Radar Data for High Resolution NWP

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Outline

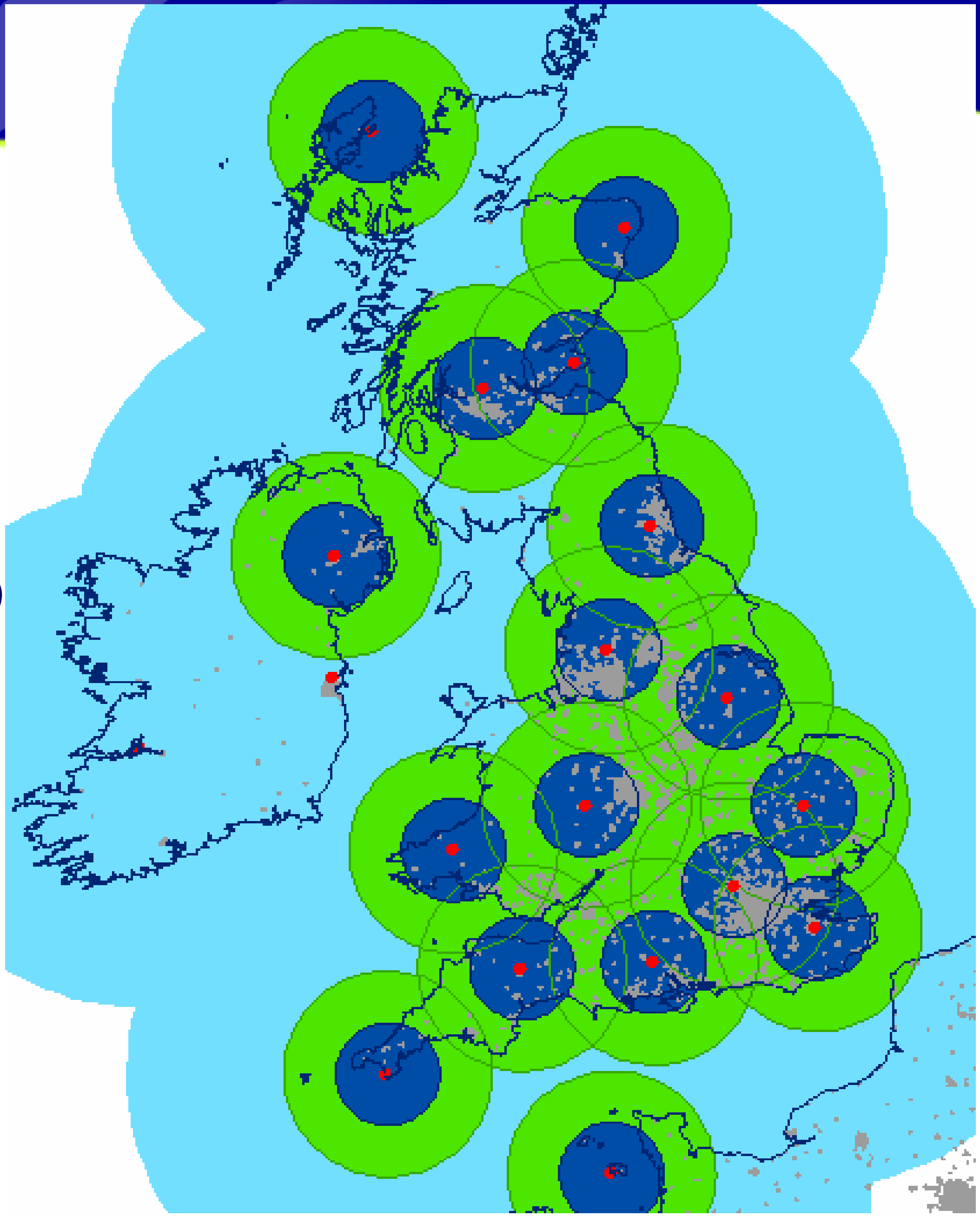
- Introduction – the UK weather radar network
- Reflectivity data
- Radial Wind data
- Refractivity data

The UK Radar Network – 2007?

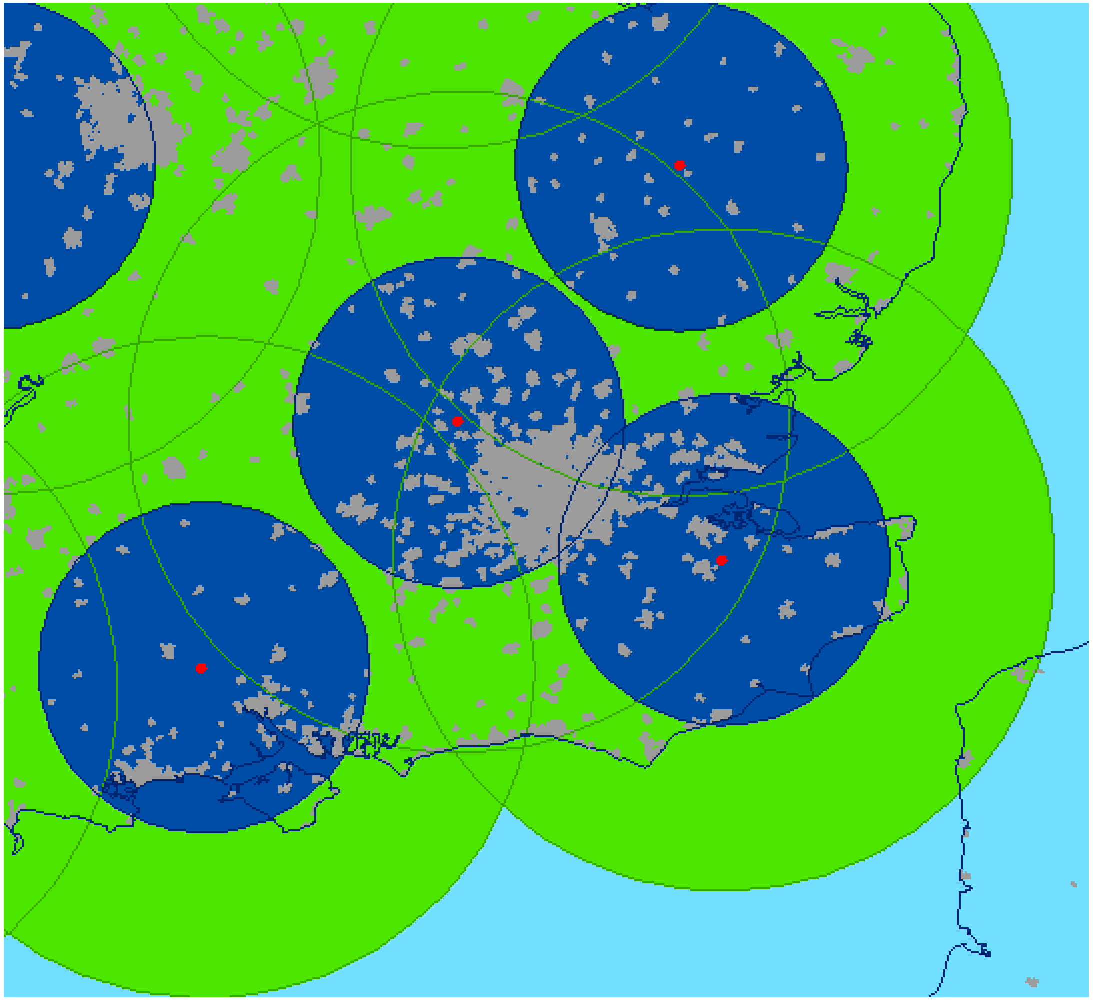
50km range (~1km resolution)

