Multi-epoch analysis of solar wind-originating oxygen inside the magnetosphere of Earth

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Abstract

Understanding the sources and subsequent evolution of plasma in a magnetosphere holds intrinsic importance for magnetospheric dynamics. Previous studies have investigated the balance of ionospheric-originating heavy ions (low charge state) from those of solar wind origin (high charge state) in the magnetosphere of Earth. These studies have suggested a variety of entry mechanisms for solar wind ions to penetrate into the magnetosphere. To expand on these preliminary findings, this study aims at comparing the evolution of O^+ and O^{6+} flux distributions in the magnetosphere of Earth during storm times. This is done through both a multi-epoch approach, investigating the flux distributions during different storm phases, as well as through a superposed epoch analysis.

Motivation

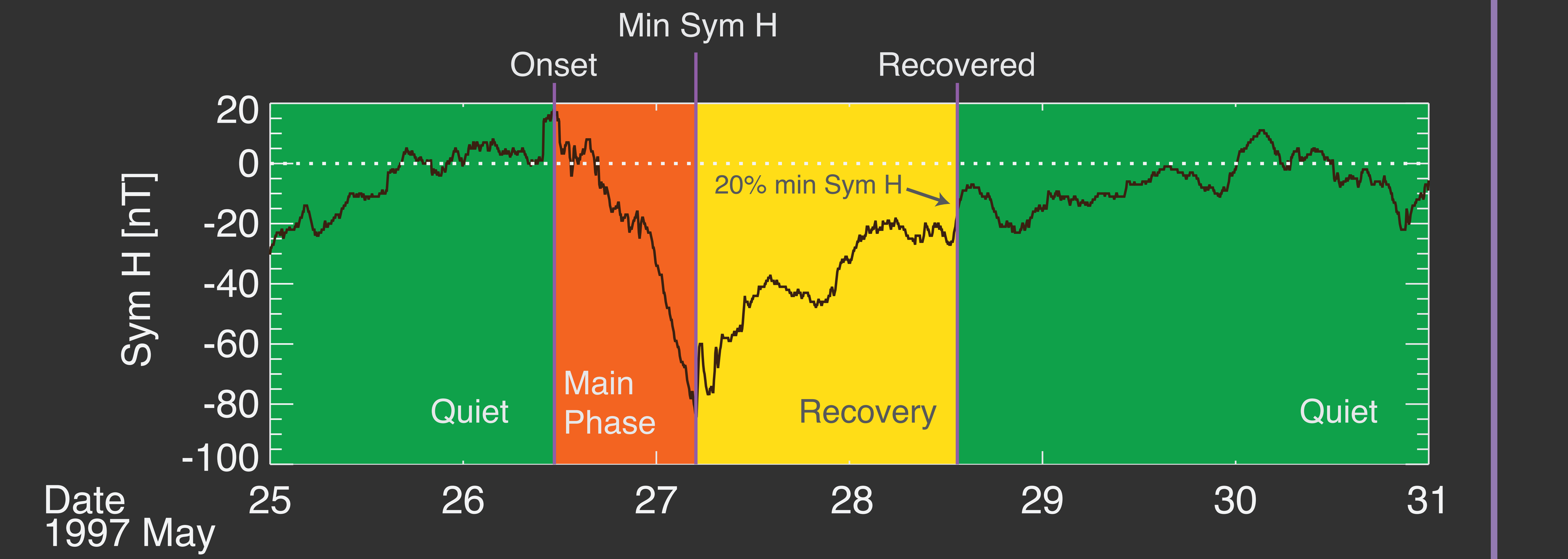
- Oxygen ions originate from two sources
  - Ionosphere (i.e., O^+)
  - Solar wind (i.e., O^{6+})
- *Allen et al.* [2016] investigated distributions of O^+ through O^{6+} with ranges of Dst, Vsw*Bz, and AE in the MLT vs. L-shell frame using Polar CAMMICE/MICS with an energy range of 1 to 200 keV/q.
- *Allen et al.* [Submitted, 2016] investigated the same parameters with the addition of IMF Pdyn in the MLAT vs. L-shell frame.
- The convective electric field, during storms, causes a sunward drift of plasma in the magnetotail.
- This study uses all data from CAMMICE/MICS for which the SSD was operational (13 September 1996 through 17 March 2000 and 12 March 2001 through 26 June 2002).

