Optimising the accuracy of radar products with dual polarisation

Project Summary SC130007/S

Background

Rainfall forecast data generated at the Met Office is vital for providing weather and flood warnings, and this project has looked at ways of improving the accuracy and reliability of the radar network as well as fully exploiting and bringing into operation the latest technology.

Radar is particularly important in detecting localised rainfall (often not detected or under-sampled by rain gauge networks), especially where it falls on catchments prone to flash flooding. The upgrade to the UKs dual polarisation radar network in 2016 and the updated data analysis methods from this study means that we can make a step change in the accuracy of rainfall estimates, in particular in very intense precipitation, where radar estimates are most valuable.

The research explored 3 distinct areas:

- Focusing on the weather – improved detection of non-meteorological signals
- Seeing through the storm – improved radar reflectivity measurement during heavy rainfall
- More accurate rainfall products when it really matters – during heavy rain and storm events

Focusing on the weather

The research has developed and implemented a new technique for cleaning up the radar data. When false echoes or data 'spikes' appear in radar products they can trigger false automated warnings of heavy rainfall – this undermines confidence in the use of radar products and limits their automated use. A technique for quality controlling the data using dual polarisation was developed as part of this project and implemented in November 2014. During instances of intense precipitation the new technique removed between 20 and 50% more bad data than before.

Work was also done in collaboration with the US National Severe Storms Laboratory (NSSL) Advanced Radar Techniques team to try to stop bad data from appearing in the raw measurement at all. As part of this collaboration we have implemented the NSSL's Clutter Environment Analysis using Adaptive Processing (CLEAN-AP) Doppler clutter filter, reducing the amount of radar data where echoes from the ground are present and allowing more high quality data to be used to generate rainfall estimates.

Seeing through the storm

We focused on making corrections to the radar measurement where errors are identified. Radars work by transmitting high power pulses of electromagnetic waves, and listening for signals backscattered by precipitation. In terms of power, in light rainfall we receive a signal 190 orders of magnitude smaller than those we transmit, which means anything in the path can have a significant effect. The introduction of dual polarisation radars means there are measurements available which are independent of the power of the signals received by the radar. By comparing the power-based and power-independent measurements, the errors in the radar system can be measured and corrected for. A test period showed that errors in the radar data were reduced using the new calibration technique.

The particular frequency used by weather radars (5.6GHz) is chosen for its efficacy in measuring precipitation, but this also means that where a lot of precipitation is present the radar signal can be severely attenuated. Attenuation is the interruption of a radar beam by intense precipitation. The large overlaps in the UK radar network, and single polarisation techniques for correcting for attenuation mean that occurrences of attenuation impacting on the radar rainfall product are rare. However, when attenuation does happen, it occurs in conditions where there is very intense rainfall, causing the radar product to severely underestimate the true rainfall, and in some cases fail to observe any precipitation at all. In short, it can cause severe problems with the measurement, exactly at the point when accurate measurements are crucial for weather and flood forecasting. The research undertaken as part of this project has provided a new calibration method which allows a much more accurate estimate of the attenuation to be calculated.

More accurate rain-rate products when it really matters

This work package developed a new hybrid rainfall rate (R) estimation scheme which made use of the phase or

the reflectivity (K_{dp}) information depending on the intensity of the precipitation.
This technique is only usable in heavy rainfall, so a hybrid method has now been implemented, which makes use of R (K_{dp}) in heavy rain, and R(Z) (the single polarisation technique) in light or moderate rainfall.

As R (K_{dp}) is only used in heavy rainfall, which is much rarer than light rainfall, its benefit is best evaluated by examining case studies rather than looking at a long archive of data. The introduction of the R (K_{dp}) estimator reduced errors to 0–5% for two of the three measurements. The research phase of this work showed such promise that the Met Office, the Environment Agency and the Flood Forecasting Centre agreed to prioritise this work to bring it from the research phase and into operational use ahead of schedule.

How much have we improved the radar product?

The improvements observed as a result of this project are generally during the heaviest rainfall, which occurs relatively infrequently and is usually very localised. This limits the number of ground truth measurements from rain gauges available for verifying the radar estimates. Therefore, the analysis of case studies has been crucial to the evaluation of the new algorithms. The storms at the beginning of July 2015 were one of many case studies examined as part of the evaluation of work packages 2 and 3. These show an improved correlation and a reduction in the radar measurement errors.
This summary relates to information from project SC130007, reported in detail in the following output(s) held at the Met Office:

Report: the guide is free to download from the Met office:
http://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/library/mo-technical-documents/dual_polarisation_09062016.pdf

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