100km range (radial winds)

250km range (extent of coverage)



Coverage in SE England



UK radar network - summary

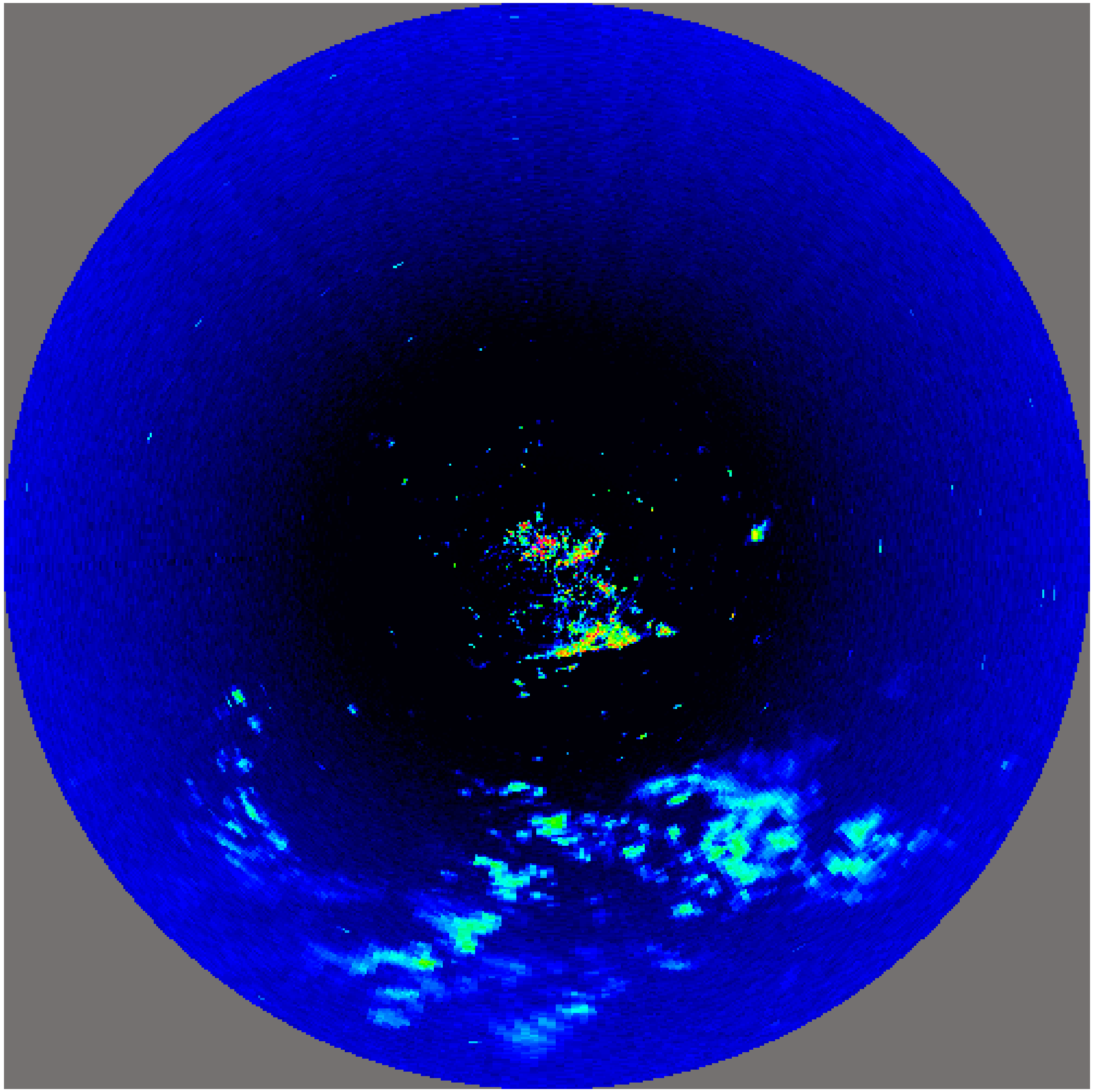
- Dense network (by International Standards)
- C-band radars – 1 deg beam width
- Very old hardware – the oldest radar was installed in 1977!
- Modern signal processing developed in-house.
- Can this old network meet new requirements for high resolution NWP?

Reflectivity from Radar

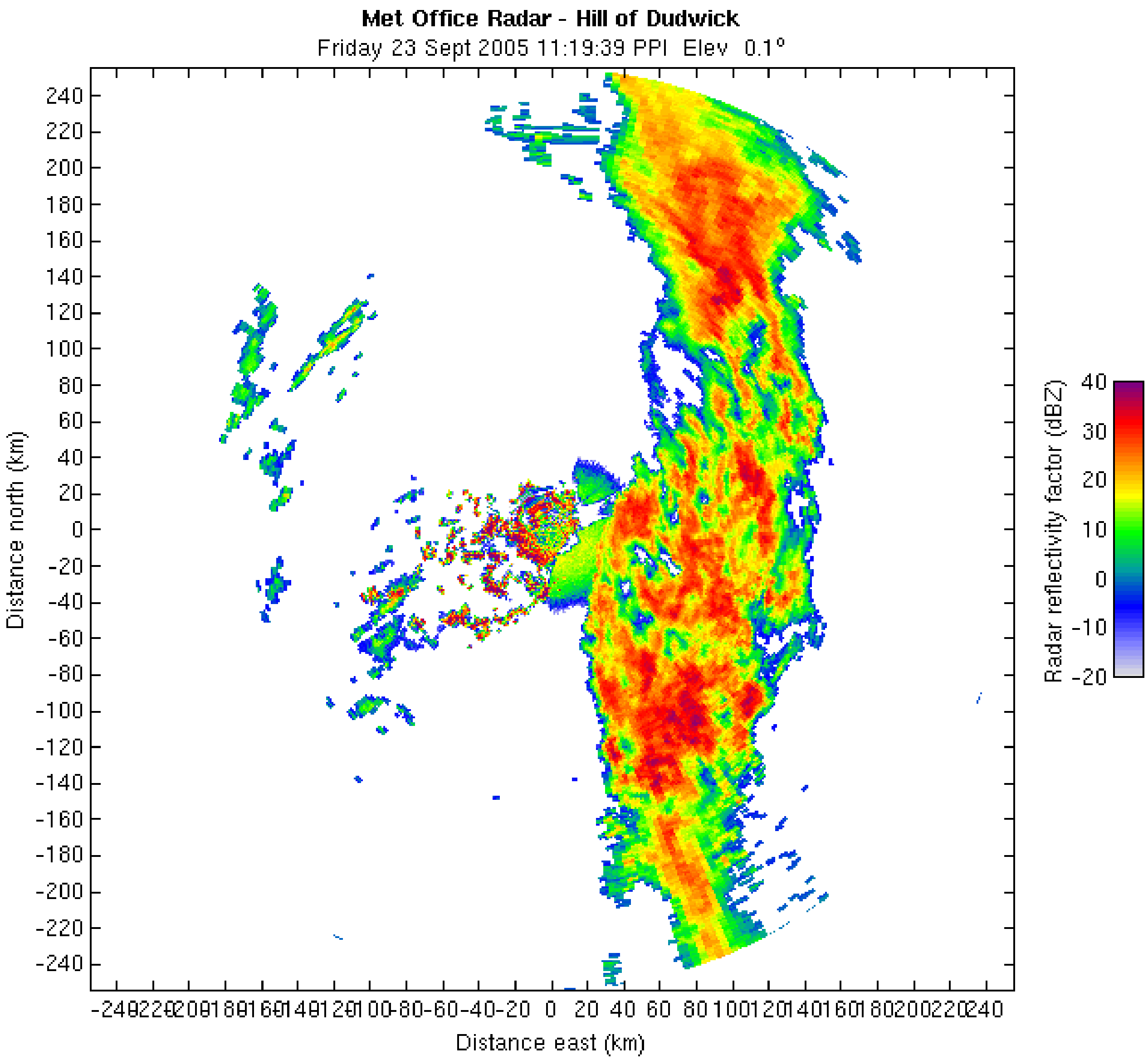
Advantages over assimilation of surface rainfall:-

