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# Radar data quality control procedures

**C. Golz, T. Einfalt, and M. Jessen**

einfalt & hydrotec GbR, Wakenitzmauer 33, D-23552 Lübeck, Germany

**Abstract.** One of the basic requirements for a scientific and operational use of rain data from raingauges, ground and space radars is data quality control. To get an overview of the existing algorithms a literature review and literature pool have been produced. Many different algorithms have been evaluated and a selection was implemented in an algorithm pool, which is based on a common HDF5 metadata format. This algorithm pool is the basic tool for performing systematic tests on 2D and 3D radar data from different origins. One new bright band correction method for 2D-radar data is presented in this paper.

## 1 Introduction

Data quality control is essential for comparing and using rainfall data e.g. in models. Rain data could be used more intensively in many fields of activity (meteorology, hydrology etc.), if the achievable data quality could be improved. This depends on the available data quality delivered by the measuring devices and additional data quality enhancement procedures.

Data quality control (QC) can be divided into quality check and data correction. Data quality check is the process to analyse data in order to categorise them (either in a discrete or a continuous scheme). Data correction is the process to modify data which have been labeled as ”suspicious” or ”error loaden” in the quality check in such a way that they would pass the quality check after correction. This requires error identification and a well documented procedure, appopriate for the identified error. Not all errors can be corrected. Only quality checked/corrected data (depending on the purpose of use) should be accepted for further processing steps.

*Correspondence to:* C. Golz
(c_golz@einfalt.de)

## 2 Metadata format

In the scope of VOLTAIRE (**V**alidati**o**n of mu**lt**isensors precipit**ati**on fields and numerical modeling in Mediter**r**an**e**an test sites) a metadata format was created. It was decided to use the HDF5 format, which allows simple but powerful hierarchical data management and is based on a freely available software library for the programming languages IDL, FORTRAN and C++ (NSCA, http://hdf.ncsa.uiuc.edu/HDF5/). The VOLTAIRE metadata format is based on the proposed format of the COST 717 group (Michelson et al., 2003), complemented with keywords of the OPERA group (OPERA, 2004) and VOLTAIRE specific keywords. Thus, the format complies with the current international standards in the field of radar data.

## 3 Literature review

For the literature review numerous sources of literature have been collected, which are associated with quality control mechanisms. This review gives an overview of known data problems for one single data source (ground or space radar, continuous or daily raingauge), which should be minimized or eliminated by the means of check and correction algorithms. Moreover it contains informations about radar-raingauge cross-checking methods and adjustment schemes.

The results were introduced as abstracts into a public domain data base structure. The literature data base is available on the VOLTAIRE website (VOLTAIRE, 2002) in “results”.

## 4 Quality control algorithms

On the basis of the evaluated literature review quality control algorithms were chosen for the different sources of errors. The selected algorithms were collected in an algorithm pool under a graphical user interface called QCTool. This tool simplifies the application of different algorithms on HDF5 data, because it offers the possibility to choose HDF5 files and QC methods. Radar data from Switzerland, Cyprus, Catalunya and Germany have been converted to HDF5 and have been analysed in this environment. One algorithm of the pool is the following bright band correction for 2D data.

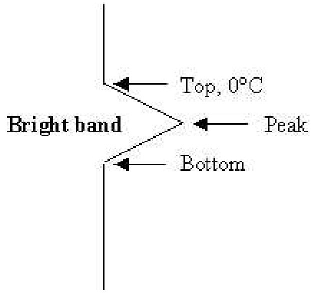


**Fig. 1.** Bright band signature in an idealised and simplified vertical profile.

### 4.1 Bright Band algorithm

The effects of bright band (BB) are difficult to detect and to correct for, if no radar volume data are available. Temperature station data can help, but the sole use of ground temperature as additional information is not sufficient because:

1. the temperatures on the ground are not always homogeneous in space to estimate the height of the zero degree level in the atmosphere with sufficient reliability,

2. the transformation of ground based temperature to the zero degree level intersected by the radar beam is leaving a certain band width of uncertainty if a mean correction factor (e.g. 0.6°C per 100 m height difference) is used.

