The three-dimensional structure of convective storms

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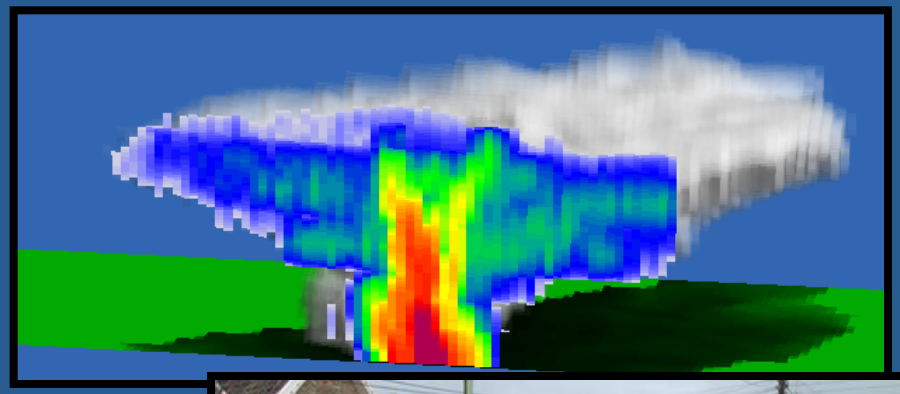
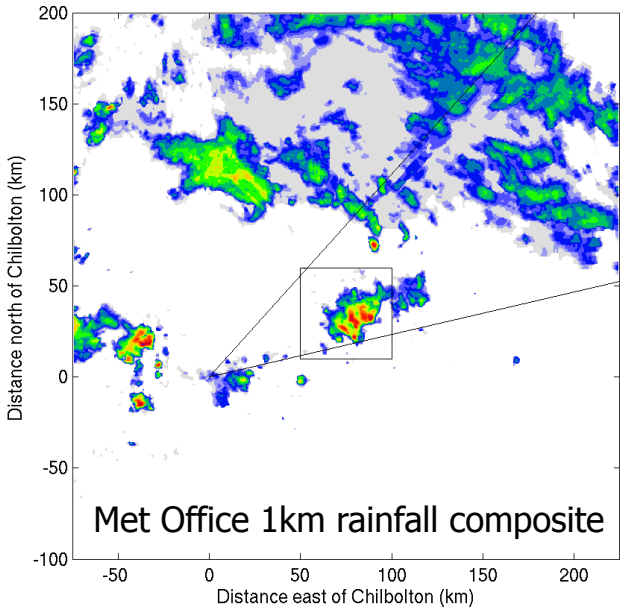


Robin Hogan
John Nicol
Robert Plant
Peter Clark

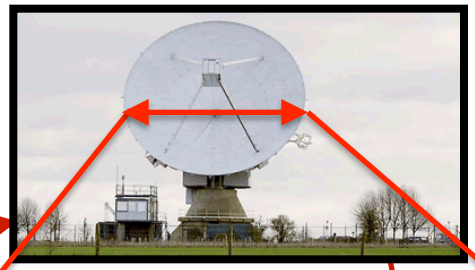
University of Reading

Kirsty Hanley
Carol Halliwell (UK Met Office)
Humphrey Lean

The DYMECS approach: beyond case studies

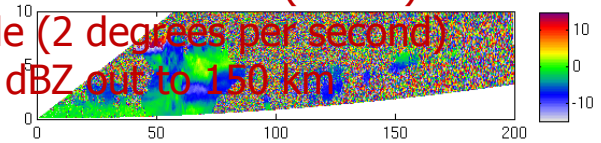


Track storms in real time and automatically scan Chilbolton radar

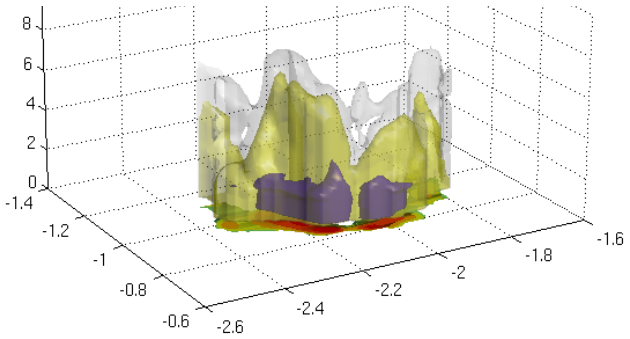


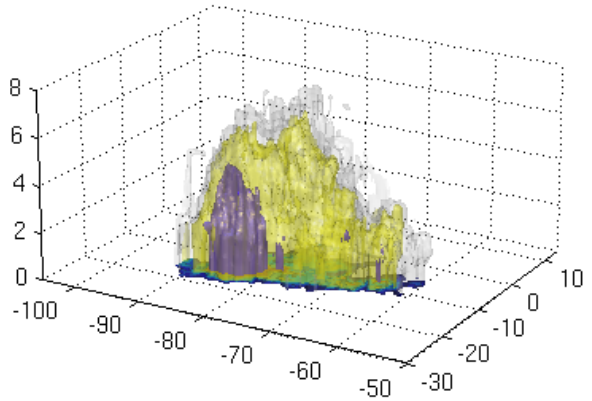
Derive properties of hundreds of storms on **~40 days**:
Vertical velocity
3D structure
Rain & hail
Ice water content
TKE & dissipation rate

