Spectra Analysis in Faraday/Double Pulse Experiment at Jicamarca Radio Observatory (JRO)

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Abstract

At the Geophysical Institute of Peru, specifically on its Jicamarca Radio Observatory (JRO) facility, there are different operation modes to obtain the main parameters of the equatorial ionosphere. One of these modes is the Faraday/Double Pulse which estimates plasma densities and electron/ion temperatures at the F region by pointing the antenna beam off perpendicular to the magnetic field. The data processing for this mode is currently done by using voltage analysis, but in order to obtain better results, spectra analysis has been implemented by using the radar data processing library developed at JRO called Signal Chain. This tool can analyze samples with the same lag and it is also possible to remove the DC clutter from them. Another advantage is that before making the incoherent integration over the spectra, these data can be stored and the outliers from samples with the same frequency can be removed. Comparisons between the different processing programs are shown on this work.

1. Old methodology

Faraday/Double Pulse raw data (voltages) are usually processed by calculating the power and the products between the two channels (cross products). Cross products are then used to estimate ACFs, the Faraday angle and finally the plasma density and temperatures. However, sometimes, data is contaminated due to coherent echoes or other causes. Figure 1 shows this contamination in the electron density RTI.

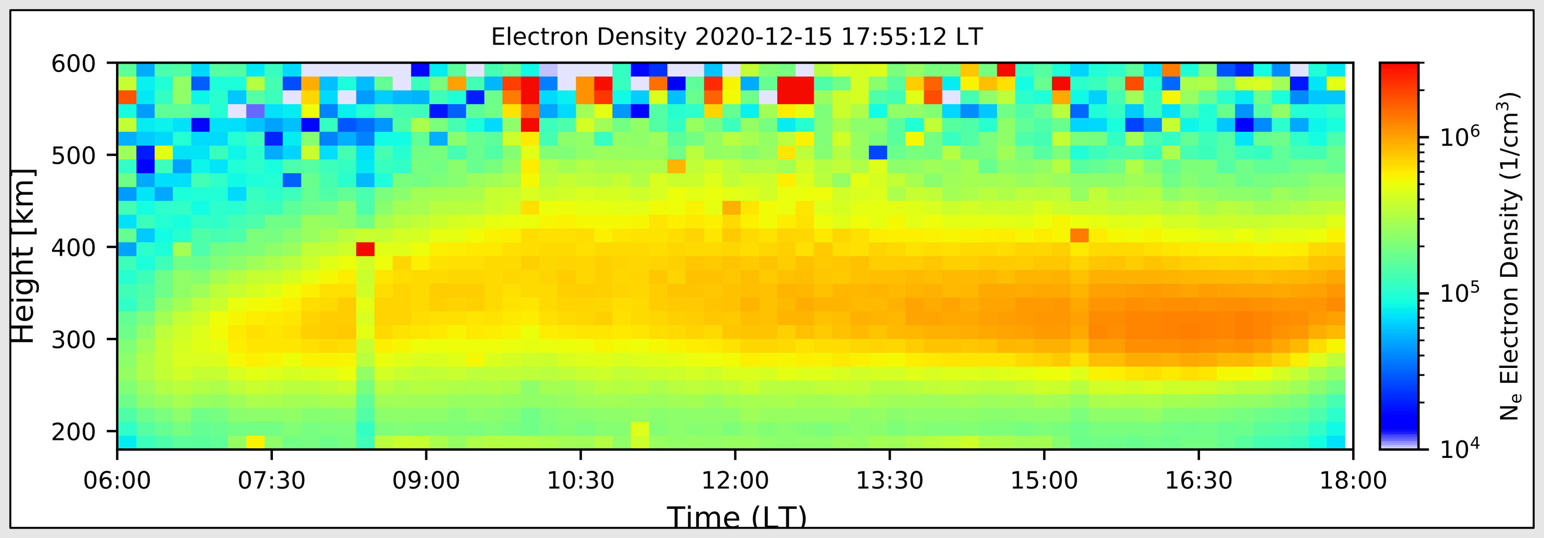

Figure 1. Electron density RTI using cross products (voltages) in the processing.

2. New methodology

Signal Chain (SCh) is the radar data processing library developed at JRO based on python. One of its main goals is to integrate all processing routines ran at JRO into this tool. This fact allows users to use routines developed for a certain experiment in another experiment.

