The impact of wet radome on the quality of polarimetric measurements

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1. Introduction

It is well known that wet radome causes attenuation of microwave radiation. Such a transmission loss is higher if the radome is dirty and not waxed. Kurri and Huuskonen (2008) reported a 3-dB two-way transmission loss by dirty and nonwaxed radome at C band for the rain intensity of 15 mm/h. Waxing gives promising results in reducing the wet radome loss by about a factor of two (in a dB scale) because waxing prevents the formation of a continuous water layer on the surface of the radome.

The impact of water / snow accumulation on the radome surface on the quality of polarimetric measurements is not well studied yet. Frech (2009) investigated the effect of wet radome on the measurements of differential reflectivity Z_{DR} at C band in the Hohenpeissenberg Metetorological Observatory (HMO) in Germany and found that the associated bias in Z_{DR} is positive and it gradually increases with rain rate reaching a plateau at about 6 mm/h (Fig. 1). The bias can be as high as 0.8 dB. The HMO radar has 12-year-old orange-peeled radome that has never been maintained / cleaned. Frech (2009) suggested utilizing these data as a reference against which the radomes of the new DWD weather radar systems will be evaluated.

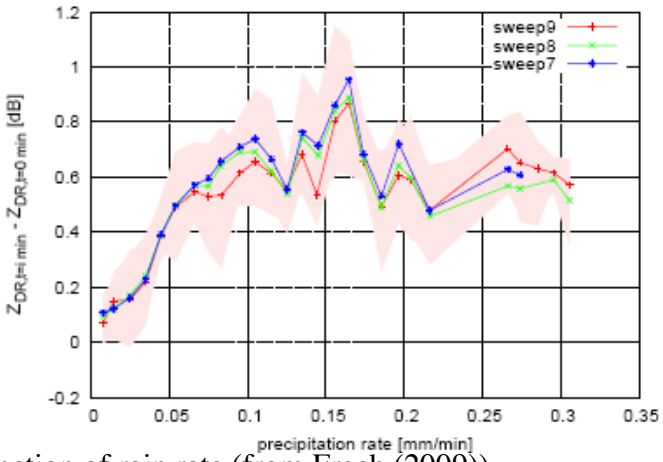

Fig. 1. Z_{DR} bias as a function of rain rate (from Frech (2009)).

Hudak et al. (2006) found large positive bias of Z_{DR} if melting snow accumulates on the radome. The observations have been made with Canadian C-band radar in the Toronto area. The Z_{DR} bias can exceed 3 – 4 dB and may exhibit strong azimuthal modulation which reflects the dependence of the thickness of snow layer on wind direction. Bechini et al. (2006) also claimed azimuthal modulation of radome transmission losses in rain. Regardless of the type of precipitation deposit on the radome surface (rain or snow), the related bias in Z_{DR} is generally positive because vertical streams (rivulets) of water caused by rain or melting snow reflect and absorb vertically polarized component of the microwave radiation stronger than its horizontally polarized counterpart.

The purpose of this study is to investigate the impact of the wet radome of the OU PRIME C-band radar on the quality of polarimetric measurements and to explore possible ways for its detection and mitigation.

2. Observations with OU PRIME

Three rain events have been examined: on 03/27/2009, 05/11/2009, and 06/02/2009. First, the PPI fields of Z_{DR} prior to the onset of precipitation over the radar site and just after rain starts have been visually inspected. The difference in the net values of Z_{DR} for dry and wet radome was obvious in al there cases. An example of such a comparison is presented in Fig. 2