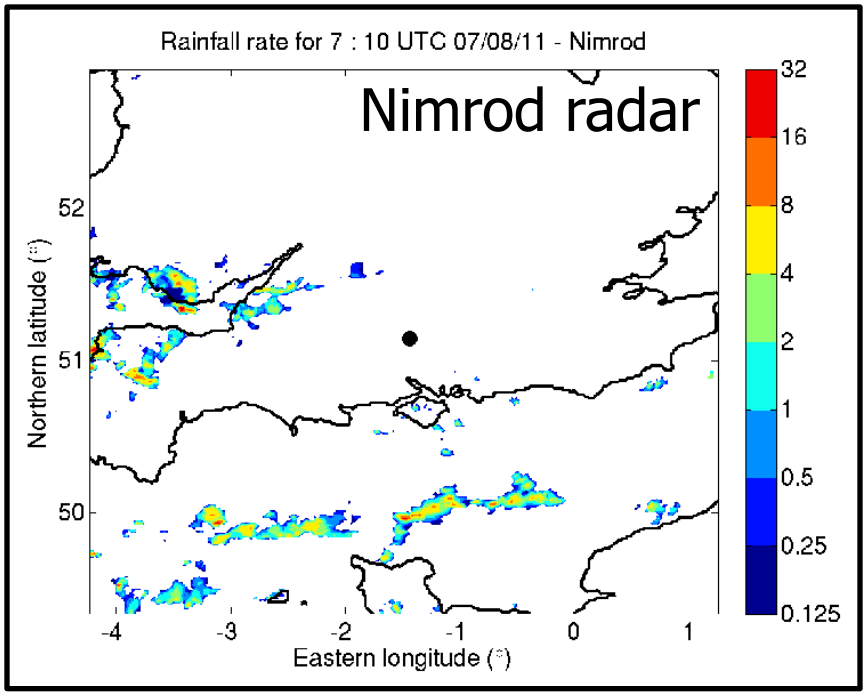
25m diameter S-band (3 GHz)
Steerable (2 degrees per second)
0 dBZ out to 150 km

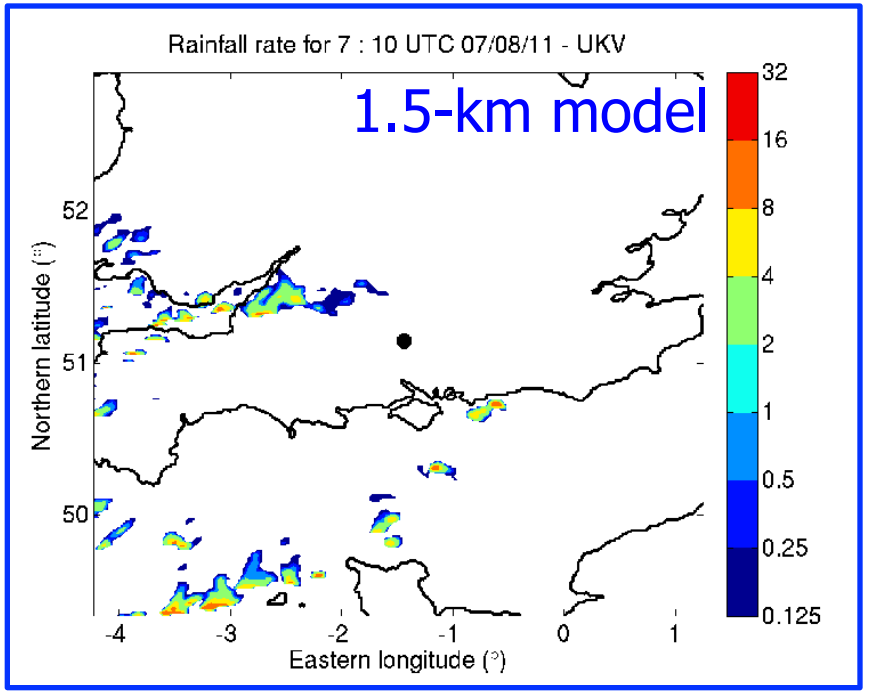


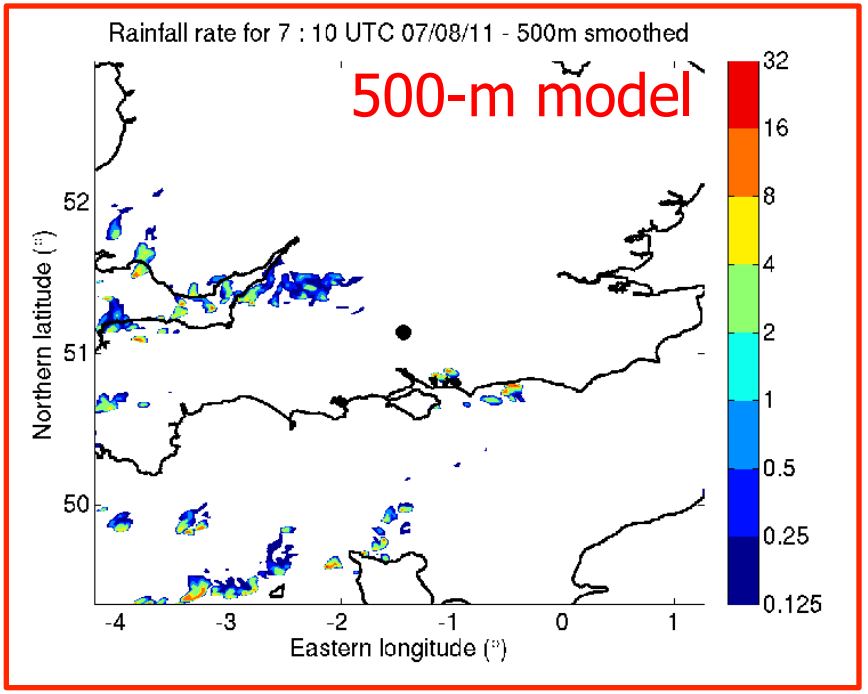
Evaluate these properties in model varying:
Resolution
Microphysics scheme
Sub-grid turbulence parametrization

