Use of rainfall data from radar

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1. Introduction

This User Note sets out good practice for using rainfall data from radar in sewerage planning. The rainfall data supplied by the UK Meteorological Office (Met Office) is used as an example source, but the principles would apply to other sources of data. This note does not address rainfall prediction.

The radar record provides continuous data equivalent to having autographic rain gauges every 1 km throughout the area covered . The data can be used for any reason that a rain gauge record would have been used.

The note includes comment on:

- Rainfall measurement systems
- Description of radar process indicating limitations
- Good practice

2. Rainfall measurement background

Historically rain data has been gathered through rain gauges. These provide a direct measurement of total rainfall at a single point. To gain knowledge of spatial distribution of rainfall, a network of gauges has to be used. The accuracy of any spatial distribution of rainfall based on rain gauges is highly dependent on the density of the gauge network.

Rainfall measured using radar data is a valuable new data source and complements rain gauge data by being able to gather data over a wide area, typically up to 250 km from the radar site, from a single location. However, radar measure reflectivity, rather than measuring precipitation directly. The reflectivity measurements require the application of data processing algorithms in order to estimate the precipitation rate at the surface. These rainfall intensity measurements are available at fixed time intervals (for the Met Office radar network, 5 minute intervals). Each intensity reading is integrated over the appropriate time period to get an actual rainfall depth.

Because the two data sources gather different information they have different limitations. Rain gauges will miss rain cells that do not pass over them. Radar takes average intensities for a small area at a point in time that may not be fully representative of the time period.

Thames Water have undertaken a comparison of Met Office corrected 1km data (see later) and independent rain gauges and found that there is good match between rain gauge and radar data in the Thames Area. Similar tests with data from the west of England by the Met Office have found reasonable match but with a wider spread between data sources. The indication is that correlation between the two sources can vary and may depend on local topography and on physical location of the radars.

3. Radar Process

This is a brief overview of the radar process used by the UK. Met Office. For full information they should be consulted.

Radar sites are chosen to offer good Radar sites are chosen to offer good coverage over as wide an area as possible. Therefore they are commonly located on hill tops so they can scan at a relatively low angle (typically 0.5 degrees) without encountering significant obstacles. The radar sends out a signal and measures the time and magnitude of a return signal from hydrometeors in the atmosphere. The magnitude of the reflected signal is related to the intensity of precipitation and the timing of the return gives the location. The radar completes a full 360 degree scan four times every 5 minutes. Each scan is at a different predetermined angle to the horizontal. The surface precipitation rate is derived mainly from reflectivity data from the lowest elevation scan. Higher elevation scans are used where the lowest scan may be partially/totally blocked by surrounding topography, vegetation or manmade obstacles.

The beam has a narrow angle approx 1 degree spread. This means that the beam width is around 1 km at 38 km and around 2km at 80 km from the radar site. For this reason, when Cartesian grid products are derived from the original polar format data, 1km by 1km grid data is limited to 50km from the site and 2km by 2km data is limited to 100km from the radar site.

Since 1995 the Met Office has had automatically quality controlled and corrected data available. However, the highest resolution (1km) data is only available from late 2002 onwards. This data undergoes a number of processing steps to correct for known sources of error in radar data (e.g. removal of spurious echoes, corrections to account for topographic and range effects). The calibration includes use of a number of local meteorological models and calibration from local real time rain gauges.

Until around 2000 the Environment Agency, the main user of data for flood warning, received raw data and calibrated against a network of rain gauges. (Hyrad process). This data gave good spatial awareness of rainfall, and an indication of intensity, but the calibration smoothed out many peaks in events. Since then, the EA have moved towards receiving corrected data directly from the Met Office.

4. Good Practice

The descriptions above indicate that there are likely to be some differences between rain gauge and radar data. Therefore comparison of data, where timed gauges are available, should look for shape and timing of events as well as rain depth. However where only daily gauges are available, depth comparison give a good indication of correlation. Tests within Thames water usually show that for a typical event of 17mm of rain on a gauge the 1 km radar will be between 14 and 20 mm. There is no pattern as to a bias as to one method over or under reading.

In Thames Water we use the radar data directly. If there are larger variations in check data than set out above we look to understand whether there is likely to be some physical feature such as local hills that has caused the variation. Other anomalies could include snow in winter, twin celled storms occurring in one measurement only and very localised events in summer.

Where no clear reason for difference in reading is seen, and rain gauge data looks very clear and sensible, then radar can be used simply to track the path of rain cells past gauges without being used quantitavely.

To gain an understanding of typical variance between rain gauge and radar data in an area, an initial comparison study would be useful. However ongoing use of rain gauges with studies will, with time, build up a level of understanding and confidence in how to use the data. Experience in Thames so far is that the 1km by 1 km data is very similar to rain gauge data for gauges located in mid square. Experience of the 2km by 2 km data is more limited, but similar correlation has been found for well located gauges. 1km by 1km data is used wherever possible because it gives better spatial resolution.

In sewerage planning radar rainfall data can generally be used in several ways:

- proactively in obtaining data for studies of sewerage network performance.
- reactively in understanding rainfall events that have caused problems.
- model verification for historic events

Proactive use of radar data is useful in large catchments where spatial distribution of rainfall is likely and collecting rain gauge data is expensive. This can either be in large towns where gauge sites are difficult to locate, and equipment likely to be damaged, or in rural catchments where there are a number of widely spaced villages. Rain gauges should be located at 1 or 2 sites. Sites should be located across the catchment and where possible be targeted to lie in the middle of radar grid squares. When analysing events the hyetographs from the gauges and Radar should be compared and any anomalies resolved through site checks.

Reactive use for major events. Rain gauges nearest to the event should be located. Radar data should be obtained to cover both the rain gauge site and the event site. Where possible, time varying gauges should be used. However daily gauges giving good correlation to total depth at the gauge site will add credibility to any time based data identified for the event. Any anomalies should be examined in order to give confidence to the analysis.

Historic model verification. This is a specific example of event analysis, but will require extra data to obtain antecedent conditions. In general it should be possible to use the radar data to obtain local antecedent conditions.

5. Reference

Murray Dale, James Lau (2004) Modelling with radar rainfall data - how and why?- Paper at WaPUG Autumn Meeting

AMENDMENTS

Ver	Description	Date
1.	First Published	2006
2.	Editorial Amendments	March 2009