Atmospheric Scale-Height and Density of Molecular Oxygen (O2) via Solar Occultations Measured by SORCE

Claudia Luna, Joshua Peter Elliott, Ed Thiemann

Laboratory for Atmospheric and Space Physics , Boulder, CO

Introduction: Let's start here

- For the past 50 years, solar occultations have been used to learn more about elements (atmospheric species) in our thermosphere
- In this chart, we can see at what altitudes we have obtained measurements
- We also see that there are still some gaps in information
- In this project we hoped to fill in some of those gaps

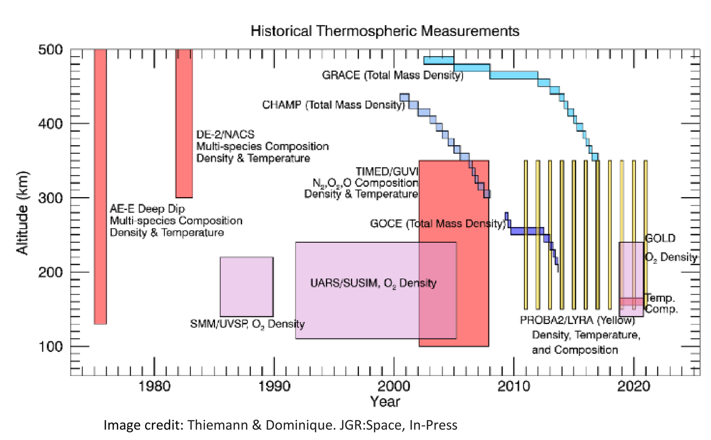
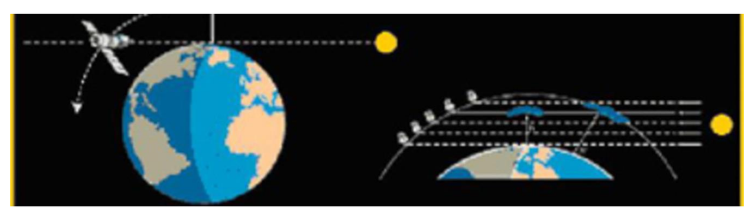


Image credit: Thiemann & Dominique. JGR:Space, In-Press

What are Solar Occultations?

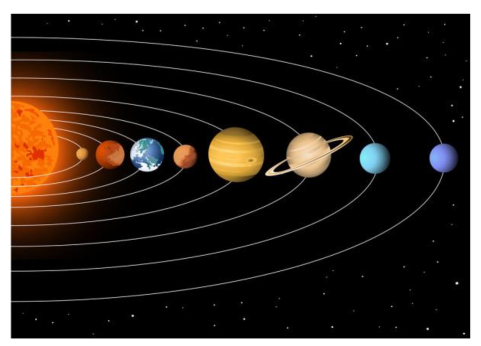
A technique that measures the change in solar irradiance after it has passed through atmosphere



We are not limited to Earth

Occultations are used to learn about any astronomical object with an atmosphere

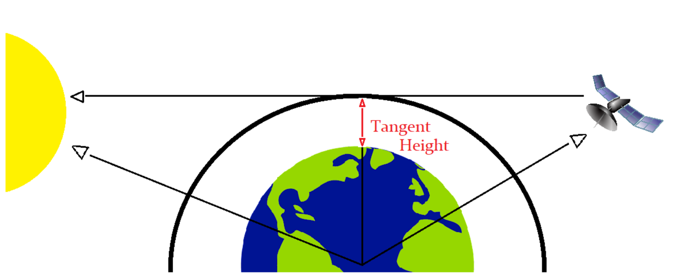
- Venus
- Mars
- Saturn
  - Titan
- Anything with an atmosphere



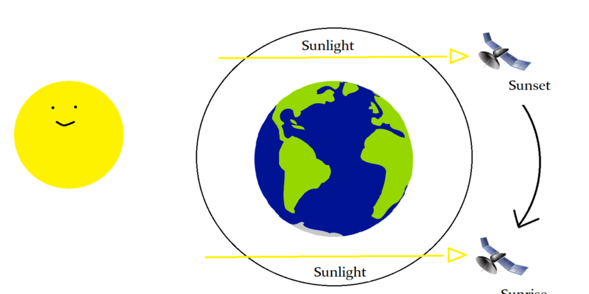
How we got our data

- Information collected by the SOlar Stellar Irradiance Comparison Experiment (SOLSTICE) instrument, which flew aboard the Solar Radiation and Climate Experiment (SORCE) satellite
- We had the files for six observations
- Collected during the months of June and July of 2004
- Latitudes ranging from 20° to 33°
- Because molecular oxygen (O_2) is the only major species absorber of the lyman-alpha line, centered at 121.6nm. We used the irradiance values taken at wavelengths in the range 120.5-122.0nm