Therefore a combination of the use of ground based temperature measurements and an image analysis approach is here proposed. Assumptions for the analysis are:

1. a mean temperature difference of 0.6°C per 100 m height difference (and, thus, no effects of e.g. temperature inversion),

2. a straight propagation of the radar beam in the atmosphere (excluding effects like ducting or anomalous beam propagation) and

3. the zero degree level is the top of the BB signature and the peak is in the middle of the BB (Fig. 1).

Key assumption for the image analysis approach is that a BB effect is characterised by increased reflectivities at a constant distance to the radar (equivalent to a constant height of the radar beam and of a stratiform character of the observed precipitation).

In a first step, the height of the zero degree level was estimated by using the average of the ground based temperatures, normalised by their respective height above sea level. The resulting height above sea level was intersected with the height of the radar beam, using the beam elevation and the beam width in order to obtain the distance for which BB effects can be expected. The thickness of the bright band B was determined using the rain intensity dependency after Fabry (1997):

$$B[m] = 140 * Z_e^{0,17} \quad \text{for rain} \quad > 100\,\text{mm}^6/\text{m}^3 \tag{1}$$

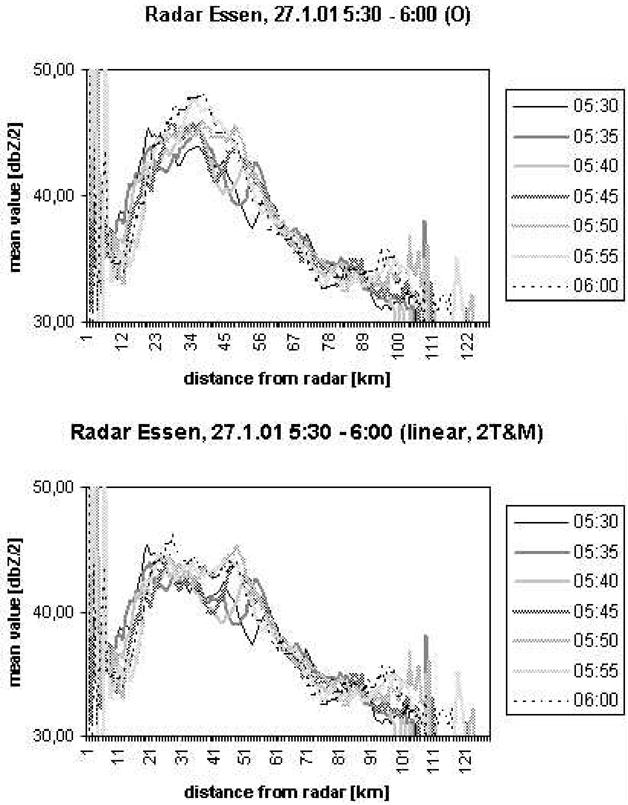


**Fig. 2.** Circularly computed mean reflectivities of original (upper image) and BB corrected (lower image) radar images.

$$B[m] = 210 * Z_e^{0,085} \quad \text{for rain} \quad < 100\,\text{mm}^6/\text{m}^3 \tag{2}$$

with the equivalent reflecivity factor $Z_e$ in dBZ. Alternative to the use of ground based temperatures existing measured freezing levels, that are available in the radardata can be used.

In a second step, the circularly computed mean reflectivities (i.e. mean reflectivities for the same distance from the radar) were analysed for every image. If there was a pronounced maximum which was persistent in time and distance (Fig. 2), the presence of a BB was assumed. The detected maximum is assumed equivalent to the peak of the BB and with the calculated BB thickness the top of the BB, the zero degree level, can be determined.

The third step is to combine the two zero degree levels. The heights of the temperature and of the image analysis approach are averaged in the ratio of 2 thirds to one third, so that the result of the temperature approach getting more weight. For example, if the zero degree level of the temperature approach would be 800 m and the zero degree level of the image analysis approach 500 m the result would be 700 m ([800 m*2 + 500 m]/3=700 m).

The correction for the BB was performed based on an idealised simplified vertical profile (Fig. 1) similar to an idealised vertical profile without orographic enhancement (Kitchen, 1994). Knowing the heights and the values of the top, the peak and the bottom of the BB, a linear function is calculated between top and bottom. This function determines how much the value of the peak is "too high" in comparison to the average of the top and bottom values of the BB. If one of these values is zero, the next pixel in the direction of the BB peak is taken. For the areas below and above the peak, linearly interpolated factors are computed, which are applied to the concerned pixels. Such a correction is not always possible, e.g. if the BB is over the radar (and the peak cannot be exactly determined).