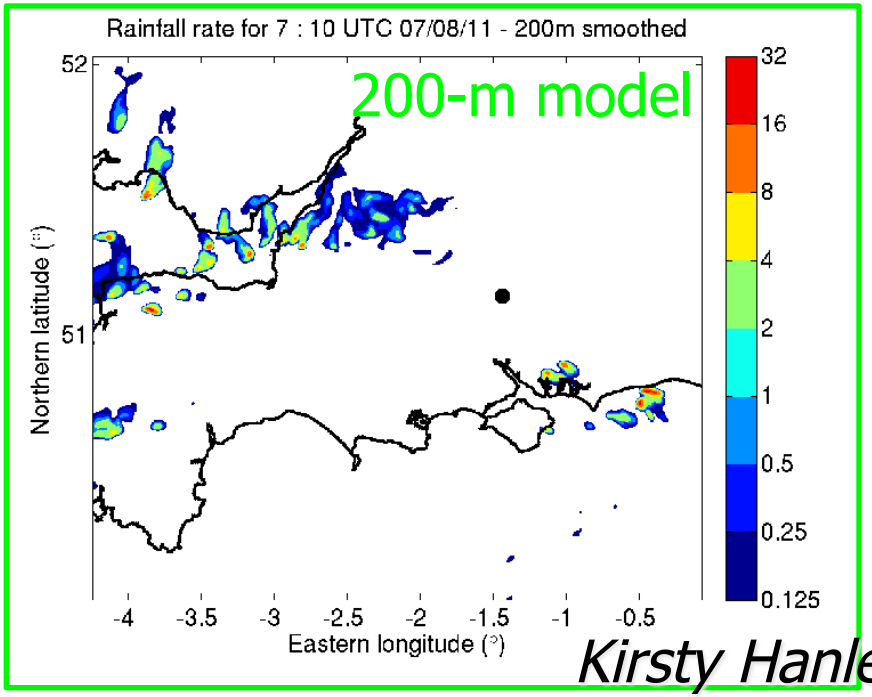






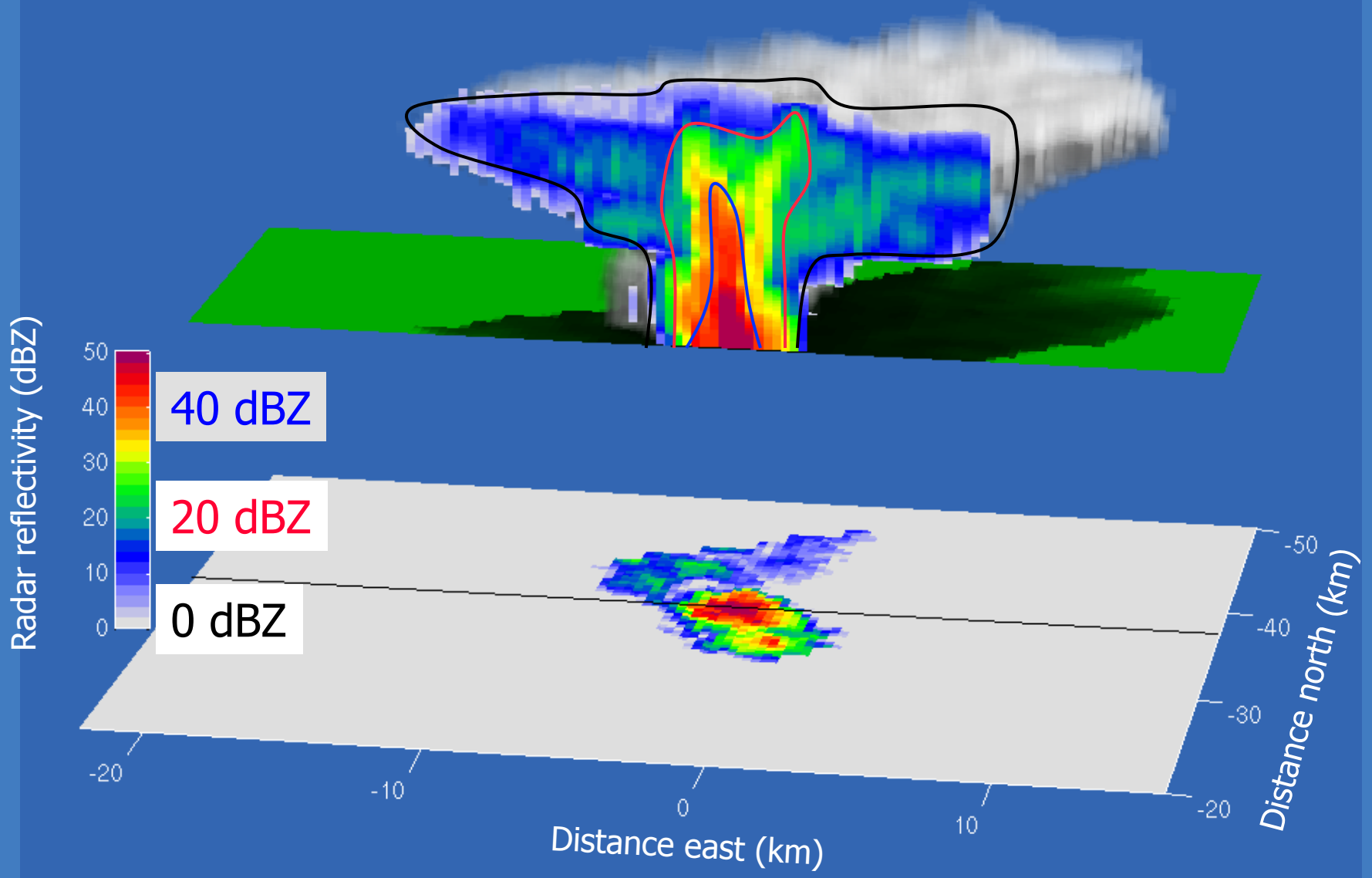




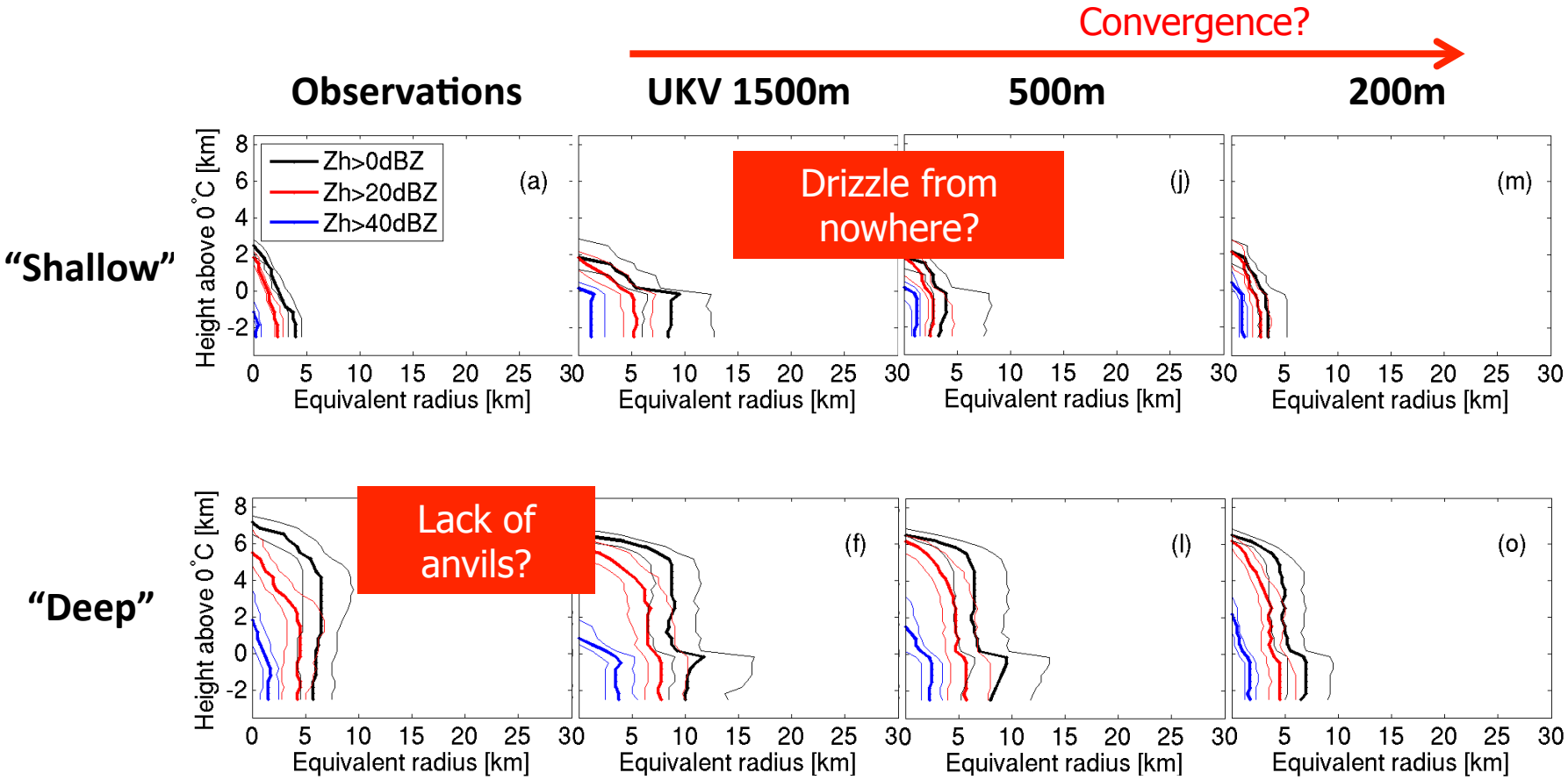


Kirsty Hanley

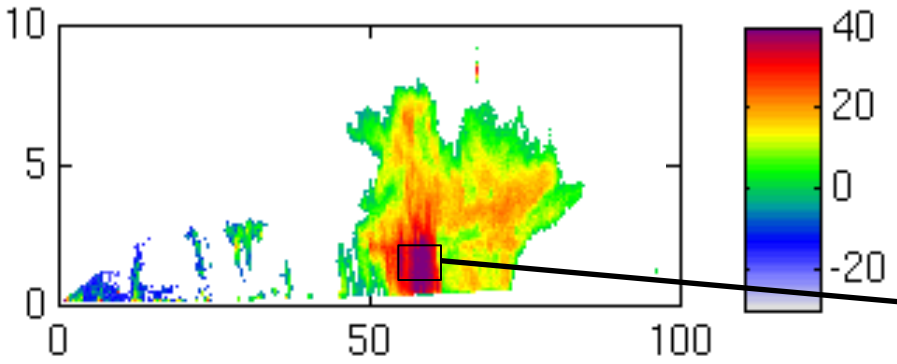
Storm structure from radar



Median storm diameter with height



