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Solar occultation measurements of the thermosphere by the TIMED Solar EUV Experiment (SEE)

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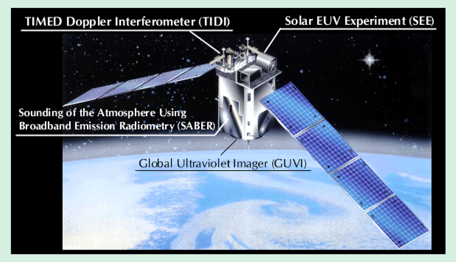
The TIMED Solar EUV Experiment

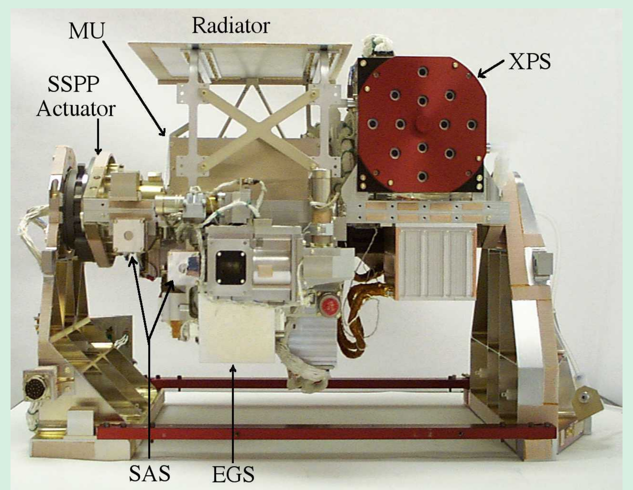
TIMED Satellite:

- Launched Dec. 7, 2001
- Normal Operations since Jan. 22, 2002
- Orbit: 74.1˚, 625 km, 96 min



SEE Instrumentation:

- XUV Photometer System (XPS)
  - Silicon photodiodes w/ broadband filters
  - 0.1 - 34 nm at ~7 nm resolution
  - Plus HI-Ly-α (121.6 nm) at ~2 nm resolution
- EUV Grating Spectrograph (EGS)
  - 1/4 m reflection spectrograph w/MCP detector
  - 27 - 195 nm at ~0.4 nm resolution
- SEE Solar Pointing Platform (SSPP)
  - Single-axis pointing platform
  - Holds Sun stable in one dimension of FOV while orbit gives drift in other dimension.

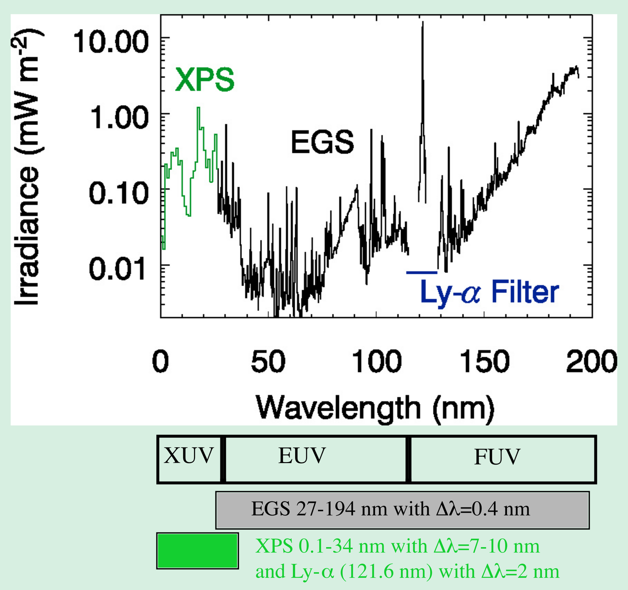


SEE Operations:

- Normal Solar Observations
  - 3-min once every orbit (96-min)
- Occultation Observations
  - Only occasional availabilities due to TIMED orbit and single-axis pointing

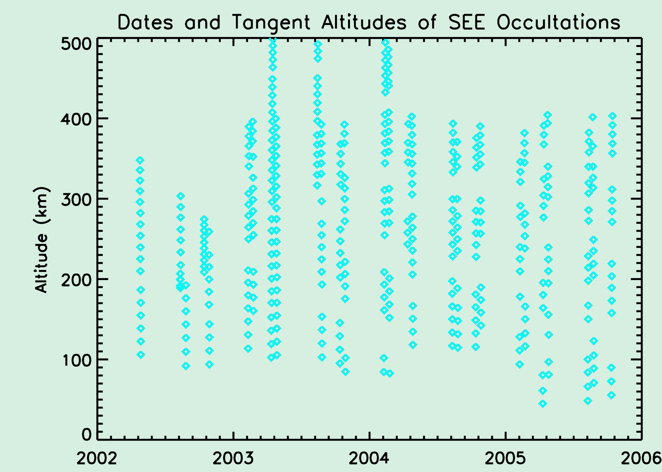
SEE Data Availability:

- Current Version 8 available at:
  http://lasp.colorado.edu/see
- Version 9 (with occultation data) to be released in early 2006.