- Able to make use of radar data from scans at multiple-elevation angles
- Less reliance on radar correction algorithms operating outside NWP – e.g. parametrization of the bright band.
- Enables optimum trade-off between rainfall detection efficiency and spatial resolution

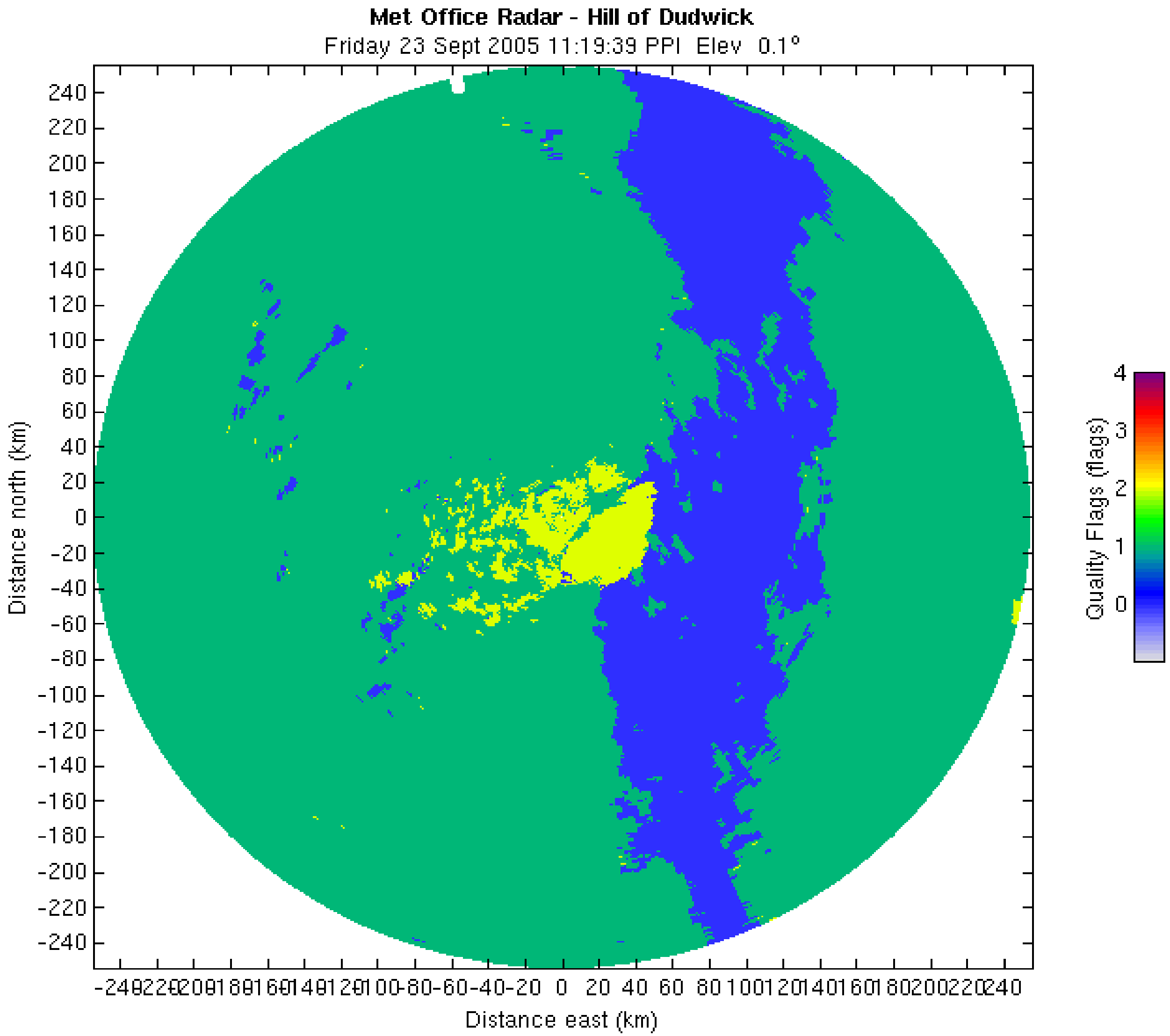
Raw Radar Data (1 deg x 600m resolution)



