Preliminary AMISR-14 radar observations of F-region incoherent backscatter echoes at the Jicamarca Radio Observatory (JRO)

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Abstract

A 14-panel Advanced Modular Incoherent Scatter Radar (AMISR-14) was installed at the Jicamarca Radio Observatory (IGP- JRO) in 2014. Because of its size, this radar was mainly used to observe coherent echoes such as those produced by the Equatorial Electrojet (EEJ) and Equatorial Spread F (ESF). However, the radar operation was intermittent until 2019 when repairs started to make the radar fully operational. Now, AMISR-14 runs regularly in parallel with the main Jicamarca radar in the JULIA (Jicamarca Unattended Long-term studies of the Ionosphere and Atmosphere) mode to monitor the Equatorial Spread F activity. More recently, we found that running these experiments with a more stable peak power, we have been able to detect not only coherently scatter (CS) signals but also what seems to be incoherently scattered (IS) echoes from the F-region ionosphere. In this poster, we will present some examples of the experiments we have been conducting with AMISR-14. More specifically, we will present and discuss examples of these interesting ISR-like echoes observed with AMISR-14 pointing in different directions along the E-W plane.

1. Observations of ESF over JRO with AMISR -14.

The AMISR-14 was installed at JRO in 2014 with 448 transmitting units (each with a capability of 500 watts of transmission) and automatic programmable pointing directions. Due to its transmission power, and the location of the JRO, the main assigned function was to observe the activity of CS echoes such as those associated with EEJ and ESF [1].

The radar operation was intermittent until 2020, when upgrades and repairs started to make the radar fully operational and work continuously and simultaneously with the JULIA mode or at specific events [2].

During day time (07:00 LT to 18:00 LT), the radar is configured with 5-beam pointing directions, and a 375 km IPP to focus mainly on EEJ, and during nighttime (18:00 to 07:00 LT), using 10-beam pointing directions along the E-W plane and a 937.5 km IPP to observe the development of the ESF. Recently, a weak signal became noticeable in the Range Time Intensity (RTI) plots.

