The Impact of a Wet Radome on Polarimetric Quality of Phased Array Weather Radars: Analysis and Calibration

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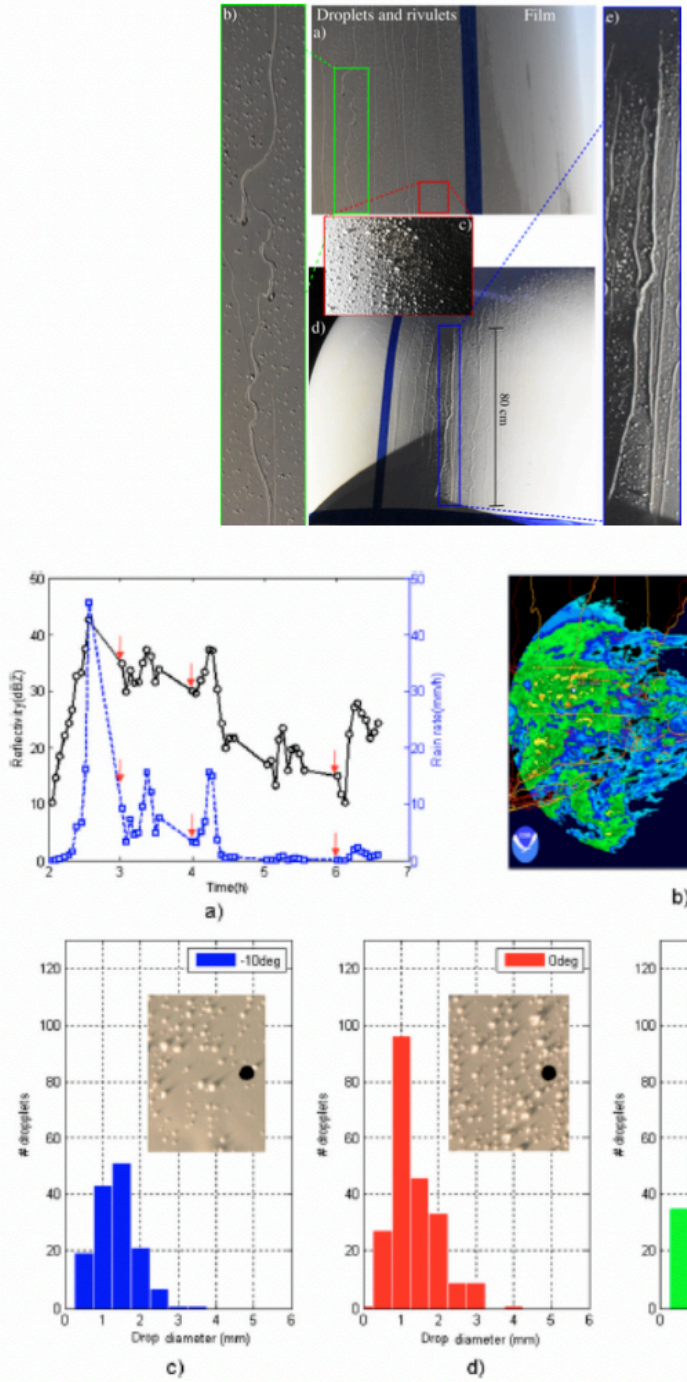
Radome is a essential component of a radar system that provides structural strength to protect the radar antenna from wind loading and provides stability and integrity for mitigating environmental conditions such as temperature, humidity, and pressure. In addition, a radome facilitates operation and maintenance of the system, increasing its life span. An adverse effect of the radome is the performance degradation of the radar signals when water or ice is present on the outer surface. A radome is designed to minimize the attenuation of the radar signal under dry conditions. This design choice also assures that the attenuation is minimized when a water layer is present on its surface. It is not possible to design a radome for a given rain rate, since the rain intensity constantly changes, and also because various water formations occur on the radome and generate different attenuations. Depending on the frequency of operation, rain intensity, wind conditions, and its shape and materials, a radome can significantly attenuate, reflect, and depolarize the radar signal. For frequencies below 2.0 GHz, the impact of a wet radome is relatively small and cannot be considered critical for radar operations. However, for higher frequencies, water formation on the radome surface can significantly deteriorate the radar signal, especially for polarimetric weather radars.

In dual-polarized weather radars, target accuracy is required for polarimetric products such as the differential reflectivity (ZDR) and linear depolarization ratio (LDR). A mismatch between the horizontal and vertical polarized radiation patterns, as well as a rise of the cross-polarization component, introduces a bias in the measurements of ZDR and LDR. A cause of the mismatch and rise of the cross-polarization is the presence of water on the radome. Despite the numerous publications available for wet radome characterization at frequencies higher than the C-band, the literature about the S-band is limited. Some quantitative analysis reported before, shows measured attenuation up to 3 dB when water distributes as a film at 50 mm h−1 rain rate, and 5.6 dB attenuation was found for 200 mmh-1 rain rate.

In this paper, a new research method to quantify the impact of a wet flat radome on the antenna radiation pattern operating from S-, C- and X-bands is presented. The study aims to investigate the impact of different water formations located of a radar radome surface in the quality of a polarimetric phased array radar. The analysis is extended for different radome shapes including spherical, cylindrical radome shapes. A real time calibration technique to mitigate mismatch between H- and V-polarized signals produced for the wet radome is proposed. Figures below illustrates different water formation (droplets, rivulets, film water in a bullet shape radome), and measured drop size distribution on a flat tilted radome in a field experiment.

Keywords: Phased array radar, dual polarization , wet radome, polarimetric, radome attenuation



In the top, a picture of different water formation in a bullet shape radome. In the bottom, a drop size distribution on a flat radome surface based on rainfall rate (a) Reflectivity and rain rate obtained from rain experiment 4 (23 Sep2011). (b) Reflectivity data from NEXRAD radar at Boston. (c) Pictures and DSD's of water droplets accumulated on a Gore-Tex radome materials a different tilted angle (-10, 0 and +10 degrees).