

1. Introduction

A well-designed and constructed radar system is a premise to acquire high quality radar data. In practice, measurement precision and system stability are primary questions to be answered for an operational weather radar system. For weather radar, the measurement uncertainty can be discerned as the variation of radar moment estimates. Considering the random nature of the radar return from hydrometeors, the sampling effect is generally the major factor contributing to the statistical fluctuation of moment estimates. Here, this uncertainty is regarded as “sampling-induced uncertainty”. On the other hand, the system hardware imperfections such as noise and instability may cause the “system-induced uncertainty”. The latter uncertainty, which has less dependence on the sampling configuration and has been addressed in previous literatures, is of more importance for radar users to assess the quality of a radar system.

Recently, the Enterprise Electronics Corporation (EEC) has proposed a robust and easily implemented approach to quantify the measurement error of weather radar. The proposed method applies the point-mode scanning strategy, which helps to quantify the measurement error more accurately than popular texture analysis method. More importantly, the system-induced error can be isolated from the total measurement error. As a result, it is particularly helpful for assessing the overall quality of an operational weather radar system.

2. Measurement Uncertainty

The measurement uncertainty is usually characterized by the statistical fluctuation of radar moment estimates. Mathematically, the measurement uncertainty is quantified as a standard deviation (SD) of the estimates.

\[ \sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2} \]

where \( \sigma \) is the standard deviation; \( x_i \) is a sample; \( N \) is the total number of samples; \( \bar{x} \) is the mean value of samples.

3. System Assessment

3.1 System-induced uncertainty

The system-induced uncertainty (due to system noise, instability, and other system imperfections) is one of major concerns in assessing the quality of radar system. However, it is usually hard to be quantified through the radar data because the sampling-induced error is ubiquitous. It is important to exclude the sampling-induced error when quantifying the system-induced uncertainty. The next section introduces a novel method to quantify the system-induced uncertainty for the purpose of radar system assessment.

3.2 Quantification of Measurement Error Using Point-Mode Data

The point-mode surveillance indicates that the radar data are collected with radar antenna pointing at one specific direction. It is reasonable to assume that the microphysics of precipitation in the same radar would keep the same within a very short time period (dwell time, only up to a couple of seconds). Therefore, the measurement error (standard deviation \( \sigma \)) can be quantified with two consecutive point-mode measurements (i.e., moment estimates), \( x_1 \) and \( x_2 \), by Eqs. (7-8).

\[ \sigma = \sqrt{\frac{1}{2} \left( x_2 - x_1 \right)^2} \]  

where \( x_1 \) and \( x_2 \) are the two consecutive moment estimates.

4. Result Analysis

4.1 Quantification of System-induced Error by Different Samplings

The measurement error estimation from Eq. (9) includes both system-induced and sampling-induced errors. The system-induced error can be isolated from the total error through removing the sampling-induced error with the following equations.

\[ \sigma_{sys} = \sigma_{total} - \sigma_{samp} \]

where \( \sigma_{sys} \) is the system-induced error; \( \sigma_{total} \) is the total error; \( \sigma_{samp} \) is the sampling-induced error.

4.2 Data Collection and Processing

From Eqs. (7-12), quantification of system-induced error requires at least two consecutive point-mode measurements with the same sampling configuration and two sets of such datasets with different sampling configurations.

The case study has used the data collected by the German Meteorological Service (DWD)’s C-band polarimetric weather radar (MWR). Two different sampling settings were used, as shown in Table 1.

<table>
<thead>
<tr>
<th>Setting one</th>
<th></th>
<th>Setting two</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PRF: 1000Hz</td>
<td>Pulse number: 325</td>
<td>PRF: 1000Hz</td>
<td>Pulse number: 325</td>
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<tr>
<td>Gate width: 25 m</td>
<td>Gate number: 4800</td>
<td>Gate width: 25 m</td>
<td>Gate number: 4800</td>
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</tbody>
</table>

5. Conclusion

This study investigates the measurement uncertainty of weather radar, which can be ascribed to two types: sampling-induced and system-induced. A novel method, which is based on the processing/analysis of weather data collected in radar surveillance with the point-mode, is proposed to isolate the system-induced error from the total measurement error. The proposed method can be used as an effective tool for the assessment of system weather radars.

Acknowledgment

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