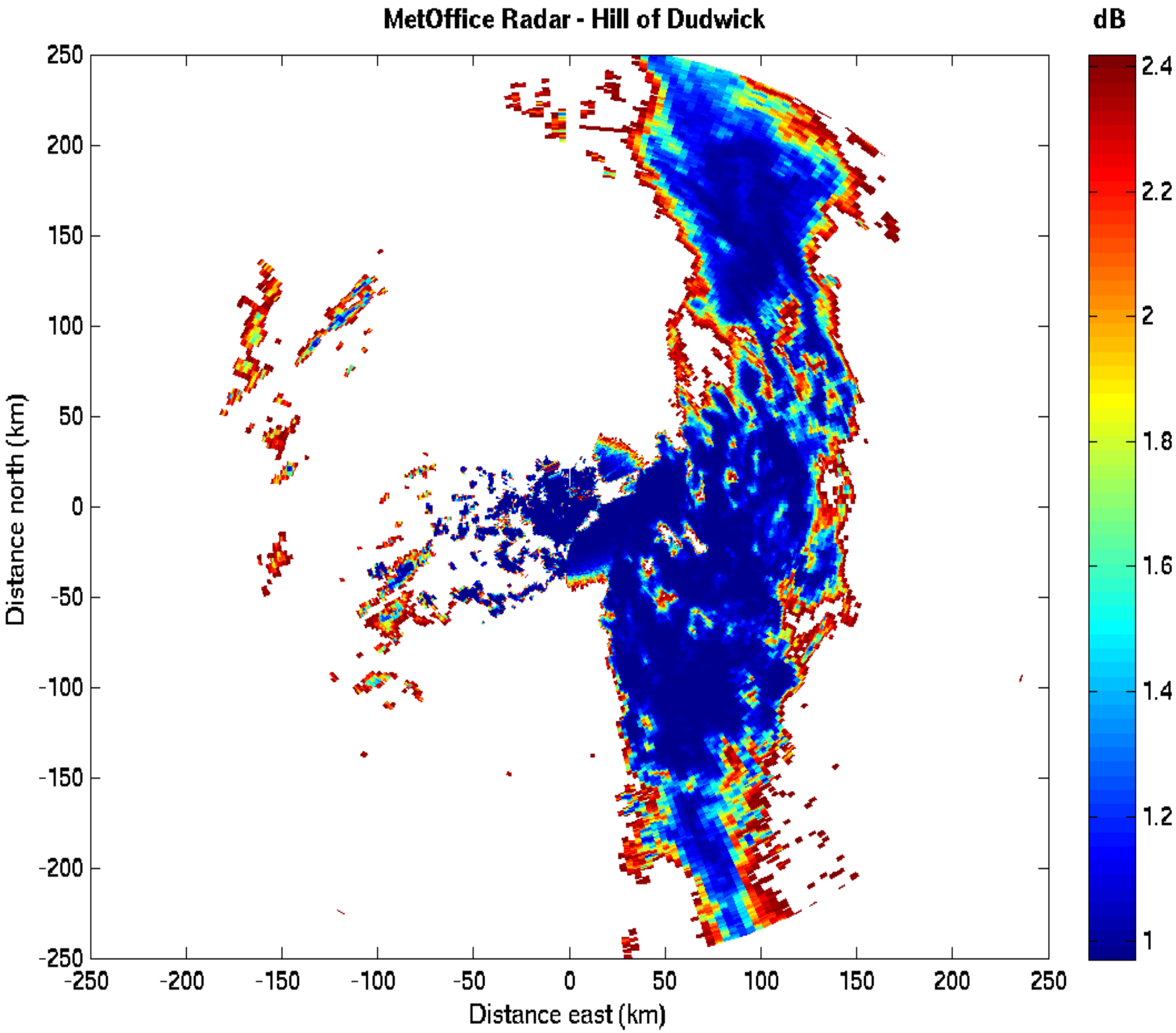
Noise Subtraction



Target flags



Random error fn of SNR

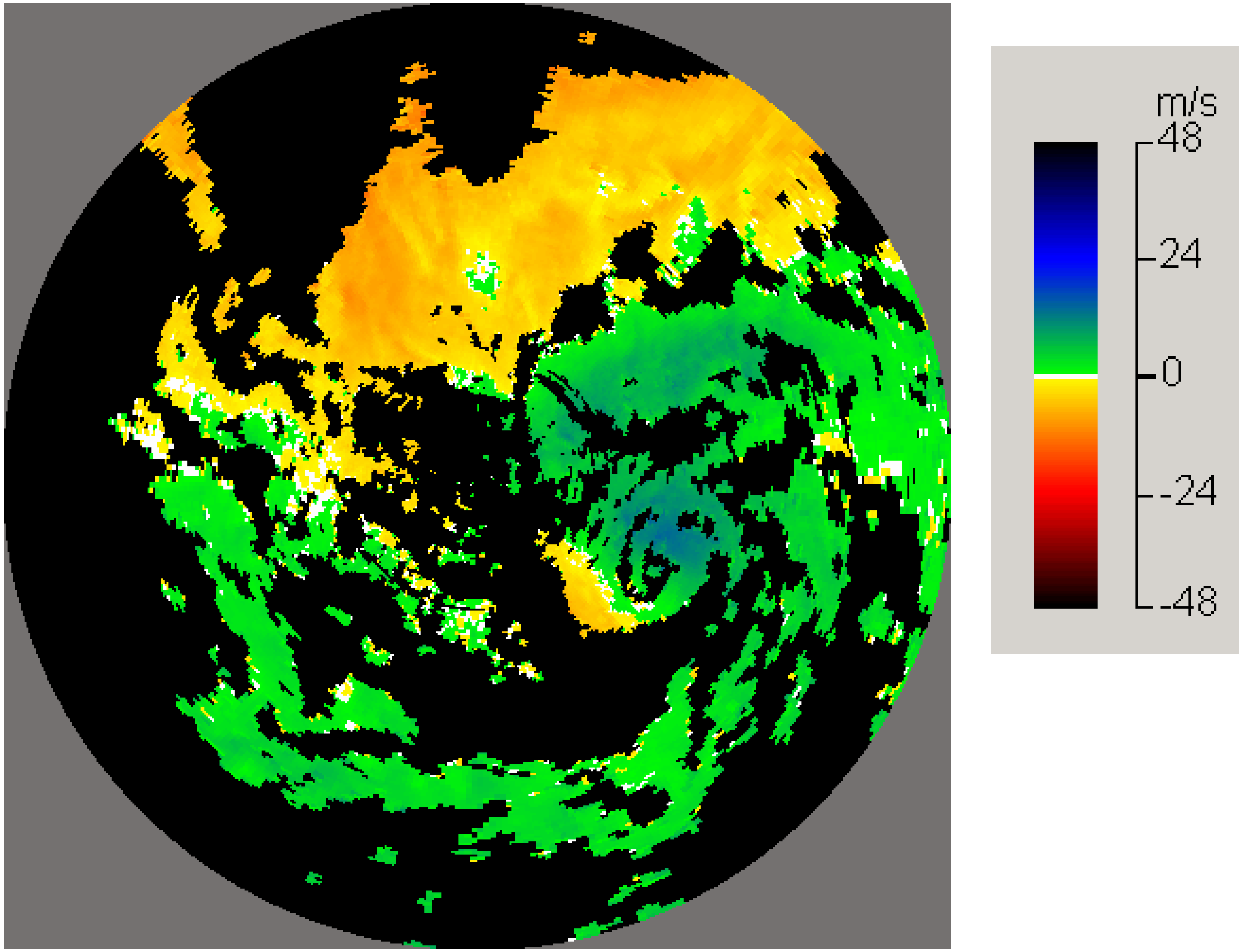


Radial Winds

Advantages:-

- No assumptions about the wind field in the radar data processing - preserves maximum information content.

Radial wind field exhibiting complex structure



Doppler radars in the UK network

- UK Met Office has 8 sets of Doppler radar hardware

- Plan to acquire wind data from the ‘non-Doppler’ radars using the staggered PRT technique of Tabery et al, 2005

Test of a staggered PRT scheme for the French radar network , P Tabery, J Perier, J Gagneux and J Parent-du-Chatelet. J. Tech 22 p352

Refractivity Measurements from Radar

- You might be able to teach old radars new tricks!