In order to remove the outliers from the data, a routine based on the Hildebrand-Sekhon (HS) algorithm is used. Instead of adding the data in the incoherent integration, this routine stores the data and analyzes each set of data at a certain channel, height and frequency. Then, it uses the HS algorithm starting from the 75% percent of the set because it is expected that most of the data are not outliers. After this, if an outlier exists, it is removed and only cleaned data is used to estimate the physical parameters. From these data, DC clutter is removed for both channels.

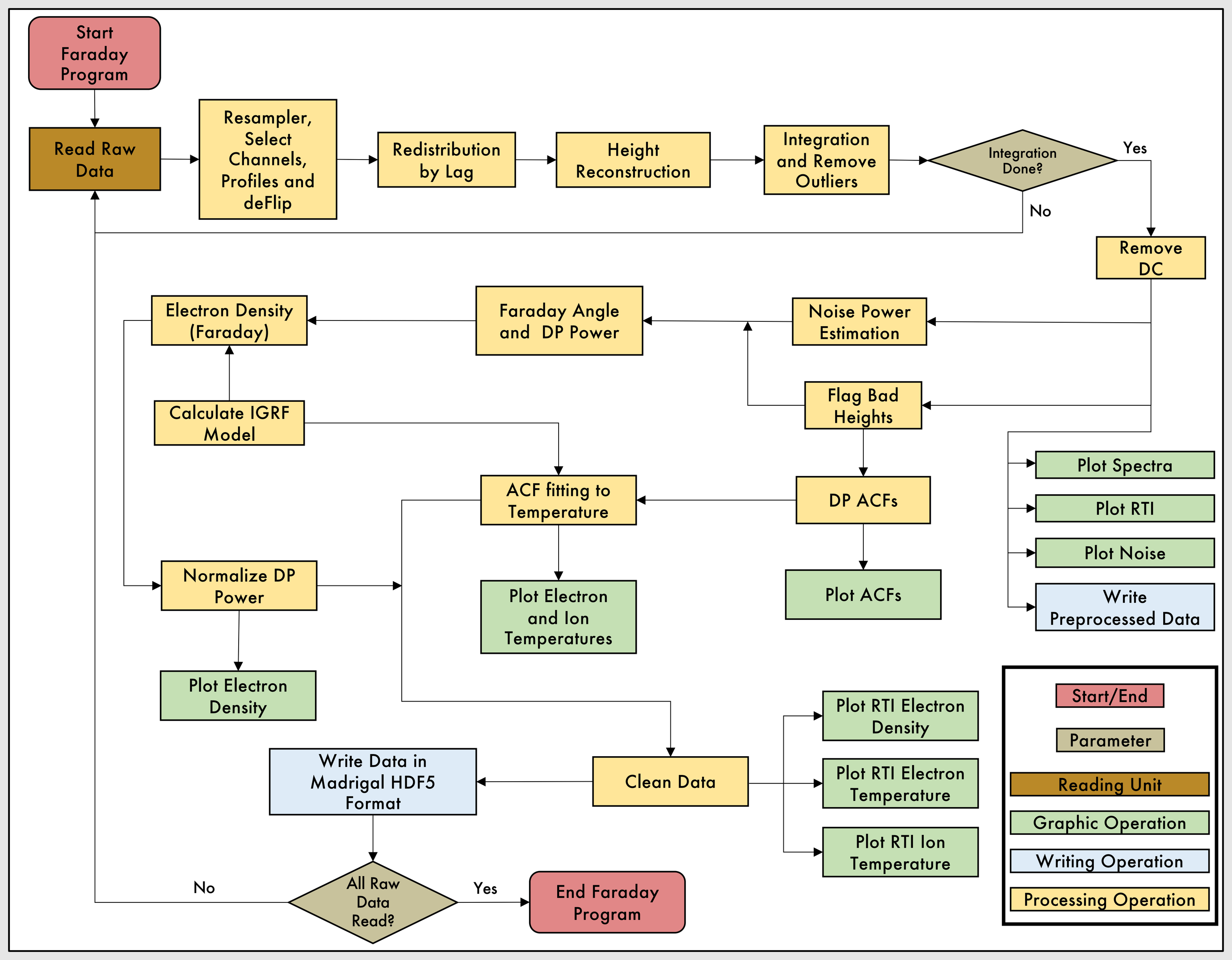

Figure 2. Program flowchart using SCh library.