The further the distance, the less pronounced the BB can be observed (Sanchez-Diezma et al., 2000) and the more the radar beam contains areas of different aggregate states of precipitation. Thus, this approach reaches its limitations where the BB peak cannot be clearly identified through the image analysis method.

Figures 2 and 3 demonstrate the results of this correction method in an example. The diagrams in Fig. 2 show the circularly computed mean reflectivities for single radar images before and after the use of the BB correction algorithm. It can be clearly seen, that the maximum, the bright band peak, was capped by the algorithm. Figure 3 shows the radar images corresponding to the diagrams in Fig. 2 before and after the application of the BB correction algorithm. The white rings in the second image indicate the corrected area, the area where the bright band was located.

This BB correction algorithm was successfully applied to three months of continuous radar data.

## 5 Conclusions

Data quality control is essential for all rain data. The literature review was the first step in VOLTAIRE to get an overview of the existing and the required algorithms in future. It offers the possibility to compare different mechanisms and decide which ones are always indispensable and which ones are useful for given applications only. This paper presented a new quality control method for bright band correction of 2D radar data. The algorithm is part of the algorithm pool under the QCTool user interface. With the possibility of using an extensive algorithm pool the next step will be to decide which kind or combination of algorithms should be used in what order for which kind of measurement device and region.

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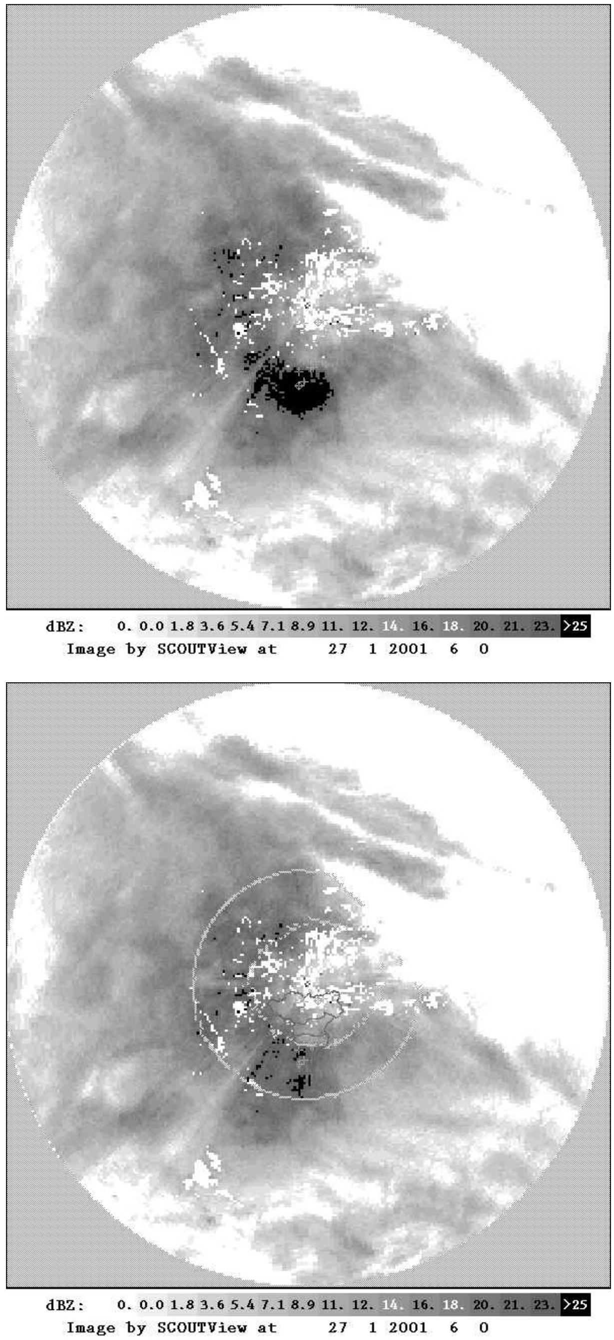


**Fig. 3.** Radar image (Essen radar, GermanWeather service (DWD)) before (upper image) and after (lower image) the use of the BB correction method.

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