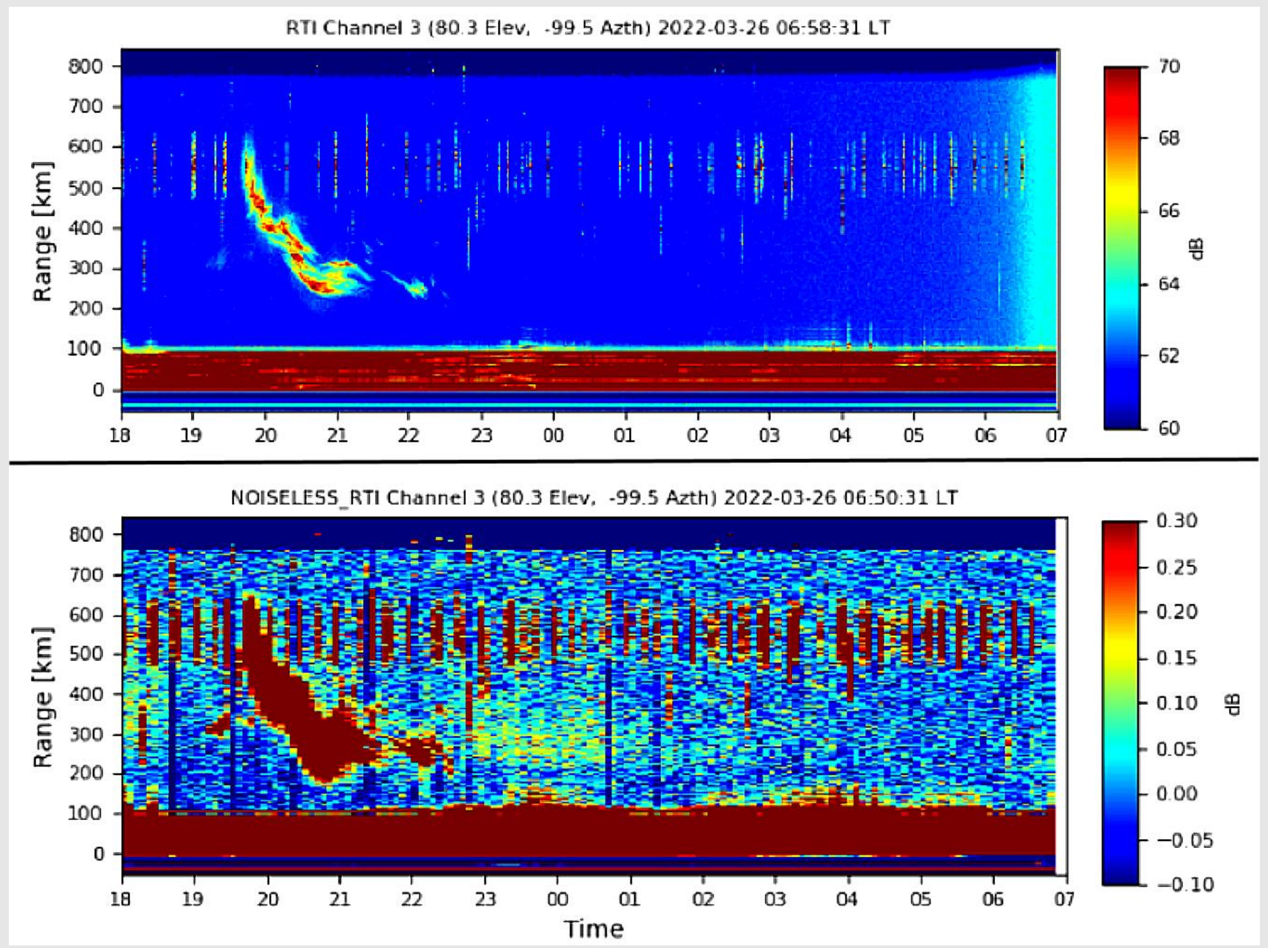

Figure 1. RTI plot of monitoring ESF with AMISR-14 (top). RTI removing noise level, increasing integration time, and decreasing dB range (bottom).

*Local Time (LT) : UTC - 05

2. Monitor F Region with AMISR-14 at daytime

After the first observations, we conducted the same experiment during all day to observe the echo at different hours of the day (Figure 2). And the spectra was calculated using samples of heights as profiles, so we can get a wider frequency range (Figure 3b).

Using this spectra to plot a new RTI for the experiment brings up the interference from satellites increase in range. Despite of the noise variations, the RTI shows promising results, the spectra seems to be a gaussian shape all the time (Figure 3c). After this first results and because of the gaussian shape, we decided to perform an experiment with a different configuration (long pulse scheme).

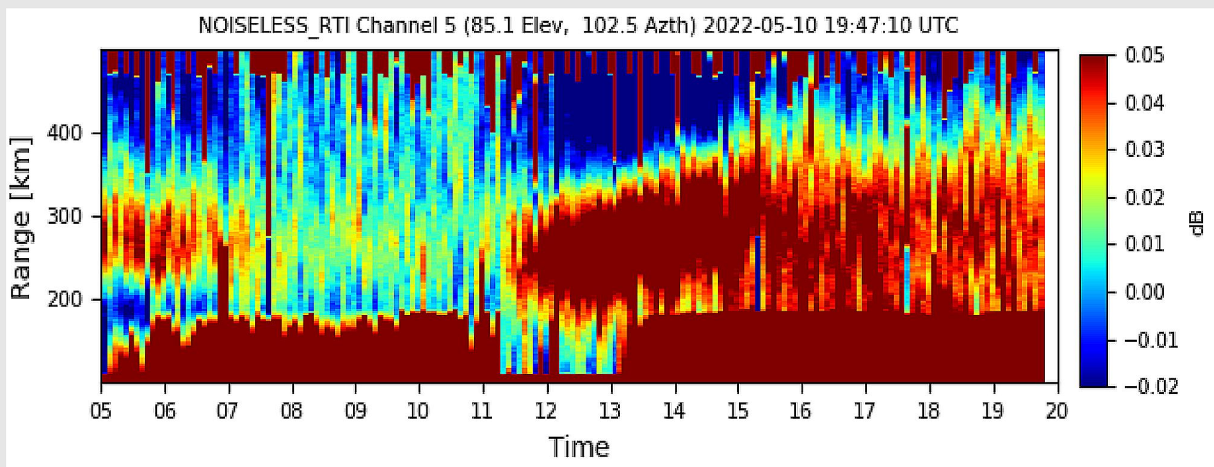

Figure 2. Daytime RTI of the 4th channel, May 10th, noise removed.

