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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Effects of wind turbines on radar data and products

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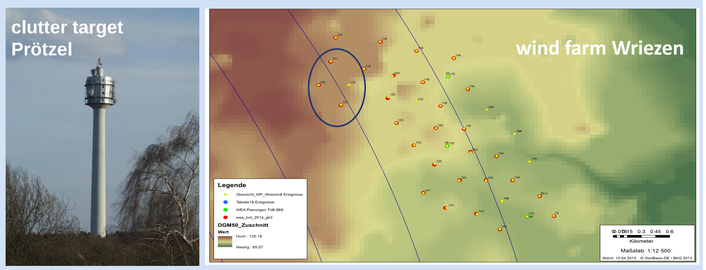
Wind turbines (WT) may bias weather radar data and increase their uncertainty. This in turn has a direct impact on radar based automated algorithms. Classic Doppler clutter filters are not effective to correct for moving targets such as wind turbines, and no method is known to correct for wind turbines due to their time-dependent clutter characteristics. Here we summarize observations on the influence of wind turbines on radar data and radar products such as hydrometeor classification (HMC) and quantitative precipitation estimate (QPE). We analyse range bin data of two dedicated clutter target scans of the Berlin (Prötzel) radar: one dwelling on a static clutter target (CT), and the second towards a small wind farm. In addition, we also extract the corresponding range bin of the scanning radar, where not all pulses are equally affected by the respective clutter target. Furthermore, we analyse the corresponding HMC and QPE results which are based on quality controlled data of the DWD radar data processing suite POLARA.

Radar data Prötzel CT and WT target scans:
WT PRO: range 13.87 km, az = 69.2º, el ~ 0.5º, Δr = 15 m
CT PRO: range 16.83 km, az = 266.3º, el ~ 0.4º, Δr = 15 m

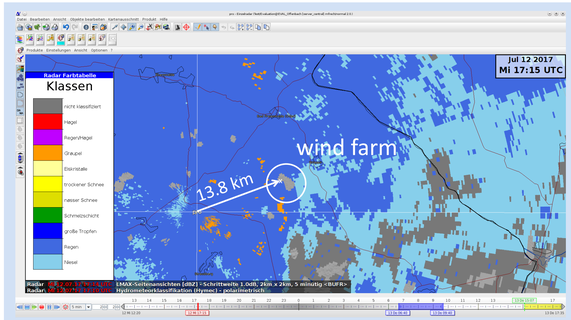
Sampling: PW 0.8µs, PRF 1000 Hz, time sampling 128 pulses acquisition time 2 s (amounts to 13 identical rays).

Volume data
Range bin resolution: Δr = 500 m (precip) and Δr = 1000 m

WT: hub height typically near 125 m, rotor radius 45 m.
Beam width 1º: Based on geometric considerations, only scans at el ≤ 0.5º should be affected.



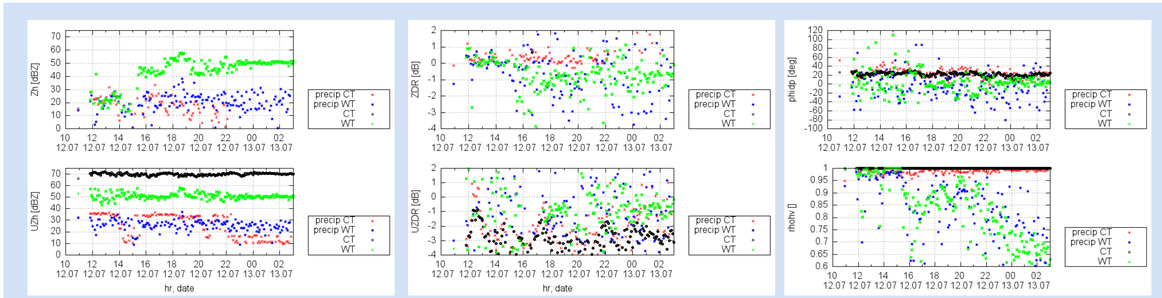
Radar data processing
Radar products are based on DWD's POLARA radar data processing framework.
Hydrometeor classification (HMC): fuzzy logic classifier using Zh, Φ_{dp}, ρ_{hv}, ZDR (see e.g. Frech and Steinert, 2014)
QPE: based on Z/R relationships. The choice of Z/R relationships is based on the HMC.



