Rethinking Ground Clutter Filtering: Regression Filtering to Improve Radar Signal Statistics

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The mitigation of ground clutter echoes from weather radar data is a common problem. Many radar groups use a ground clutter filtering technique that operates on the Doppler spectrum of the radar echo. Since stationary ground clutter echo has primarily a zero-velocity component relative to a ground-based radar, the ground clutter echo is manifest as a power spike centered around the zero velocity component of the Doppler power spectrum. The ground clutter echo is greatly attenuated by eliminating the part of the Doppler spectrum around zero velocity by setting those values to zero and subsequently calculating the desired radar variables from the remaining part of the Doppler spectrum. In order to eliminate as much ground clutter as possible, the time series signal of the clutter echo (with possible weather echo overlaid) is usually weighted by a window function such as a von Hann window or a Blackman window. These window functions tapper the endpoints of the time series to zero or near zero. This causes the ground clutter signal to cluster around zero velocity and this is simply a property of the finite discrete time Fourier Transform.

A disadvantage of applying a window function to the time series is that it attenuates the signal and eliminates some of the information about the weather signal that may be present along with the ground clutter signal. This translates to higher measurement standard deviations for the weather signal. This disadvantage has been accepted as a necessary feature when using this frequency domain (Doppler spectrum) ground clutter filter, which is very common in practice.

Another known technique for removing ground clutter signal is a regression filter. Torres and Zrnic, (1999), have investigated ground clutter cancelation using regression type filter. This technique uses the fact that the ground clutter signal varies very slowly in time whereas weather signals generally vary substantially more. Thus, to remove the slowly varying part of the signal, a regression curve (i.e., a polynomial) is fitted to the signal and then subtracted, thus leaving the weather signal intact. This has been investigated and has not been implemented because of perceived inferior clutter rejection as compare to the windowing followed by Doppler spectrum notch technique. Thus, the regression technique has not been pursued by the weather radar community. The advantage of the regression filter is that no time domain window is required and thus better weather signal statistics are possible *if* the ground clutter signal can be adequately eliminated.

The paper shows how a regression filter can reject clutter as well if not better than a Doppler spectrum based filter while retaining more of the weather signal. Thus, the reduction of measurement error of the radar variables is greatly increased. Experimental data from NEXRAD and NCAR’s S-pol radar is used to illustrate the theory.

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