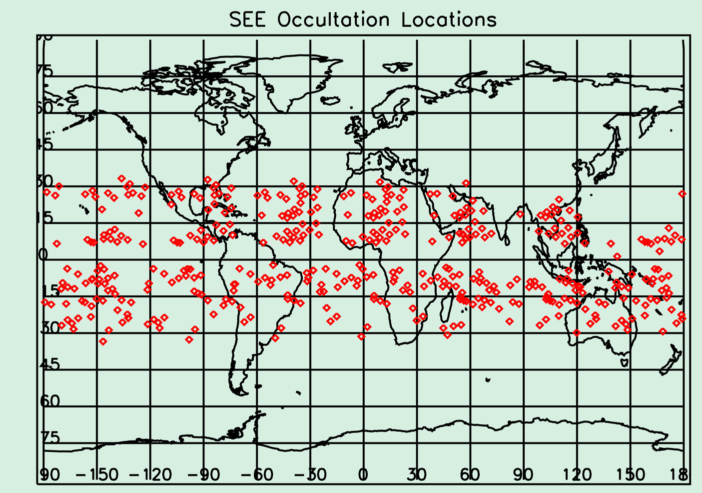


SEE Solar Occultation Measurements

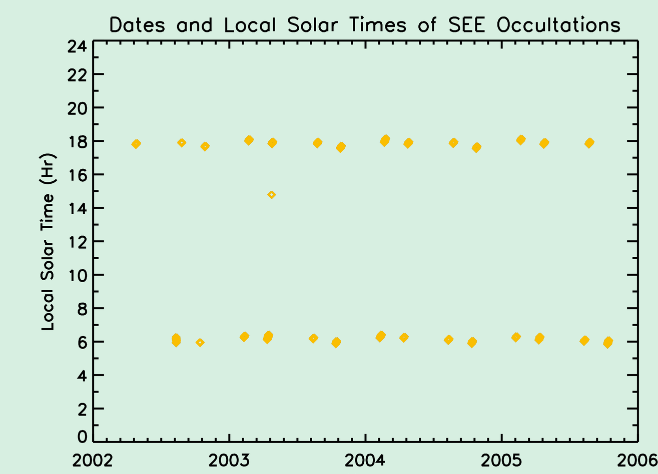
- **Notes about SEE Occultations:**
  - Because of TIMED orbit and single-axis pointing:
    - Only get occultation opportunities for a few days twice an orbit beta cycle (~60 days).
    - Only make one occultation measurement in an orbit during availabilities.
    - Altitude profiles are not possible, occultations occur at at single altitude at a time.
  - Only SEE EGS data (27-194 nm) is used.
  - To date 427 solar occultation measurements have been made by SEE



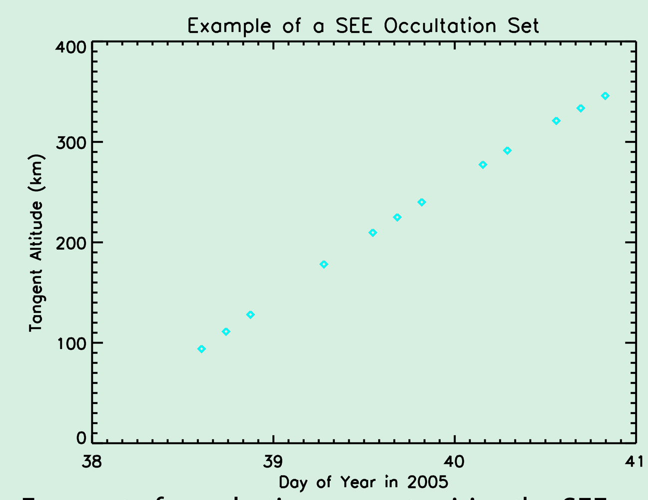
Occultation tangent altitudes range from ~40 km to ~500 km and are grouped in time.



