School of Earth and Environment

Evaluation of 3D dual-polarised radar-based hydrometeor classification algorithms over the UK

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Introduction

The UK Met Office are currently upgrading their 15 radars from single to dual-polarisation. Dual-pol radar enables identification of hydrometeor type on a near real-time scale. This will enable forecasting of the surface precipitation type and more accurate estimates of precipitation quantity.

In this research, rigorous and novel verification techniques will be used to evaluate different types of Hydrometeor Classification Algorithm (HCA).

UKMO Radar Network

- ***Plessey 45C/D***
- ***Met Office Dual-Pol***
- ***Upgrading***
- ***Non-MO***

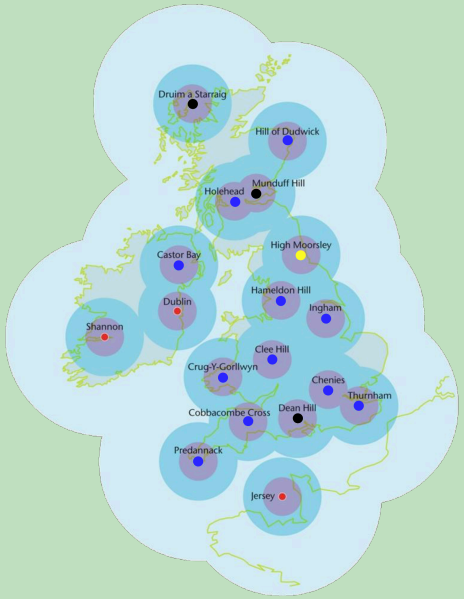

Figure 1: UKMO weather Radar network as of June 2016. Three Radars remain to be upgraded (black). It is unknown whether the non-MO Radars (red) will be upgraded.

What is Dual-Pol Radar?

- Electromagnetic waves are 'polarised' when confined to oscillate in one vector only.
- Single-pol radars have horizontally polarised waves.
- The horizontal and vertical components of dual-pol radar pulses interact with hydrometeors differently.

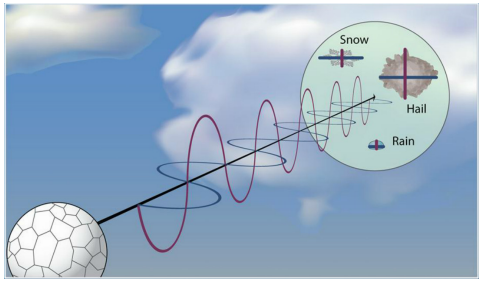

Figure 2: *Interaction between dual-polarisation atmospheric Radar and three different hydrometeors. [1]*

Table 1: *New products derived from dual-polarisation radar. LDR_{vh} is a unique operational observation compared to other countries.*

Name (Units)	Equation	Description
Z_{DR} (dB)	$10log_{10}\frac{\lvert S_{hh}\rvert^2}{\lvert S_{vv}\rvert^2}$	Indicates shape of hydrometeors in the sample volume.
K_{DP} (°/km)	$\frac{1}{2}\frac{\partial(\Phi_{hh}-\Phi_{vv})}{\partial r}$	Specific differential phase. A measure of pulse attenuation, caused by heavy rainfall or hail.
ρ_{hv}	$\frac{\lvert\langle nS_{hh}S_{vv}\rangle\rvert}{(\langle n\lvert S_{hh}\rvert^2\rangle\langle n\lvert S_{vv}\rvert^2\rangle)^{1/2}}$	Correlation coefficient. Indicates diversity of hydrometeor shapes.
LDR_{vh} (dB)	$10log_{10}\frac{\lvert S_{vh}\rvert^2}{\lvert S_{hh}\rvert^2}$	Ratio of the cross-polar to co-polar backscattered signal powers. The cross-polar is transmitted in the horizontal and received in the vertical polarisation.

Prior HCA research

- Fuzzy logic algorithm combined with a neural learning technique to allow the algorithm to change based on training data (Liu and Chandrasekar, 2000).[2]
- Fuzzy logic algorithm with estimation of confidence factors. Weighting of the radar variables by quality of observation such as distance and attenuation data (Park et al. 2009).[3]
- Chandrasekar (2013) reviews the literature and advances in the HCA field since the 2000 paper. Discussion of the affect on operational forecasting and novel techniques is performed.[4]

Novelty and Impact

LDR_{vh} observations are unique to the UK from an operational standpoint. Therefore an outcome of the research will be to determine whether having LDR_{vh} adds skill to the HCA.

The novelty of this research is that it will be the first rigorous verification of an operational network.

The impacts are significant for the hydrology community and for flood forecasting. Near real-time precipitation quantification and type can be fed into flood models. Atmospheric hydrometeor information can also be assimilated into models for NWP, and the snow/rain boundary can be diagnosed in near real-time.

Figure 3: *[Left] Boscastle flood 16/08/04 © Nick Gregory. [Right] UK as seen from Terra satellite 26/01/13 © NASA.*

Verification Network

- Fourteen Theiss disdrometers are being prepared for deployment at various sites around the UK (see Fig 3).
- The NCAS mobile X-band, Chilbolton S-band and Ka-band radars are all co-observing with the MO radars.
- The FAAM research aircraft will be conducting flights to measure hydrometeor species at radar beam altitude.

Figure 4: *Potential disdrometer observation sites in the UK, and FAAM.*

References

1. Science of the South website. Accessed 24/10/16 http://bit.ly/2f4By16
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3. Park, H. S., Ryzhkov, A. V., Zrnić, D. S., & Kim, K.-E. (2009). The Hydrometeor Classification Algorithm for the Polarimetric WSR-88D: Description and Application to an MCS. *Weather and Forecasting*, *24*(3), 730–748.
4. Chandrasekar, V., Keranen, R., Lim, S., & Moisseev, D. (2013). Recent advances in classification of observations from dual polarization weather radars. *Atmospheric Research*, *119*, 97–111.