The role of sub-grid mixing on the scale and evolution of convective storms in high resolution simulations

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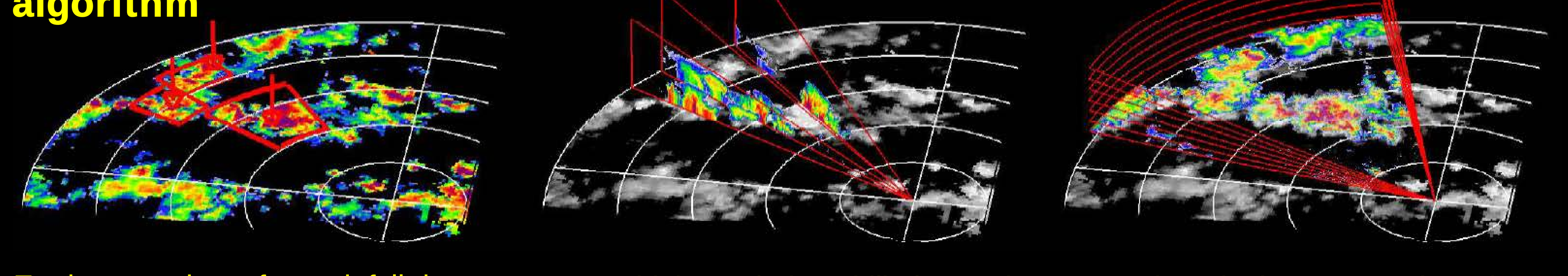
1. Introduction to DYMECS

- **Convection-resolving forecast models** are the new frontier in operational regional forecasting, but how realistic are the simulated clouds? Does higher resolution always improve the realism?
- In the **Dynamical and Microphysical Evolution of Convective Storms** project we evaluate the Met Office forecast model via a statistical analysis of thousands of storms on many days.
- Test impact of model resolutions from **1.5 km to 100 m** as well as mixing length and microphysics.
- **Three dimensional cloud structures** and estimates of **updraft intensity & width** are derived from the high-resolution Chilbolton radar using **automated storm tracking** to scan the 25-m dish.
- **Lifecycles** of surface rainfall features compared to UK radar network (5-min and 1-2 km resolution).

