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Improving Polarimetric Radar Parameter Estimates and Target Identification : A Comparison of Different Approaches

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MOTIVATION

-- To find optimal ways of combining different approaches to achieve good clutter mitigation and improved estimates of polarimetric parameters, especially at low SNR values, for the McGill radar data.

-- Towards this end, the relative performances of three approaches, namely, the McGill Spectral filter, the CLEAN_AP filter and the Multilag Correlation Estimators are evaluated

CLUTTER MITIGATION : MCGILL SPECTRAL FILTER

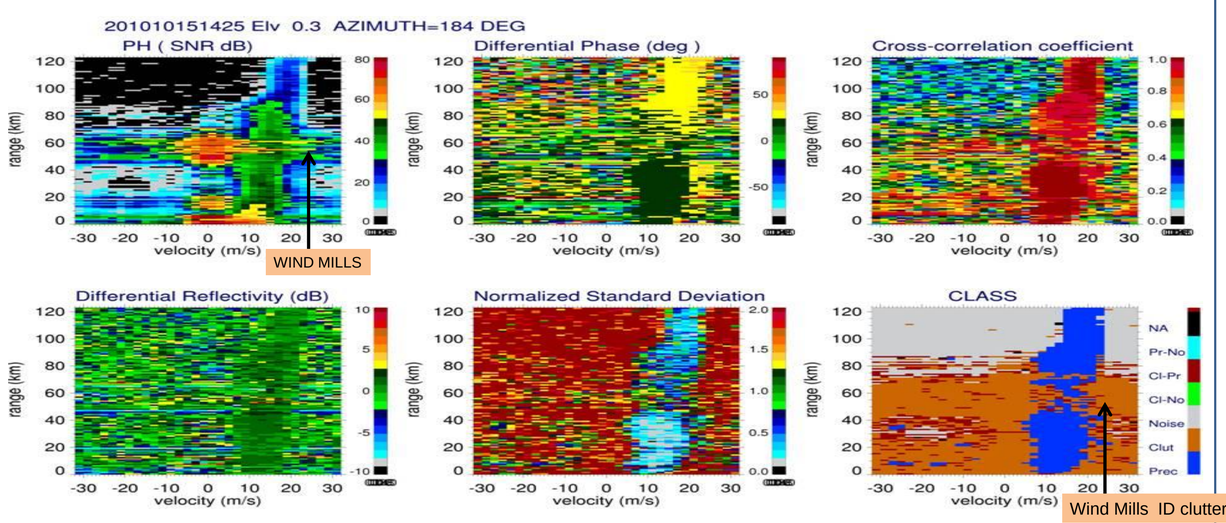
-- The variance of Z_{DR} and φ_{DP} in clutter is higher than in precipitation.

-- This feature is used in McGill Spectral filter to differentiate between clutter contaminated spectral components and precipitation spectral components.

-- The Normalized Standard Deviation (NSD) of the complex ratio of the Horizontal H(k) and Vertical V(k) Fourier terms is used as a measure of the variance.

-- A fuzzy logic scheme based on NSD (with heavier weight) , SNR and Z_{DR} is used for the classification of the spectral components as illustrated in the image below.

-- The frequency side lobes due to the large phase noise in our system of strong clutter within 20 km and between 50-60 km from the Adirondack mountains are seen in the power spectrum and NSD and are correctly classified as clutter.

