The three-dimensional structure of convective storms

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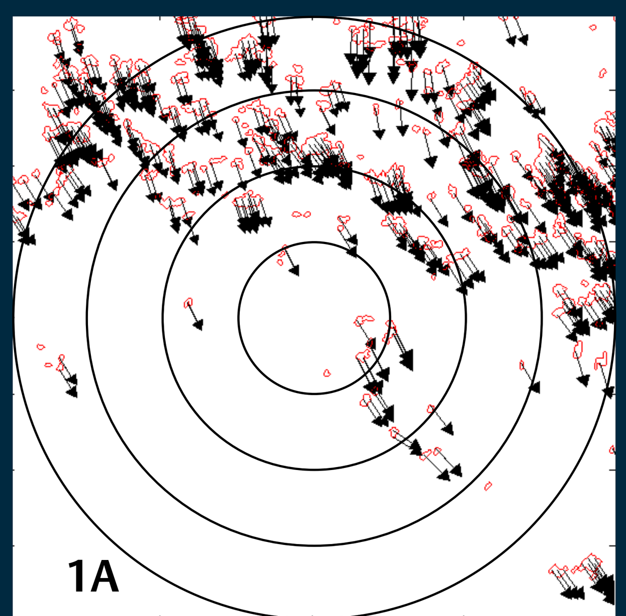
Motivation

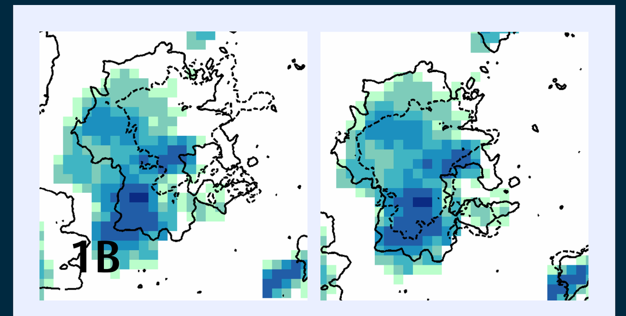
This work forms part of the **NERC** funded **DYMECS** project in partnership with the UK **Met Office**, to study the **Dy**namical and **M**icrophysical **E**volution of **C**onvective **S**torms. Convection-permitting models, such as the Met Office UK 1.5km forecast model (**UKV**), regularly fail to reproduce the timing and characteristics of convective storms seen in rainfall observations. By tracking convective storms in real time with the **Chilbolton** 3-GHz radar, high-resolution volume scans showing the evolution of **storm height** and extent can be obtained for a large number of storms.

Rather than focusing on single-storm case studies, the DYMECS project aims to provide **statistical analyses** of convective storms to evaluate the UKV and other models to highlight systematic biases in modeled convective processes. On this poster, the Met Office **Unified Model** (UM) is evaluated against the Chilbolton observed storm structures, using various grid lengths and model configurations, including the UKV.

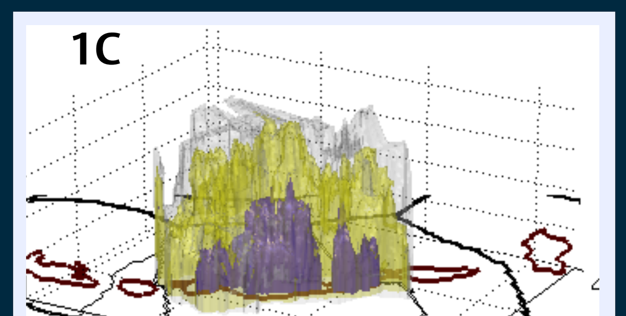
Radar storm-volume reconstruction



Arrows indicate the 30-minute displacement derived from the auto-correlation method. Concentric circles are at 50km intervals from the Chilbolton radar.

