Seasonal Variation of F2 peak of Ionosphere

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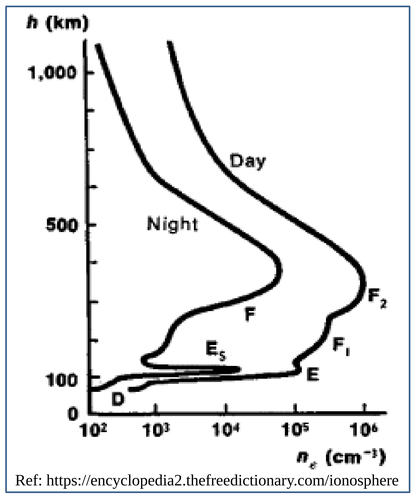
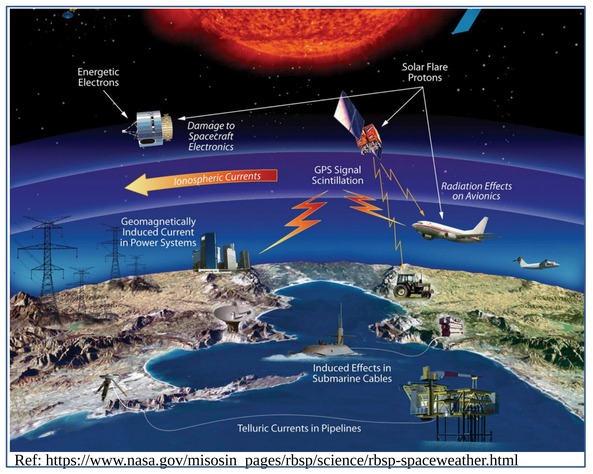
Abstract: The environment in the top layer of the Earth's atmosphere, which we call the Ionosphere, changes from hour to hour and from day to day, due to its interaction with the Sun. As a part of this research, we are studying the F2 peak of the ionosphere using ionosonde data. We are using the data from Ahmedabad (latitude 23.00 degree, longitude 72.50 degree) station and Norilsk (latitude 69.20 degree, longitude 88.00 degree) station . We will also be using predicted ionosphere data from the International Reference Ionosphere model to compare to the actual data that was collected by the digisounde. During winter time of the year 2012, Ahmedabad's F2 peak varies around ~5 MHz to ~15 MHz and the height varies from ~220 km to ~270 km. The IRI model predicted that the frequency should have been ~13 MHz to ~14 MHz and the height's around ~270 km to ~300 km. Norilsk's winter time F2 peak varies between ~2 MHz to ~3 MHz with a height between ~250 km to ~350 km. The results are compared with IRI (International Reference Ionosphere) model for both F2 peak frequency and height. This research work will be important in terms of space plasma studies and space weather predictions, which play a significant role in radio and satellite communication as well as GPS navigation.

Ionosphere:

- Part of Earth's upper atmosphere ionized by solar and cosmic radiation.
- It extends (75-1000 km) and is composed of 3 regions: D, E, F.
- The ionosphere's electron density undergoes seasonal, diurnal and solar cycle variation.
- Maximum electron densities occur in the F-region and minimum electron densities occur in the D-region.
- Ionosphere affects the radio wave propagation at distant places on the Earth and between Earth and satellites.



Ref: https://encyclopedia2.thefreedictionary.com/ionosphere



Ref: https://www.nasa.gov/misosin_pages/rbsp/science/rbsp-spaceweather.html

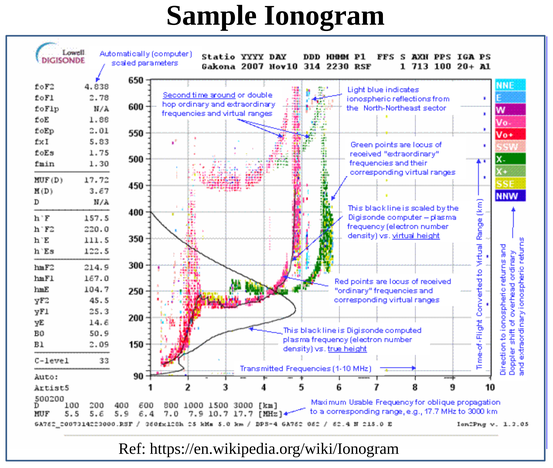
Tools to study Ionosphere: "DIGISONDE"