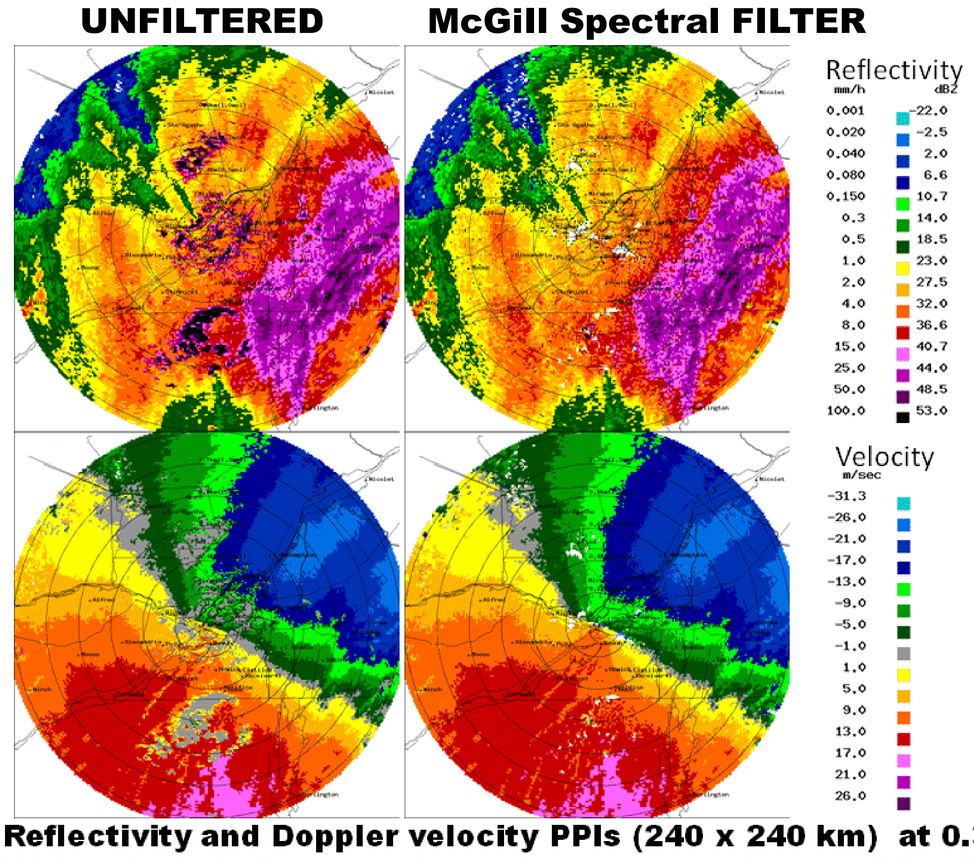


Spectral decomposition vs. range of various parameters. The Power spectrum is computed over 32 pulses in 1 deg (1200 PRF) for 1 ray at azimuth 184⁰ and elevation 0.3⁰

-- If sufficient number of precipitation spectral components are available, values from a Gaussian shaped fit over the precipitation components replace the clutter components.

-- Otherwise dynamically determined noise values are used to replace the clutter components.

-- Reflectivity and Doppler Velocity are computed from all components and polarimetric parameters are computed using the spectral components identified as precipitation. Unfiltered and filtered images of reflectivity and Doppler velocity are given below.



Reflectivity and Doppler velocity PPIs (240 x 240 km) at 0.3⁰ elevation. White pixels indicate regions where proper clutter mitigation is not possible.

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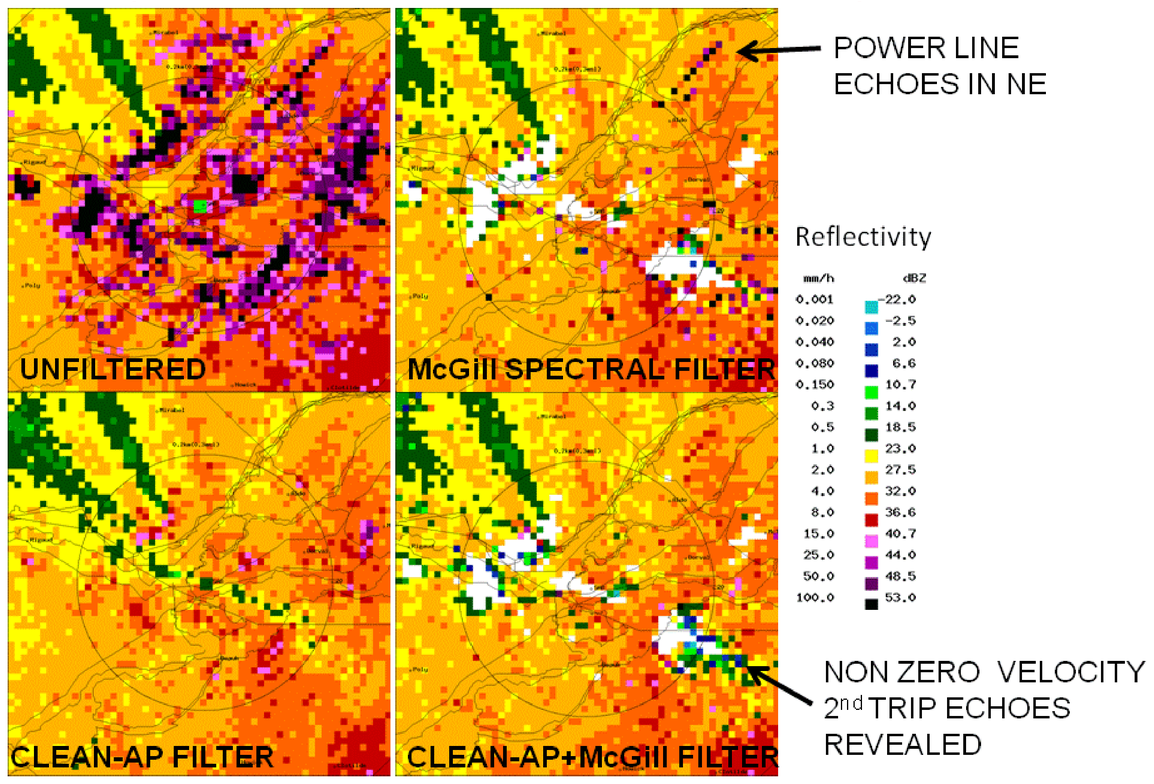
CLUTTER MITIGATION: MCGILL + CLEAN-AP FILTERS

