Web-Based Application for the Visualization and Analysis of Ionogram Data Observed by GNU Chirpsounder2

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Abstract

The focus of the system is to develop a web-based application for the visualization and analysis of data observed by GNU Chirpsounder2. Each day many ionograms are received from different transmitters placed around the world. The unclassified data in the form of LFM files and ionograms is first classified by using chirp-rate and distance of the transmitter from the receiver. Using these two parameters, application provides methods for sorting, analyzing, and visualizing the collected ionograms to conduct scientific studies or make the observations useful for radio communications operations.

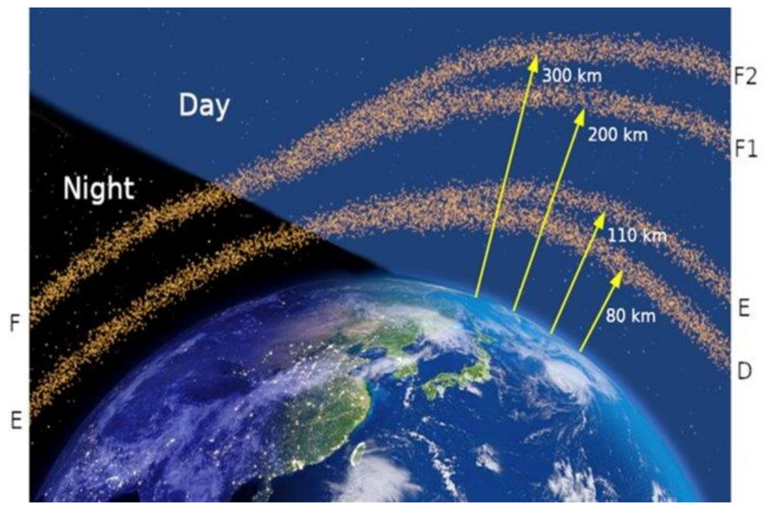
Introduction

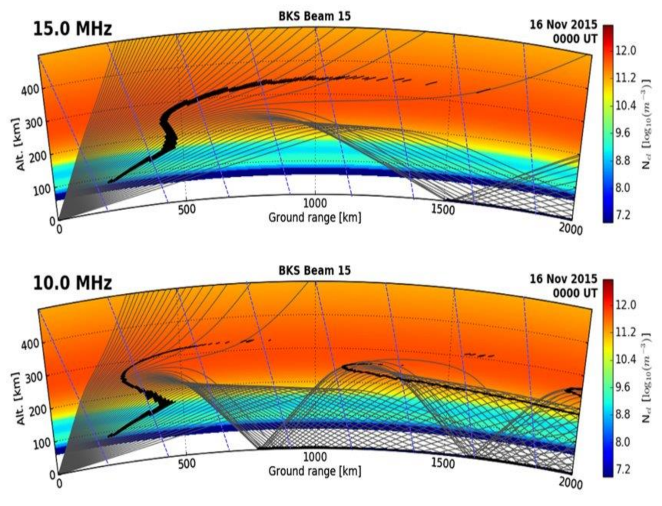
The ionosphere is an electrically charged layer of the upper atmosphere. Solar Ultraviolet Radiation (UV) can ionize particles in the ionosphere creating a plasma of free-floating negative electrons, positive ions, and neutral particles. During the day, the ionosphere splits into the D, E, F1, and F2 layers. At night, the ionosphere reduces to the E and F layers.

The ionosphere can refract high frequency (HF) radio waves back to Earth. The amount and height of refraction is dependent on the electron density profile along the radio propagation path. 15 MHz signal is refracted less than the 10 MHz signal.

This frequency dependence allows instruments to be built that can remote sense the ionosphere using radio signals. An ionosonde is a system for making these needed ionospheric measurements by transmitting MF/HF signals up to the ionosphere and measuring the time delay of the refracted signal. This allows for the determination of bottom-side ionospheric electron densities as a function of height in the case of vertical transmission, or refracting frequency as a function of slant range in the case of oblique ionospheric sounding. An ionogram is created by receiving this signal after it has been refracted back to Earth and then plotting the received time delay as a function of frequency.

