Atmos. Meas. Tech. Discuss., 8, C864–C866, 2015
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Atmospheric Measurement Techniques
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Discussions

Interactive comment on "Estimating reflectivity values from wind turbines for analyzing the potential impact on weather radar services" *by* I. Angulo et al.

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Received and published: 28 April 2015

I read your paper with great interest. Recently, a paper was published investigating the impact of wind turbines by comparing radar observations before and after construction of five wind turbines: Norin, L.: A quantitative analysis of the impact of wind turbines on operational Doppler weather radar data, Atmos. Meas. Tech., 8, 593-609, doi:10.5194/amt-8-593-2015, 2015. Following your equation 13, I estimated a radar reflectivity factor Z of ~81 dBz for the blades of your wind turbine model 2 in 13 km distance. I neglected the mast assuming that it will be removed by the radar clutter filter. Norin (2015), however, did not find any disturbance caused by similar wind turbines

which was greater than ~15 dBz. How do you explain this large difference? For sure, non-metallic components and the effect of the surface on beam propagation will reduce Z, but can these two effects explain the difference of more than 60 dB? Regards, Maximilian Maahn

The authors would like to thank Dr. Maximiliam Maahn for his comment.

The difference between the reflectivity values provided by the model and the reflectivity values shown in (Norin, 2015) may be due to multiple factors: The main reason might be that the model provides an upper bound on the signal scattered by the blades, i.e., a worst-case estimation that is aimed at preventing a potential impact on the radar performance. However, as shown in Fig. 2 to Fig. 6, scattering from wind turbines is extremely dependent on the relative location between radar and wind turbines, rotor orientation, and blades position. Depending on these factors, and according to the figures, the observed RCS might be as low as -15 dBsm, leading to a reflectivity value Z of about 27 dBz for the mentioned case. The upper bound value provided by the model might be detected sporadically, periodically or even never, depending on the combination of these factors. Then, as commented by Dr. Maahn, the model is based on some conservative assumptions, with the aim of providing a worst-case estimation: Wind turbine blades are not metallic but made of composite materials, which greatly reduces signal scattering. The effects of terrain are not included in the analysis. In the context of signal scattering, near field effects occur when the target is not illuminated by a plane wave, and thus, the phase of the incident wave at the center of the target is different from the phase at its extremes. A widely accepted requirement is to limit the phase deviation to be less than 22.5âĹŸ, obtaining the condition of far field distance for signal scattering ðİŚĚ0 as a function of the lateral dimension of the object ðİŘů, according to R_0=(2Dˆ2)/λ[5]. Taking into account the wind turbine dimensions (rotor diameter of 90 m), the scattering signals clearly correspond to near field condition for a 13 km distance. Near field effects in the context of signal scattering and for monostatic reception will result in a RCS reduction (see Knott et al. (1985), Sknolnik (2008) and

Welsh and Link (1988)). Moreover, in the case described in (Norin, 2015), the main radar lobe for the lowest tilt angle is not directly pointing to the wind turbine rotors (see Fig. 1 in (Norin, 2015)), so that, in equation (13), the maximum radar gain should not be applied. However, this difference will be lower than 3 dB, as the rotor of the wind turbine is illuminated by the half-power beam width of the main radar lobe for the lowest tilt angle.

References E. F. Knott, J. F. Shaeffer, andM.T.Tuley, Radar Cross Section: Its Prediction, Measurement and Reduction, Artech House, Norwood, Mass, USA, 1985. M. I. Skolnik, Radar Handbook. McGraw-Hill, 2008. B. Welsh and J. Link, “Accuracy criteria for radar cross section measurements of targets consisting of multiple independent scatterers,” IEEE Trans. Antennas Propag., vol. 36, no. 11, pp. 1587–1593, 1988.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/8/C864/2015/amtd-8-C864-2015-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 1477, 2015.