- Digisonde is a radar system that uses high frequency waves in order to examine the ionosphere.
- DIGISONDE stands for "Digitally Integrating Goniometric IonoSONDE".
- We have used the DIGISONDE data from Lowell DIDbase for low latitude station Ahmedabad and for high latitude station Norilsk.

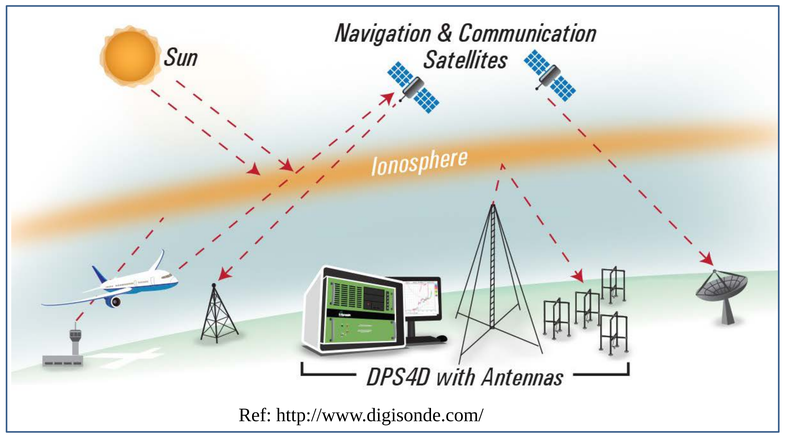
Ionogram:

- An ionogram is a pictorial representation of the data produced by an ionosonde.
- Virtual height of the ionosphere plotted against the frequency of the signals.
- The frequency of the signal (plasma frequency) can be converted to electron density.