Ninjo screenshot of the HMC product 17:15 UTC, 12.7.2017. Indicated is the area of the wind farm and the range bin of the WT target (white cross). HMC input radar data are based on the DWD precipitation scan (0.8º elevation).

HMC product in a wind farm area
There was no valid HMC classification possible over the wind farm. This was persistent for several scans during this event. Interpolation would have been not trivial: for example how to deal with graupel spots (often hail precursor) in the vicinity?

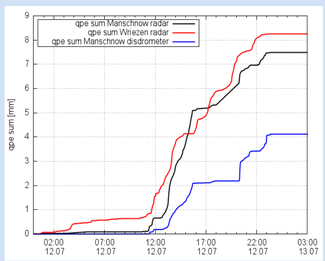
Summary
The influence of WT on HMC and QPE products has been illustrated. There is increased uncertainty of HMC in the presence of WT.
Obviously, WT contaminated pixels passed the DWD operational QC prior HMC and do not fit HMC membership functions.
In consequence, we find biased QPE estimates.
Mitigation of WT influence: Not available yet. E.g. simple interpolation may lose important meteoro-logical information, in particular for convective situations. See also DWD's efforts with the WT problem on Poster 269 by Böhme and Seltmann.



clutter filtered Z_h and unfiltered UZ_h *clutter filtered ZDR and unfiltered UZDR* *Φ_{dp} and ρ_{hv}*
Time series at rangebins of clutter (CT) and wind turbine target (WT) and at rangebin of operational scan @ 0.8º elevation („precip").
Data shown: 12.7.2017, 10:00 UTC – 13.7.2017, 3:00 UTC. Onset of precipitation around 10:00. It lasted until around 22:00 UTC.

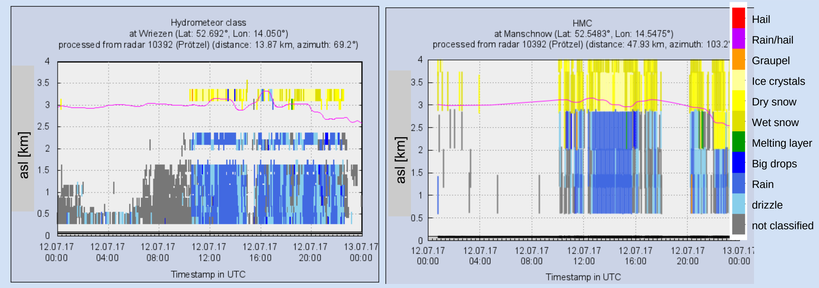
Characteristics of the time series data of selected radar moments
Z_h: Doppler filter most effective for the clutter target scan CT and corresponding precip data.
UZDR: CT: smaller scatter than WT values, predominantely negative values. This is also true for the precip data.
ZDR: CT: ZDR effectively Doppler filtered, no weather signal. Precip. weather signal visible (ZDR slightly positive). clutter micro suppression works in this example. WT: predominantely negative ZDR values; precip data: large scatter, same pattern as for UZDR.
Φ_{dp}: CT: constant (~20º); precip: observed increase related to precipitation. WT: on average ~ 0º, large scatter; precip: large scatter, predominantely negative values.
ρ_{hv}: CT: values close to one; precip: same is true; both about 1 even if there is no precipitation. WT: large scatter, small values, which are not indicative for precipitation.

In general: weather signal partially can be retrieved for isolated clutter targets. This appears not to be the case in the presence of wind turbines.



accumulated precipitation based on QC radar data for the WT target and the reference range gate Manschnow, compared to the disdrometer data from the Manschnow site.

QPE on 12.7.2017
Prior to onset of precipition (based on disdrometer data) at 12 UTC: about 1 mm of precip accumulated due to biased HMC. Overestimation of QPE is still a matter of investigation.



time-height plot of HMC at the WT site Wriezen on 12.7.2017
time-height plot of HMC at the Manschnow site (weather station) on 12.7.2017.

Time series of HMC at two reference locations
Aside from differences in precipitation duration and geometry: prior to the precipitation (before 10 UTC) a significant number of unclassified pixels (up to z = 2 km; left figure), close to the surface classifications of drizzle / rain / non-classified. These reflect the increased uncertainty of the radar moments due to the presence of WT, which lead to questionable HMC results. In contrast, QC works well if there are no WT present (right figure): radar data over the weather station site Manschnow is shown.

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