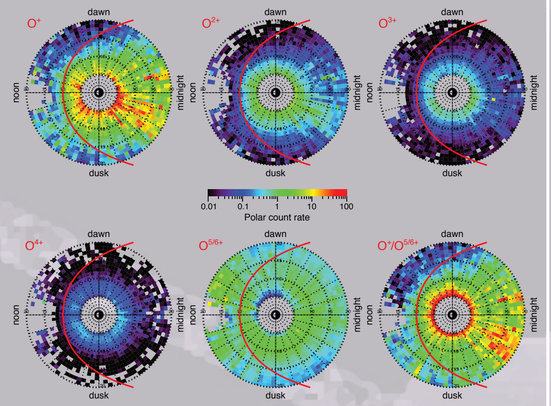
where, $a_n = \frac{1}{12}\int_0^{24} S(x)\cdot\cos\left(\frac{\pi n x}{12}\right)dx$ and $b_n = \frac{1}{12}\int_0^{24} S(x)\cdot\sin\left(\frac{\pi n x}{12}\right)dx$

Conclusions & Future Work

- The model captures oxygen charge state abundances and structures fairly well.
  - We can provide an accurate estimate of solar wind-originating plasma based on measured O^+
- To improve the model, the coefficients from the Fourier expansion will be fitted with Bessel functions.
- Connections can be inferred between the dominant coefficients and physical processes for the different proxies of magnetospheric activity.
- Results will be compared with *Kremser et al.* [1987] and model results from *Spjeldvik and Fritz* [1978].

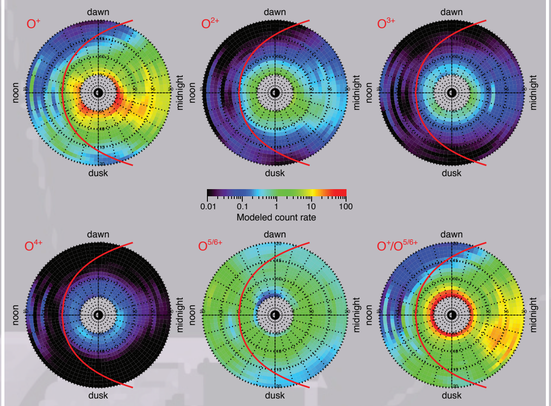
Data Model Comparison: Average Distributions

Actual Distribution



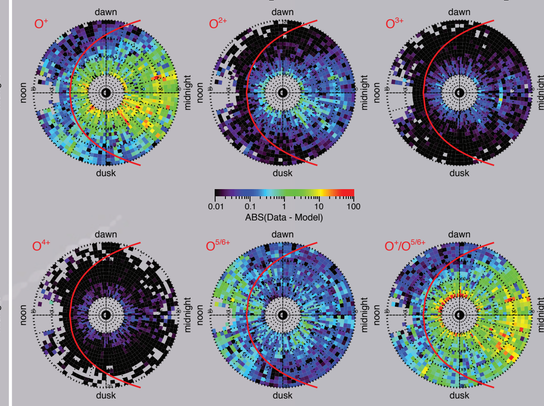
- Large pre-midnight enhancement for O^+ and O^{2+}, but broad $O^{5/6+}$ distribution
- Lower abundances observed near dawn for all charge states

Modeled Distribution



- Model captures pre-midnight enhancements and dawn-dusk asymmetry
- Tends to smooth out structure in pre-midnight region

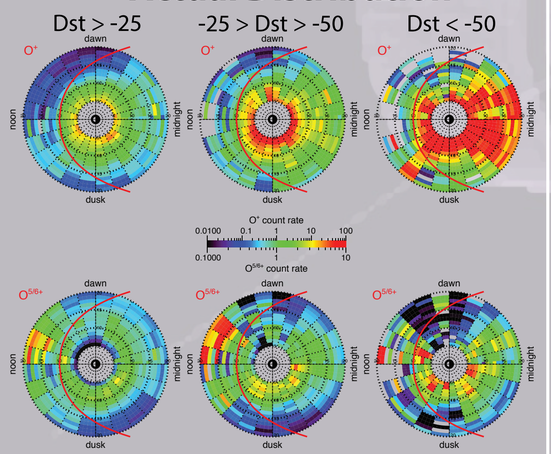
Difference |Data - Model|



- Generally small difference between model and data
- Slight over-prediction for post-midnight O^+

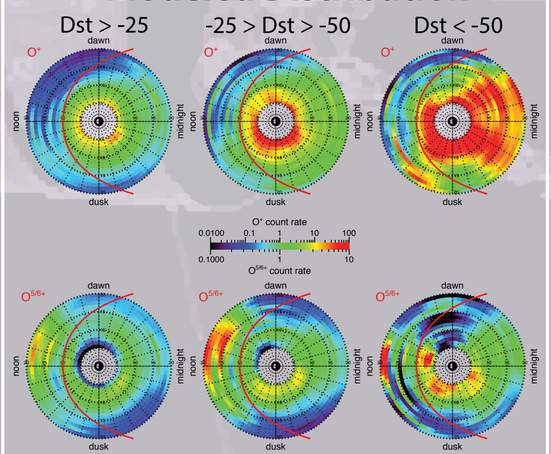
Data Model Comparison: Variations With Dst

Actual Distribution



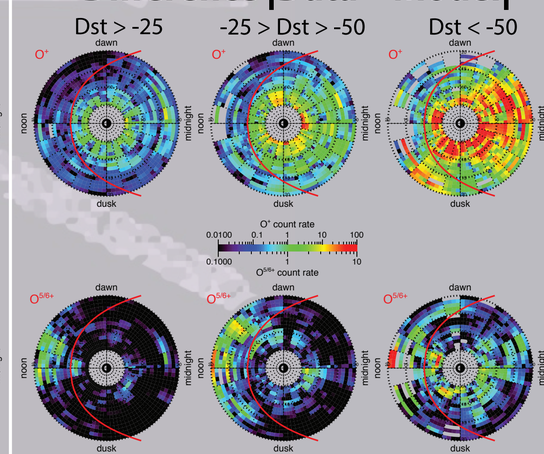
- O^+ sees large enhancement with increasing |Dst|
- $O^{5/6+}$ only sees slight enhancements, predominantly for lower L-shells

Modeled Distribution



- O^+ nightside enhancement and asymmetries captured
- $O^{5/6+}$ lower L-shell enhancements and asymmetries also reproduced

Difference |Data - Model|



- Largest differences seen during strong storms
- Generally good agreement with data

References

- *Allen et al.*, Variations of oxygen charge state abundances in the global magnetosphere, as observed by Polar, Submitted to J. Geophys. Res.
- *Kremser et al.* (1987) doi:10.1029/JA092iA05p04459
- *Spjeldvik and Fritz* (1978), doi:10.1029/JA083iA04p01583

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