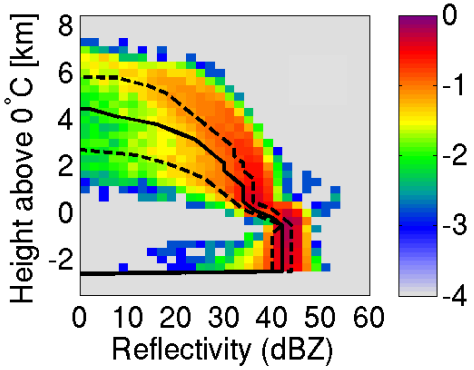
Vertical profiles of reflectivity



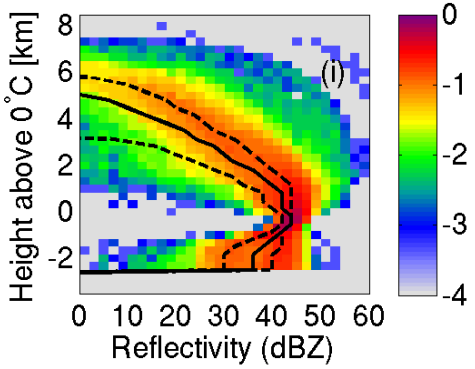
Model:
High rainfall rate from storms lacking ice or have ice cloud dBZ<0

Reflectivity distributions for profiles with this mean Z 40-45 dBZ are shown.

