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Diagnosis of precipitation detection range

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1 Introduction

Many algorithms and radar system solutions have been developed to maximize the detection visibility of precipitating echoes. For example, the most representative measurement bin at a fixed range and azimuth angle can be selected to be the one among the neighbouring bins which indicates the weakest ground clutter contamination. However, the longer is the measurement range the larger is the probability that a radar does not detect any precipitation due to total beam overshooting or due to partial beam overshooting and increasing minimum detectable dBZ (Joss and Waldvogel 1990). Rapidly decreasing probability of detection (POD) as a function of range is most common in cold climates where shallow precipitation and weak reflectivities are frequent especially in snowfall (Koistinen et al. 2003). In the worst cases moderate snowfall intensities at ground are detectable only to ranges of 50–75 km. The problem can be severe also in mountaineous regions where beam blocking reduces the visibility and thus, the POD (Pellarin et al., 2000). Although radar meteorologists are well aware of the fact that "invisible" precipitation can exist below the lowest elevation beam, the end users often rely on radar images as a truth up to the nominal measurement range of 250 km shown in the products. As far as we know no Institute estimates and presents operationally the POD of precipitation as a function of range. It should be one of the important real time quality measures at each pixel of a precipitation product from every radar system.

2 Methods

At the Finnish Meteorological Institute we have started to test estimates of POD of ground level precipitation obtained applying three different methods:

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(1) The visibility of precipitation (V) can be estimated as a function of range applying the measurement geometry of radar beam, minimum detectable dBZ and high resolution measured VPR from the polar radar data at close ranges to each radar. As a first guess we can assume that the measured VPR approximates well enough the average VPR at all ranges. By using Gaussian beam convolution of the VPR at all ranges applying the known lowest elevation angle we obtain a single value for the maximum distance of detection. Probability of precipitation detection at each range is obtained by repeating the convolution procedure for an ensemble of VPRs. The ensemble members can be obtained from the following sources:

- Applying old measured VPRs from the same radar. The representativity of VPRs is enhanced by quality weighing each measured individual VPR, diagnosed as precipitation or overhanging precipitation.
- By using climatological VPRs applying the actual freezing level height at each time moment. Climatological VPRs are necessary when no precipitation is detected or when the measured VPRs represent clear air echoes.
- Applying VPRs from the neighbouring radars.
- Generating simulated VPRs from the measured VPR by keeping its shape constant but modifying the ground level dBZ according to the observed PDF of the dBZ values at the lowest level PPI, inside the range from which the measured VPR is obtained.

(2) The actually observed POD can be quantified at the ranges where overlapping radar pairs measure the same precipitation area with the lowest elevation PPI. The close range radar (R1) measures almost at the ground level (which represents well the actual precipitation) the area of precipitation A(R1) whereas the distant radar (R2) detects only part of the precipitating area A(R2). The ratio A(R2)/A(R1) is a measure of POD at the average range r, which is the distance from radar R2 to the center of the compared overlapping subgrid area.

(3) POD as a function of range can be estimated also from the ratio f=A(p)/A(np) where A(p) is the area of precipitation and A(np) the area of no precipitation in a circular range belt r2–r1 from a radar. If the precipitation coverage fraction (f) is horizontally homogeneous the decrease of f as a function of range will measure the quantity POD(r). Applying a large sample of POD(r) from methods (2) and (3) and V(r) at all ranges r, a good correlation between POD(r) and V(r) denotes that VPRs can be used in real time to estimate the actual POD(r). When POD(r) is presented as a quantitative shade underlay on an operational precipitation product the users immediately recognise at least semi-quantitatively the detection probability of precipitation in each pixel of the composite image.

References

Joss, J. and Waldvogel, A.: Precipitation measurement and hydrology, in Radar in Meteorology, D. Atlas (Ed), Am. Me teorol. Soc., pp. 577–597, 1990.

Koistinen, J., Michelson, D. B., Hohti, H., and Peura, M.: Operational Measurement of Precipitation in Cold Climates, in Meischner P. (Ed): Weather Radar: Principles and Advanced Applications. Springer, Berlin Heidelberg, pp. 78–114, 2003.

Pellarin, T., Delrieu, G., Creutin, J. D., and Andrieu, H.: Hydrologic visibility of weather radars operating in high-mountaineous regions: A case study for the Toce Catchment (Italy) during the Mesoscale Alpine Programme, Phys. Chem. Earth (B), 25, 953–957, 2000.