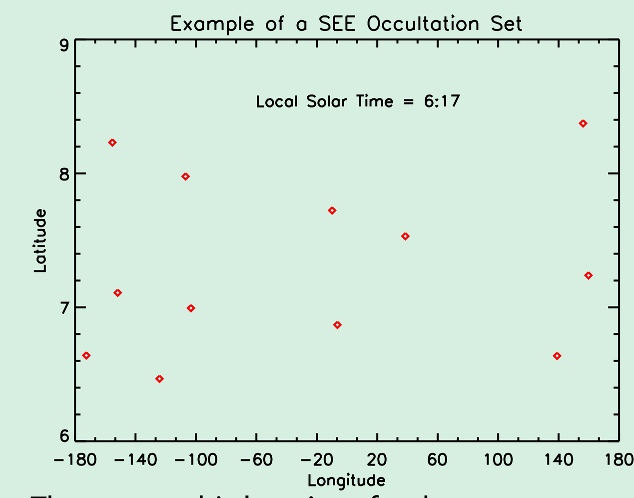
The geographic locations of the occultations are confined to lower latitudes, but all longitudes.



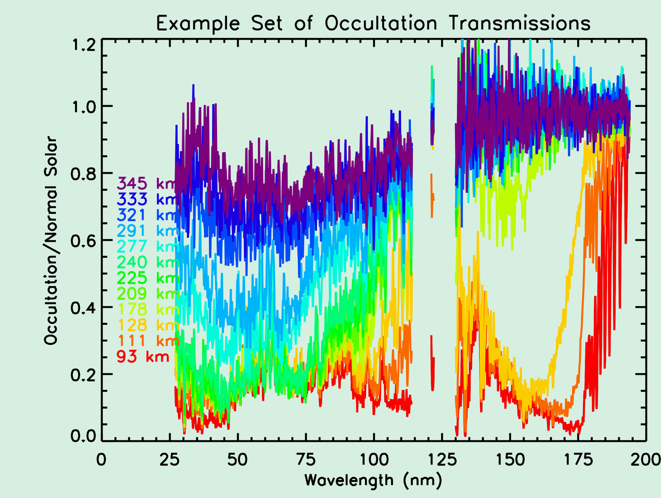
Local solar time for occultations occur around 6:00 (sunrise) and 18:00 (sunset).



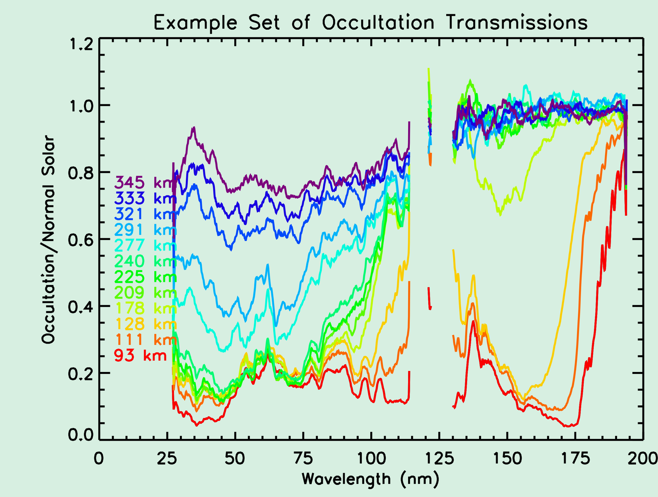
For a set of occultation opportunities the SEE measurements span a range of tangent altitudes through the thermosphere and are spaced out over about three days.



The geographic locations for the set are grouped in latitude, but span the range in longitude, and are at a single local solar time (sunrise in this case).



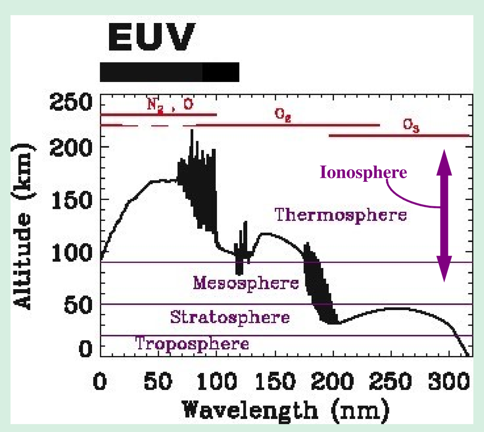
Atmospheric transmissions are determined by ratioing the EGS occultation measurements with the nearest normal solar measurements (not occulted).