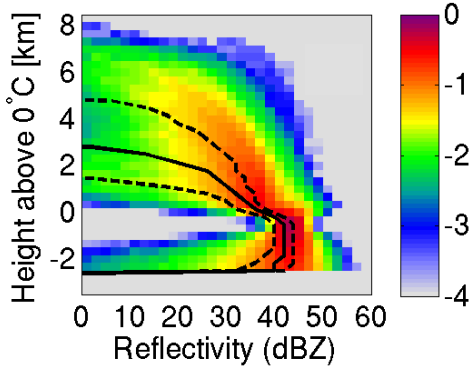
1.5-km



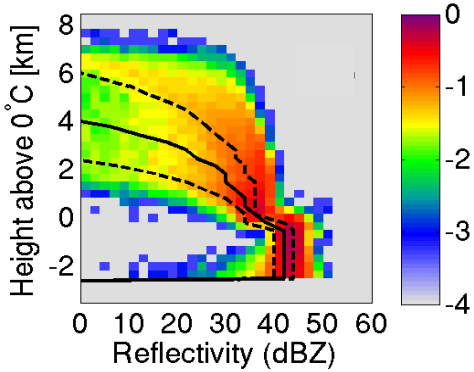
1.5-km + graupel



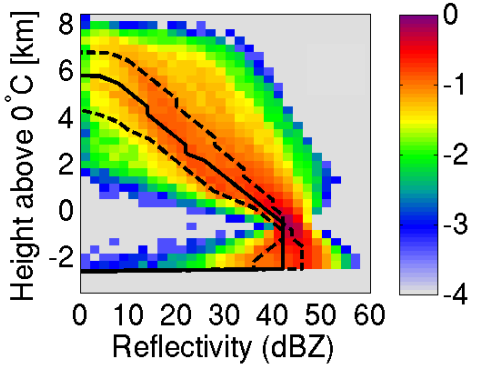
200-m



1.5-km new PSD

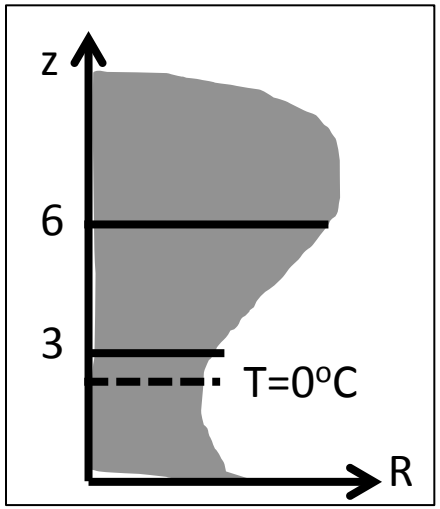


Observations

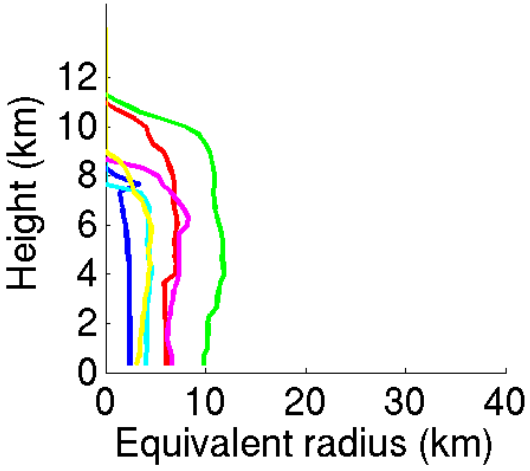


Missing anvils?

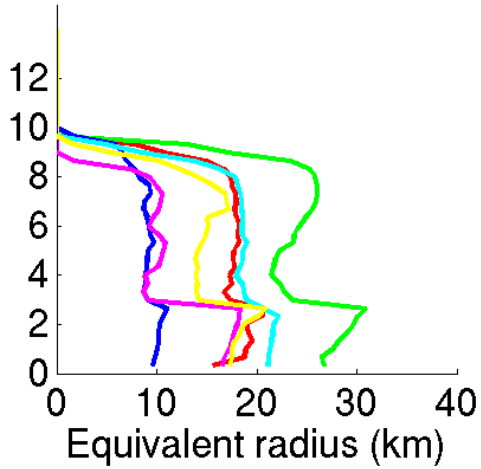
- Define anvil as cloud above 6km with diameter larger than storm diameter at 3km.
- More than 40% of storms above 6km have anvil (model and observations).



