6.5 DOES GROUND CLUTTER LOOK DIFFERENT TO A PHASED ARRAY?

Christopher Curtis

Cooperative Institute for Mesoscale Meteorological Studies, The University of Oklahoma, and
NOAA/OAR National Severe Storms Laboratory, Norman, Oklahoma

1. INTRODUCTION

Because of the increasing use of phased array antennas for weather observations, it is a good time to revisit the characterization of ground clutter signals for these possibly stationary antennas. Rotating antennas increase the spectrum width of clutter signals because of the changing clutter field illuminated by the antenna beam. Stationary phased array antennas look at the same clutter field over the whole dwell when using electronic scanning. This leads to narrower spectrum widths, but it also leads to different spectral shapes for the clutter signals. To better characterize ground clutter signatures for stationary antennas, a ground clutter model is explored that allows researchers to look for novel ways to mitigate ground clutter on phased arrays. This two-part model improves on earlier clutter models and better captures the true decorrelation time of the clutter. Time series data from the National Weather Radar Testbed phased array antenna are used to characterize ground clutter signals for different wind conditions, foliage levels, and terrain types.

2. DATA COLLECTION

Ground clutter data were collected using the National Weather Radar Testbed (NWRT) Phased Array Radar (PAR). At each beam position, 4096 pulses were collected in order to better characterize the clutter spectrum. The beam positions were spaced 1° apart, and data from the 10° sector near broadside were examined. Collections occurred for differing wind and foliage conditions and for three terrain types. The wind conditions were light, breezy, and windy with one case collected during gale winds. The foliage conditions included both full and light foliage corresponding to whether the leaves were on the trees or not. The terrain types were classified as urban, prairie and wooded. Fig. 1 shows a satellite view of the three terrain sectors.

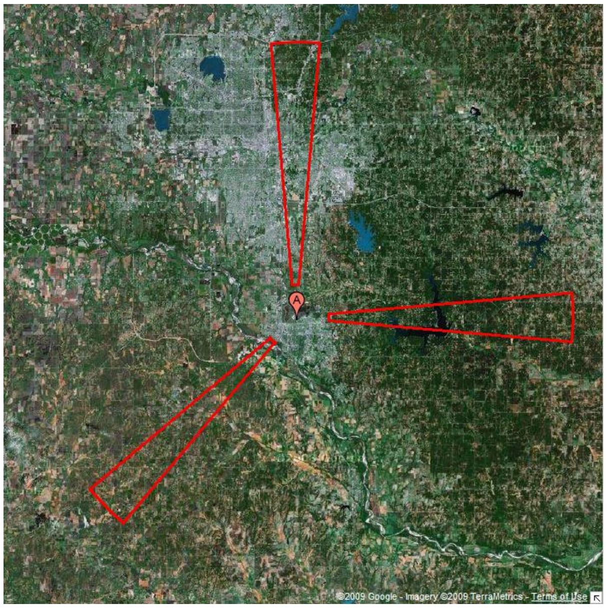

Fig. 1. Satellite image illustrating the three terrain type sectors. The urban terrain is to the north, prairie to the southwest, and wooded to the east.

3. TWO-PART CLUTTER MODEL

A two-part clutter model that was introduced by Billingsley (2002) was utilized to characterize the ground clutter spectra. This model splits the spectrum into two parts a DC and “AC” component. The DC component corresponds to hard targets such as buildings and tree trunks. The “AC” component corresponds to the fluctuating part of the clutter including branches and leaves that are more affected by the wind. This type of model better characterizes the spectrum compared to a traditional Gaussian model for ground clutter.

Fig. 2 is an example of a spectrum that illustrates the two-part nature of ground clutter spectra when collecting using a stationary antenna. This is a spectrum collected from urban terrain and full foliage under windy conditions. The DC part of the clutter sticks up above the “AC” portion at zero velocity. The “AC” portion is characterized using a linear fit to capture both the spread of that part of the spectrum and the fact

---

Corresponding author address: Christopher Curtis,
120 David L. Boren Blvd, NWC Room 4417,
Norman, OK, 73072; e-mail: Chris.Curtis@noaa.gov

that it decreases quickly as the magnitude of the velocity increases.

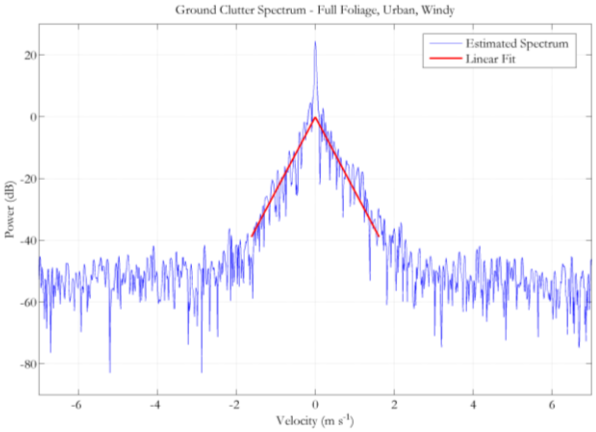

Fig. 2. Ground clutter spectrum collected from urban terrain with full foliage under windy conditions.

To see the effects of wind and foliage on the shape of the ground clutter, a slightly modified version of the two-part model that allowed for a quadratic fit was utilized. A representative clutter shape was chosen for each set of foliage and wind conditions. Fig. 3 shows the results of this exercise.