Methodology

Multi-Epoch

By hand identified 301 storms
- Min Sym H less than -40 nT
- Marked time of minimum Sym H
- Marked time of storm onset
  - Time when the slope of Sym H is almost always negative
- Marked time of the end of recovery
  - Time when Sym H has recovered 80%
  - Same definition used in Halford et al. [2010] and Saikin et al. [2016]
- Create oxygen flux distributions for data within each phase

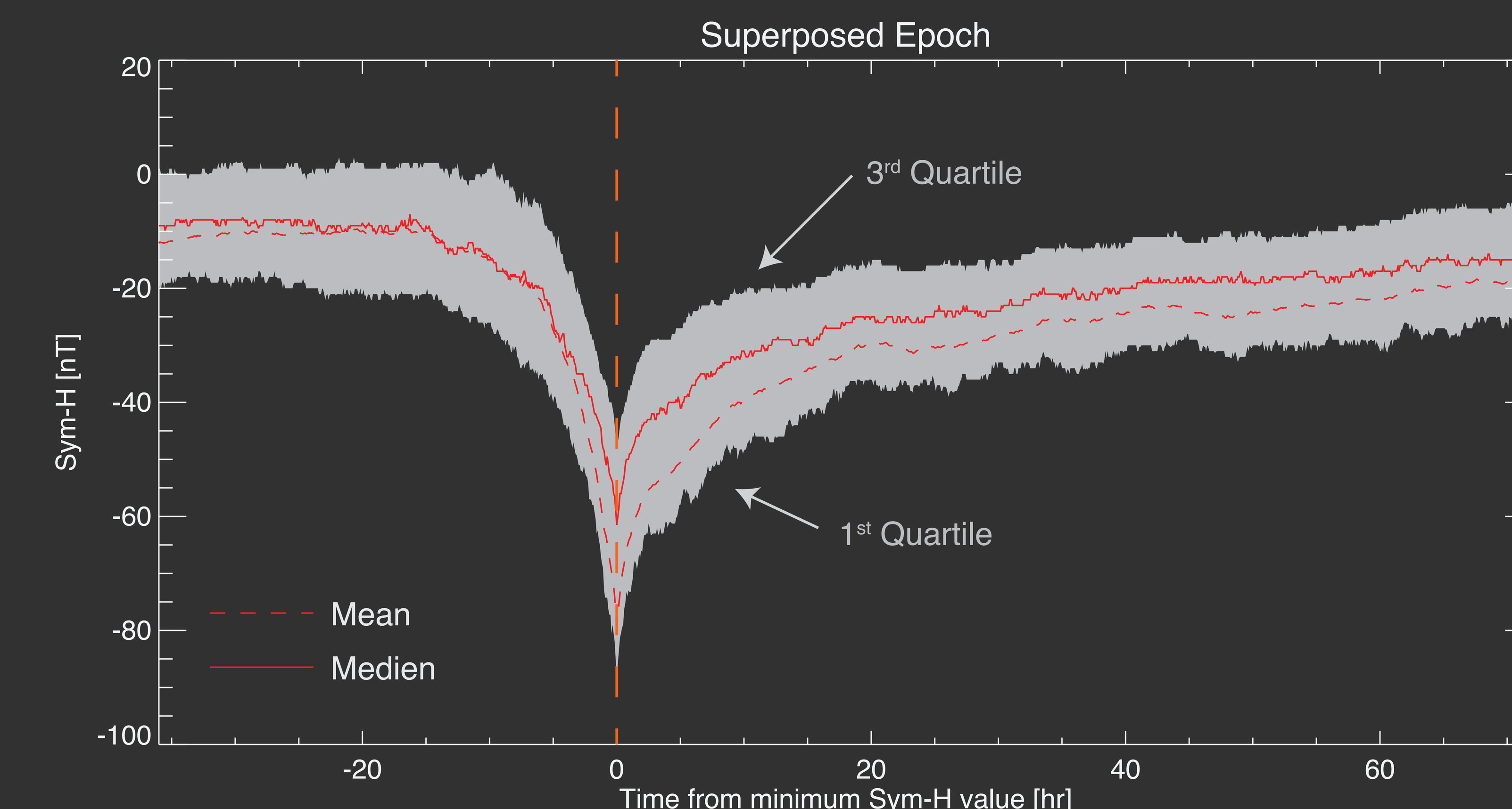
Shown as leftmost Figure below



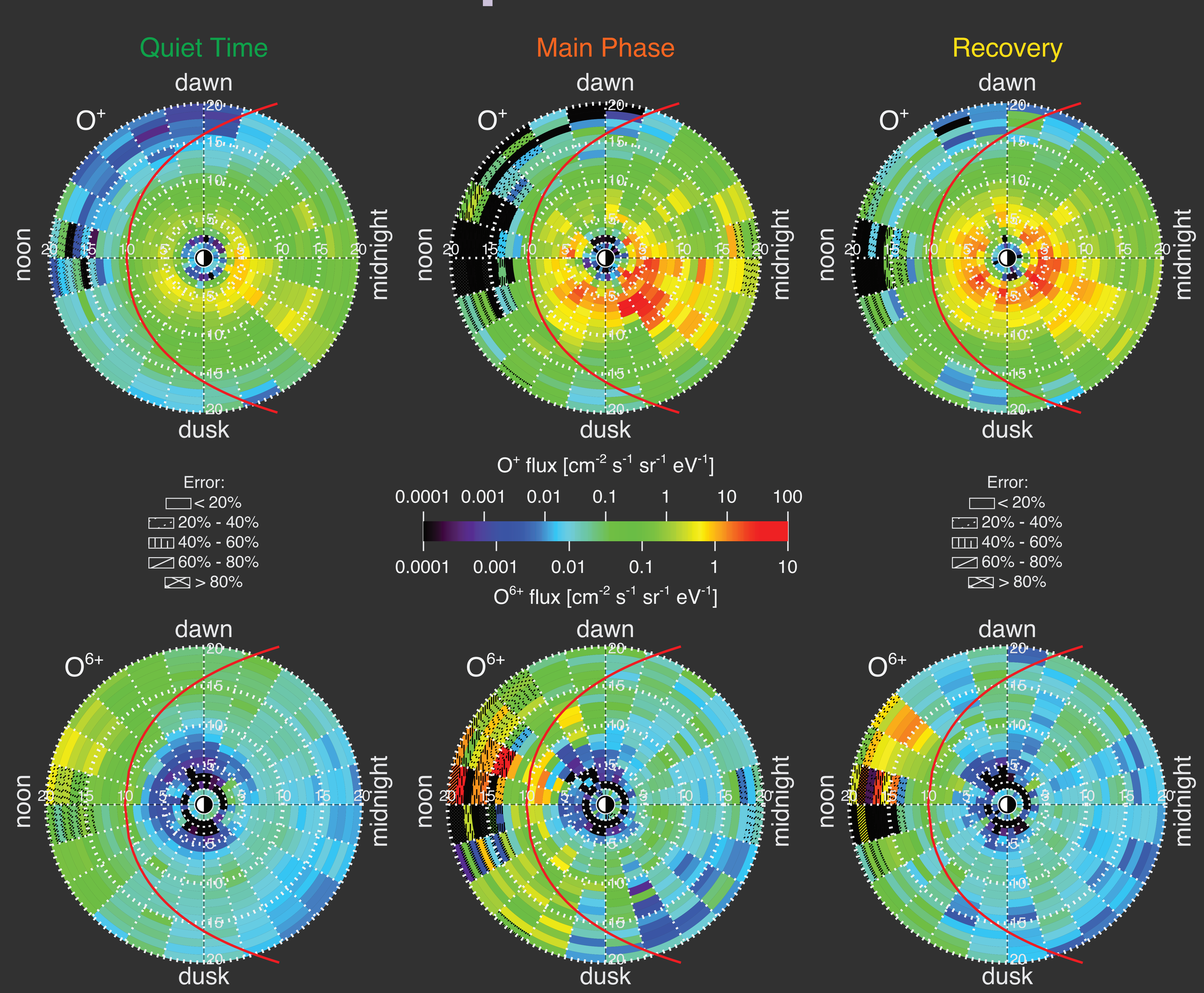
Superposed Epoch

Using storm list from above:
- Line up all storms by minimum Sym H
- Remove any data from time in other recovery or main phases
- Create a four hour sliding window to create oxygen flux distributions