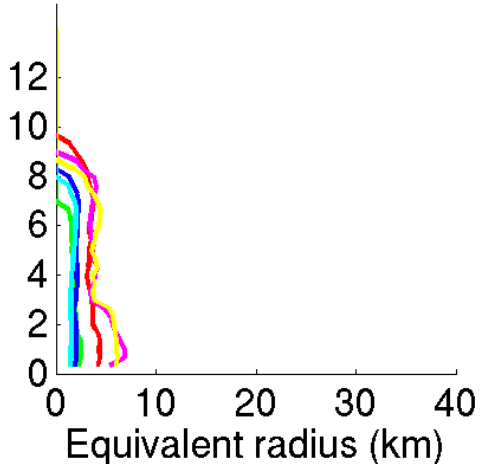
Observations



UKV 1500m



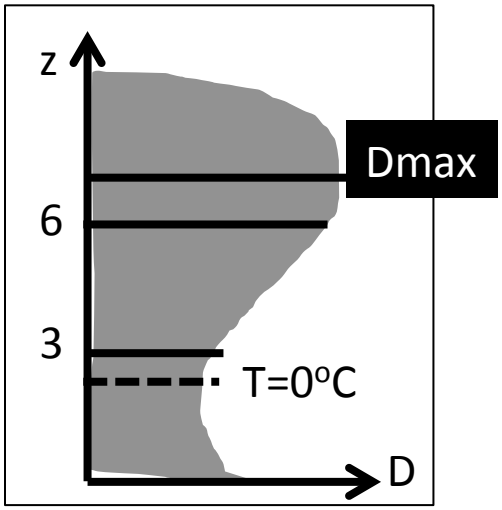
200m

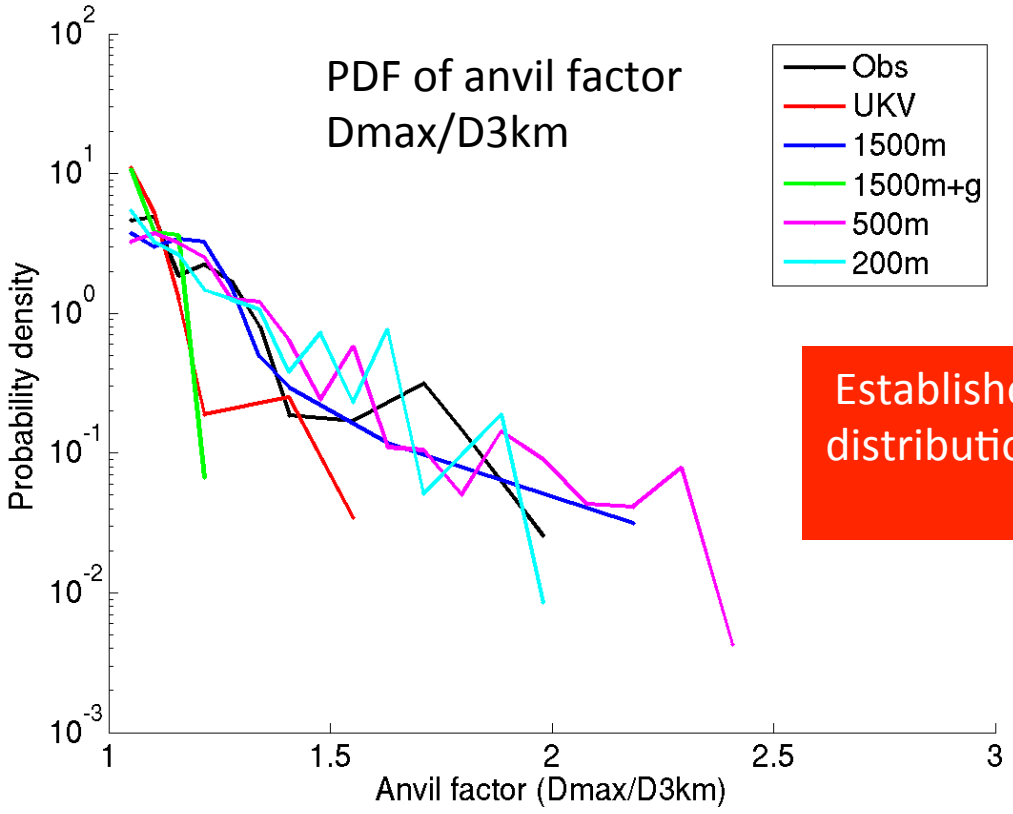


A selection of individual profiles shows anvil factors will be small (close to 1)

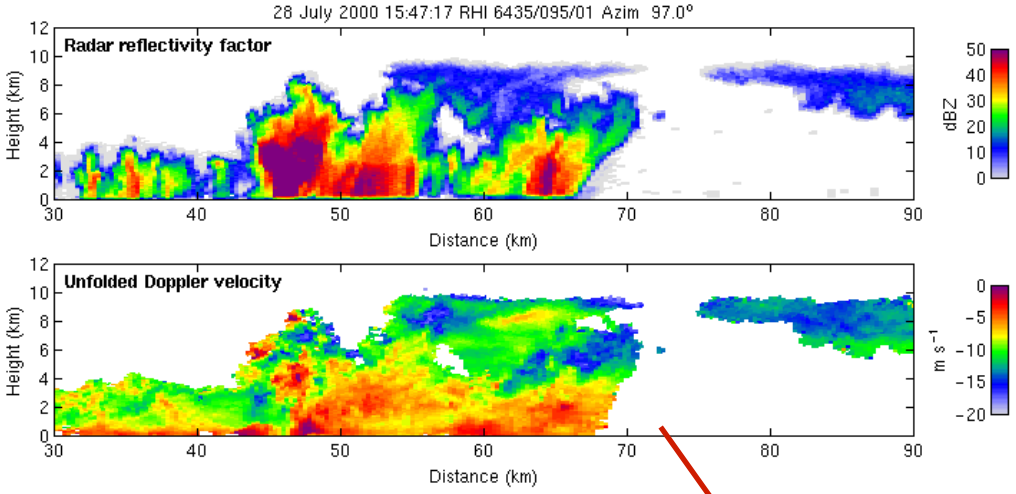
Missing anvils?

- Define anvil as cloud above 6km with diameter larger than storm diameter at 3km (500m above the melting layer).



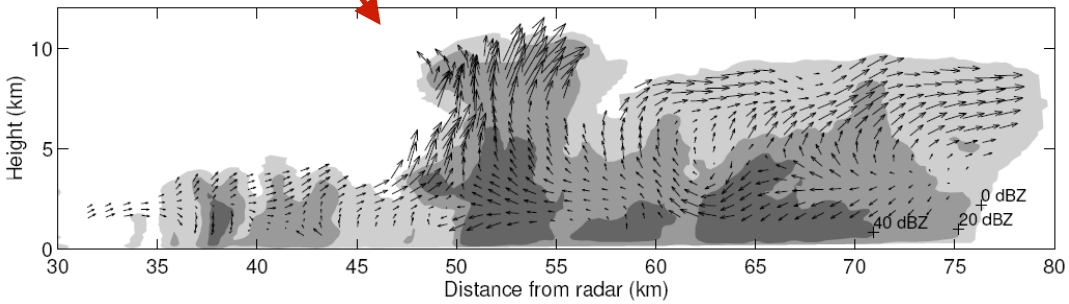


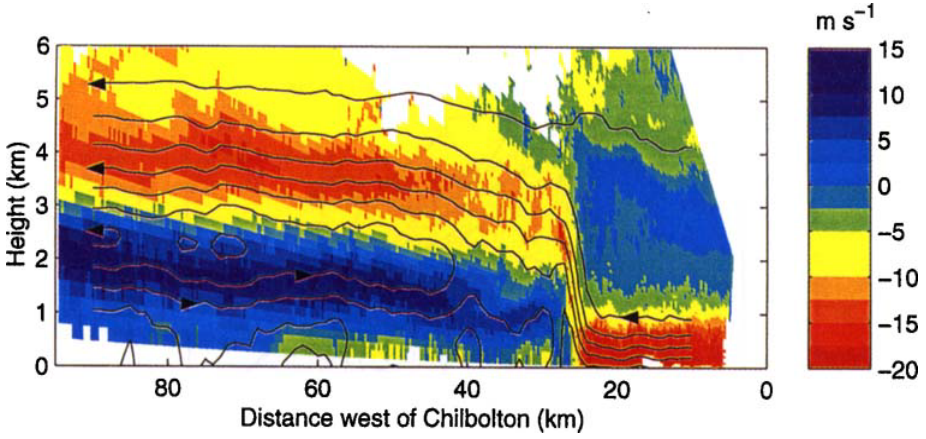
Established typical anvil distribution for southern UK



Updrafts?