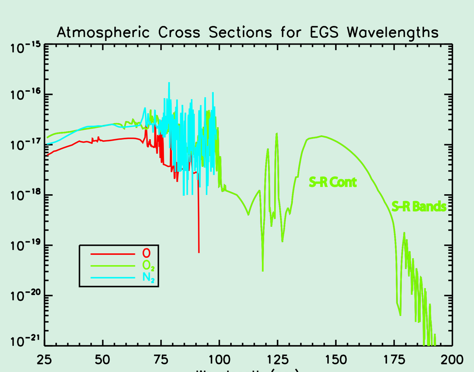
Same as at left, but subjected to a 3-nm smooth in wavelength.

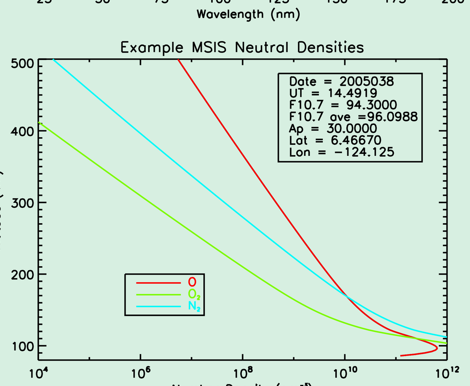
The Atmosphere and EUV Irradiance

The primary constituents of the Earth's upper atmosphere extinguish solar EUV and FUV irradiance through photo-ionization, dissociation, and absorption. Deposition is dependent on wavelengt, the state of the upper atmosphere, and the solar zenith angle.



Altitude of optical depth unity in a standard atmosphere. EUV is absorbed in the thermosphere and FUV in the lower thermosphere and mesosphere.





Extinction of the solar irradiance is given by:

$$I = I_0 e^{-\tau_{tot}}$$

Where the total optical depth is given by the sum of the optical depths of each absorbing species:

$$\tau_{tot} = \sum_i \tau_i$$

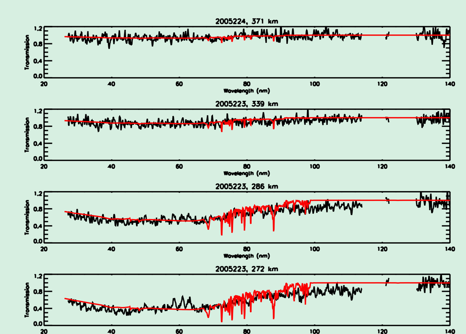
And the individual optical depths are the number density of the species times its cross section, integrated over the slant line of sight between the Sun and the instrument:

$$\tau_i = \int_{LOS} \sigma_i n_i ds$$

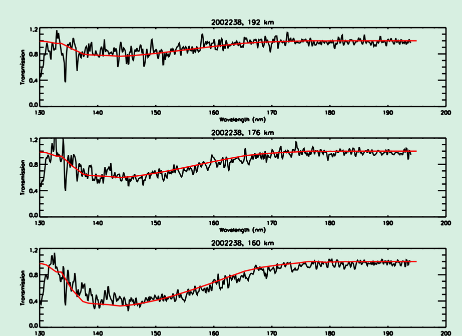
Comparisons with MSIS

- The NRLMSIS-00 model was run for the conditions of each SEE occultation.
- Slant optical depths were determined for the viewing geometry of the occultations assuming the MSIS atmosphere (and spherical symmetry).
- Model transmissions are compared with occultation measurements.

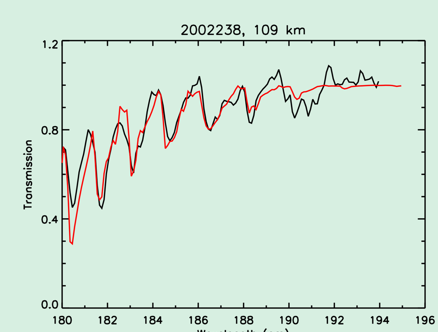
Sometimes the comparisons are very good (black is SEE data, red is model):



Good EUV comparisons, dominated by O absorption.

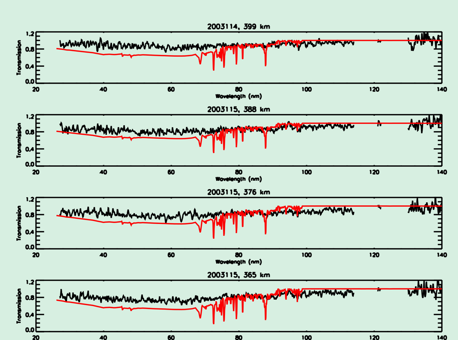


Good FUV comparisons, dominated by O2 Schumann-Runge continuum.