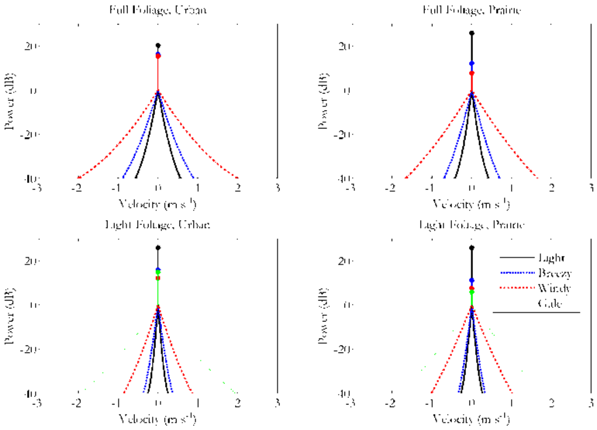

Fig. 3. Representative ground clutter spectra for different foliage and wind conditions.

As expected, the width of the spectrum increases with increasing wind speed, and the light foliage spectra are narrower than the full foliage cases for the same wind speed. The gale winds for the light foliage case led to widths that were similar to windy conditions for full foliage. As the wind speed increases, more of the power from the DC part of the spectrum seems to migrate to the "AC" part of the spectrum. Both Fig. 2 and Fig. 3 also appeared in my dissertation (2009).

4. EFFECTS OF ROTATION

As mentioned in the introduction, a rotating antenna causes the clutter spectrum to become wider compared to a stationary antenna. One way to see this using only a phased array is to collect clutter with the antenna stationary and then simulate rotation by electronically steering the phased array. An example of this type of simulated rotation is shown in Fig.4 (Curtis 2009).

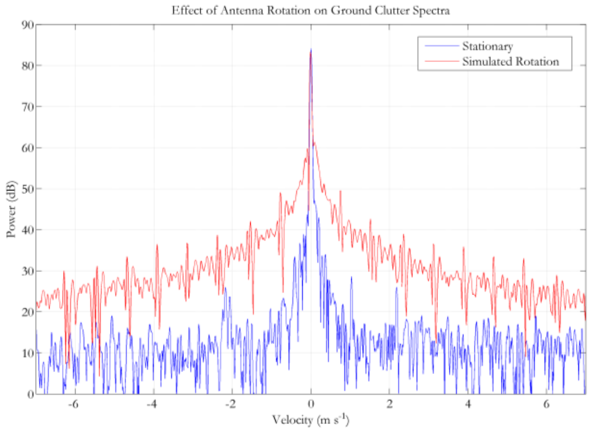

Fig. 4. Ground clutter spectra collected with a stationary antenna (blue) and using simulated rotation with a phased array (red).

The spectrum from the simulated rotation is depicted in red and is clearly wider than the spectrum from the stationary antenna depicted in blue.

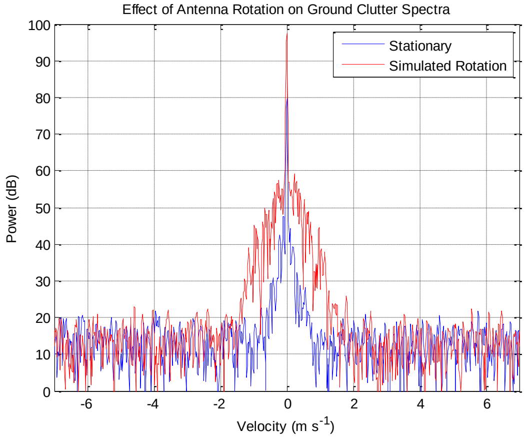

Fig. 5. Ground clutter spectra simulated for a stationary antenna (blue) and using simulated rotation with antenna pattern weights (red).

The two-part clutter model for stationary antennas can also be used to simulate ground clutter spectra for rotating antennas. If time series data is simulated for appropriately placed scattering centers, antenna pattern weights can combine properly shifted samples to produce time series data for a rotating antenna. Fig. 5 shows the results of this type of simulation. Although the time series for each scattering center is independent, the simulation is not realistic because the model for each scattering center is the same. Real ground clutter would have different parameters for the overall power, width, and spectral shape. Even though it is not completely realistic, the simulation can still give some insight into what the effects of rotation are in isolation.

5. CONCLUSIONS

Better models for ground clutter can aid in both detection and filtering. More accurate simulations can make it easier to try out new techniques without having to use real clutter data. By characterizing the shape of clutter for different conditions and terrain types, we can better understand how to tailor clutter filters to varying situations.

We can also use the model to study the effects of rotation on clutter spectra. We can compare the performance of clutter filters for both stationary and rotating cases to isolate the effects of rotation. By using a more accurate, non-Gaussian clutter model, we can better study all aspects of ground clutter for weather radar.

6. REFERENCES

Billingsley, J. B., 2002: *Low Angle Radar Land Clutter: Measurement and Empirical Models*, William Andrew Publishing, 703 pp.

Curtis, C. D., 2009: Exploring the Capabilities of the Agile Beam Phased Array Weather Radar. Ph.D. dissertation, Dept. of Engineering, The University of Oklahoma, 187 pp.

ACKNOWLEDGEMENTS

This extended abstract was prepared by Christopher Curtis with funding provided by NOAA/Office of Oceanic and Atmospheric Research under NOAA-University of Oklahoma Cooperative Agreement #NA11OAR4320072, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.