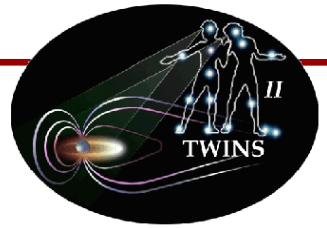

Experimental Study of the Asymmetric Time Varying Exosphere by Lyman-α Detectors on the TWINS Mission

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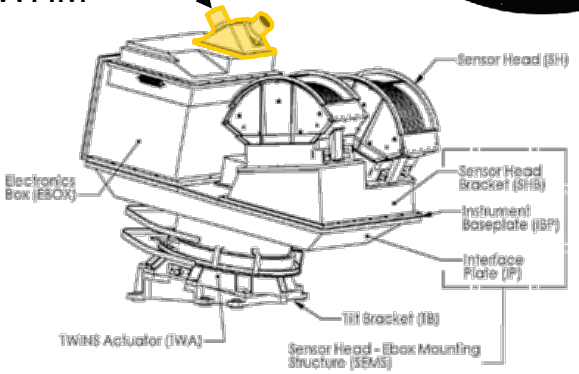
Agenda

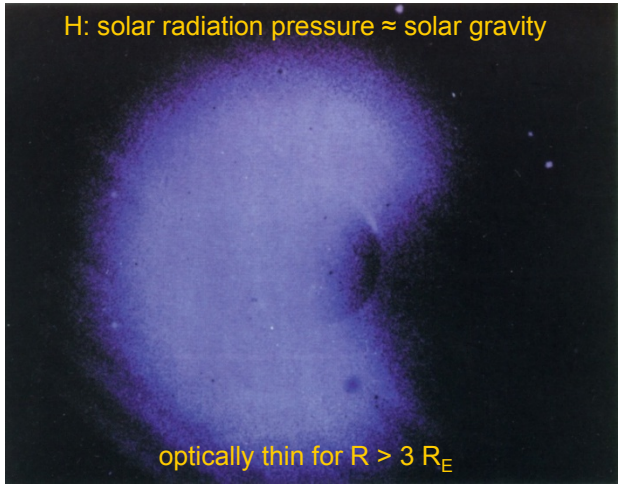
- TWINS Lyman-α Experiment
- LAD Observational Geometry
- Exospheric H Distributions
- Exosphere Variations During Geomagnetic Storms

Lyman-α Detector (LAD)
Broadband (10 nm) photon counter, FOV is 4° FWHM

TWINS images the magnetosphere in ENA fluxes and additionally carries LADs to investigate exospheric H atoms