A bit of geometry



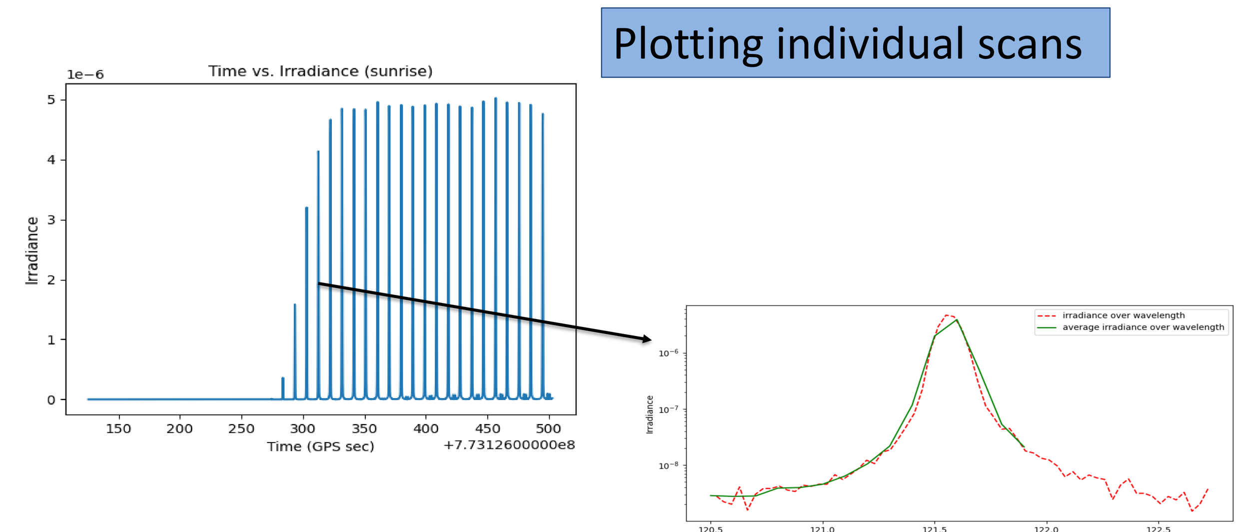
- Our data were obtained at altitudes ranging from ~100-200 km (at tangent height)



- Observations were taken during the sunrise and sunset of SORCE satellite's orbit