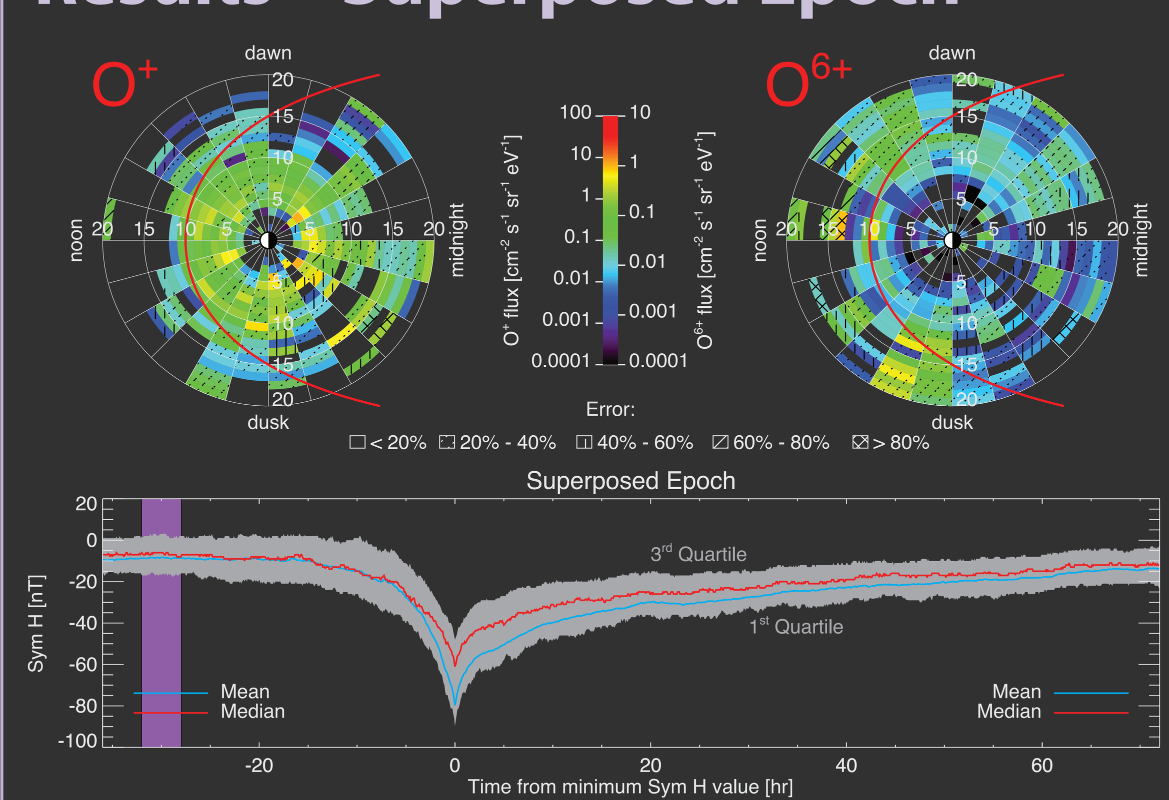
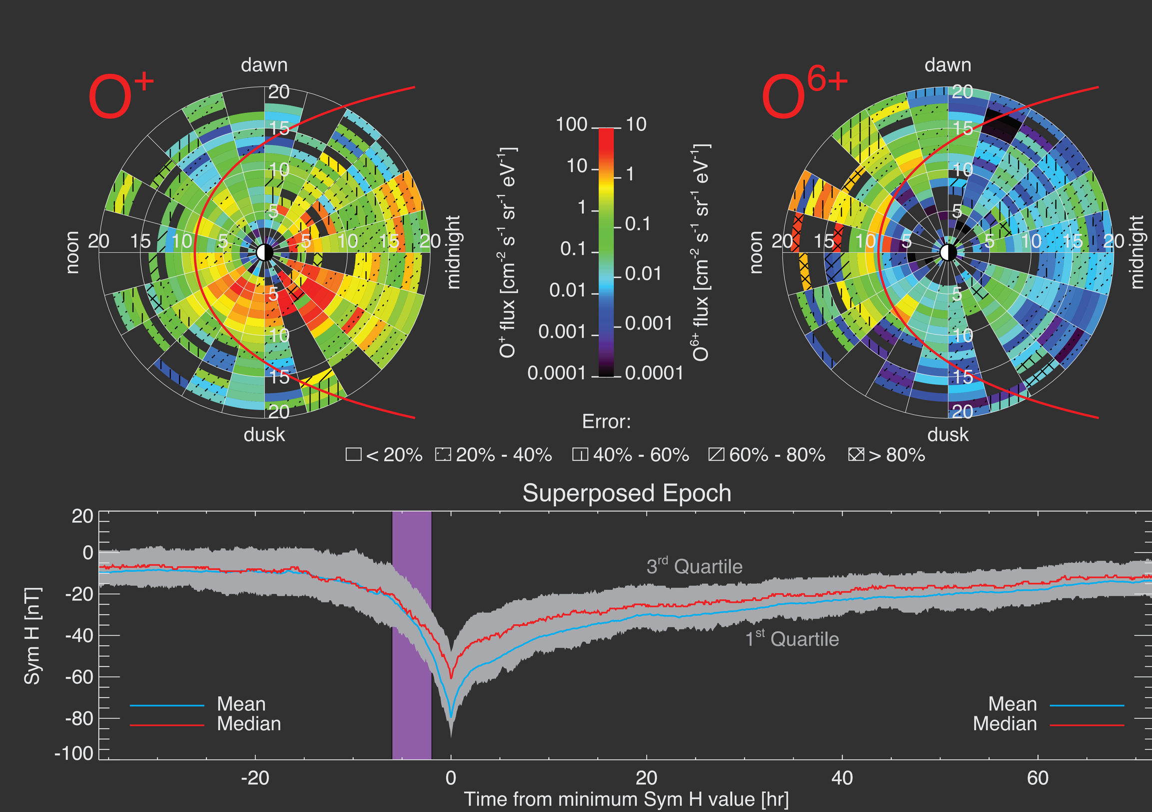
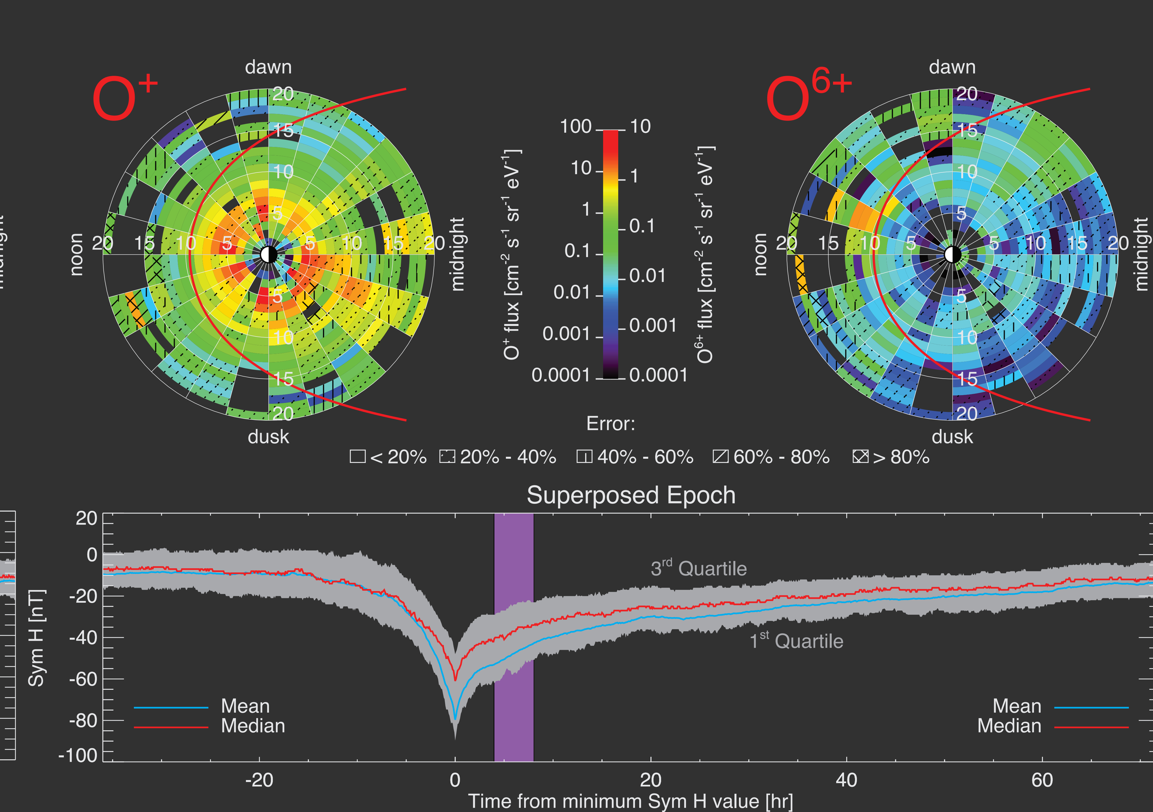
Example frames shown as right three figures below



Results – Multi-Epoch



Results – Superposed Epoch

Distributions of O^+ show the build up of the ring current
- Quiet time shows little signature of the ring current near L ~ 5
- Main phase shows an asymmetric ring current build up with broad pre-midnight peak
- Recovery shows the development of a symmetric ring current
- Late recovery (not shown) shows the deterioration of the ring current

Distributions of O^{6+} show only slight storm phase dependence
- Quiet time shows an dawn-dusk asymmetry in O^{6+} favoring dawn
- Main phase shows a flux enhancement along the dayside magnetosphere, likely related to compression
- Recovery shows the relaxing of the magnetospheric compression and return to the dawn-dusk asymmetry
- Indicates that increased convection is not bringing in significant O^{6+} from the magnetotail

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References

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