An Overview of Oblique Soundings from Chirp Ionosondes

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Abstract

An ionospheric sounder, typically known as an ionosonde, is a radar device which is used to make observations of the ionized layer of the Earth's upper atmosphere known as the ionosphere. The ionosonde works by transmitting high frequency (HF, 3-30 MHz) radio waves and observing the time delay of the ionospheric echoes. Ionosondes play an especially crucial role in our understanding of how radio wave propagation is impacted by the ionosphere. The data from an ionosonde is displayed in a type of plot known as an ionogram. A chirp ionosonde is a type of ionospheric sounder that produces ionograms by transmitting an HF signal that changes linearly in frequency with time. Chirp ionosondes may be used in an oblique sounding configuration, in which the transmitter and receiver are separated by a significant geographic distance. This type of Ionosonde is frequently used in conjunction with the Relocatable-Over-The-Horizon-Radio (ROTHR) transmitter. We give a brief overview of chirp ionosondes and their uses in studying variation of the ionosphere.

Introduction

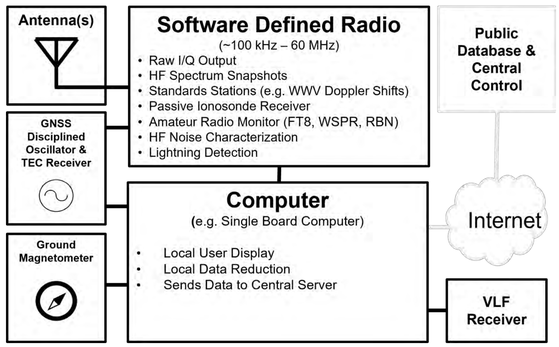

Figure 1. An overview of the architecture involved in the HamSCI PSWS

HamSCI Personal Space Weather Station

The HamSCI PSWS is a multi-instrument ground-based system that can aid in gathering space weather data including ionosonde recordings. This project is led by the University of Scranton in currently in collaboration with Tucson Amateur Packet Radio (TAPR), Case Western Reserve University, The University of Alabama, The New Jersey Institute of Technology Center for Solar Terrestrial Research, and the Massachusetts Institute of Technology Haystack Observatory. Not only will this device allow ham radio operators to answer question involving radio propagation, but it can also answer scientific research questions such as those regarding ionospheric disturbances.

Discussion

Expanding our knowledge about the impact of the ionosphere is an imperative aspect of understanding radio wave propagation. Aside from learning insightful knowledge on the characteristics of the ionosphere, the information gathered from studying its impact on HF communications can be implemented in a variety of ways including tracking natural occurrences such as earthquakes and observing meteors (Shi, 2017).
Typically, an ionosonde HF radio transmitter has a frequency range of 1 to 20 MHz and a sweep duration of 12 seconds to 5 minutes.
The pulse transmitter sweeps this range and an ionogram can plot the height versus the frequency.

GNU Chirpsounder2

The GNU Chirpsounder2 is a software package written by Juha Vierinen which can create ionograms from FM chirp ionosonde data. This software is utilized in the HamSCI Personal Space Weather Station (PSWS) which allows for ground-based remote sensing of the space environment.

The traces pictured in the oblique ionogram from the Chirpsounder ionosonde coincide with layers of the ionosphere, more specifically the E, F1, and F2 layers. The various hops between traces provide information about the electron density of the F-layer of the ionosphere (Bernhardt). In figure 5, the left signal cluster is an ordinary signal path and the right is an extraordinary signal path. The cause of these paths are differences in polarization. The bistatic scatter noticed throughout the pulses are the result of reflected HF transmissions.

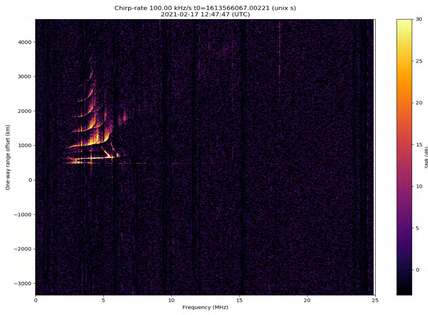

Figure 2. calculated ionogram outputted by the GNU Chirpsounder2 software from a Chirpsounder located in Spring Brook, PA. The chirp signals are transmitted from the ROTHR located in Chesapeake, VA

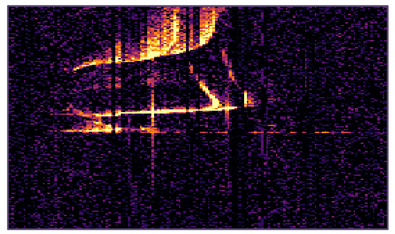

Figure 3. Closeup of signal clusters from the pictured ionogram

Conclusion

We presented an overview of oblique soundings from chirp ionosondes and their various implementations and uses. Chirp ionosondes enable remote sensing of the state of the ionosphere. Such information is crucial for radio wave propagation and HF transmissions. The data presented in the Ionogram collected from Spring Brook, Pennsylvania works an example of a typical ionogram outputted from the GNU Chirpsounder software.
It's implementation in the HamSCI Personal Space Weather Station will allow ham radio operators and researchers to study various ionospheric science questions. The chirp output presented in the ionogram specifically targets the ROTHR in Chesapeake, Virginia, however, In future work we hope to modify the GNU Chirpsounder software to allow for identification of various transmitters.

References

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