- Hogan et al. (2008)
  - Track features in radial velocity from scan to scan



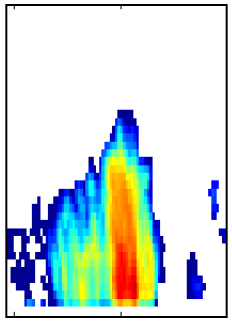


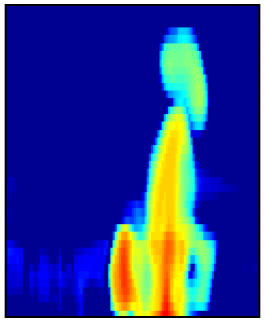
Chapman & Browning (1998)

- In quasi-2D features (e.g. squall lines) can assume continuity to estimate vertical velocity

Updraft retrieval

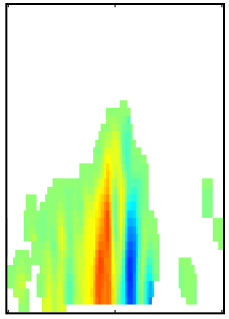
Observations **UKV 1500m**

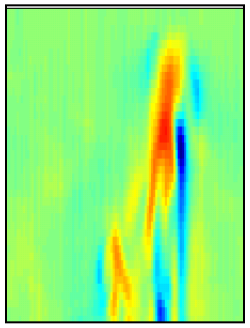




Reflectivity

40 dBZ

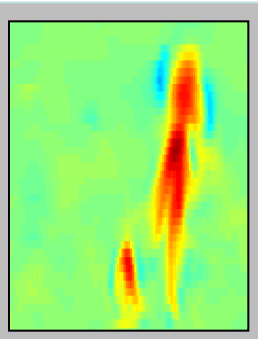




Estimated vertical velocity

+10 m/s

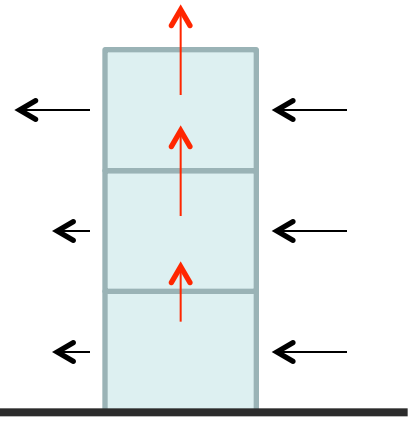
-10 m/s



Actual model vertical velocity

10 km height

20 km width

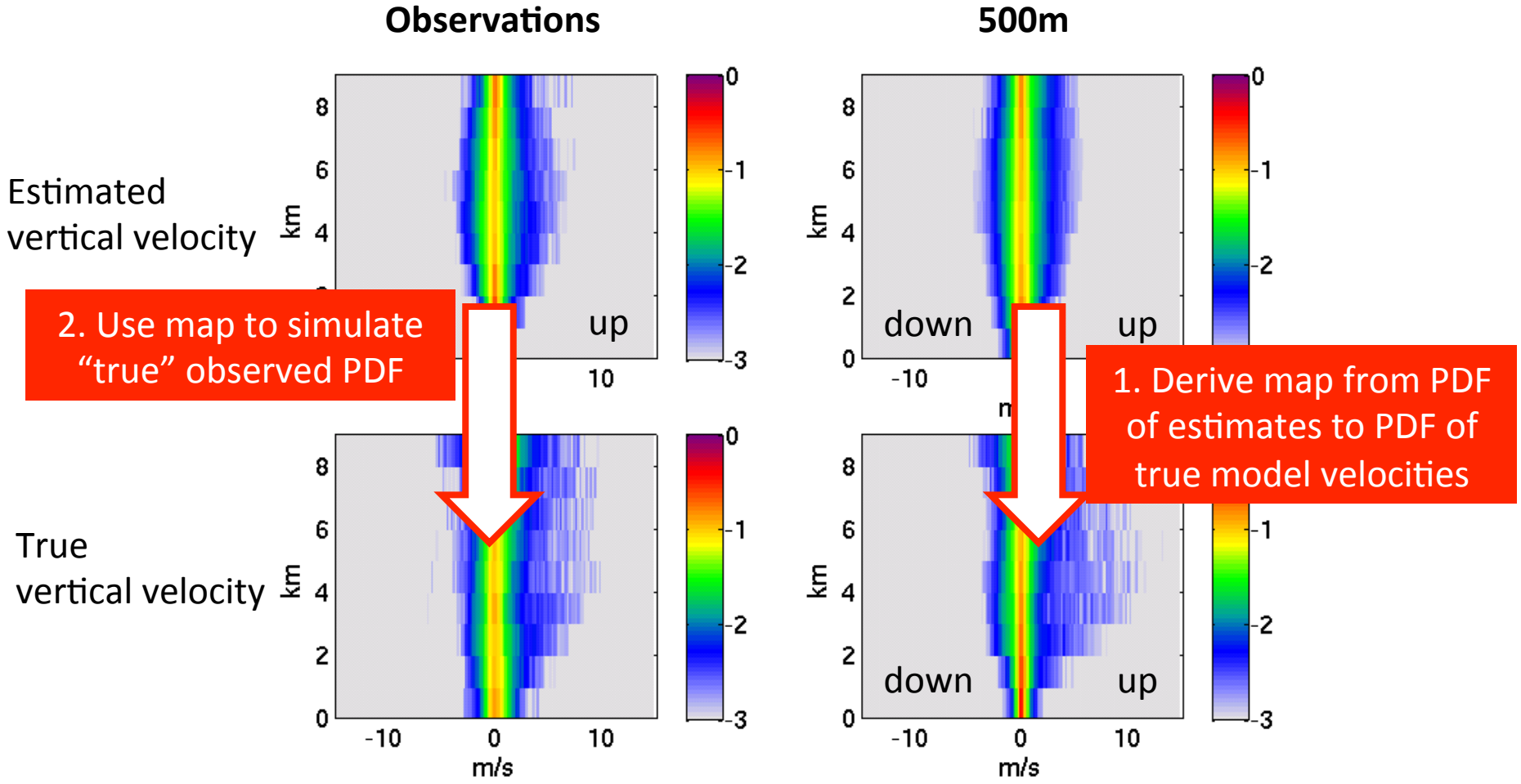


Estimate vertical velocity from vertical profiles of radial velocity, assuming zero divergence across plane.