3. Results

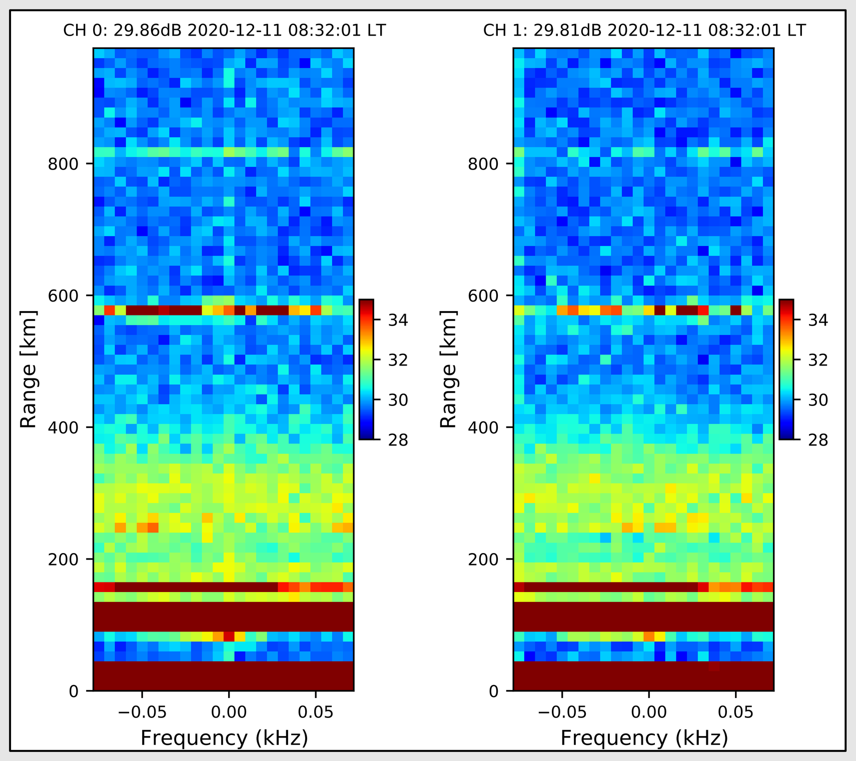

Figure 3. Contaminated self spectra at channels 0 and 1.

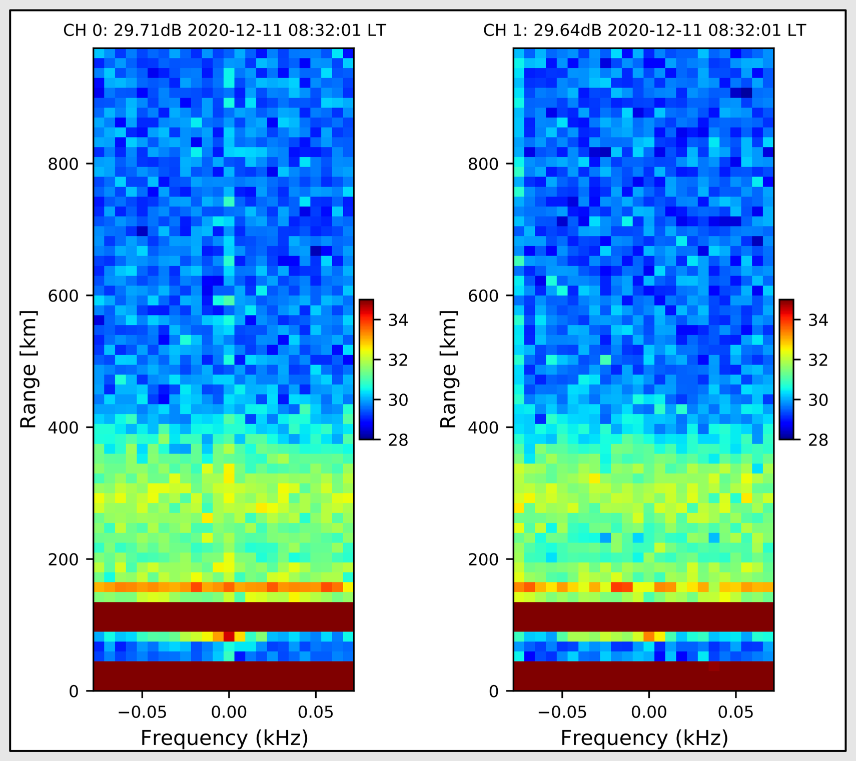

Figure 4. Cleaned self spectra using Hildebrand-Sekhon algorithm.

