LITES: EUV and FUV from the ISS

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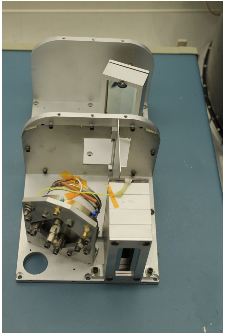
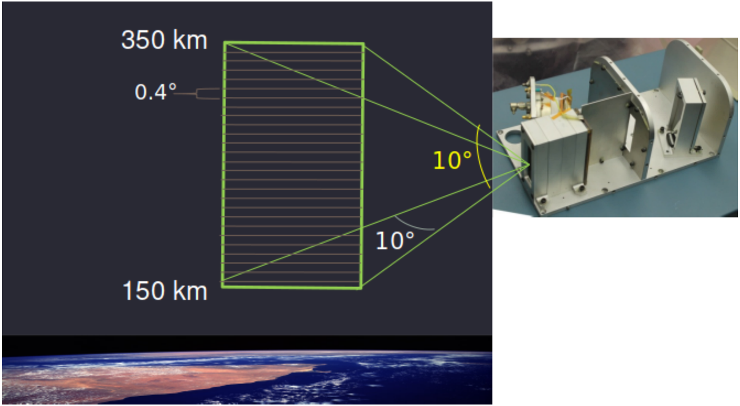
LITES

Limb-Imaging Thermospheric Extreme-ultraviolet Spectrograph

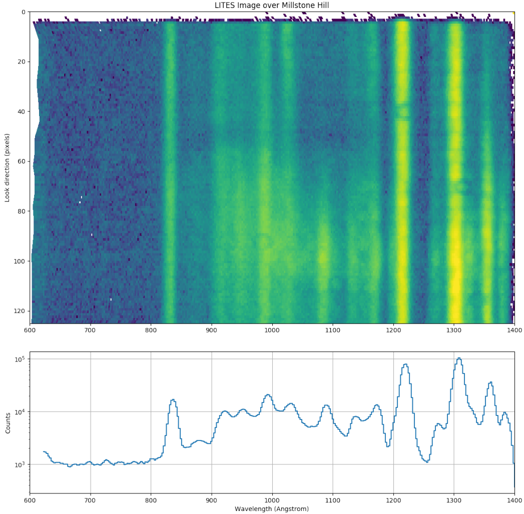
- 10° x 10° field of view
- 150 - 350 km line-of-sight tangent altitude
- 140 - 60 nm spectrum
- Aft viewing from the ISS ($\simeq$ 410 km)
- Launched March 2016
- Began operations April 2016



LITES Viewing Geometry

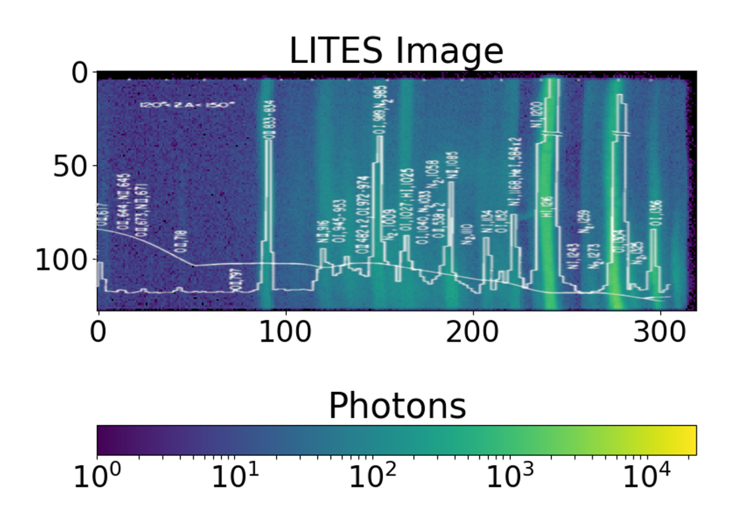


LITES Spectral Image



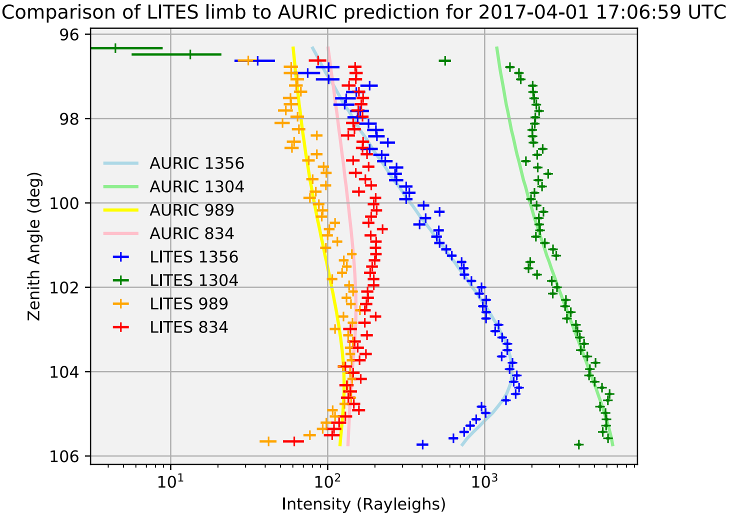
Features

Tons of O O_2, and N_2 features.