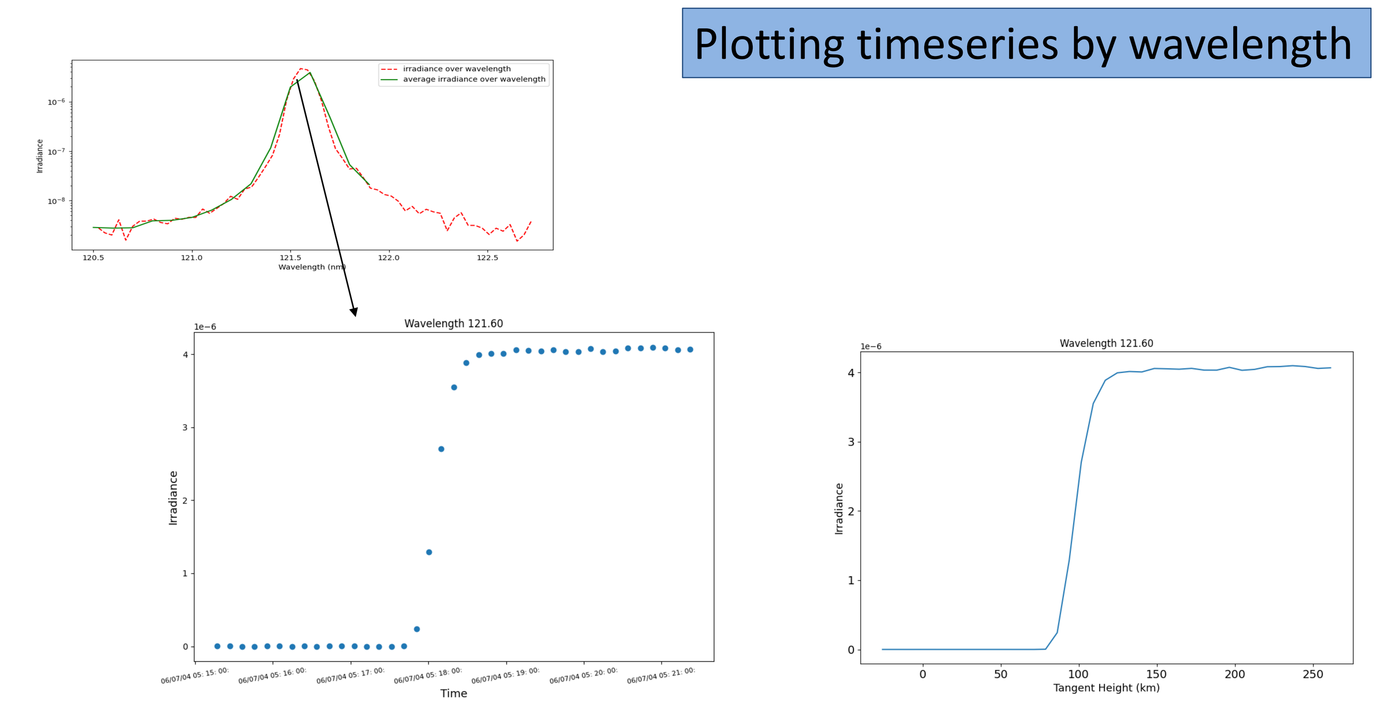
Plotting our data

Plotting individual scans



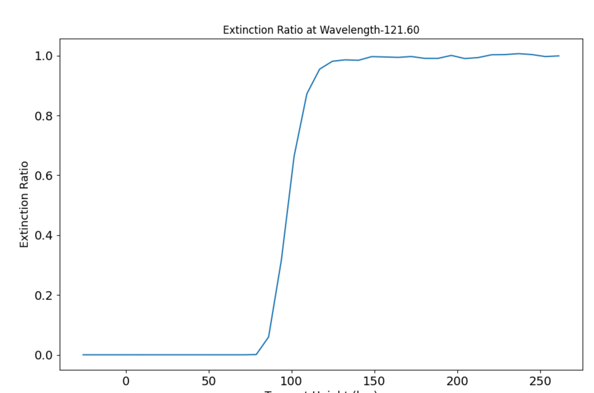
- Each spike we see in the irradiance vs time plot (right) corresponds to one individual scan (left)
- Our first step was to separate out each of these individual scans, resulting in 40 individual scan plots

Plotting timeseries by wavelength



- Each individual scan has irradiance values across the spectrum range we have chosen, 120.5-122.0 nm
- We now had to separate all the irradiance values and plot them by wavelength (left)
- Once this was done, we simply replaced the irradiance values with our tangent values (right)

Extinction Ratio



- $Extinction\ Ratio = \frac{measured\ irradiance}{average\ irradiance\ at\ high\ tangent\ height}$

- The extinction ratio lets us know the difference in irradiance before it traveled through the atmosphere
- This was obtained by taking the average of all irradiance values at the highest tangent height and dividing the measured irradiance values by that average

O2 cross-section

- The O2 cross-section is how the size of a molecule of O2 looks to an incoming beam of light
- This was provided in a NETCDF file

Finally! The equation to our complex word problem

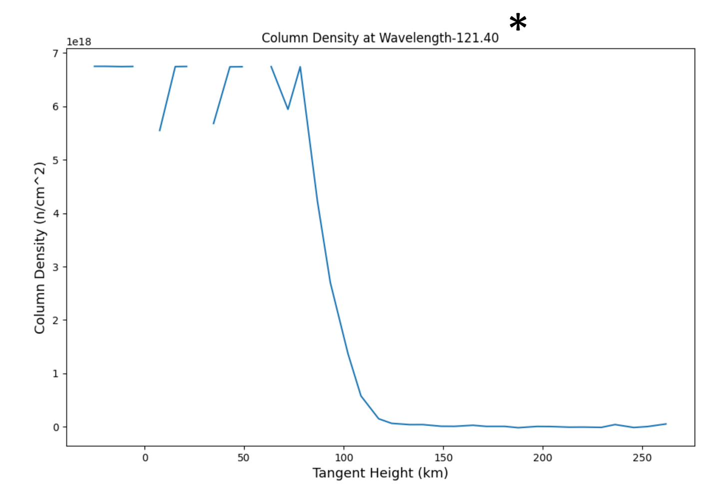
$$\boxed{ER = e^{-\sum N_i \sigma_i}}$$

- The summation symbol is used when it is being used with multiple species. Since we are only working with one species, O2, we don't need to include it in our simplified equation

$$ER = e^{-N_i \sigma_i} \xrightarrow{\text{Solve for N}} N = \frac{-\ln(ER)}{\sigma}$$

Where:
$ER = extinction\ ratio$
$N = column\ density$
$\sigma = O2\ cross\ section$

We have column densities!