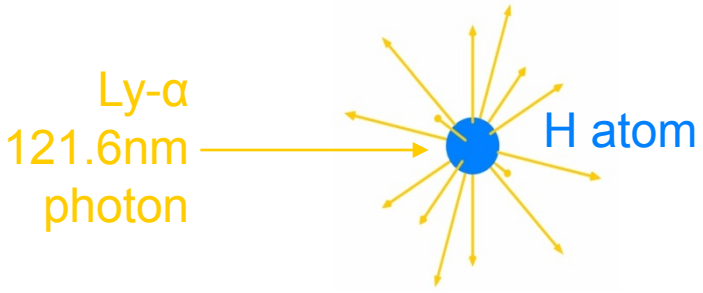
TWINS ISD Version E (2008), Fig 1.4-1



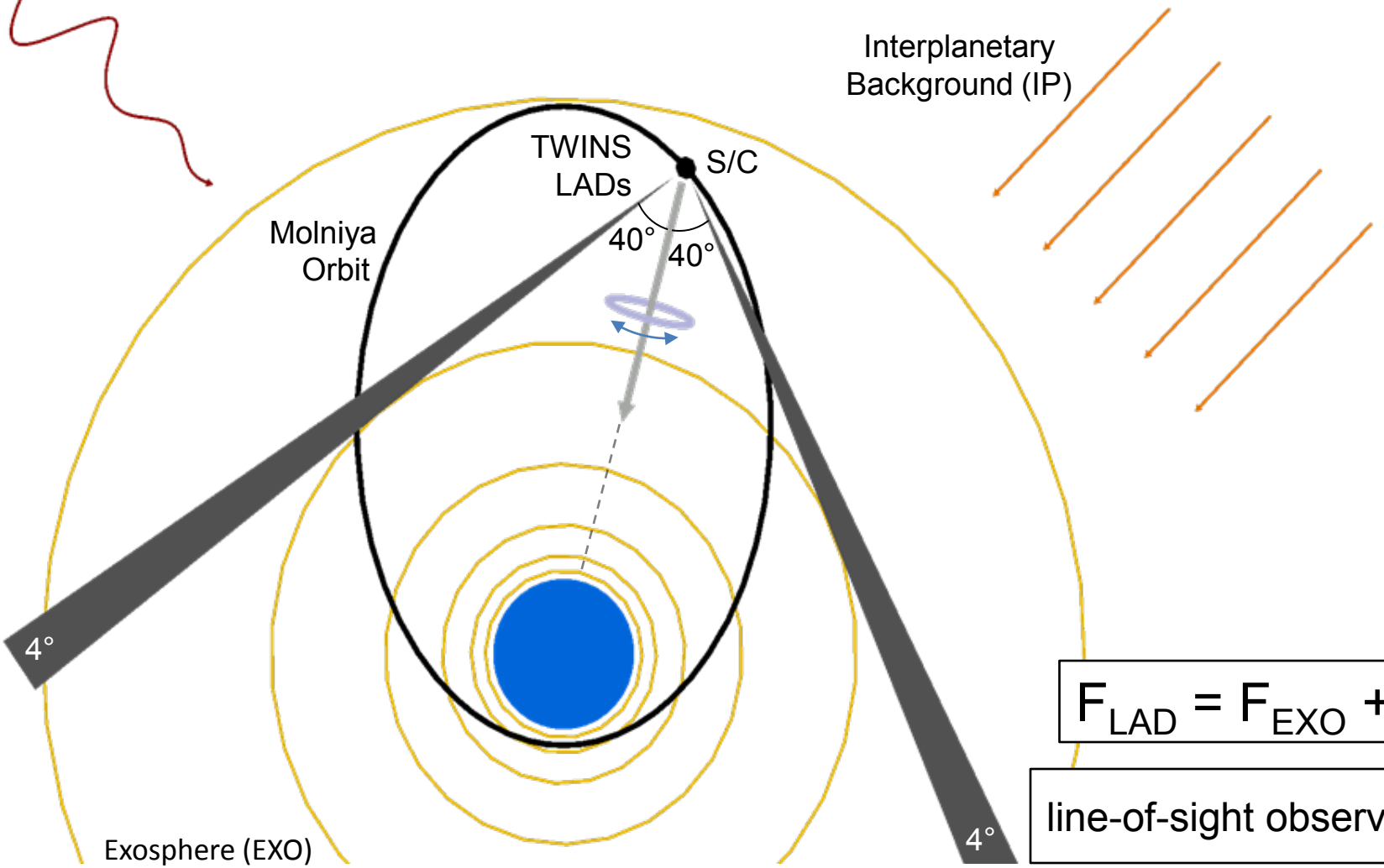
Apollo 16 (1972) image of geocorona glow
105-160 nm, 1-min exposure
Carruthers et al., 1976

Density and structure influenced by

- Solar EUV and X-rays prior to observations (heating)
- Solar Lyman-α radiation pressure on exospheric hydrogen atoms
- Variations in temperature and density of the atmosphere at the exobase
- Plasmasphere-exosphere coupling



- TWINS LAD count rate proportional to the instantaneous flux of solar Lyman-α at the moment of observation
- Consider only region > 3 R_E (optically thin)