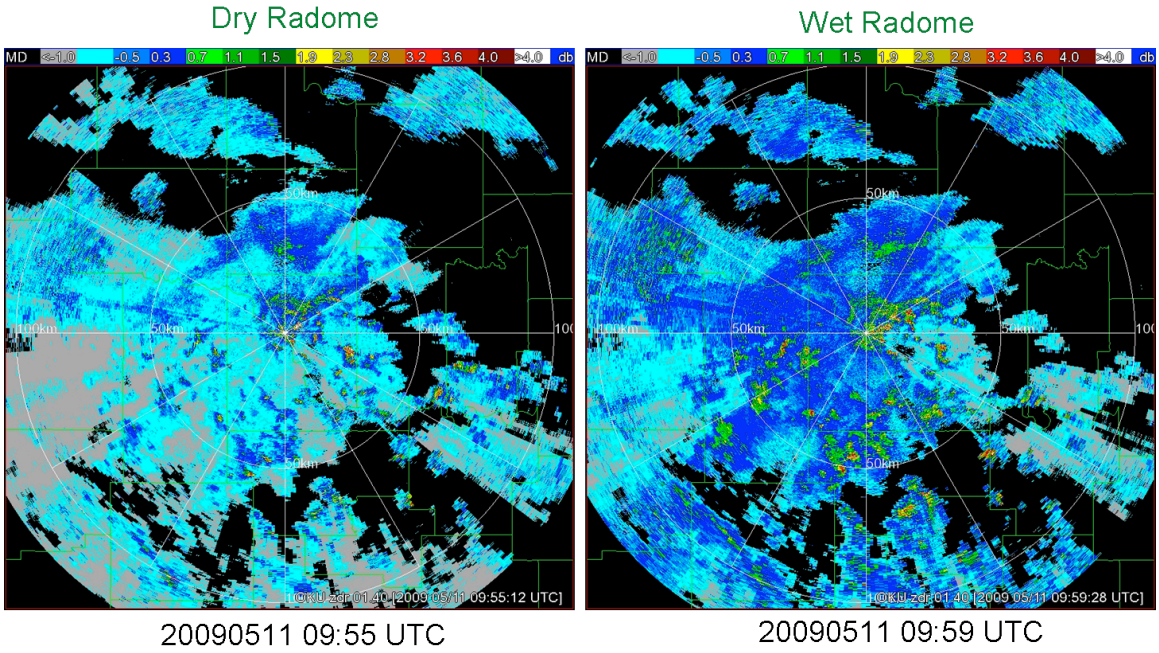

Fig. 2. Fields of Z_{DR} measured by OU PRIME before rain starts at the radar site (left panel) and after it starts.

Positive jump in Z_{DR} everywhere in the radar coverage area after the radome became wet is clearly seen. In order to quantify the change in the net Z_{DR}, the following methodology was utilized. For each sweep of the radar data, we estimate median value of Z_{DR} across the field in the pixels containing weather echo within the range interval between 30 and 80 km where $Z < 50$ dBZ, cross-correlation coefficient $\varrho_{hv} > 0.9$, and differential phase Φ_{DP} is less than 30° (to exclude the areas affected by strong differential attenuation). The median values of Z, Z_{DR}, and ϱ_{hv} are plotted as functions of time (Fig. 3). Shaded areas in Fig. 3 indicate time intervals when it was raining at the radar site. It is evident that Z_{DR} tends to increase rapidly when rain begins and to decrease at slower pace after rain ends. The sharpest increase in Z_{DR} occurred at about 10 UTC on 05/11/2009, i.e., between the radar scans illustrated in Fig. 2, and the change in Z_{DR} is about 0.8 dB.