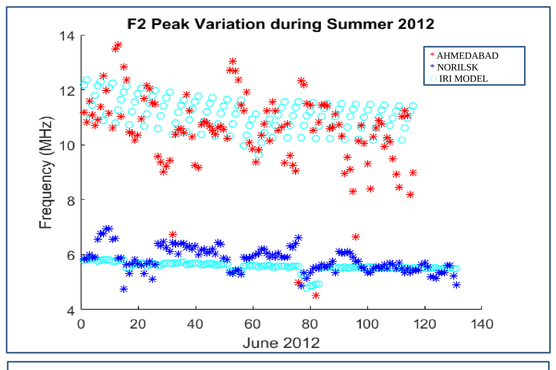
Sample Ionogram

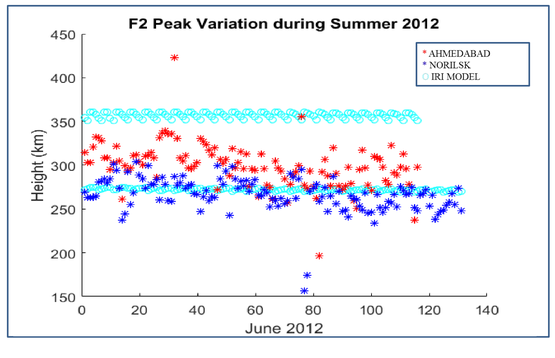


Ref: https://en.wikipedia.org/wiki/Ionogram



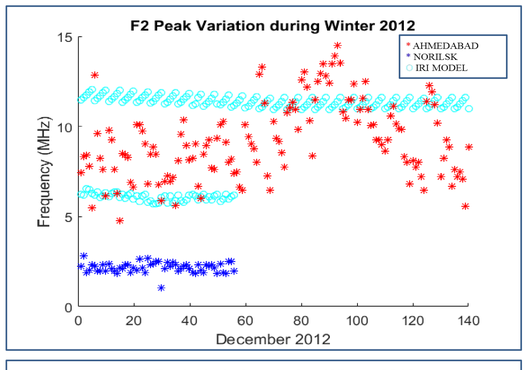
Ref: http://www.digisonde.com/

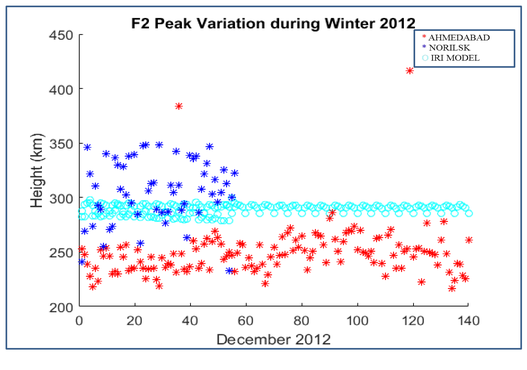




F2 variation during summer

- During June 2012, the F2 peak frequency of Ahmedabad (lat 23.00, long 72.50) varies between 8 MHz to 14 MHz.
- The IRI model for Ahmedabad shows variation between 11 MHz to 12 MHz.
- The height of the F2 peak for Ahmedabad varies between 275 km to 350 km.
- F2 peak height from the IRI model for Ahmedabad ranges between 350 km to 360 km.
- For high latitude station Norilsk (lat 69.20, long 88.00), F2 peak frequency varies between 5 MHz to 7 MHz.
- The IRI model for Norilsk shows variation between 5 MHz to 6 MHz.
- The height of the F2 peak for Norilsk varies between 240 km to 300 km.
- F2 peak height from the IRI model ranges around 270 km.





F2 variation during winter

- During December 2012, the F2 peak frequency of Ahmedabad varies between 5 MHz to 15 MHz.
- The IRI model for Ahmedabad shows variation between 13 MHz to 14 MHz.
- The height of the F2 peak for Ahmedabad varies between 220 km to 270 km.
- F2 peak height from the IRI model for Ahmedabad ranges around 270 km to 300 km.
- For high latitude station Norilsk, F2 peak frequency varies between 2 MHz to 3 MHz.
- The IRI model for Norilsk shows variation around 6 MHz.
- The height of the F2 peak varies between 250 km to 350 km.
- F2 peak height from the IRI model is around 260 km.

Conclusion & Discussion:

- Low latitude regions have a higher F2 peak magnitude and height during both winter and summer, than high latitude regions.
- The difference in magnitude of the F2 peak is more in the summer (~6.5 MHz) month than winter (~3.5 MHz).
- The difference in magnitude for the (IRI) model data in summer is (~8 MHz) and the difference in winter is (~9.5 MHz).
- The IRI model agrees well with F2 peak density during summer for low latitude region; it does not agree the height variation.
- The IRI model does not agree with the density and height of the F2 peak for the high latitude region.

Acknowledgement & Reference:

We acknowledge the Lowell Digisounde and the International Reference Ionosphere for providing the data for this research. (Ref: http://ulcar.uml.edu/DIDBase/ and http://irimodel.org/)

Bilitza, D., D. Altadill, V. Truhlik, V. Shubin, I. Galkin, B. Reinisch, and X. Huang (2017), International Reference Ionosphere 2016: From ionospheric climate to real-time weather predictions, Space Weather, 15, 418–429, doi:10.1002/2016SW001593.
Aikio, A. (2011), Introduction to the ionosphere, *Eiscat*, Available from: https://www.eiscat.se/eiscat3d/drupal/sites/default/files/IISRWS2011/01-Aikio_Intro_Ionosphere.pdf .
Anon(n,d), *NOAA*, Available from: https://www.ngdc.noaa.gov/stp/iono/ionogram.html.
Garner, Rob. "Earth's Pulsating Ionosphere." *NASA*, NASA, 4 Apr. 2016, www.nasa.gov/image-feature/goddard/2016/earths-pulsating-ionosphere.

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