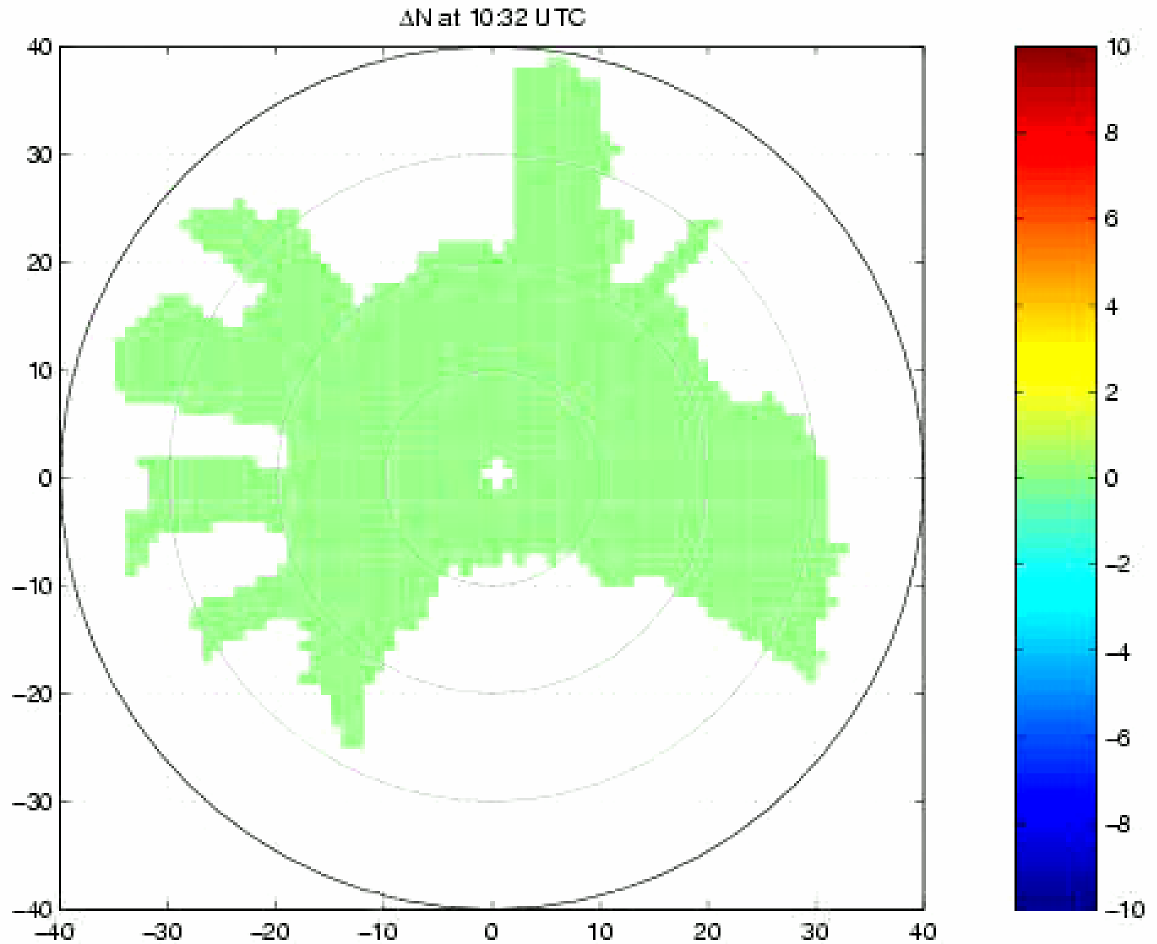
On the extraction of near-surface index of refraction using radar phase measurements from ground targets.
By Frederic Fabry, C. Frush, I. Zawadzki and A. Kilambi, Jtech. 1997

- Use returns from fixed targets in the field of view (ground surface, mobile phone masts, buildings, pylons etc) to detect changes in path average refractivity, N.

Radar refractivity measurements – history

- In the last few years, RAL and Reading University have demonstrated the technique on an L band research radar
- In the US – demonstrated on an S-band weather radar in IHOP.
- Implementation on C-band operational radars is technically very difficult.

