The development of diagnostics and radar monitoring capability within a newly implemented radar data quality management system (RDQMS)

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Introduction

The use of radar based quantitative precipitation estimates (QPE) within hydrological applications, nowcasting and for assimilation into Numerical Weather Prediction (NWP) is currently limited by issues relating to radar data quality and reliability. Issues range from problems with the performance of radar hardware components to limitations associated with the post-processing algorithms.

A comprehensive radar data quality management system (RDQMS) is currently being developed within the Met Office. This will deliver a range of monitoring and verification information and tools, including: quality monitoring of the radar system performance, comparison of radar-based QPE with rain gauge measurements, and monitoring of Doppler wind and radar reflectivity data using NWP model fields.

Such an improved monitoring system and its associated diagnostic products are expected to result in earlier identification of any issues arising with the radars or radar data quality.

Quality monitoring of radar performance and radar product quality

In the case of radar quantitative precipitation estimates (QPE), quality is often quantified using comparison with rain gauge measurements. Although this can be very useful, interpretation can be problematic due to the sampling differences. A comprehensive radar data quality management system (RDQMS) is being developed, which will deliver a range of monitoring and verification information and tools.

Fig 1: (a) The quality management cycle

(b) The quality management and radar data processing. Source – Harrison et al. (2011)

The following will be used to monitor radar system performance (Harrison et al., 2011):

a) Scan mean transmitter pulse power
b) Scan mean transmitter frequency (GHz)
c) Scan mean receiver noise (dBc)
d) Scan mean antenna rotation rate
e) Antenna elevation (variation within single scan)

Long-term integrations of QPE products can help identify and quantify persistent anomalies, which may result from errors in the basic reflectivity measurement and/or limitations of any quality control (QC) and correction algorithms applied. When looking at accumulation periods greater than 1 month, the appearance of good quality products should correspond well with the climatological variance of precipitation, with variations due to the topography and terrain aspect. Other anomalies may exist due to partial beam blockages or clutter breakthrough (Harrison et al., 2011).

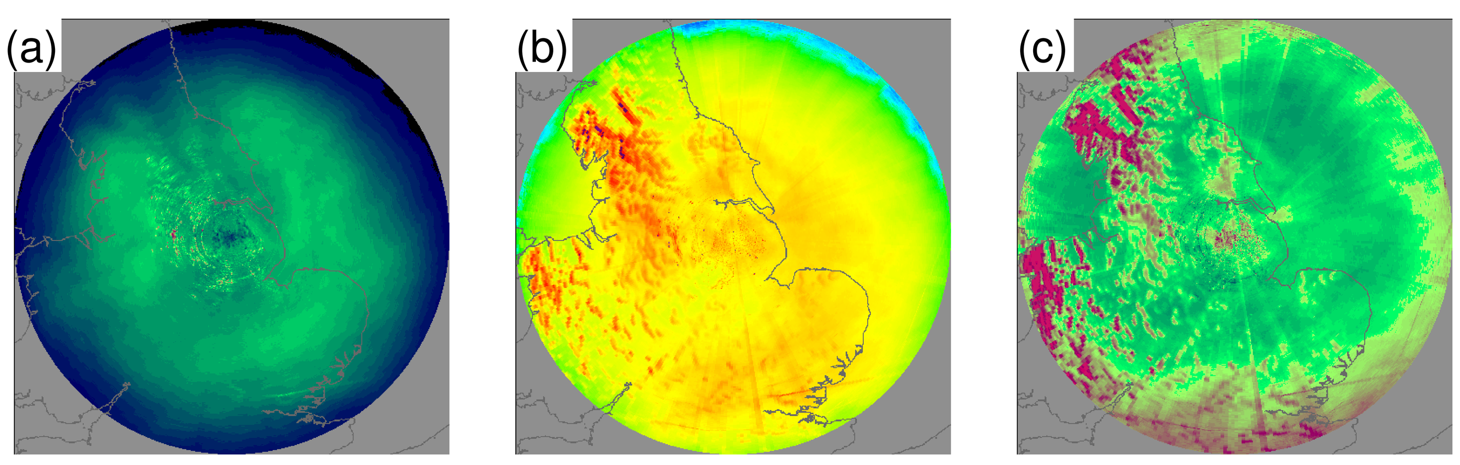

Fig 2: Ingham radar, January 2011.
(a) Probability of precipitation (%)
(b) Precipitation accumulation.
(c) Average precipitation rate (precip. rate > 0)

Assessing radar calibration

Long term statistical comparison between synthetic and real observations has the advantage of identifying individual radar calibration problems through relative comparisons with other radars. The effectiveness of the forward modelling of the reflectivity can also be evaluated through absolute statistical comparisons. The biases arising from a combination of the bright band effect, beam broadening and attenuation can also be observed. The average O-B value has been calculated over 5 to 140 day time periods (T). T varies inversely with variance in the averaged data (fig.3).