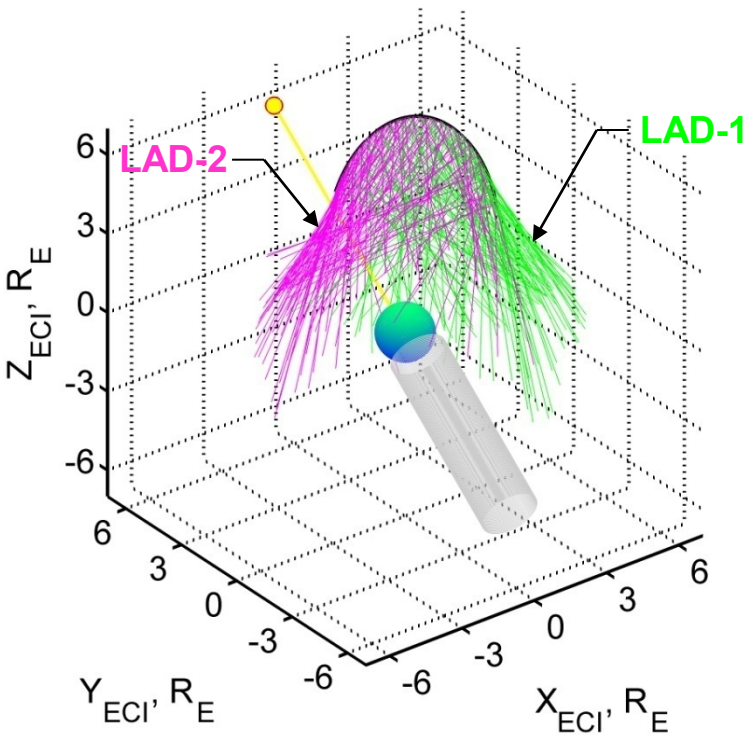
$$F_{LAD} = F_{EXO} + F_{IP}$$

line-of-sight observation

Exospheric H Distribution

- LAD observations are used to reconstruct a model of the exospheric hydrogen density distribution
- Some **regions are covered better than others**, model is sensitive only to those regions where coverage is adequate
  - excluded regions include a large portion of the southern hemisphere, Earth's shadow, and sometimes there are outage periods
- Certain days are not available due to incomplete/unfavorable coverage

Using TWINS LAD measurements from the second orbit of TWINS-1 on 11 Jun 2008, an example of the exospheric neutral hydrogen density distribution $n_H(r,\theta,\phi)$ was obtained

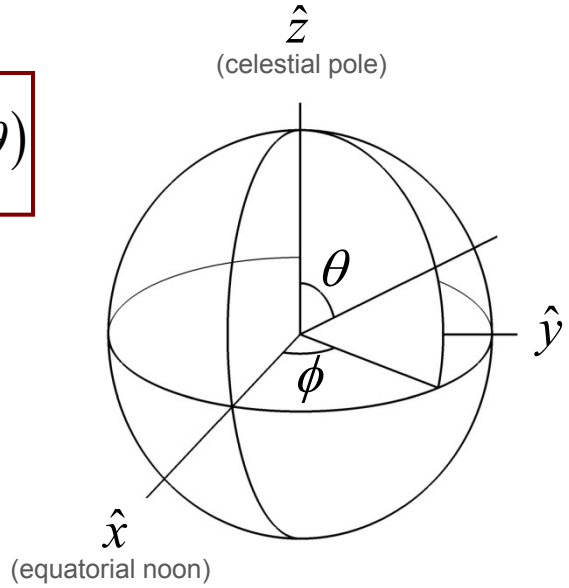


Every 100th LAD LOS for the second orbit of TWINS-1 on 11 Jun 2008

Exosphere Model

$$n_H(r) = N(r)\sqrt{4\pi}\sum_{l=0}^{2}\sum_{m=0}^{l}\left(A_{lm}(r)\cos(m\phi) + B_{lm}(r)\sin(m\phi)\right)Y_{lm}(\theta)$$

$$N(r) = a \cdot r^b \qquad A_{lm}(r) = a_{lm} + b_{lm} \cdot r \qquad B_{lm}(r) = c_{lm} + d_{lm} \cdot r$$