GNU Chirpsounder2 (https://github.com/jvierine/chirpsounder2) is free, open-source software for using Software Defined Radios (SDRs) to automatically generate ionograms from received signals of opportunity. This presentation presents a web-based application for the visualization and analysis of data observed by GNU Chirpsounder2.

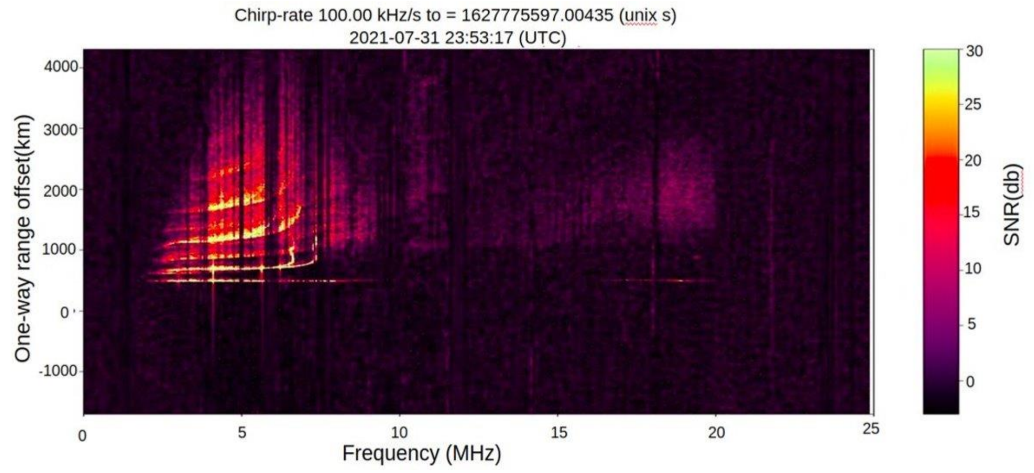




What kind of Data?

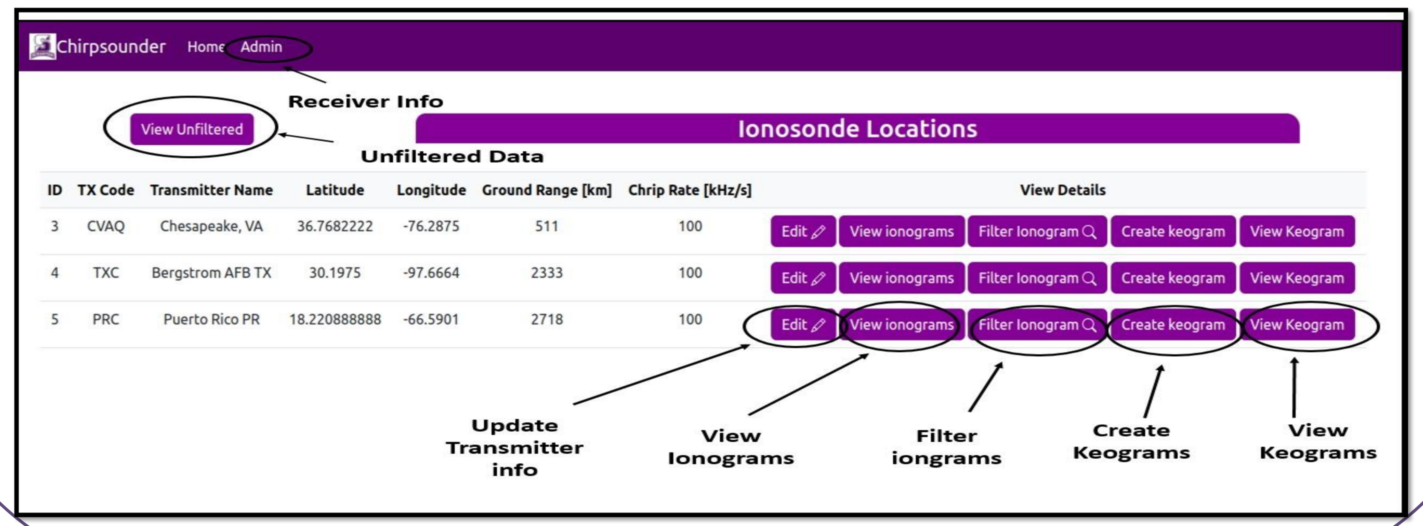
LFM(Linear frequency Modulation) files contain the actual ionogram array (S) that is derived from the observed chirp, as well as additional metadata pertaining to the observation: Ch, rate, station_name, t0. Ch is a variable that contains the name of the channel used on the SDR, rate is the chirp-rate in kHz/s, the station name is the name of the station from which data is collected, and t0 is the start time of the entire chirp. We will take the scalar values from these data files as well as parameters derived from the S ionogram array to populate a PostgreSQL database to enable efficient organization and visualization of the parameters needed to identify the likely ionosonde transmitter for each observation. LFM signals can be stored in various file formats. This system specifically uses HDF5 format. HDF5 files are a hierarchical data format that can store LFM signal data along with additional metadata, such as signal parameters and processing results. **Below plot is a typical example of ionogram.** An ionogram is a graphical representation of the ionosphere's electron density distribution as a function of altitude and frequency.