Refractivity Fields from the RAL L-band radar

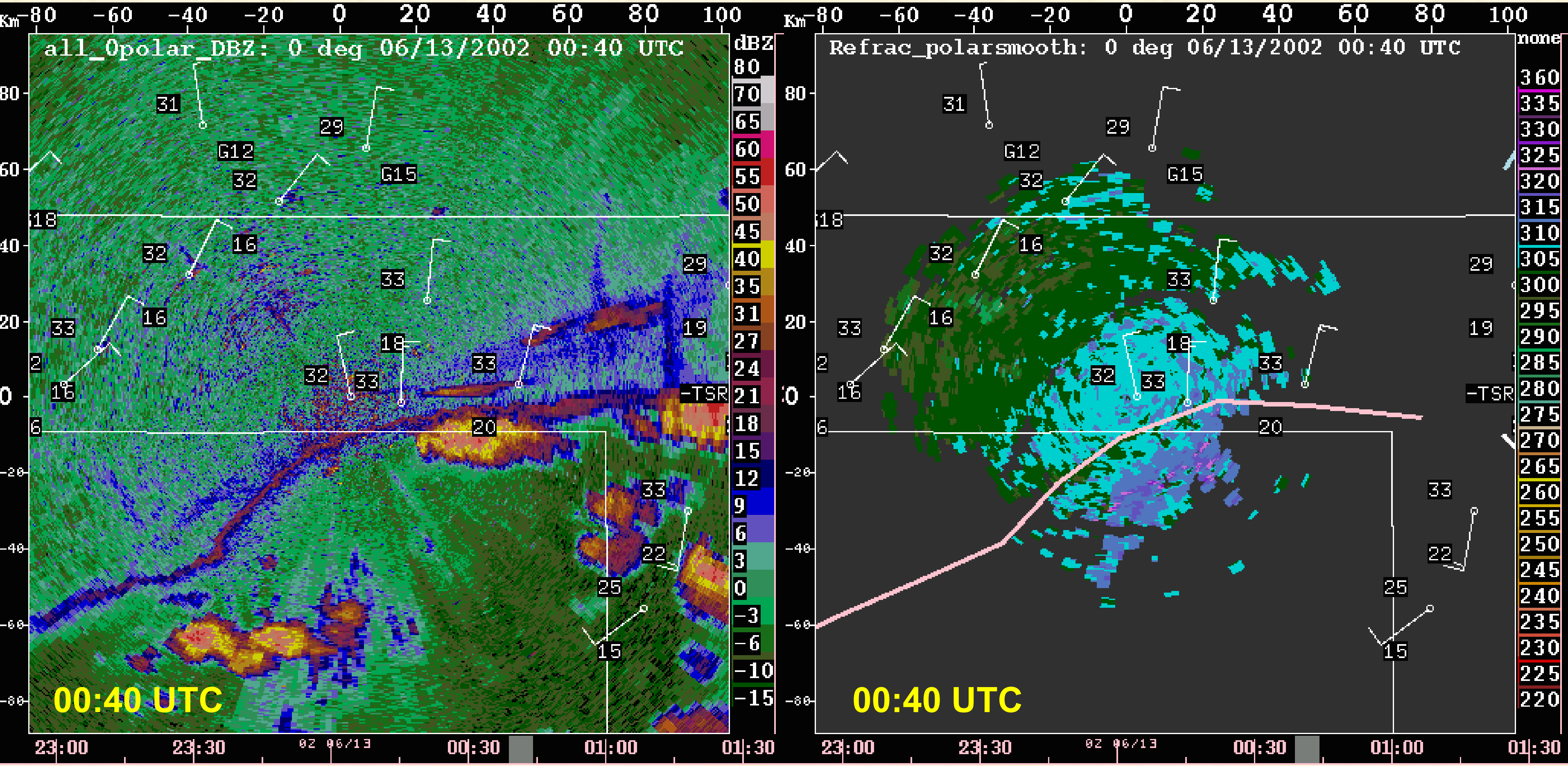


The University of Reading

Ed Pavelin

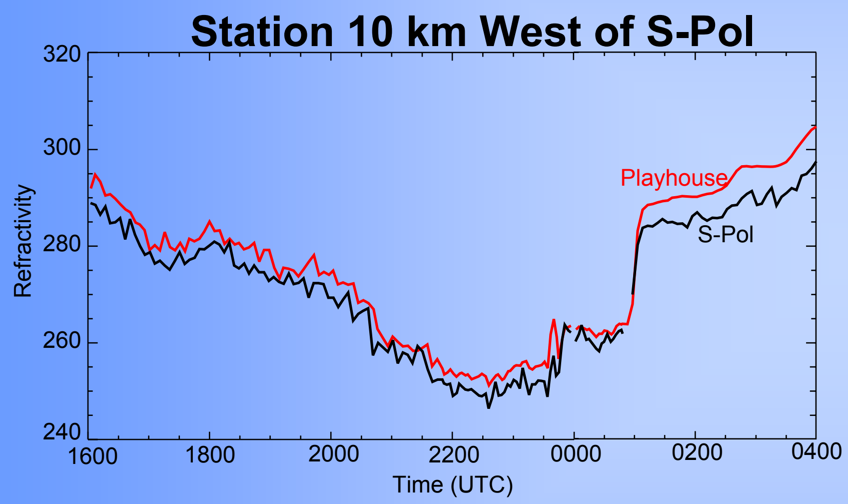
Progress in the US

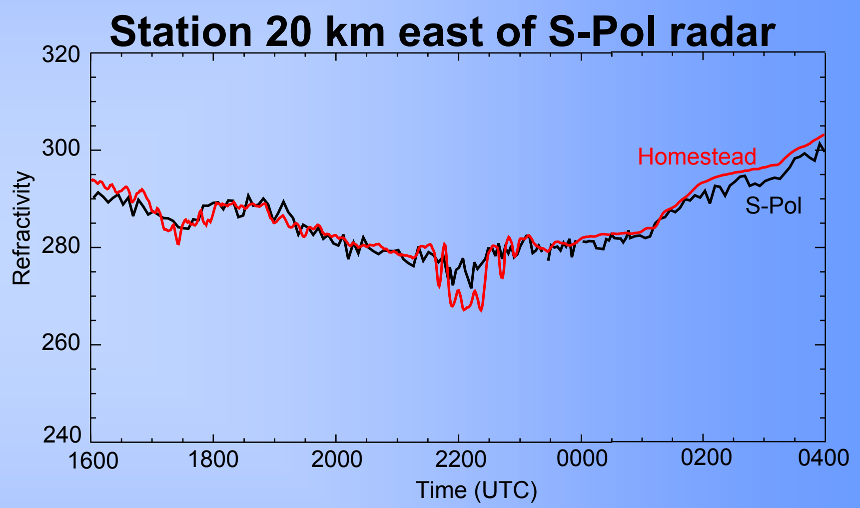
Forecasting Challenge: Tracking the "pockets" of boundary layer moisture so critical for convection initiation and growth



Moisture gradients and convergence boundaries associated with thunderstorm development, June 12, 2002

Radar Refractivity Estimates Compared to Surface Mesonet Stations

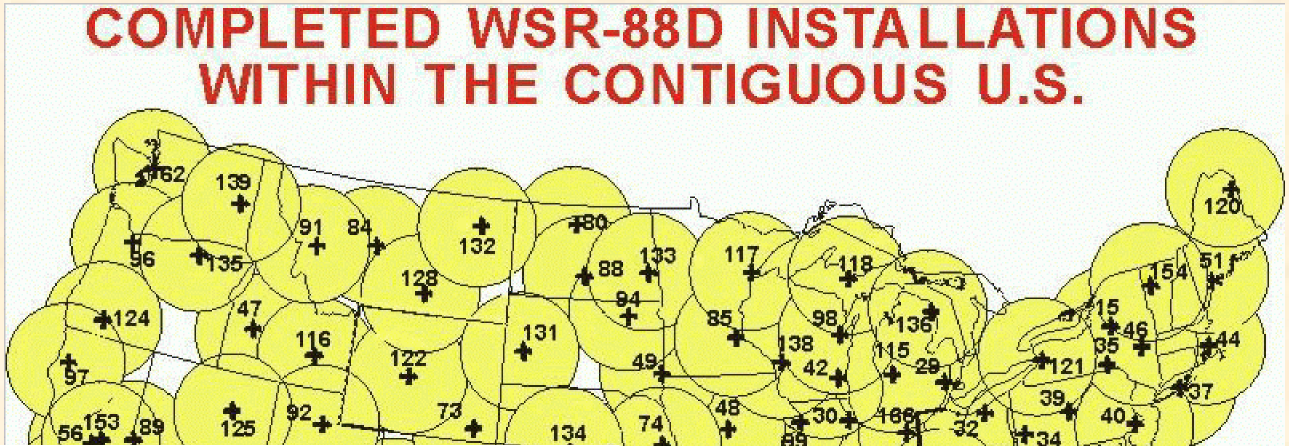




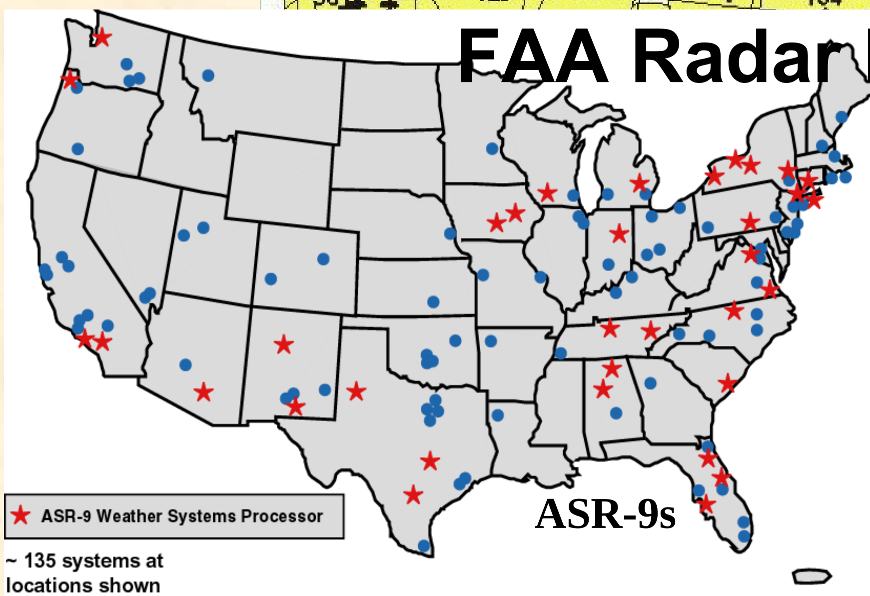
Mixing ratio (g/kg)