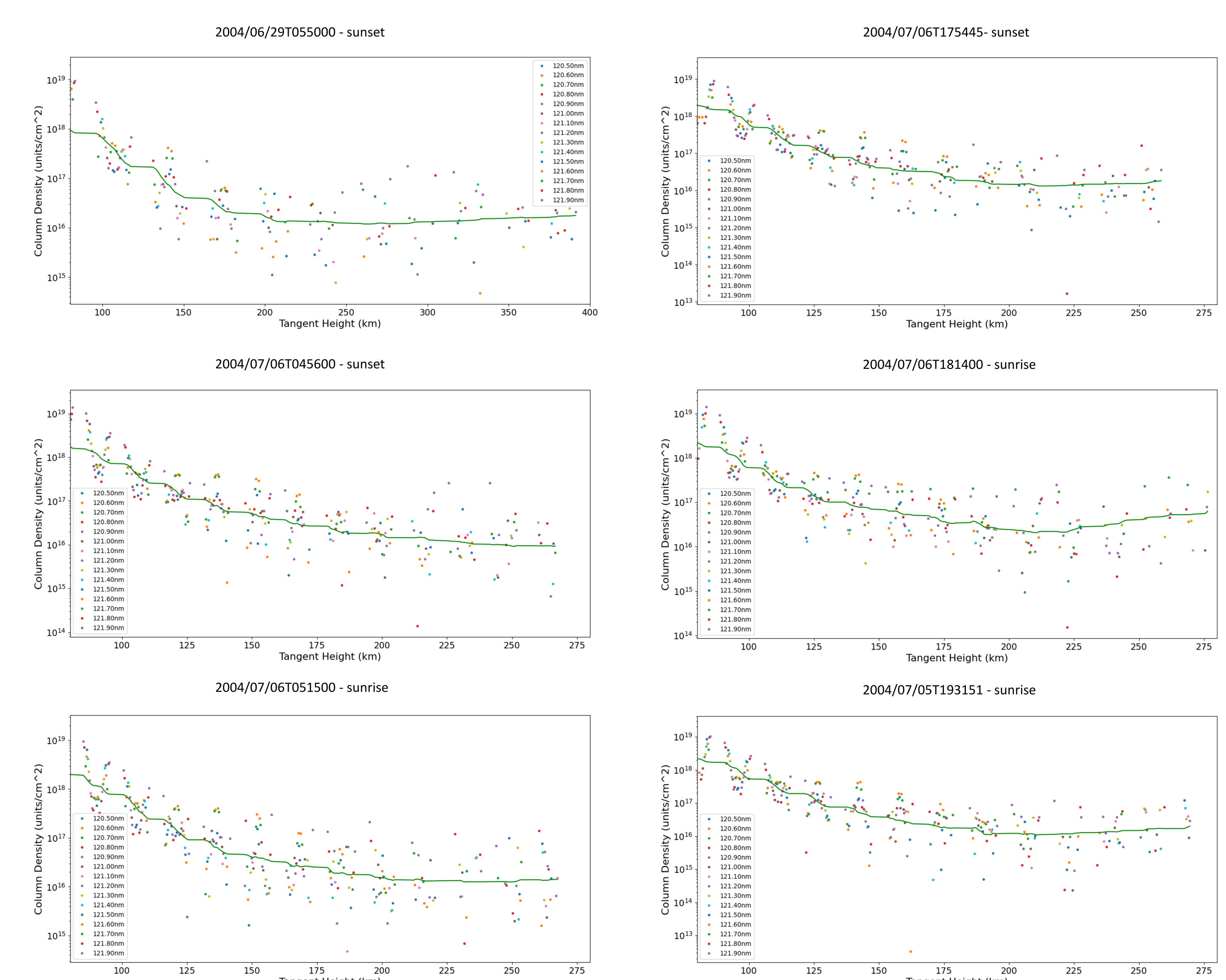


- We now have all the variables needed to solve for our column densities by wavelength
- Column densities are given in units/cm^2 or O2 atoms per cm^2

* The gaps in the curve are due to insufficient data at lower tangent heights

Results

- We plotted all our column density values in a scatter plot and then used a box car smoothing function in python to create a solid line.



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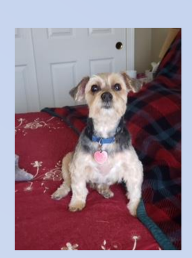

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