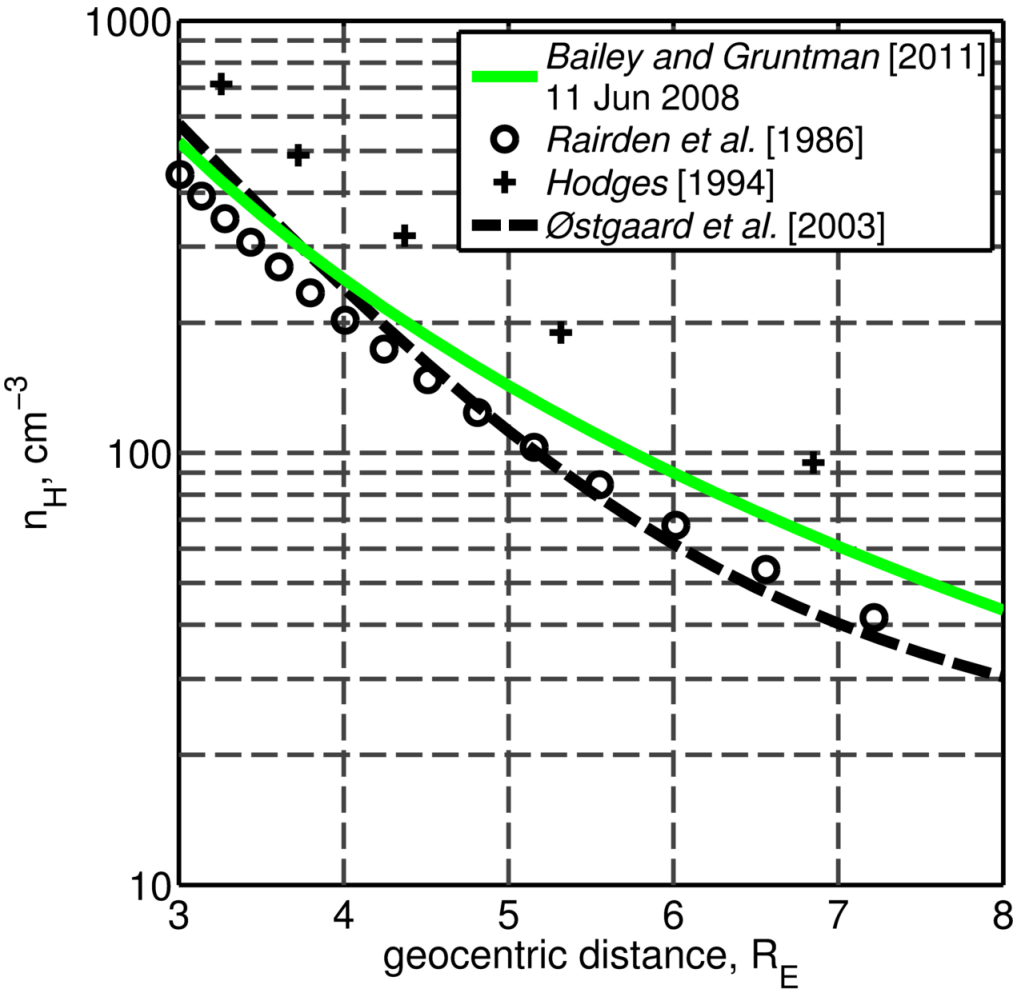


- Introduced by UBonn in 2006 – 12 parameters
- Expanded by USC in 2009 to enable probing of dawn-dusk asymmetry – 18 parameters
- Photon scattering rate at 1 AU (g-factor) from independent measurements of the solar Lyman-α
- Interplanetary glow background derived directly from SOHO SWAN measurements