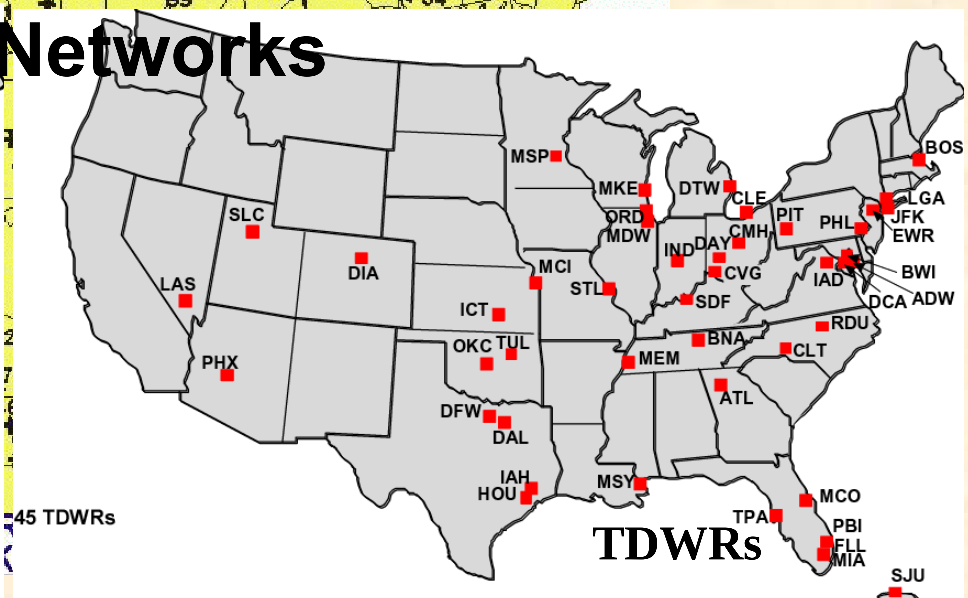
C. Pettet, T. Weckwerth, F. Fabry, J. Wilson, 2003

Future:
Install refractivity on all available operational radars



FAA Radar Networks

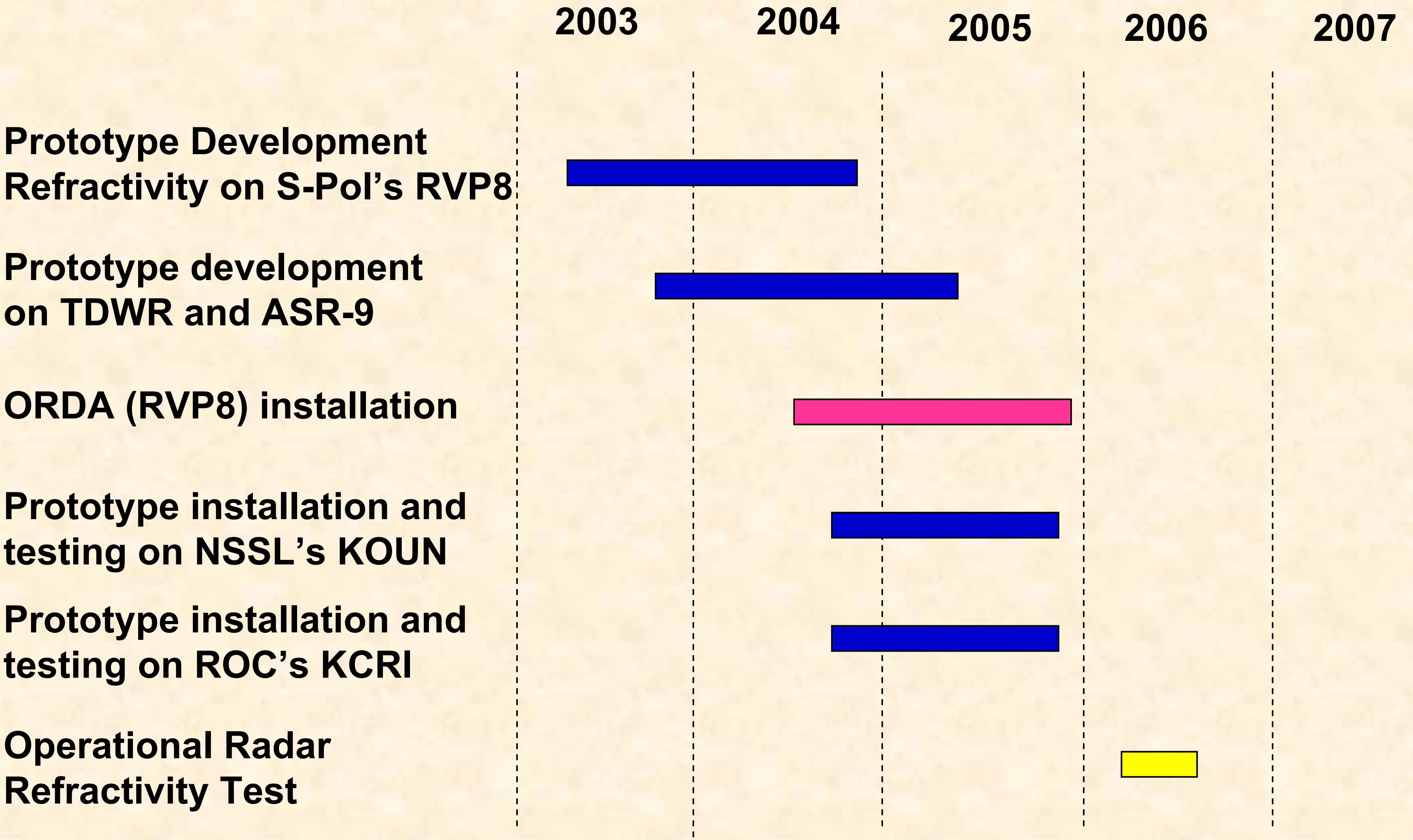




λ = 10 cm
P_T = 1000 kw
1.4° x 5° fan beam

λ = 5 cm
P_T = 250 kw
0.5° pencil beam

Timeline


2003
2004
2005
2006
2007
Prototype Development Refractivity on S-Pol's RVP8
Prototype development on TDWR and ASR-9
ORDA (RVP8) installation
Prototype installation and testing on NSSL's KOUN
Prototype installation and testing on ROC's KCRI
Operational Radar Refractivity Test