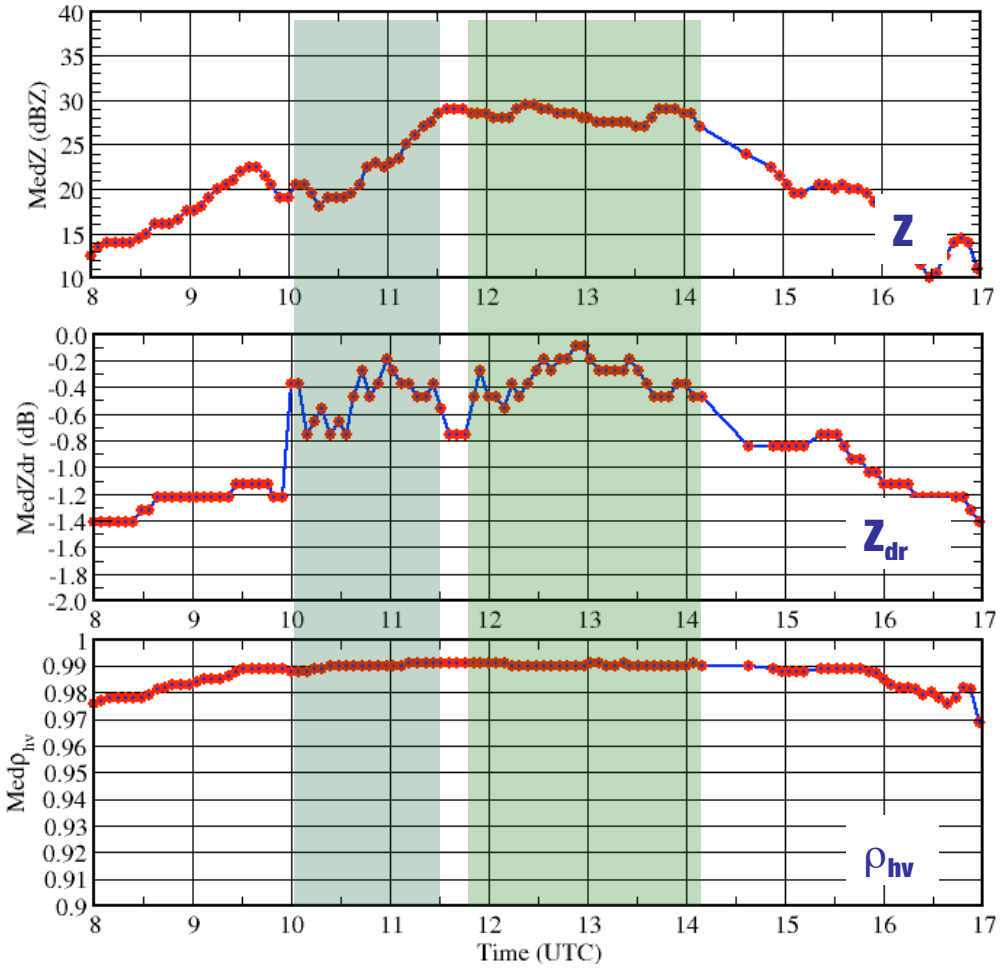

Fig. 3. Time evolution of the "net" Z, Z_{DR}, and ϱ_{hv} on 05/11/2009. Shaded areas indicate time intervals when it was raining at the radar site.

Note that differential reflectivity was miscalibrated for this day and net Z_{DR} values remain negative during the observation period. As expected, the cross-correlation coefficient is not affected by water on the radome surface. It is difficult to evaluate the impact of radome wetness on the radar reflectivity factor using similar methodology because the intrinsic median Z varies significantly throughout the event and relative changes of Z associated with the changes in the state of radome are relatively small.

A more rigorous procedure for estimating the impact of wet radome on differential reflectivity implies the examination of Z – Z_{DR} scatterplots and the dependence of median Z_{DR} on Z. The corresponding dependencies in rain for dry and wet radome are shown in Fig. 4 for the 05/11/2009 event. We believe that the most accurate estimate of Z_{DR} bias is obtained as an average difference between the two curves in the Z interval between 20 and 40 dBZ. We routinely utilize this methodology for data-based automatic calibration of Z_{DR} in our analysis of polarimetric radar data. In this particular situation, the bias induced by wet radome is about 1 dB which is in good agreement with the result of assessment using Fig. 3.