3. Simulation and new configuration.

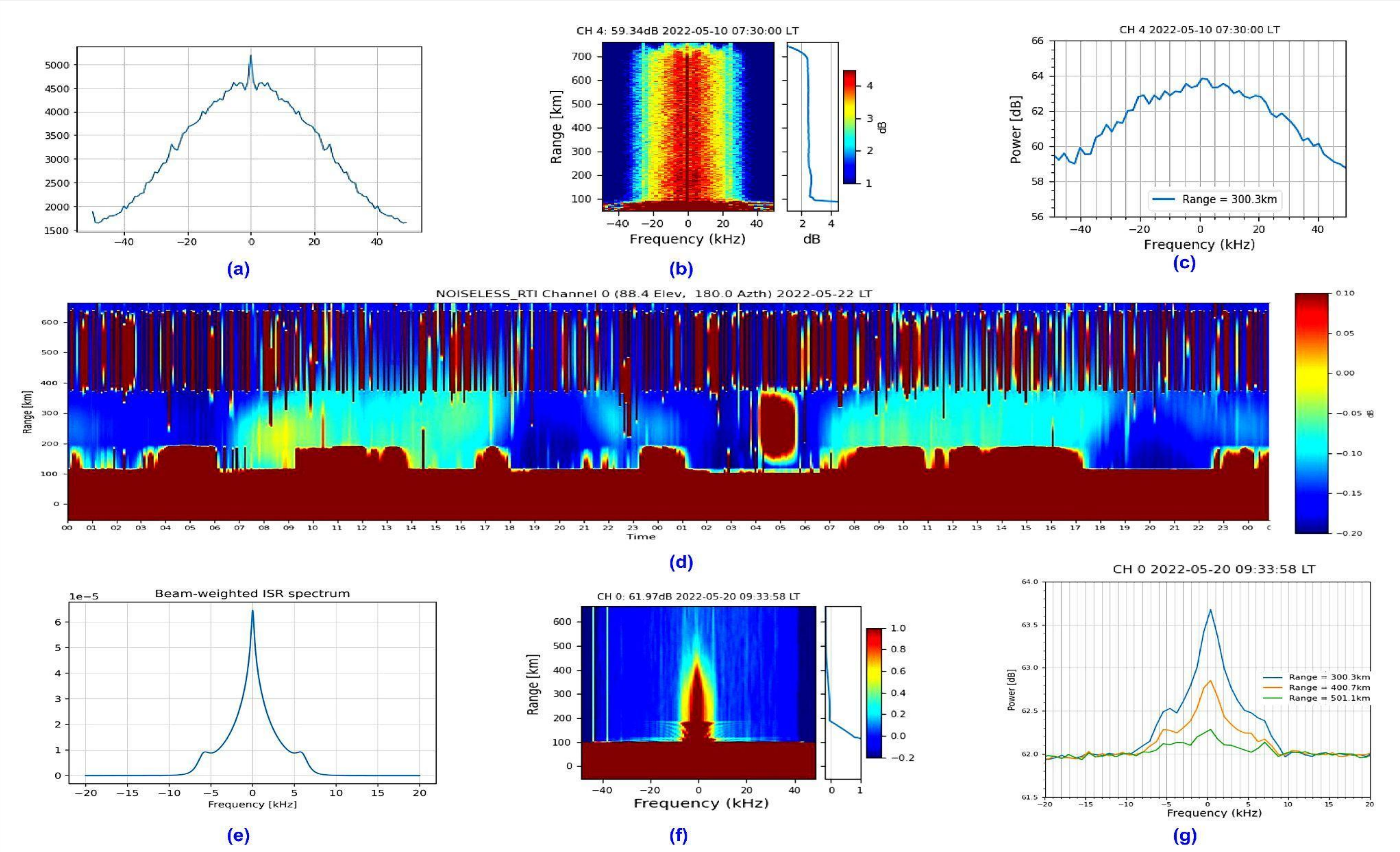

Figure 3. Ambiguity function of code Binary 28 (a). Spectrum plot of ESF_EW experiment(b). Spectrum cut at 300 km for ESF_EW experiment(c). RTI with noise removed of the ESF_ISR experiment over 2 days of continuous working and presence of ESF (d). Incoherent scatter spectral model resultant from weighting the theoretical collisional ISR spectra with a radar beam(e). Spectra plot of the ESF_ISR experiment (f). Spectrum cut at 300, 400, and 500 km taken with the ESF_ISR experiment (g).

The main reason for setting a long pulse experiment was due the ambiguity function of the code used in the ESF_EW experiment, which prevents us to get a spectrum only related to the echoes in observation.

The radar parameters for the regular and the new radar experiments are presented in the Table 1. The ESF_ISR experiment has been running for several days with a perpendicular direction pointing to the EW plane. Simulations for the ESF_ISR experiment have been also been carried out. The simulations have considered a Gaussian beam shape with a beam width of 0.5 degrees and ambiguity function effects were not taken into account yet. Typical ionospheric plasma parameters for and O+ plasma were considered in the calculations: Ne= 10^{12} m^{-3}, B = 22,000 nT, Te = Ti = 1000 K. The effect of Coulomb collisions was considered assuming a Brownian model for ionospheric particle trajectories.