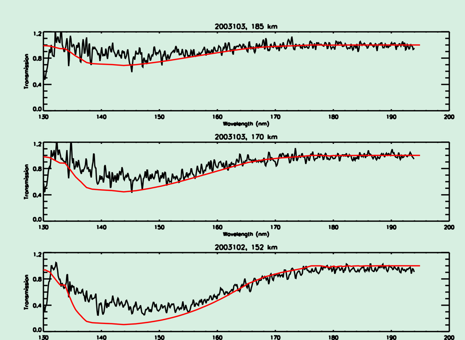


Good FUV comparisons, dominated by O2 Schumann-Runge bands

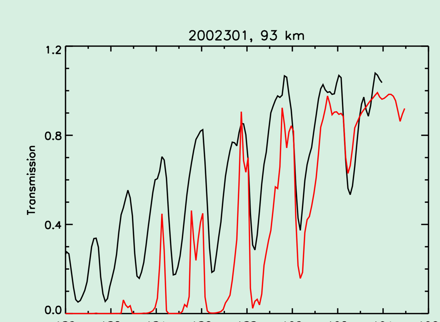
At other times the comparisons are not so good:



Poor EUV comparisons, probably due to MSIS overestimate of O densities.



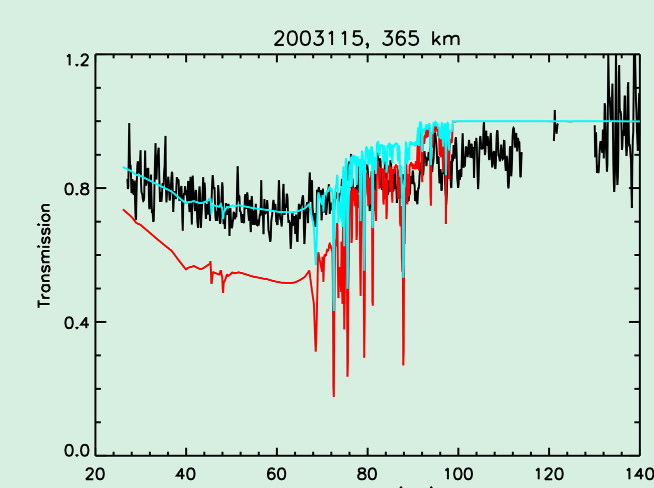
Poor FUV S-R cont. comparisons, probably due to MSIS overestimate of O2 densities.



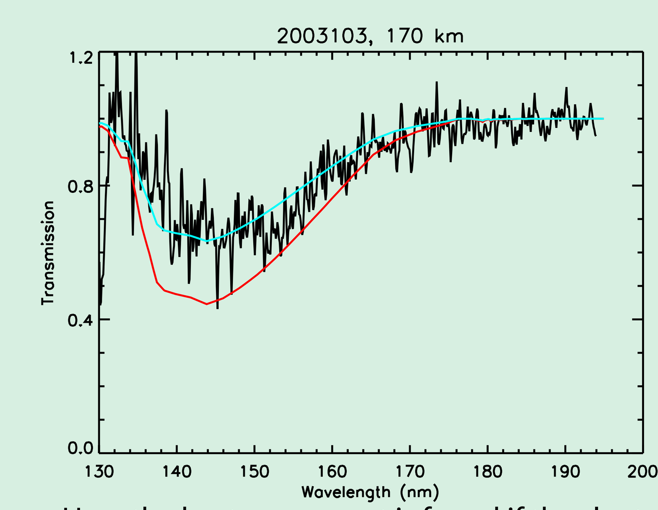
Poor FUV S-R band comparisons, probably due to MSIS overestimate of O2 densities.

Discussion

- The SEE solar occultation measurements can be used to adjust MSIS densities for the particular location/conditions of the occultation:



In this case, agreement is achieved if the slant column density of O is reduced by a factor of 2.1 from the MSIS model value.



Here the best agreement is found if the slant column density of O2 is reduced by a factor of 1.8 from the MSIS model value.

- The SEE solar occultation data will be publicly available in early 2006 with the release of SEE data version 9.
  http://lasp.colorado.edu/see
- The SEE occultation measurements provide a means to validate/adjust model neutral densities.