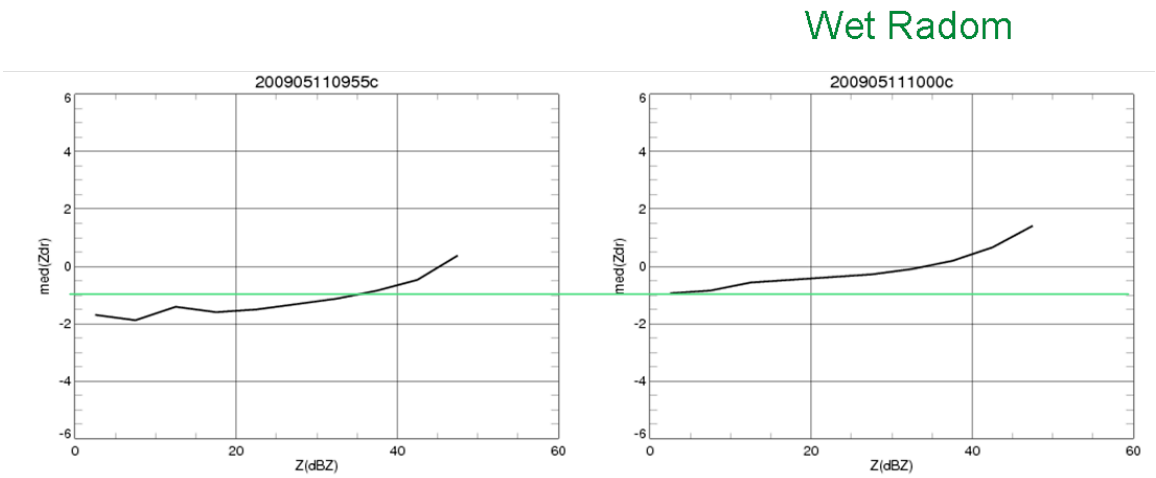

Fig. 4. Observed dependencies of the median Z_{DR} on Z for dry (left panel, time 0955 UTC) and wet (right panel, time 1000 UTC) radome on 05/11/2009.

Figs. 5 – 8 illustrate the results for the two other examined storms. For the case on

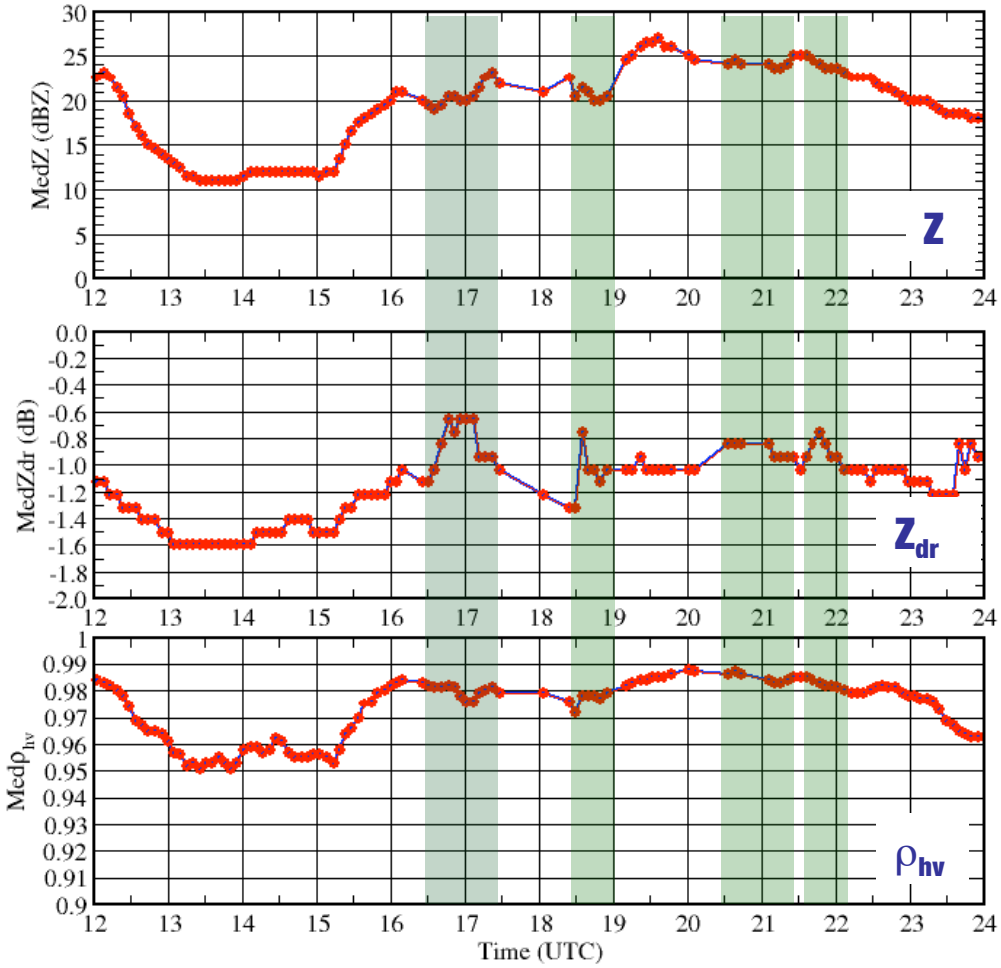

Fig. 5. Same as in Fig. 3 but for the event on 03/27/2009.