Example of Exospheric H Distribution

Averaged H Density Radial Profile

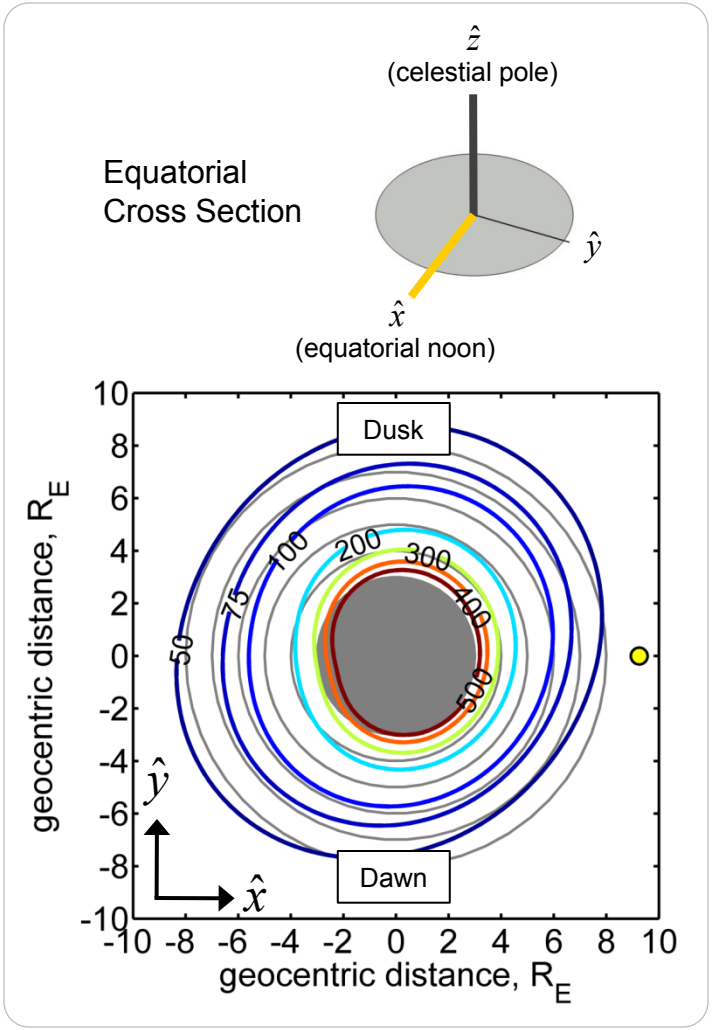
- ***Bailey and Gruntman* [2011] remarkably close to those obtained by *Rairden et al.* [1986], *Hodges* [1994], and *Østgaard et al.* [2003], with differences less than 50% between 3 R_E to 8 R_E**
- Similar dependence obtained from LAD/TWINS data by UBonn [*Zoennchen et al.*, 2012]
- Conditions of our observations correspond to solar minimum

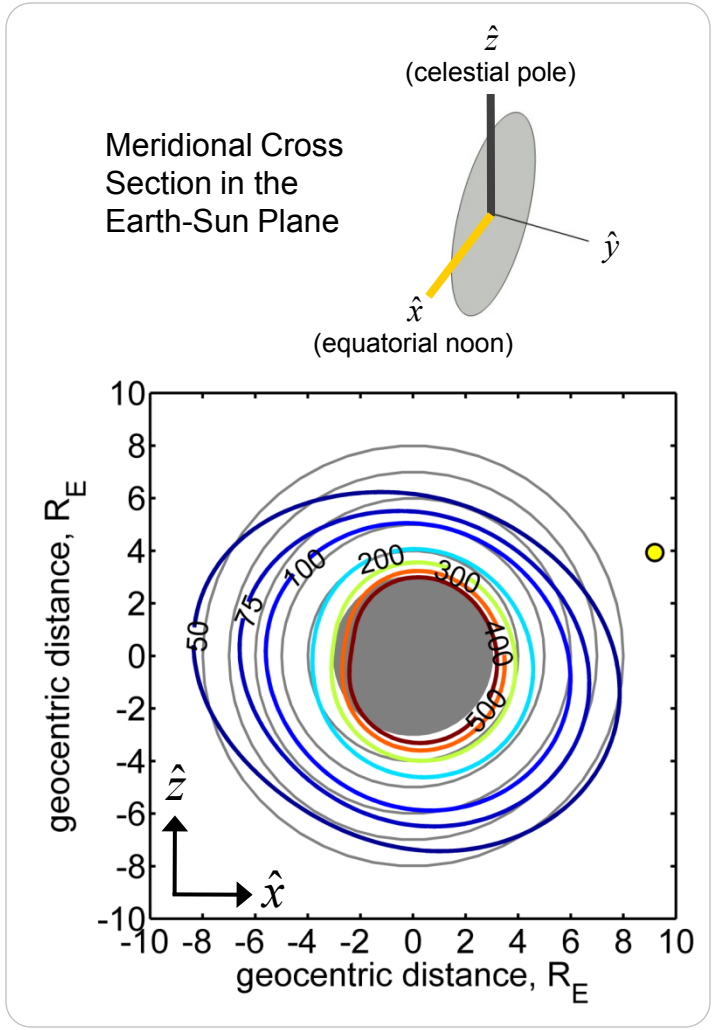


Example of Exospheric H Distribution

- 11 Jun 2008
- Contours are lines of constant atomic hydrogen density (cm^{-3})
- Yellow dot is the projection of the direction to the Sun (left) and the direction to the Sun (right)
- Filled gray circle represents the region with radius 3 R_E
- The grid of gray concentric circles for $r > 3$ R_E, with a 1 R_E step, highlights the asymmetry of the distribution