Comparison of LITES image and Chakrabarti et al. (1984).

Limb Profiles



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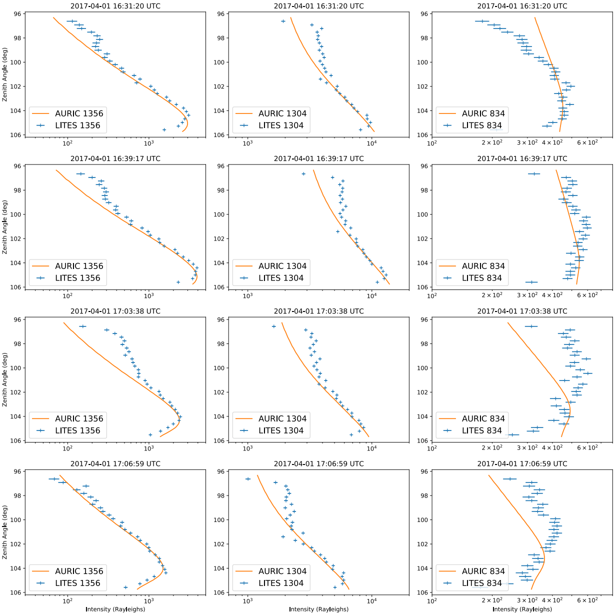
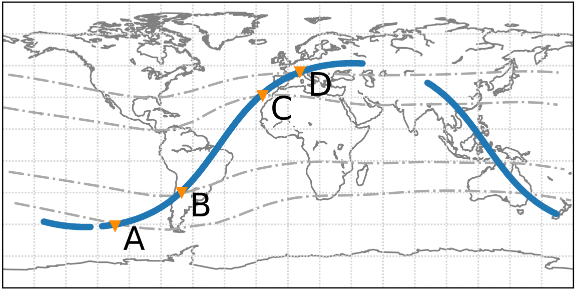
More Limb Profiles



Map

ISS path

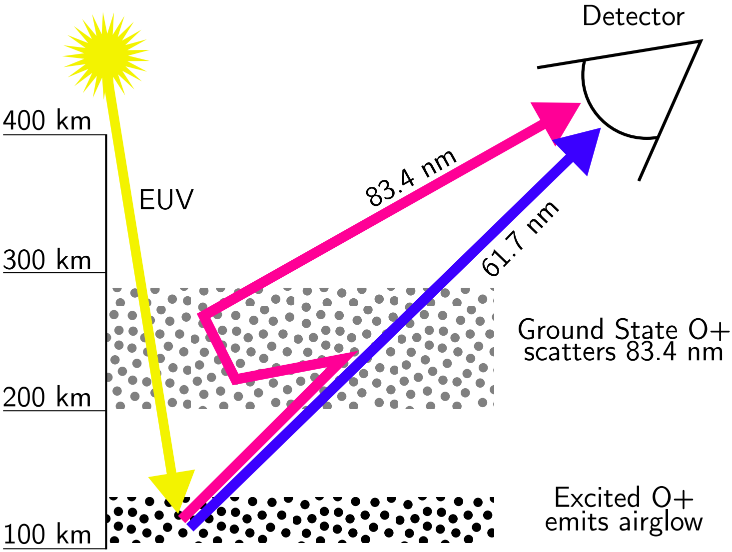


Locations for the profiles on the previous slide.

Orbit Movie

Open Movie. . .

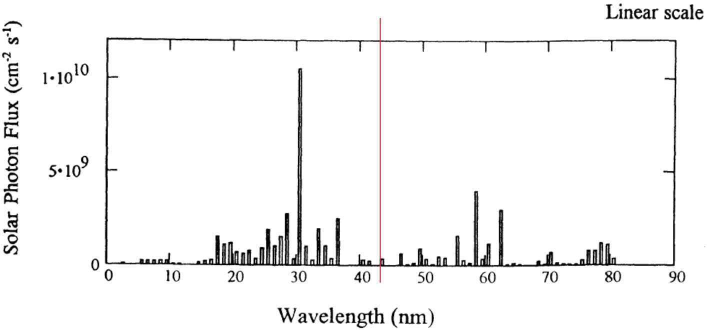
OII Dayglow



Detector
400 km
300 km
200 km
100 km
EUV
83.4 nm
61.7 nm
Ground State O+
scatters 83.4 nm
Excited O+
emits airglow

Excitation

- Excited by solar EUV photons < 43.6 nm
- Main contribution from He 30.4 nm



SOHO solar EUV spectrum Judge et al. [1998].