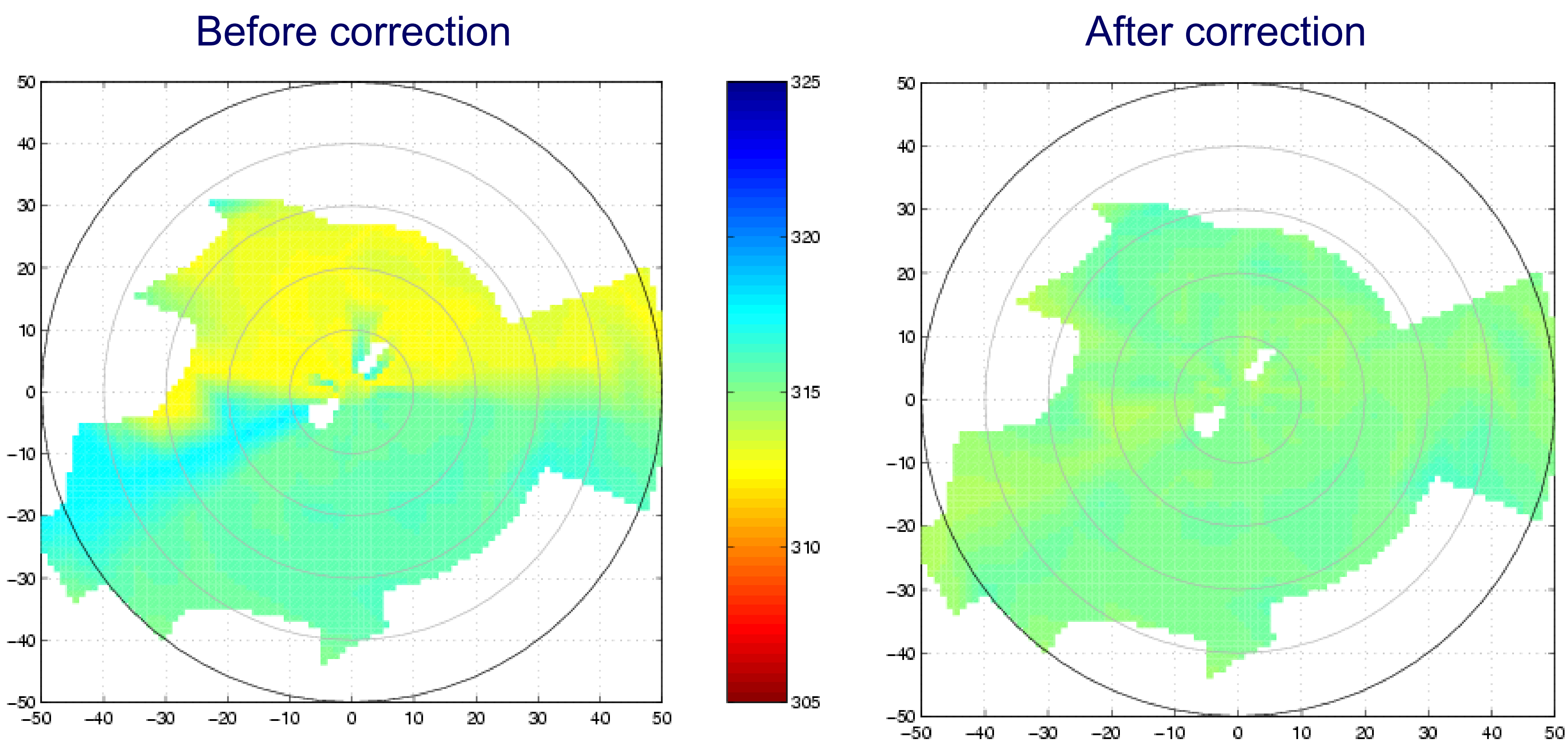
Feasibility Study in the UK

Technical issues for operational C-band radars

- Measurement of absolute phase of radar returns
- Availability and automatic identification of suitable fixed targets
- Transmitter frequency drift and monitoring
- Multiple 'folding' within the fields (phase change $>2\pi$)
- Baseline updating

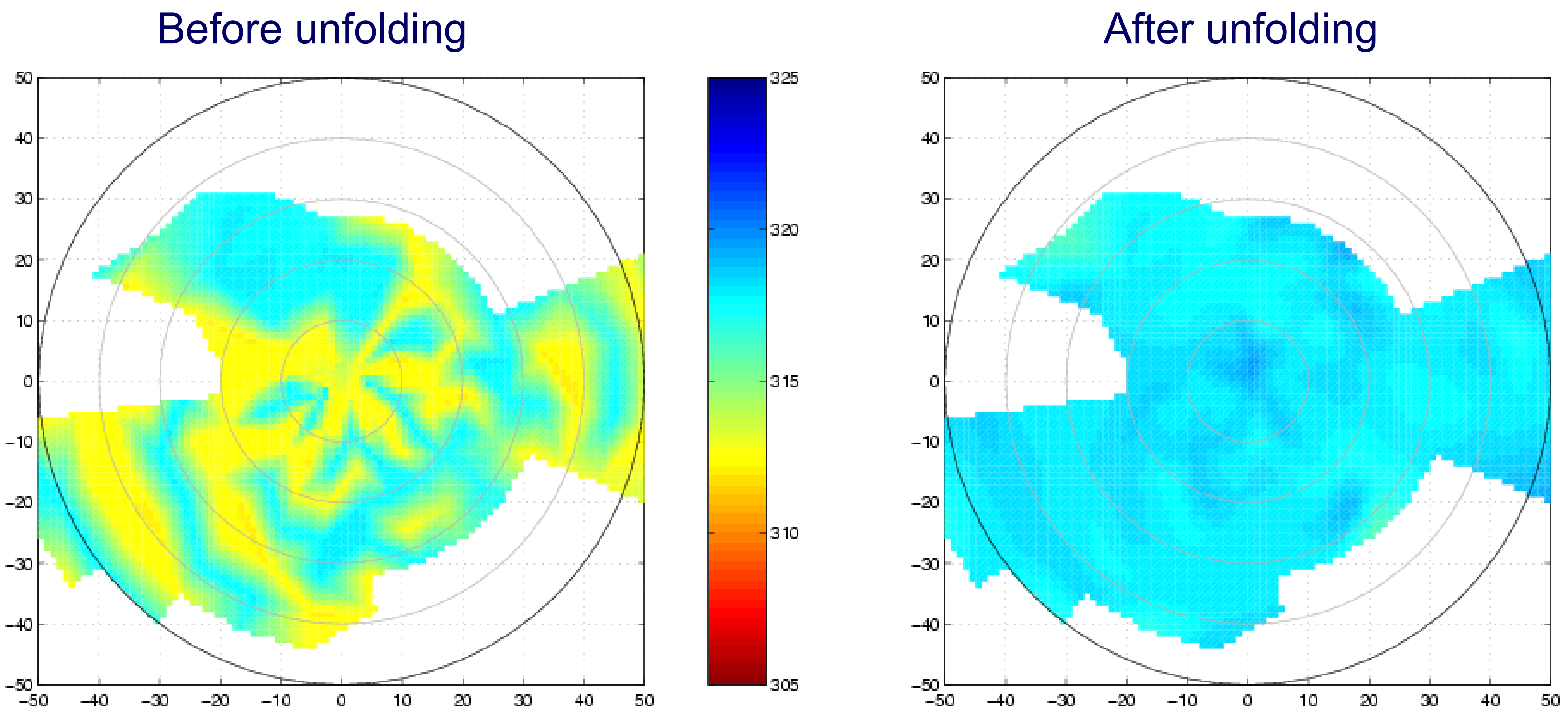
Correction for transmitter frequency drift

Refractivity Difference field between radar scans 19 minutes apart



Folding Errors

Refractivity Difference field between radar scans 26 minutes apart



The University of Reading

John Nicol

Baseline Updating

- Measurement is an increment - ΔN
- To derive N, frequent baseline updating would be required
- Baseline derived from other observations? (GPS IWV + surface measurements)
- Inferred baseline? (assume 100% RH in rain and fog?)

Feasibility Study in the UK

Technical issues:-

- Measurement of absolute phase of radar returns - OK
- Availability and identification of suitable fixed targets - Looking good (for one radar in winter!)
- Transmitter frequency drift and monitoring – OK so far
- Multiple 'Folding' within the fields – OK at least in sample data obtained so far
- Baseline correction – not yet addressed

Quality Control Issues

The technique is likely to break down in:-

- rain
- anomalous refraction conditions (radiation nights)
- high winds?

Development and tuning of quality control algorithms will take months or even years!

Radar refractivity - summary

- An opportunistic technique potentially delivering useful data. Does not require any new hardware.
- Progress is being made in overcoming some of the technical hurdles at C-band, but significant challenges remain
- Even with a relatively dense network of weather radars, data coverage is likely to be patchy

Happy to answer any questions