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 Dynamical and Microphysical Evolution of Convective Storms. 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.

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).

Radar storm-volume reconstruction

- 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.