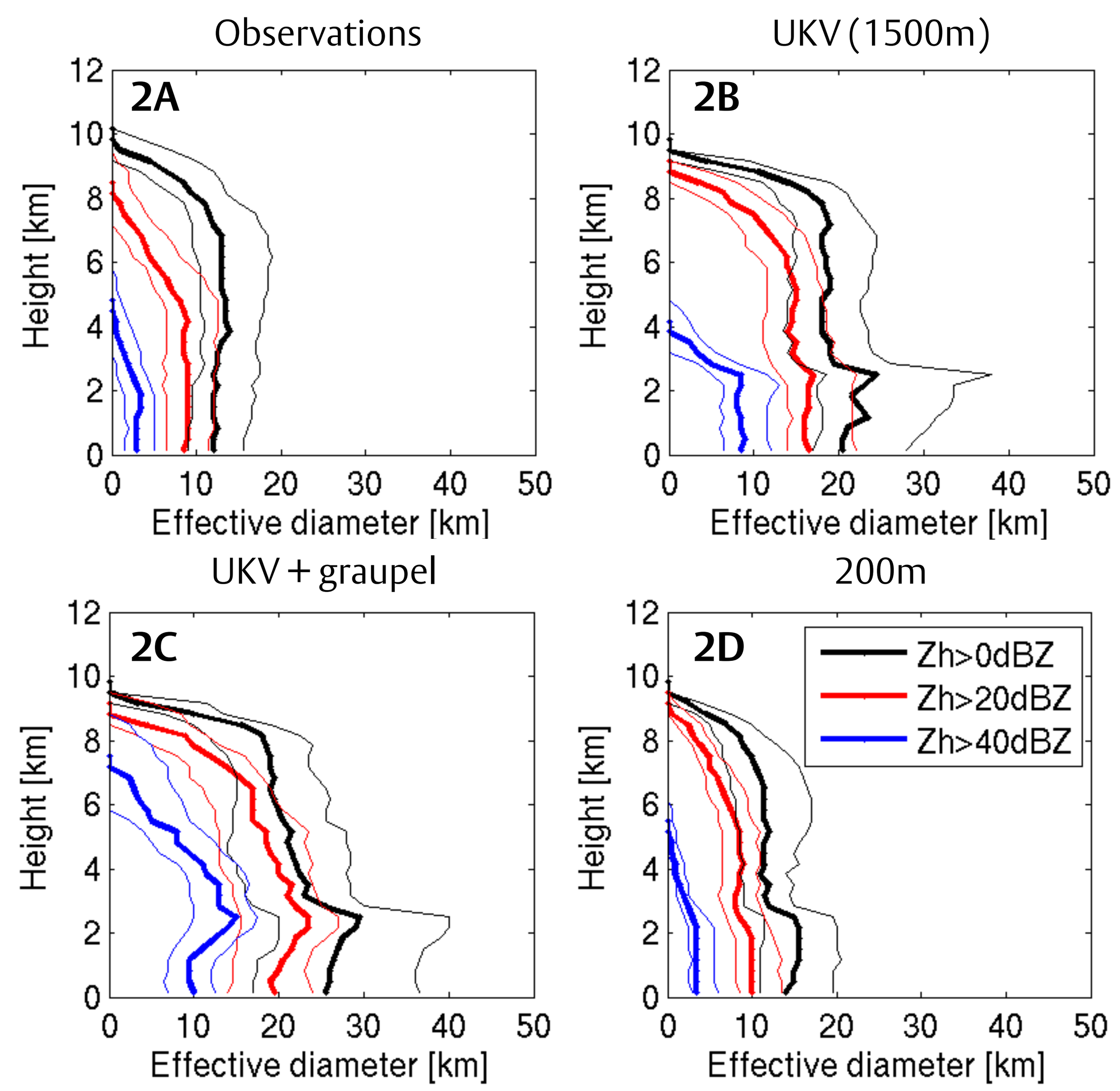


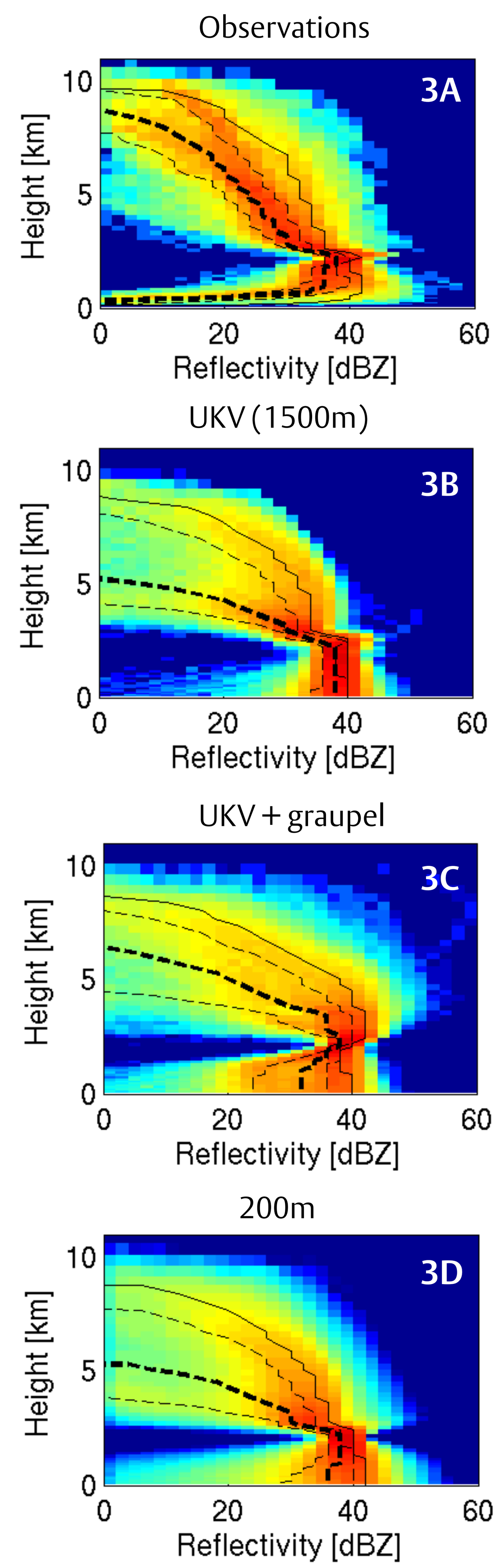
Rainfall at 11:00:00
10 dBZ at 0.5° elevation at 11:04
10 dBZ at 4.1° elevation at 11:08