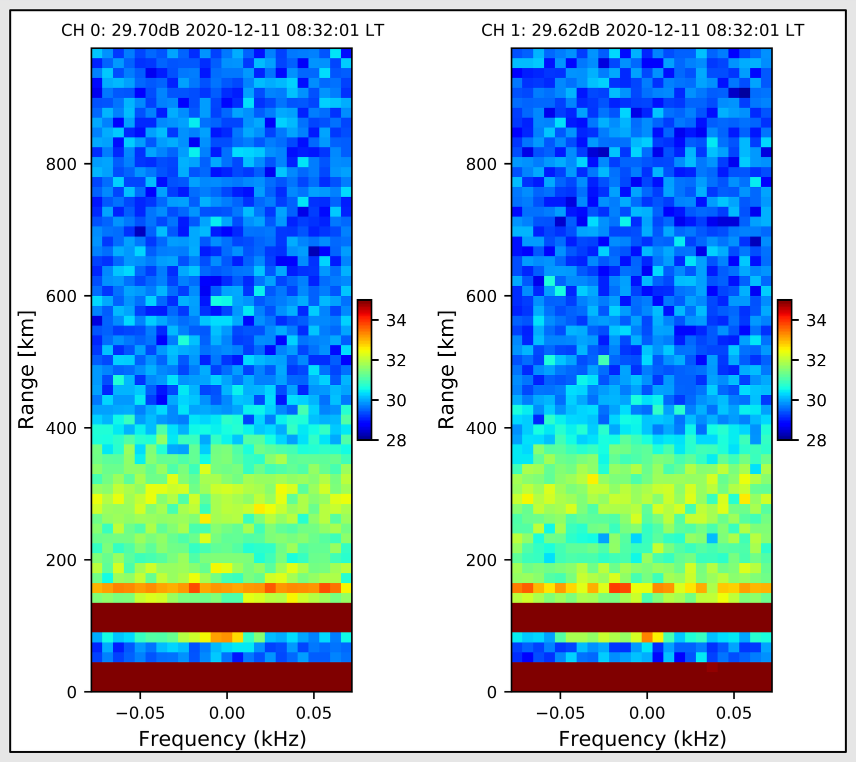

Figure 5. DC clutter removed from cleaned self spectra.

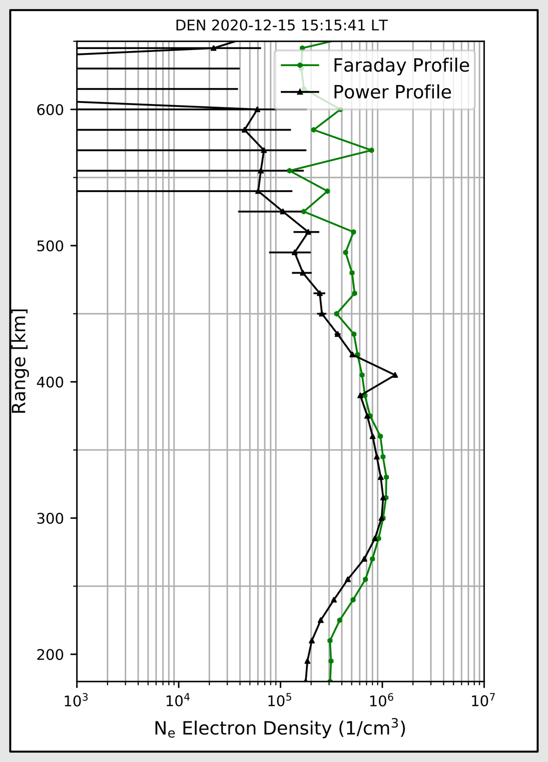

Figure 6. Electron density profile using voltage analysis. It can be seen that there is an outlier at ≈ 400 km.

