

CAC and Asti Bhatt, Michael Kelley, and SRI International

Gravity Waves Detected in Plasma Line

What causes electron density fluctuations in plasma line observations?

Finding the Answer

Plasma line observations taken with the Poker Flat Incoherent Scatter Radar (PFISR) over a period of five months in the International Polar Year (IPY) have revealed that significant electron density fluctuations occur ~50% of the time. Asti Bhatt and Michael Kelley of Cornell University and Michael Nicolls and Craig Heinselman of SRI International are collaborating to better understand plasma processes in the ionosphere at auroral latitudes.

Understanding the Plasma Line



Poker Flat, Alaska radar facility

The spectra obtained of the incoherent scatter from thermal fluctuations in the ionospheric plasma contain an ion component and an electron component. The ion component known as the ion line has a width which is controlled by ion thermal motion. The electron component of the spectra consists of two pairs of resonance lines known as the plasma line and the gyro line, both solutions of the dispersion relation for a magnetized plasma. The plasma

line is due to the scatter from electron plasma waves or Langmuir waves enhanced by energetic photo-electrons and depends heavily on the electron density. The plasma line is widely used to infer the electron density profile in the ionosphere.

Improved Research

Research Metrics

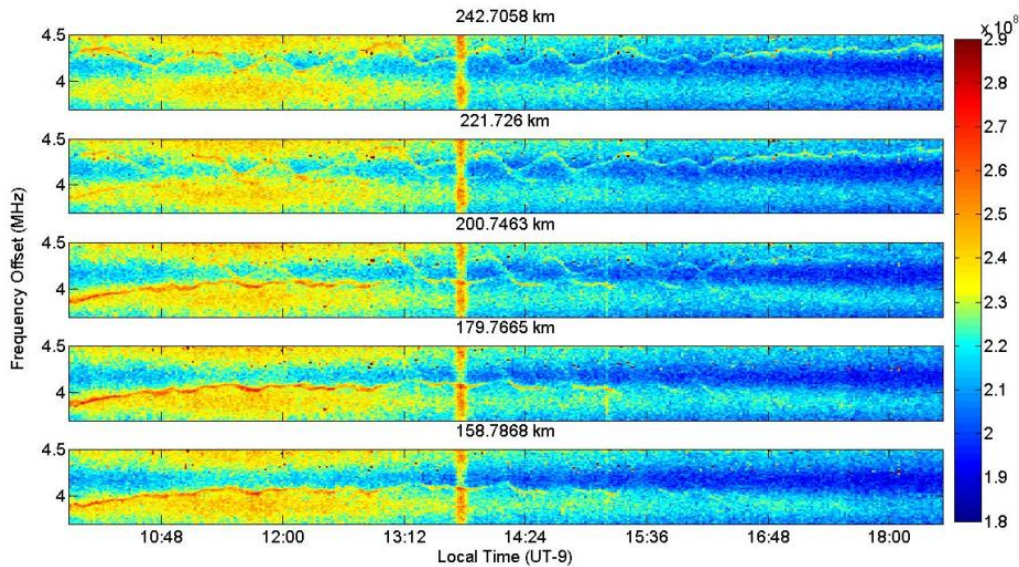
- Reduce analysis time: enable and speed-up research data analysis with a large memory CAC computer with significant disk storage.

Research Challenge

At high latitudes, auroral precipitation, electric fields, and plasma instabilities add to the complex nature of the ionosphere and make it difficult to find the source of the gravity waves in the thermosphere.

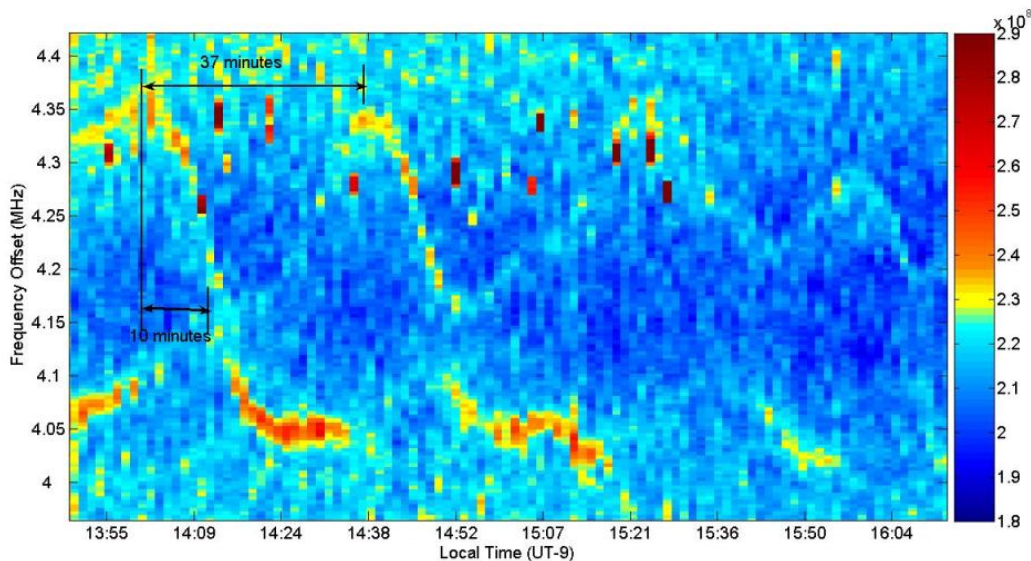
Solution

Asti Bhatt, a Ph.D. candidate whose advisor is Professor Michael Kelley, Cornell Electrical and Computing Engineering, used a high-performance desktop and disc system with MATLAB to enable the data analysis.



Gravity wave signatures in plasma line

The gravity wave signatures above show a series of density-time-intensity images for altitudes from 158 to 242 km. The signal of interest here is the temporally fluctuating enhancement in the intensity above the noise floor. Since the received signal was sampled at a higher rate than the transmitted signal, the same signal appears in multiple range bins. Notice that the plasma line trace seen in the lowest two altitude bins is qualitatively different from that seen in the upper two altitude bins.



Inferring gravity wave parameters

The wave period in the image above is 37 minutes which is greater than the buoyancy period (7-11 minutes) at these altitudes. The phase delay between the lower altitude wave and the higher altitude wave is $dt = 10$ minutes, which is almost certainly due to the downward phase propagation. Using this information, the research team inferred that the vertical wavelength equals approximately 233 ± 10 km, and vertical phase velocity of -105 m/s.

Future Research

A CAC system helped to enable the rapid analysis of large input and output data files. Although gravity waves in thermosphere are difficult to understand, the researchers expect new observation methods to further enhance their insights. In addition, electron plasma waves, which create the resonance line known as the plasma line, have velocities near the tail of the Maxwellian distribution that gets enhanced by energetic particles such as photoelectrons. Since auroral precipitation also gives rise to superthermal electron flux, the researchers may be able to develop techniques to study this component, which is difficult for particle detectors.