

Exploring Ionosphere Structures

Before you Begin

Discuss in your groups

- How do you think the density of the ionosphere changes with latitude? Is it denser at the poles, at the equator, or at the mid-latitude regions?
- Will the ion density be greater at night-side or on the day - side?
- Will the ion density be greater in the summer hemisphere or the winter?

Global Structure of the Ionosphere

Choose one of the published results from the “Solar Cycle” series on this page:

http://ccmc.gsfc.nasa.gov/support/HSS_2015/cycles_iono.php

- Click “View 3D Ionosphere/Thermosphere (low altitude: 80-500 km)”. Then click “Update Plot”.
- The parameter plotted, “N_e”, is the electron number density.
- **What features do you see in these results? What are the external “drivers” that generate those features?**
- **Based on these simulation results, what season is this?**

Keep this plot open and open the same run in a new window or screen.

Vertical Structure of the ionosphere

- Open the same run result in a new window.

To plot the vertical structure of the ionosphere above a particular latitude and longitude, choose the following settings on the page:

- Plot Mode - > “Vertical Line (1D)”
- Choose Plot Area -> lon1 and lon2 -> 180 [Why 180?]
- Choose Plot Area -> lat1 and lat2 -> 0
- Choose Plot Area -> click the radio button next to “H1”
- Now choose “Update”.
- **Can you identify different layers of the ionosphere?**

Ion Species contributing to the layers of the ionosphere

Find which species of ions contribute to the various layers of the ionosphere.

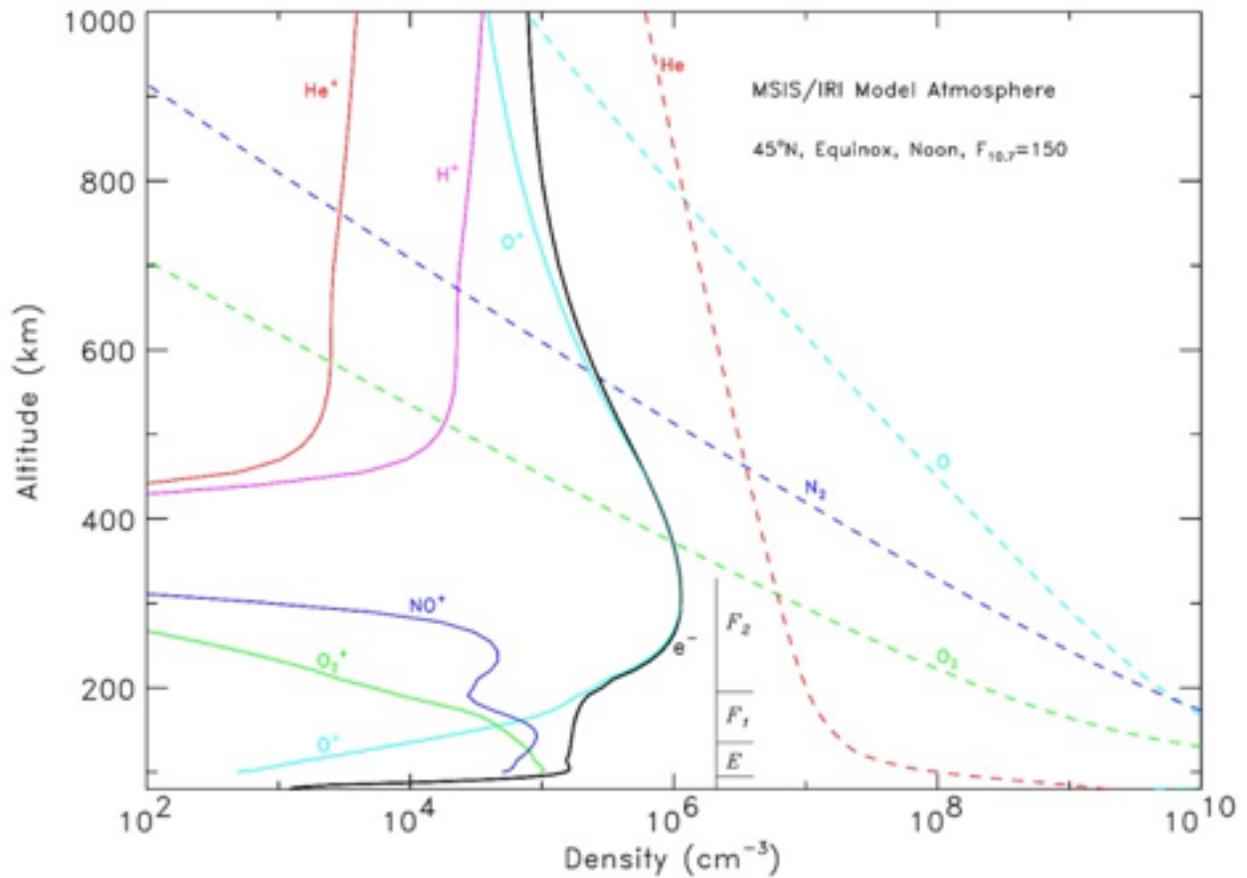
- From “Change quantities”, choose various ions number densities [N_O⁺, N_{O2}⁺, N_{NO}⁺, etc.] and compare these results to the electron number density.
- **Which ions contribute to which layers?**
- To see this better, you may want to fix ranges that you are looking it.
 - Scroll to “Plot Options for selected Plot Modes”.
 - Click “Lock Color Range” under “Color Contour, (Vertical) Line”
 - Choose ranges that you think are appropriate.
 - Select “Log scale” and click “Update Plot”.