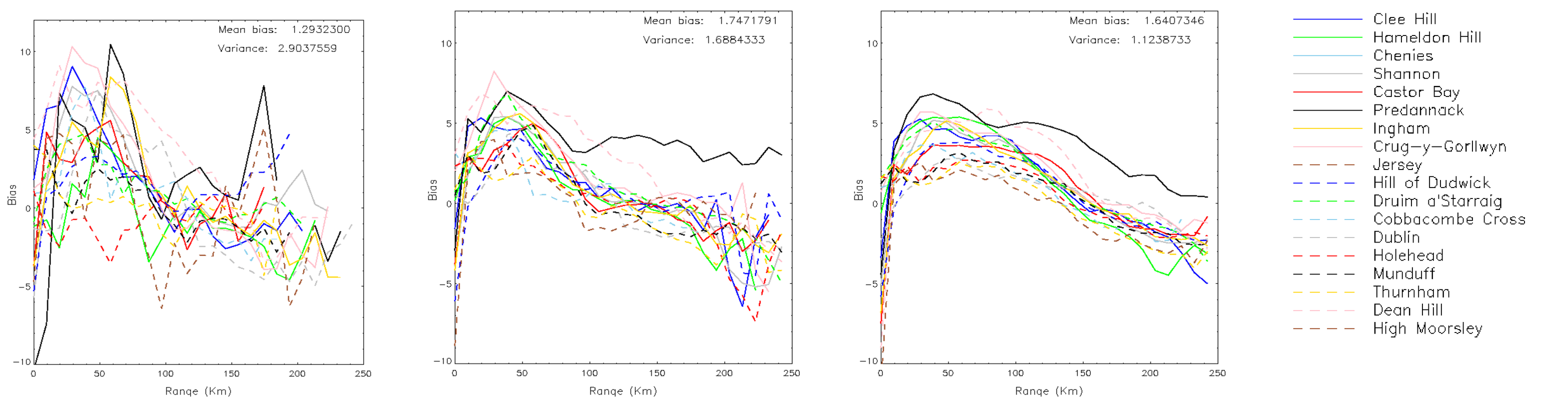

Fig.3: Corrected bias between model and radar observations at 0.5 degree scan elevation calculated over time periods: (a) 5 days (b) 30 days (c) 90 days, starting on 1st May 2010.

In Fig 3(c), the data is smoothed over a long enough time period such that the relative calibration of the radars can be assessed within ~1dB variance. The radar that shows the greatest relative difference in calibration is Predannack, situated in Cornwall, for which the majority of observations are over the sea. Part of the relative bias anomaly may be explained by differences in the NWP model performance over the sea compared with over land, but this may only account for a small part of the observed difference in calibration. Ingham, High Moorsley and Dublin radars are also showing evidence of slight mis-calibration when compared with the other radars.

Radar data processing within the Observation Processing System (OPS)