Quantify errors due to 2D flow assumption

(thanks to John Nicol)

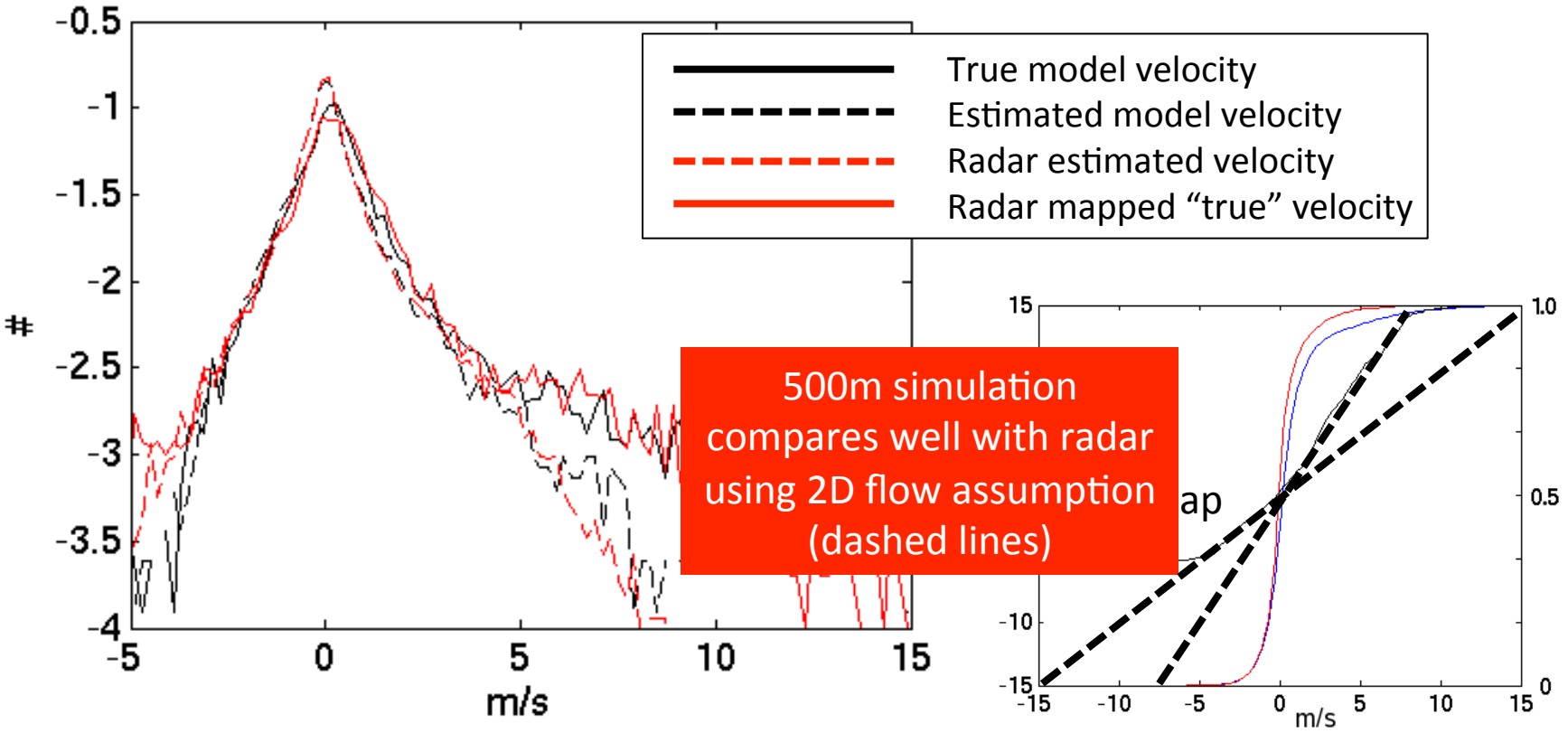
Vertical velocity distributions with height



(thanks to John Nicol)

Radar data with dBZ>0 within 90 km of the radar

Vertical velocity distribution between 7-8 km



(thanks to John Nicol)

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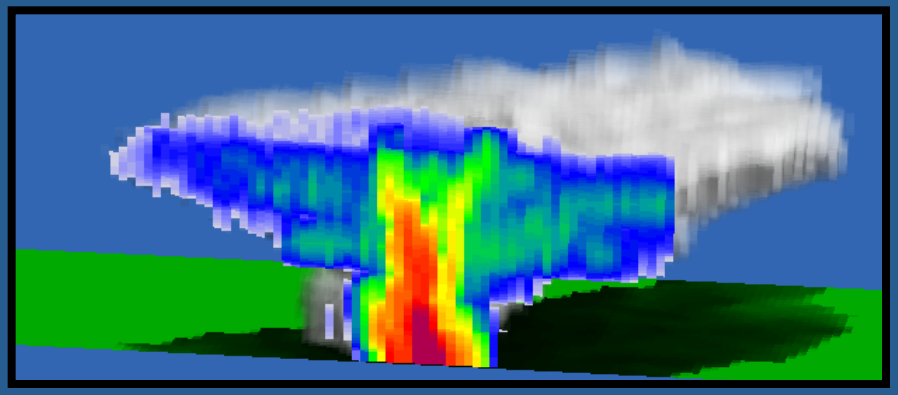

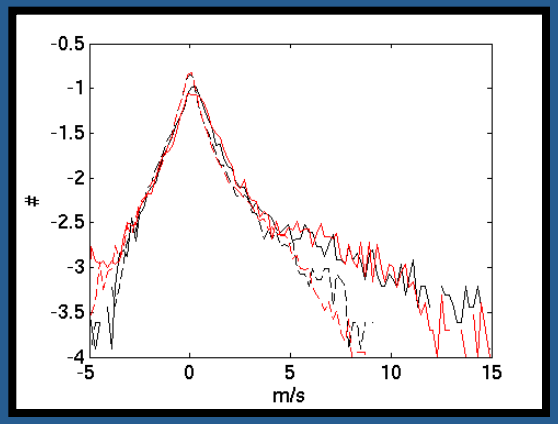

Model ice cloud has too low ice water content associated with high rainfall.

Similar probabilities of anvil in model and observations.

PDF of vertical velocity estimates using 2D flow assumption shows good agreement between 500m model and observations.