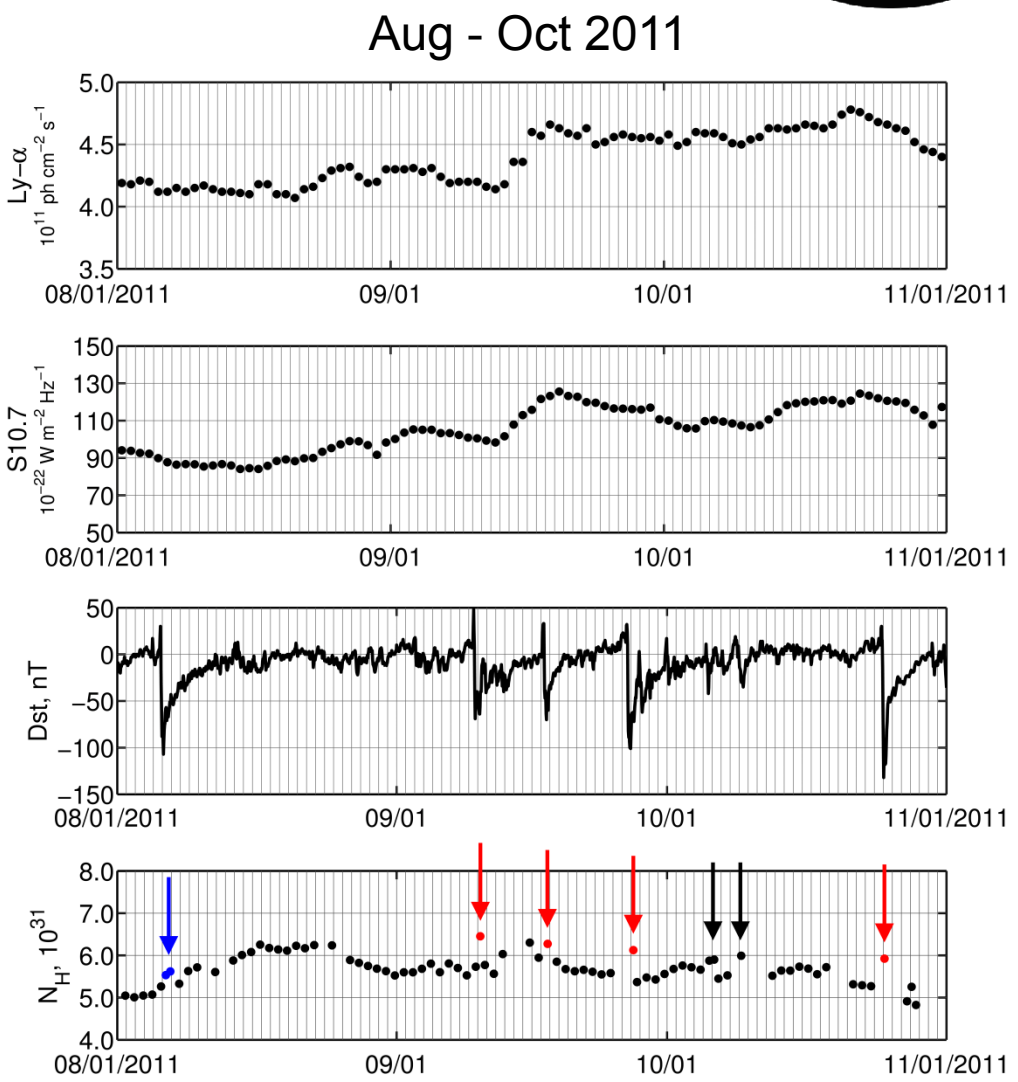
Bailey and Gruntman [2011]