0 dBZ | 20 dBZ | 40 dBZ

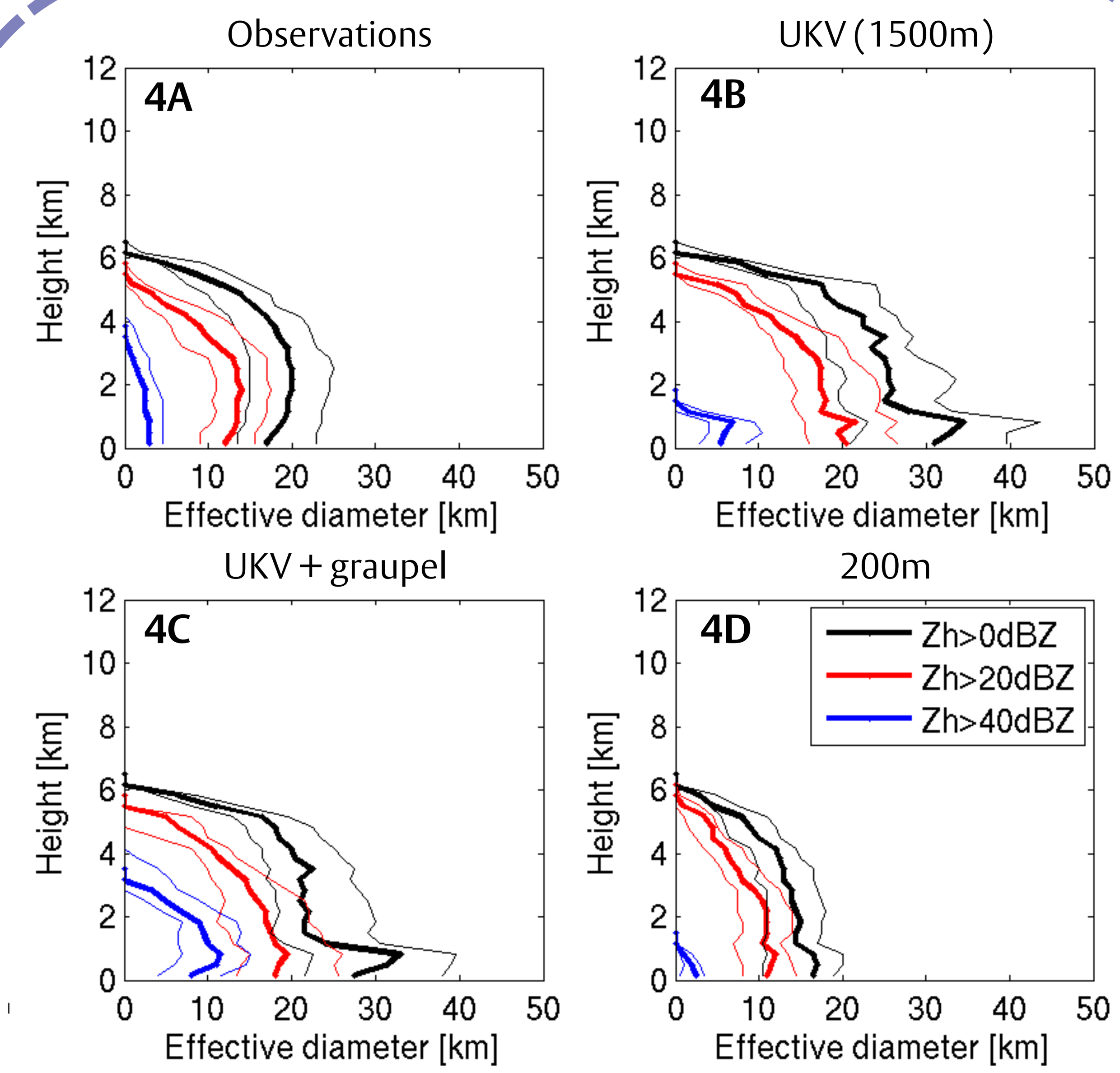
- The Chilbolton radar has a 25 m dish and hence very high resolution (0.25° beamwidth) but low scanning velocity (2° s^{-1} in azimuth).
- The delay between first and last scan within a volume can be 5 minutes or more.
- Use the rainfall radar network images to derive storm motion vectors from auto-correlation (see figure 1A).
- Use average storm motion to translate individual scans to a single time (see figure 1B).
- Reconstruct storm volumes (see figure 1C) from bottom up using the following rules:
  - Overlap with previous layer.
  - Nearest storm only.
  - Within 25 km of rain area.





Deep convection

- Models at 1500m resolution produce storms that are too wide at all levels (compare figures 2B and 2C with 2A: median widths are thick lines, with 25th and 75th percentile widths in thin lines).
- Models at 200m resolution produce realistic storm microphysical structures (figure 2D).
- Inclusion of graupel improves the core reflectivities but the core is too wide and deep (figure 2C).
- All models show a sharp increase at the melting layer that is not observed.
- Reflectivity vs height distributions conditioned on reflectivity at 2 km between 35-40 dBZ indicate high rainfall from clouds with low ice water content (figures 3A-D).
- Analysis of model cloud and humidity fields should reveal microphysical processes responsible for heavy rain from little ice.



Small, scattered showers

- A very different synoptic situation reveals mostly similar model errors (figures 4A-D).
- Models at 200m resolution now produce storms that are slightly too narrow and with too low reflectivities in the ice core.

Future work

- Evolution of storms.
- Relation to large-scale thermodynamic environment (soundings).
- Vertical velocity retrievals (tracking spectral width features).