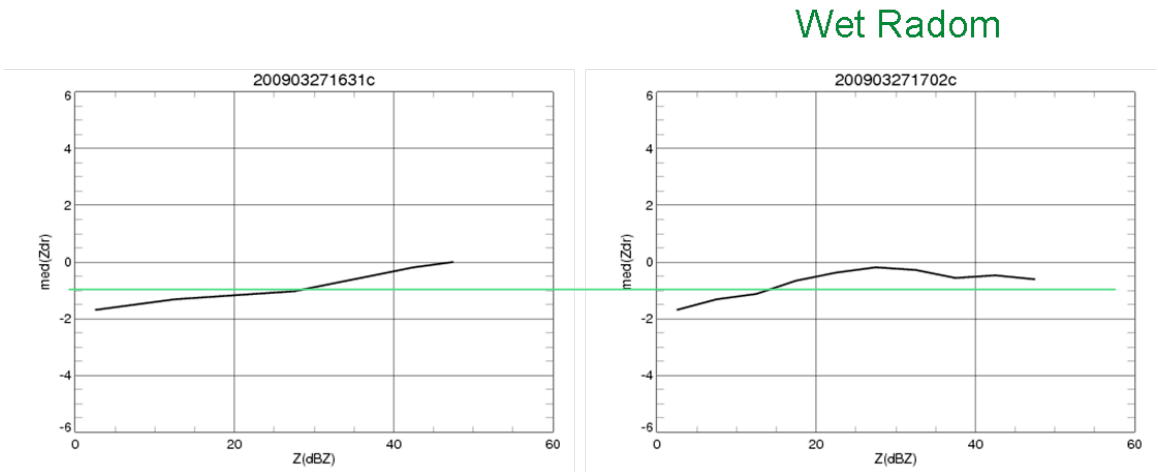

Fig. 6. Same as in Fig. 4 but for the event on 03/27/2009.

03/27/2009, the Z_{DR} change due to the radome wetness is smaller. Both Fig. 5 and 6 indicate that it is within the range 0.4 – 0.5 dB. Similar analysis of the 06/02/2009 event