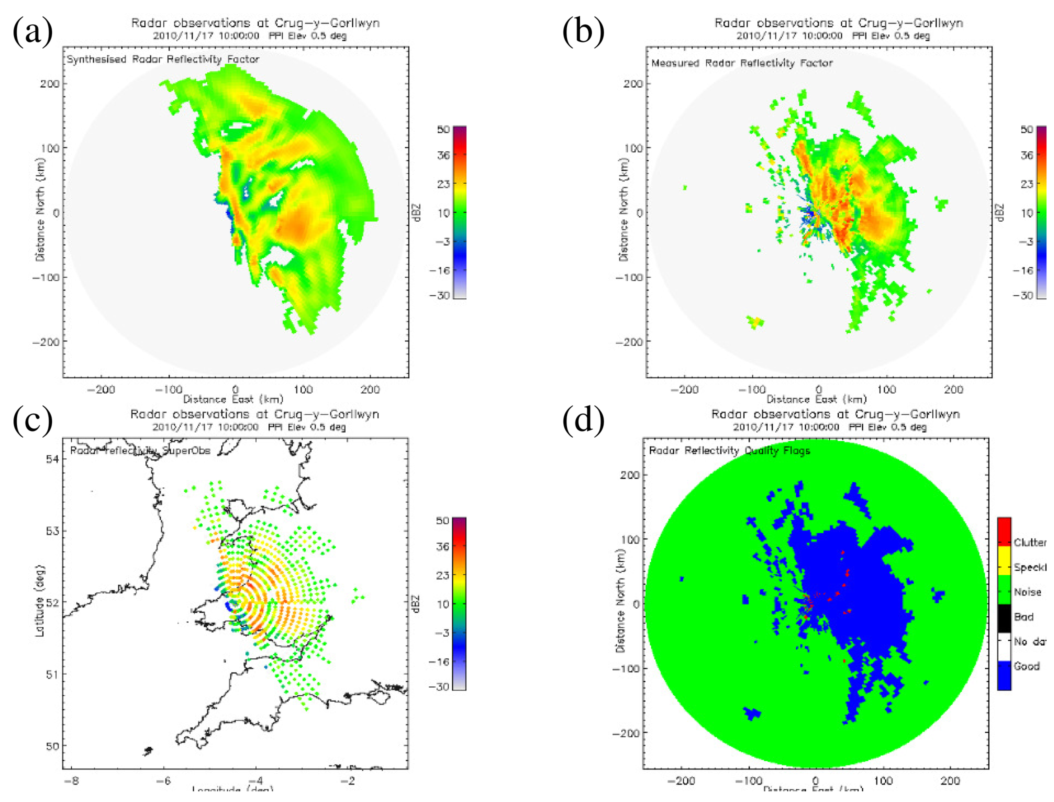

Fig.4: Examples of the modelled and observed reflectivity values at the Crug-y-Gorllwyn radar on 17 Nov 2010.

(a) Modelled reflectivity factor.

(b) Measured radar reflectivity factor.

(c) Superobs of the measured radar reflectivity.

(d) Quality flags associated with the measured radar reflectivity.

For the purpose of comparing radar and model data, it is necessary to average the rays and gates of the radar data to a similar resolution as that of the model. This is achieved by superobbing the observations, which involves spatially averaging the difference between the real observations and their synthetic equivalents produced using the model background fields.

The quality flags, produced by the radar pre-processing, are used in the superobbing process such that only the observations that passed the minimum quality criteria are taken into account. This involves flagging of radar bins affected by ground clutter and partial beam blockage.

Superobbed differences between measured (radar) reflectivity measurements and synthesised (model) reflectivity (the O-B value) are useful for 3 key areas of analysis: data assimilation (initialising the model with high resolution radar data), model verification and radar quality control (QC).

Doppler winds monitoring

Monitoring of Doppler wind data has recently been implemented operationally as part of the RDQMS system, and involves monitoring of Doppler radial wind scans against the model background every three hours.

The Doppler monitoring has proved useful in identifying issues within the initial Cyclops processing of radar data. An example is the identification of a location error, flagged by the O-B difference in the data. Once the criteria for testing the quality of the Doppler winds has been well defined, it is expected that this monitoring will form an integral part of the operational acceptance process for future testing of developments within Cyclops.

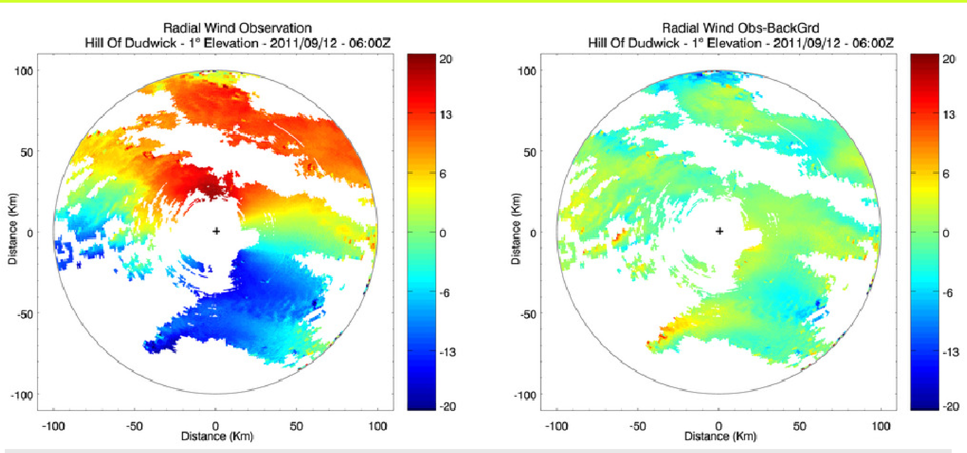

Fig 5: Doppler monitoring at Hill of Dudwick, 12 Sept 2011. (a) The radar wind observations (b) the difference between the observed and modelled winds.

Since July 2011, Doppler radial winds have been assimilated using the UK4 (4km) and the UKV (1.5km) unified model output. In the future it is expected that radar reflectivities will also be assimilated within NWP.

Summary

The monitoring has already been effective in identifying several faults with radar system components and post processing algorithms, leading to their resolution. The diagnostic products are proving useful in their own right within the QC processes. Over the coming year work will focus on putting in place the elements of the RDQMS. It is anticipated that a complete RDQMS will lead to significant improvements in the quality and reliability of radar data and products, by quickly identifying any problems thus enabling either short term solutions and/or long-term improvement strategies to be devised. It is also envisaged that the QM information will serve to inform customers about radar product quality issues thus increasing confidence in the use of the products or promoting realistic expectations.

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