LFM File (Variables)
Ch: channel name data was collected from
rate: chirp rate in kHz/s
station name: Identifier of receiving station
t0: start time of entire chirp
r0: calculated from the S array

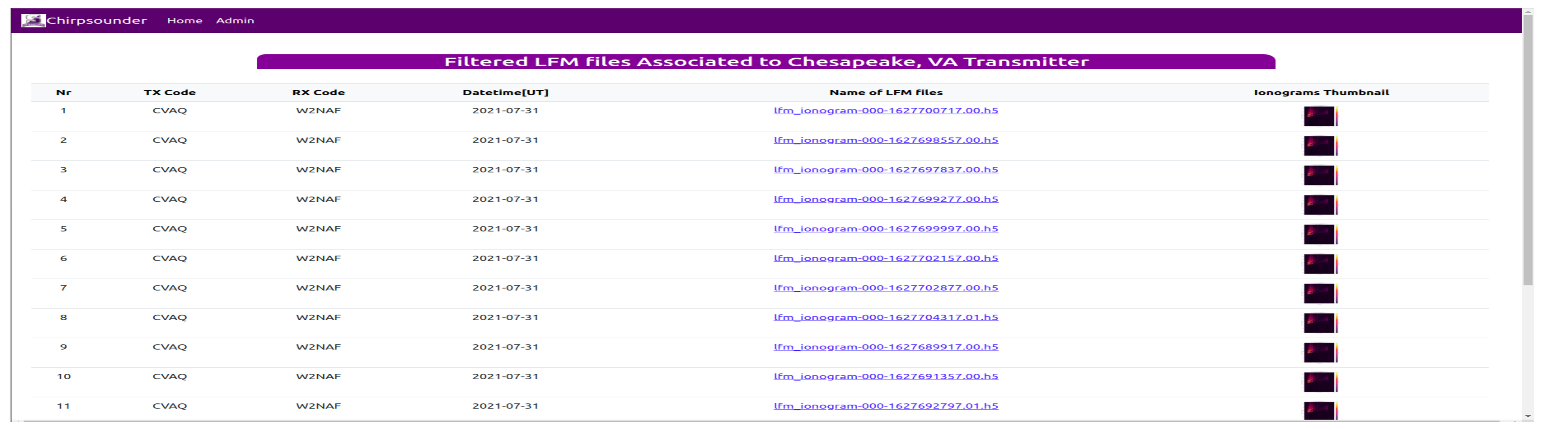


Website Overview

Data (LFM files and ionograms) collected by GNU Chirpsounder2 with an SDR receiver are classified based on chirp rate and distance between transmitter and receiver. This system displays all transmitter and receiver information across the world. Transmitter information includes the code (TX Code), transmitter location, latitude and longitude, ground range (km), and chirprate (kHz/s). Receiver data includes the code (RX Code), receiver location, Lat, and Long. The transmitter and receiver information can be updated at any time, allowing atmospheric scientists or amateur radio operators to examine the information for their experiments straight away. This system allows user to filter data, identify the location of the transmitter, and obtain the TX code for that transmitter. User would be able to see the keograms(combination of ionograms)