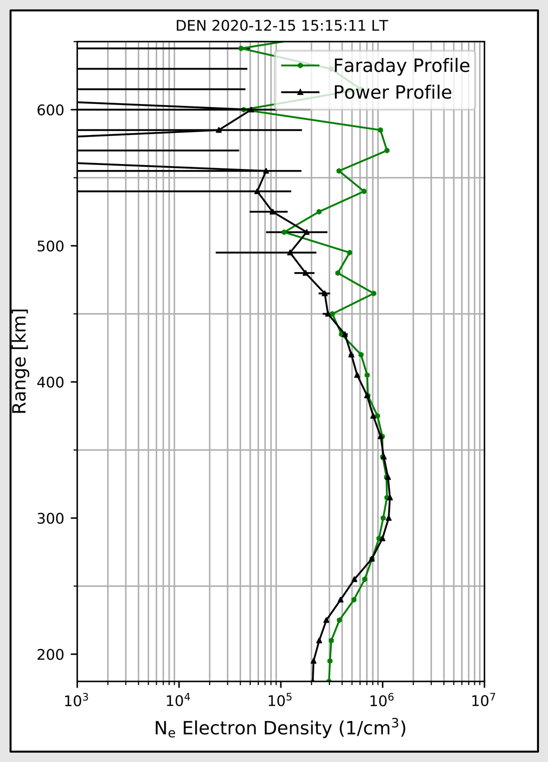

Figure 7. Electron density profile using spectra analysis.

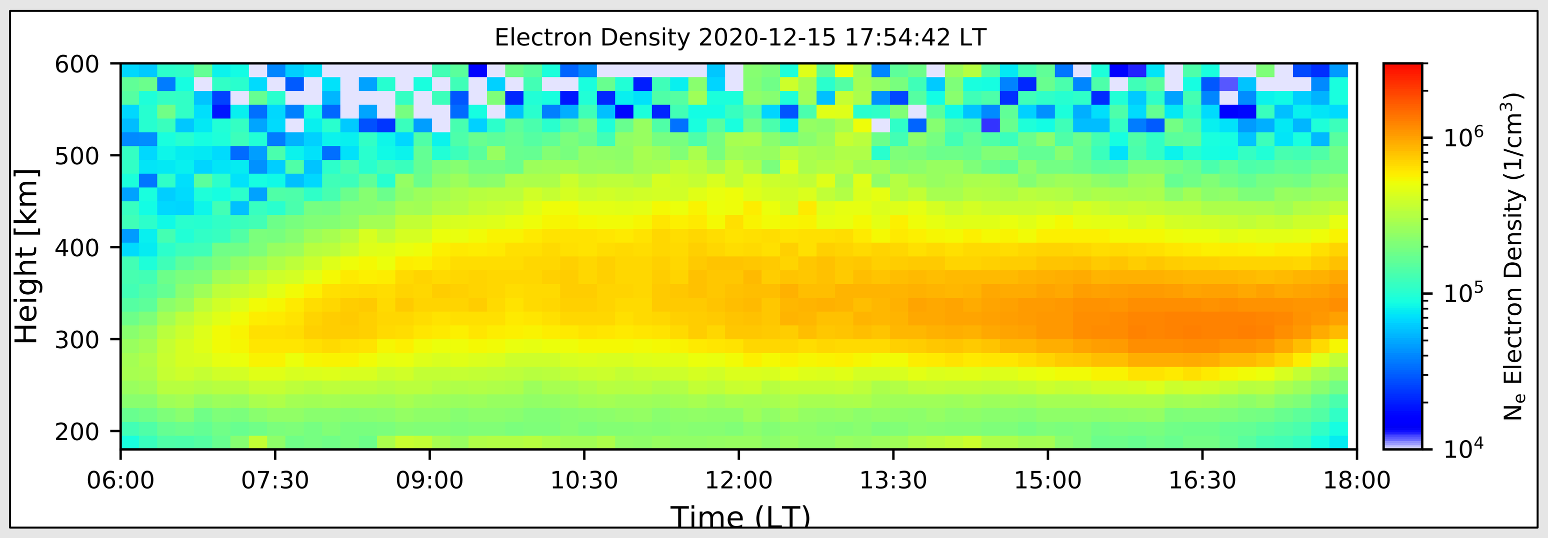

Figure 8. Electron density RTI using spectra analysis.

4. Conclusions

- Spectra analysis is useful to remove outliers and DC clutter.
- Hildebrand-Sekhon algorithm can be used to analyze outliers in samples taken from a small time range.

5. References

[1] J. E. Pingree, “Incoherent scatter measurements and inferred energy fluxes in the equatorial f-region ionosphere,” 1 1990.

[2] P. H. Hildebrand and R. Sekhon, “Objective determination of the noise level in doppler spectra,” Journal of Applied Meteorology, vol. 13, no. 7, pp. 808–811, 1974.

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