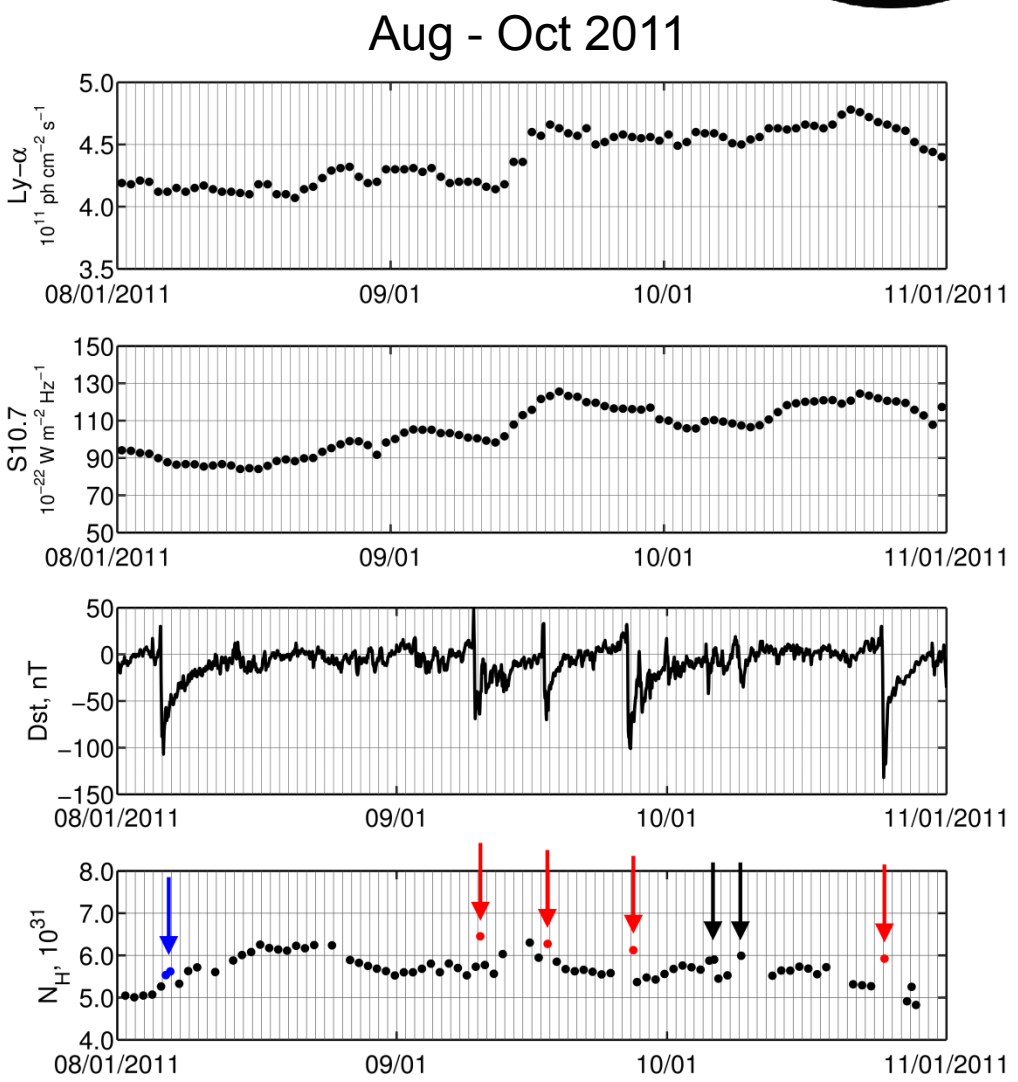
Temporal Variation

- Prior models of exospheric H distributions were usually developed under assumptions of being spherically symmetric, or representative of typical (not actual) solar conditions, or averaged over an extended period of time
- TWINS allows for the first time probing changes of the global exosphere on a daily basis
- **Introduced new parameter, N_H, number of H atoms in the spherical shell from 3 R_E to 8 R_E, to quantitatively characterize in a simplified way global exospheric conditions**



Temporal Variation

- 5 geomagnetic storms observed during 3 months in the second half of 2011 are accompanied by abrupt temporary increases, spikes, of N_H from 6% to 17%, lasting not longer than a day
- Clearly, N_H enhancements correlate with standalone Dst events
- Detailed study eliminated contamination by energetic particles
- Future Work: LAD/TWINS data for 2012-13 is available



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Questions?