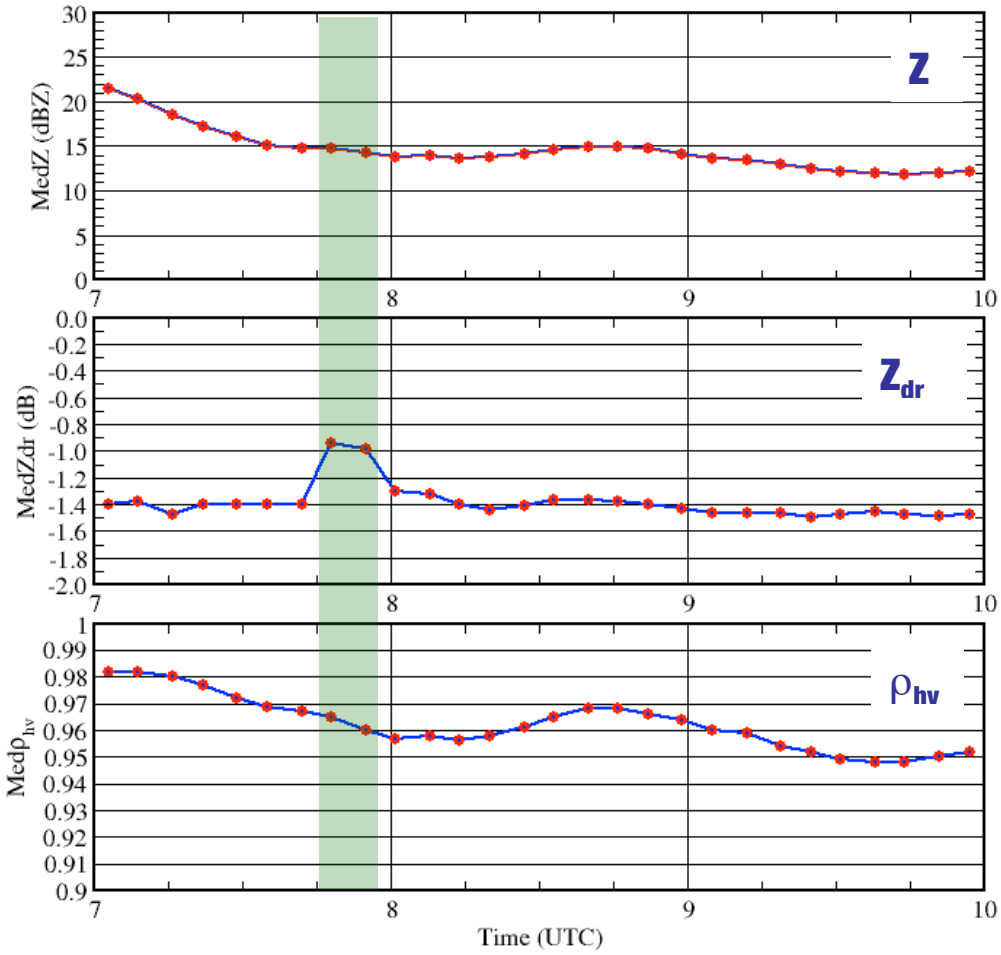

Fig. 7. Same as in Fig. 3 but for 06/02/2009.

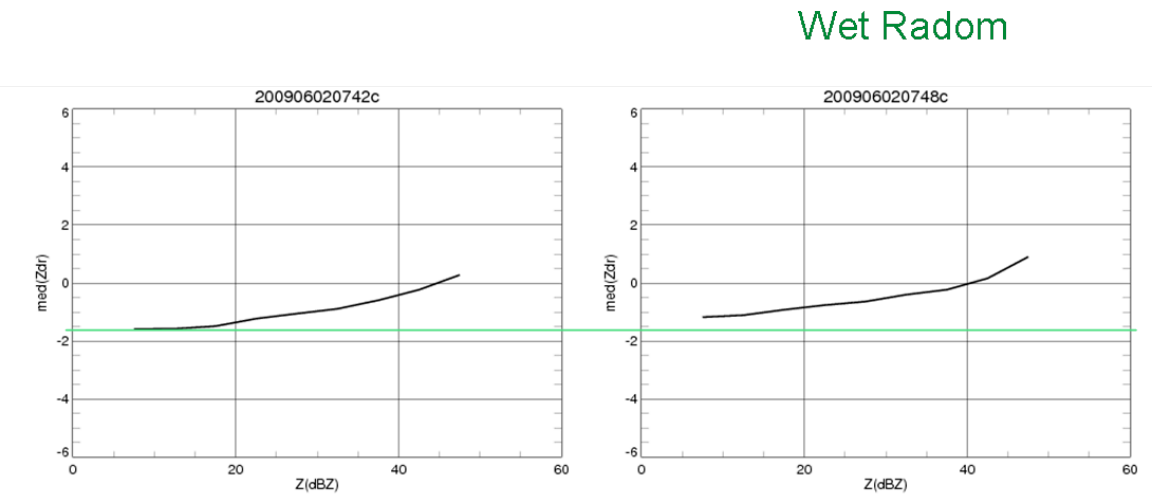

Fig. 8. Same as in Fig. 4 but for 06/02/2009.

yields the estimate of Z_{DR} bias of about 0.4 dB. Again, the estimates from Fig. 7 and 8 are quite consistent.

3. Conclusions

Three storms with significant rain over the OU PRIME radar have been examined in the study. Our analysis of the Z_{DR} bias induced by wet radome of the OU PRIME radar shows that the bias is always positive and it varied between 0.4 and 1.0 dB for the examined three events depending on the intensity of rain. These results are consistent with what Frech (2009) reported for the experimental dual-polarization radar at the Hohenpeissenberg Meteorological Observatory (HMO) in Germany with old orange-peeled radome. Our preliminary conclusion is that wet OU PRIME radome causes very similar "net" Z_{DR} bias compared to the HMO radar.

The corresponding bias in Z_{DR} can be effectively monitored and accounted for on the scan-to-scan basis using the same technique which we routinely use for calibration of Z_{DR} from the data collected in light-to-moderate rain with reflectivities between 20 and 40 dBZ.

We haven't noticed any pronounced azimuthal modulation of Z_{DR} which is often observed in the case of orange-peeled radomes.

As expected, there is no impact of the wet radome on the quality of the cross-correlation measurements.

The impact of wet radome on radar reflectivity is less visible compared to Z_{DR} because natural variability of the net Z is usually higher than possible radome-related bias. Again, the corresponding bias in Z can be quantified using consistency between Z and K_{DP} which is not affected by any water on the surface of radome. We can perform such a study later if needed.

References

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