Complete this table for the layers you can identify.

Solar Phase _____

Layer / Solar Phase	Density / Indicator Species	Altitude
E Layer, Noon		
F Layer, Noon		
E Layer, Midnight		
F Layer, Midnight		

Are your results consistent (though not necessarily identical) with the another model output represented below.



1. Variations in the ionosphere with latitude

Before you start:

- **How do you think the ionosphere structure varies at different latitude?** Discuss in your group and make some predictions.

- Go back to the “Map” view of the ionosphere.
- From the Quantity → Q1 Menu choose “TEC” to look at the “Total Electron Content”. (TEC is the integrated electron content over the column of the thermosphere/ionosphere)
- “Update” the plot.
- **For a specific longitude, how does the structure vary with latitude?**
- Look at the vertical plots for specific attitudes. **How does the structure of the layers change at various latitudes?**
- From the “Seasonal Variation” list, choose a result either the winter or summer (Northern Hemisphere) solstice. Look at the TEC map and the structure of the layers for different latitudes.
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2. Daily Variations and Variation with Longitude

Before you start:

- ***How do you think the ionosphere structure varies at different time of day? Is this different from the variation in longitude?***
Discuss in your group and make some predictions.

Looking at the Global Ionosphere

- Go back to the “Map” view of the ionosphere.
 - From the Quantity → Q1 Menu choose “TEC” to look at the “Total Electron Content”. (TEC is the integrated electron content over the column of the thermosphere/ionosphere)
 - ***What variations do you see in longitude?***
 - Open another window and plot vertical plots for various longitudes for the electron density [NE].
 - ***How does the vertical structure of the ionosphere change for different longitudes?***
- You can also change the simulation time for a fixed longitude.
- For both the map and the vertical plots change the simulation time using “Choose data time” near the top of the page.
 - ***How does the structure of the ionosphere change with varying time of day?***

3. Seasonal Variations in the Ionosphere

Before you start:

- ***How do you think the ionosphere structure (density and height) varies through out the year? Is it different from the variation in latitudes? Do the hemispheres respond differently?***
- ***At mid latitudes at noon, what time of year do you think has the largest TEC.***
Discuss in your group and make some predictions.
- From the original run list, choose a run from the seasonal variation study.
- From the Quantity → Q1 Menu choose “TEC” to look at the “Total Electron Content”. (TEC is the integrated electron content over the column of the thermosphere/ionosphere)
- And plot the total electron content.

In a new window, choose a latitude to plot a line plot for varying longitude.

- From “Plot Mode” select “Line (1D)”

- Set Q1 -> TEC, Q2 -> NmF2 (the maximum density of the F layer), and Q3 -> HmF2 (height of the F layer) [Note: all of these quantities are independent of height]
- In “Choose Plot Area” set lon1 -> 0 and lon2 -> 360, lat1 = lat2 -> [your choice]
- For a specific longitude, read the values for the three quantities plotted
- Complete the chart below for various times of the year.

Date/Day							
TEC							
NmF2							
HmF2							

- **Revisit the questions you started with given the results tabulated.**

4. Variations through Out the Solar Cycle

Throughout the solar cycle (<http://solarscience.msfc.nasa.gov/SunspotCycle.shtml>) the solar F10.7 radio wave emissions flux varies in the same way as the average sunspot number (<http://www.swpc.noaa.gov/phenomena/f107-cm-radio-emissions>). F10.7 flux is a very good proxy for the EUV flux which affects the ionosphere.

- **Why do you think we use a radio flux rather than a direct measurement of EUV?**
- **How do you think the density and height of the ionosphere various with solar cycle?**
- **At mid latitudes at noon, what time of year do you think has the largest TEC.**
Discuss in your group and make some predictions.

- From the original run list, choose a run from the solar cycle study study.
- From the Quantity —> Q1 Menu choose “TEC” to look at the “Total Electron Content”. (TEC is the integrated electron content over the column of the thermosphere/ionosphere)
- And plot the total electron content.

In a new window, choose a latitude to plot a line plot for varying longitude.

- From “Plot Mode” select “Line (1D)”
- Set Q1 -> TEC, Q2 -> NmF2 (the maximum density of the F layer), and Q3 -> HmF2 (height of the F layer) [Note: all of these quantities are independent of height]
- In “Choose Plot Area” set lon1 -> 0 and lon2 -> 360, lat1 = lat2 -> [your choice]
- For a specific longitude, read the values for the three quantities plotted
- Complete the chart below for various times of the year.

Solar Cycle Phase	Solar Min	Rising Phase	Solar Max	Declining Phase
TEC				
NmF2				
HmF2				