Emission Processes

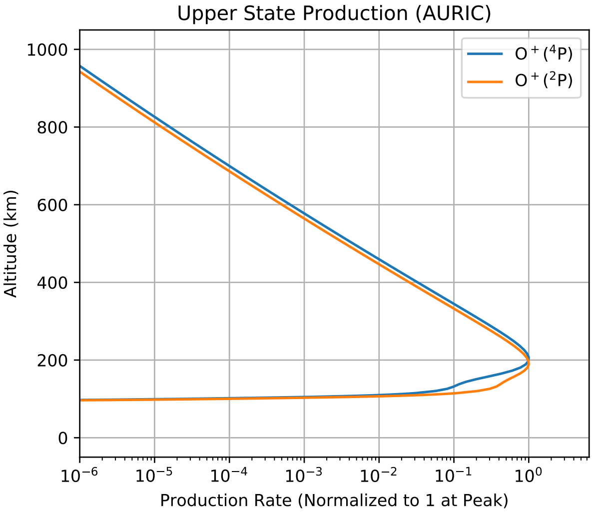
$$O^+(^4P) \rightarrow O^+(^4S^o) + \lambda_{83.4\,\mathrm{nm}}$$

- Final state is ground state O^+
- Optically thick ($1 \lesssim \tau \lesssim 10$)
- Brightness $\sim$ 1 kR

$$O^+(^2P) \rightarrow O^+(^2D^o) + \lambda_{61.7\,\mathrm{nm}}$$

- Final state is forbidden from ground state
- Optically thin
- Brightness $\sim$ 100 R

Similar Production



Combining Observations

- Both emissions are produced by (almost) same solar EUV
- But O II 83.4 nm has O^+ information from multiple scattering
- We can use this!

O^+ Retrieval

By comparing optically thick and optically thin observations, we can fit an O^+ density with few nuisance parameters.

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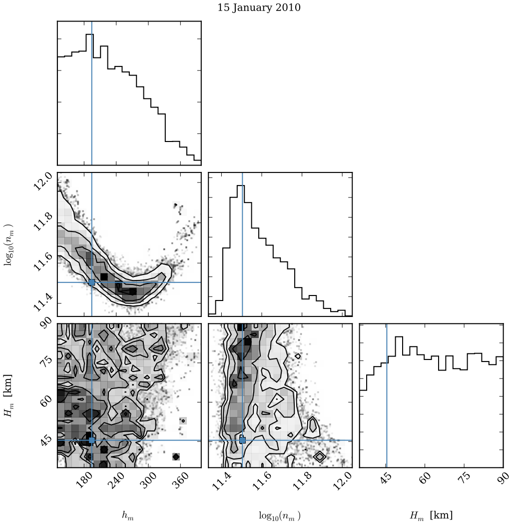
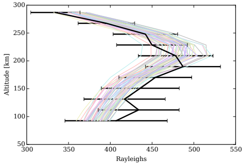
Procedure

1. Make an O II 83.4 nm limb observation
2. Model a thermosphere, ionosphere, and solar EUV
3. Check fit to data
4. Tweak ionosphere parameters and model again
5. Repeat 2-4 until we get a satisfactory fit

Monte Carlo Results



Geddes et al. [2016]



Geddes et al. [2016]

Uncertainties

This procedure doesn't take systematic uncertainties in the model or instrument into account.
Picone et al. [1997] introduce an overall scale parameter to remedy this.

Scale Parameter

An overall scale parameter is the simplest model we can use to account for systematic errors (in the model or instrument)

The scale factor accounts for uncertainty in instrument calibration, [O], and solar EUV irradiance.

Using OII 61.7

Adding O II 61.7 nm adds a new parameter and is insensitive to the others, so how can this help?

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Bayesian Prior Probability

Instrument degradation and the small solar EUV difference are the only sources of variance between the two scale factors.
This means the two should be closely correlated.
We can impose this constraint on our fit using a prior.

Another Possibility

Limb emissions:

$$I_{83.4} = V_{83.4} M j_{83.4}$$

$$I_{61.7} = V_{61.7} j_{61.7}$$

Suppose T transforms the 61.7 nm source into the 83.4 nm source.

$$I_{83.4} = V_{83.4} M T V_{61.7}^{-1} I_{61.7}$$

- T is *almost* a simple scaling.
- Subtract l.h.s from r.h.s and we get a new r.v. that looks like a volume emission rate of something.
- This method separates systematic errors in calibration and neutral density from errors in solar EUV.
- Doing this would introduce yet another fit parameter which accounts for solar EUV, but systematic errors from different sources are more isolated

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$$M^{-1} V_8^{-1} \eta_8 I_8 - T V_6^{-1} \eta_6 I_6 = r$$

- r "residual" emission
- Estimate r using a model and iterate over parameters to fit
- With a Markov chain scattering model, M^{-1} is cheaper to compute

Markov Chain Scattering Model

- A photon scattering through the F2 layer is a Markov process.
- Multiply scattered profile is a geometric series in the single-scattering probability (Q) [Vickers, 1996]

$$M = 1 + Q + Q^2 + Q^3 + \cdots \quad (1)$$
$$= (1 - Q)^{-1} \quad (2)$$

References

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