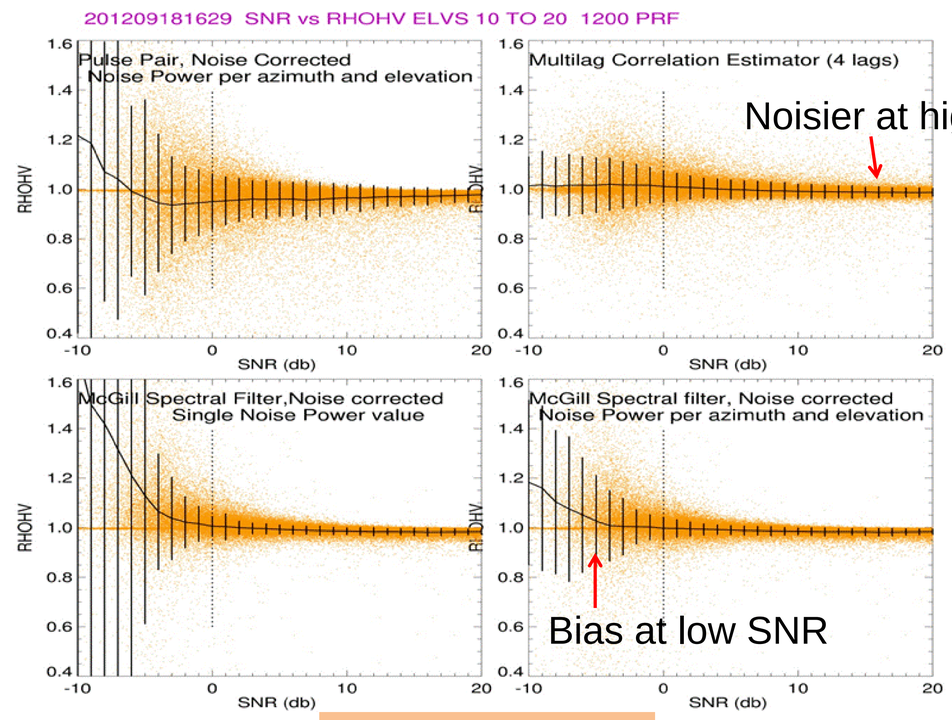
Sometimes clutter has low variance of Z_{DR} and φ_{DP} and is missed in the McGill filter as with the point targets of the power lines in the NE in the image below. The CLEAN-AP FILTER uses a different feature of ground clutter, Its narrow spectrum width compared to the wider spectrum widths of precipitation, to identify the clutter spectral components around the zero Doppler velocity. The high phase noise in our system limits the amount clutter it removes. However it is very effective in removing the point targets . Hence CLEAN-AP filter's identification of clutter spectral components is integrated into the McGill spectral filter classification selectively. It helps as seen below



Reflectivity PPIs (60 x 60 km) at 0.3⁰

BETTER ESTIMATION OF POLARIMETRIC PARAMETERS AT LOW SNR VALUES: NOISE CORRECTED MCGILL SPECTRAL FILTER AND MULTILAG ESTIMATION

The McGill Spectral filter computes the polarimetric parameters using the precipitation spectral components only and Horizontal and Vertical powers corrected with dynamically determined noise power as a function of azimuth and elevation. The scatter plots of ρ_{HV} Vs SNR below show the relative performance of the spectral filters & the multilag correlation estimators. These plots are based on the 10 high elevation scans of the McGill Radar(1200 PRF, 32 pulses/deg) for a stratiform event. Noise corrected Spectral filter estimations of ρ_{HV} are better up to~ 0 dB SNR and Multilag estimation is superior below ~0 dB SNR.



CONCLUSIONS

The McGill Spectral and CLEAN-AP filters use different characteristics of clutter in the identification of clutter spectral components. Hence their combination is complementary and has the potential for yielding a better clutter mitigation. The optimal procedure to combine these two techniques needs further investigation.

The McGill Spectral filter with dynamically determined noise correction gives good estimates of ρ_{HV} up to 0 dB SNR. The multilag estimators are superior below 0 dB SNR . Noise correction is possible only if total power is greater than the noise power. Multilag estimation does not have this limitation.