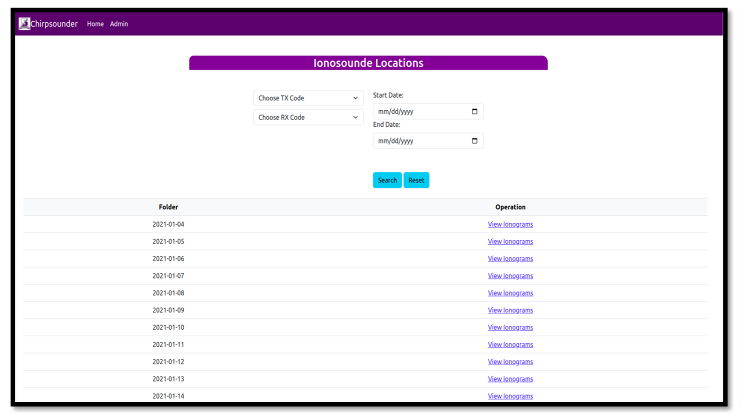


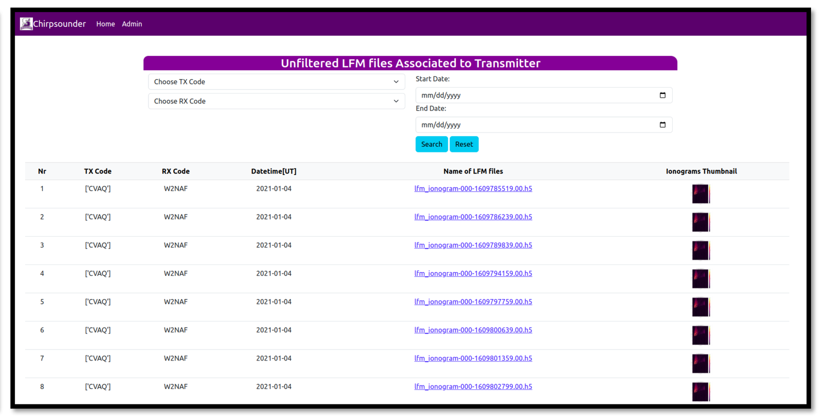
How does this application help atmospheric scientists?



As shown in the above screenshot of the current view of the filtered page.

- Atmospheric scientists would be able to view the sorted and filtered data of the selected date.
- The System allows the user to download the LFM files into the local system.
- User is able to see the ionograms corresponding to the LFM files.
- User can use this system for the dynamic data.
- User can compare historical data to the current data.
- Keogram(combination of ionograms) is created by using series of ionograms coming from the one transmitter. Keogram is a graphical conclusion of the data is coming from the one particular transmitter.





The above screenshot is the current view of the unfiltered data page.

- The application allows the user to search unfiltered data by selecting parameters from the dropdown TX_Code, RX_Code and date from the date-range.
- Atmospheric Scientists can make their experiments effective by comparing the filtered and unfiltered data.
- System is managing the 6.5 TB of data as of now.

References

- D. Joshi, N. Frissell, W. Liles, J. Vierinen and E. S. Miller, "Early Results from the Ionospheric Sounding Mode Using Chirp Ionosondes of Opportunity for the HamSCI Personal Space Weather Station," 2021 XXXIVth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS), Rome, Italy, 2021, pp. 1-3, doi: 10.23919/URSIGASS51995.2021.9560441.
- Yadav, N. (n.d.). *Nisha-Yadav-1/chirpsounder*. GitHub. Retrieved February 12, 2023, from https://github.com/Nisha-Yadav-1/chirpsounder.git

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