Table 1. Radar parameter used with AMISR-14 for the ESF mode experiment (ESF_EW) and for the new long pulse experiment (ESF_ISR).

Experiment / Parameter	ESF_EW	ESF_ISR
Ipp	937.5 km	937.5 km
Tx	84 km	90 km
Δh	1.5 km	1.5 km
Freq	445 Mhz	445 Mhz
Code	Binary 28	None
Beam directions	10	1

5. Conclusions and future work

- AMISR-14 seems to be able to observe echoes that do not conform with typical coherent scatter.
- Simulation of incoherent scatter for UHF have been made (see, for instance, Figure 4) for different aspect angles.
- The observed echoes resemble those expected from incoherent scatter (see Figures 3e and 3g).
- Removal of clutter caused by satellite and adequate analyses of the signals might allow estimation of plasma parameters.

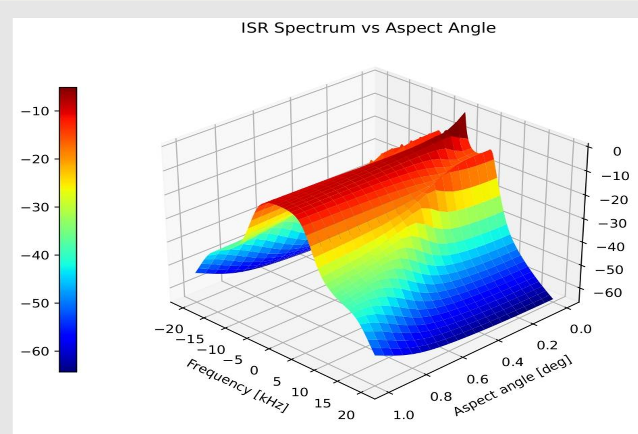

Figure 4. Incoherent scatter spectral model resultant from weighting the theoretical collisional ISR spectra with a radar beam.

6. References

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[2] Rodrigues, F. S. & Hickey, D. Weijia, Z., Martinis, C. Fejer, B., Milla, M. and Arratia, J. (2018). Multi-instrumented observations of the equatorial F-region during June solstice: large-scale wave structures and spread-F. Progress in Earth and Planetary Science. 5. 14. https://doi.org/10.1186/s40645-018-0170-0

7. Acknowledgements

AMISR-14 repair and new observations were support by NSF Award AGS-1916055 to UT Dallas. We also would like to thank the technical assistance of SRI International.

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