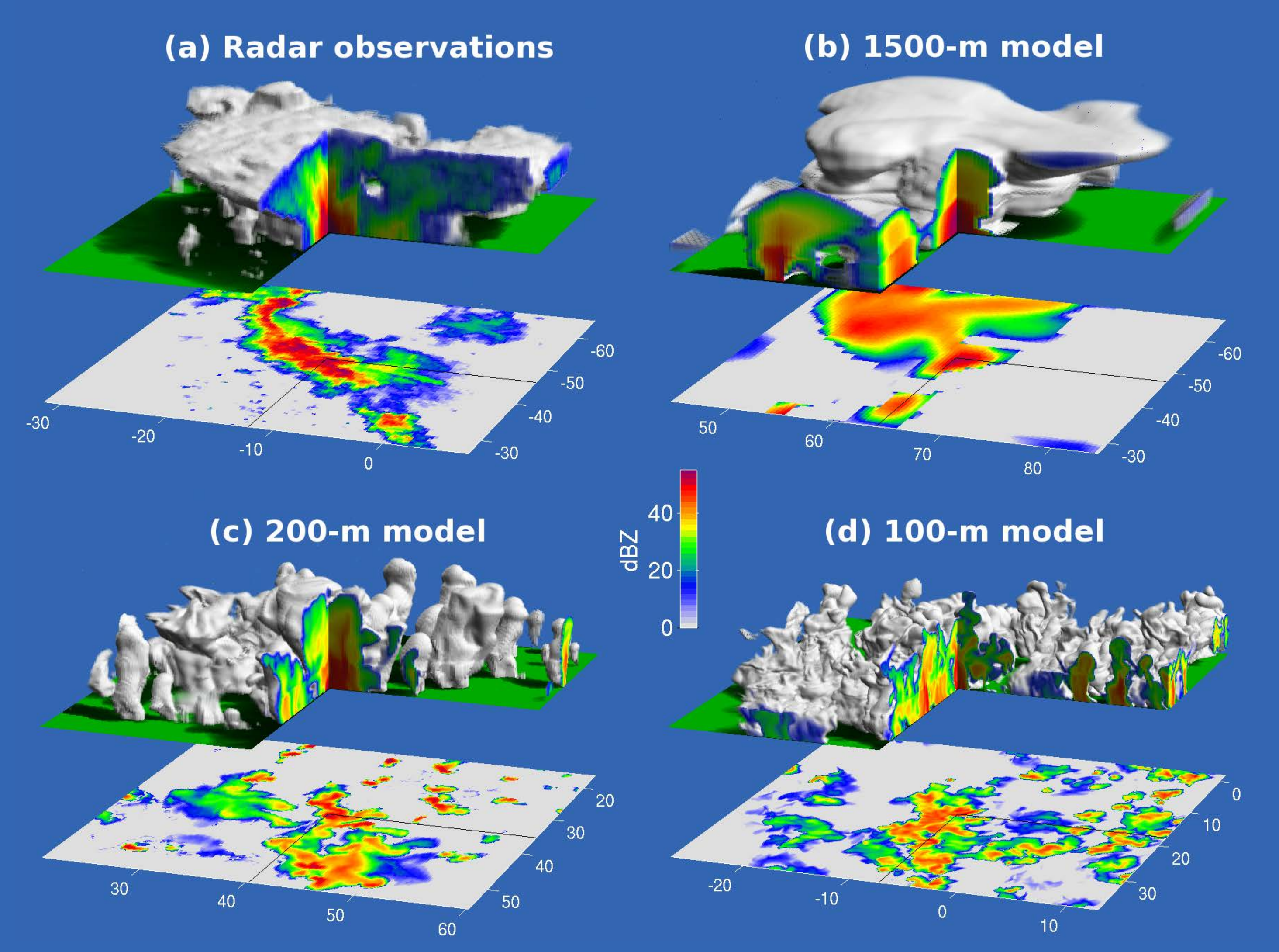
Automated storm tracking algorithm



Track storms in surface rainfall data and prioritize them…

Instruct high-resolution Chilbolton radar to do RHIs through storm cores…

…and stacked PPIs to retrieve three-dimensional structure of storms.

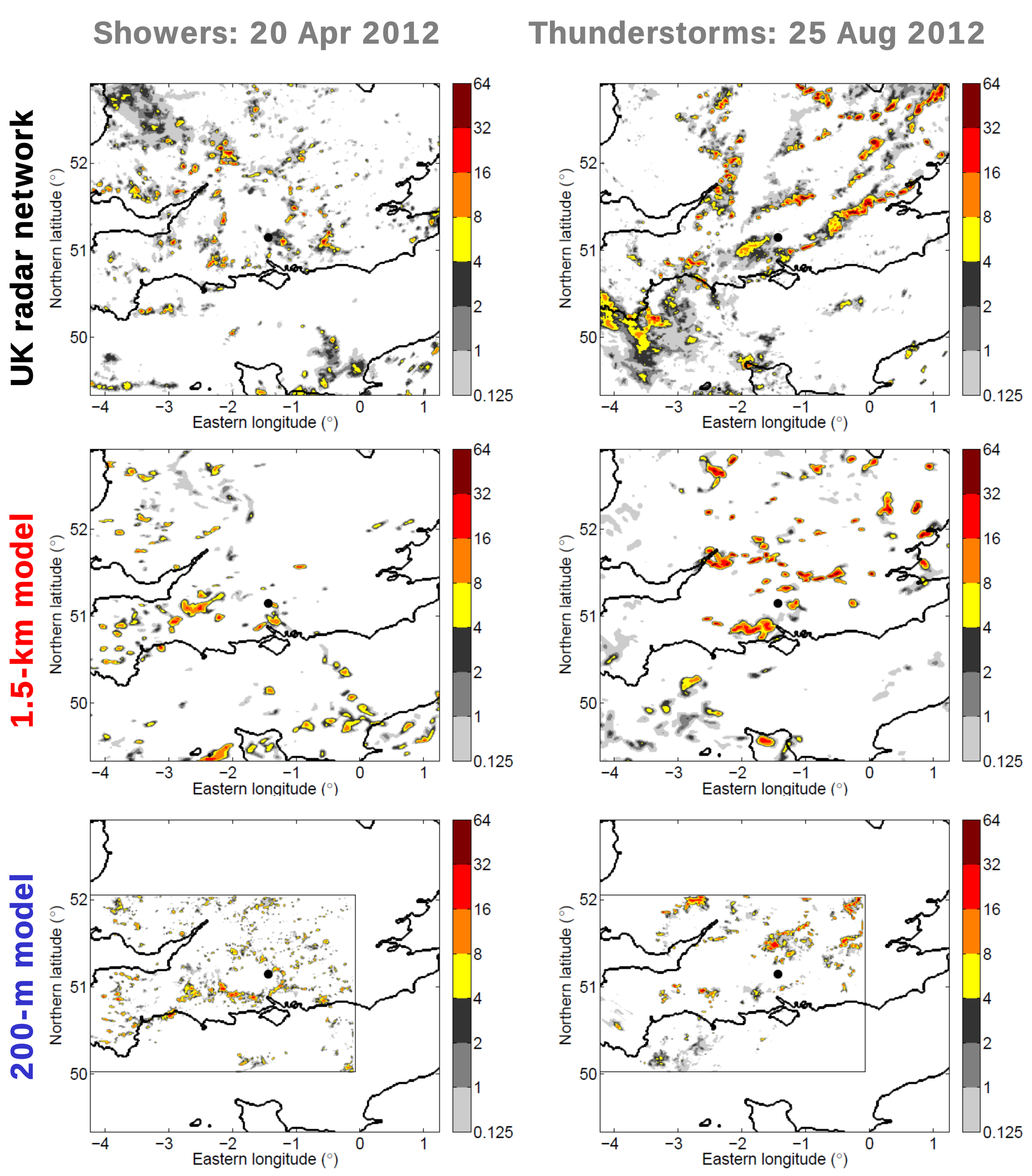


3D snapshots from deep case 25 August 2012

Simulated radar reflectivity using model's microphysical assumptions

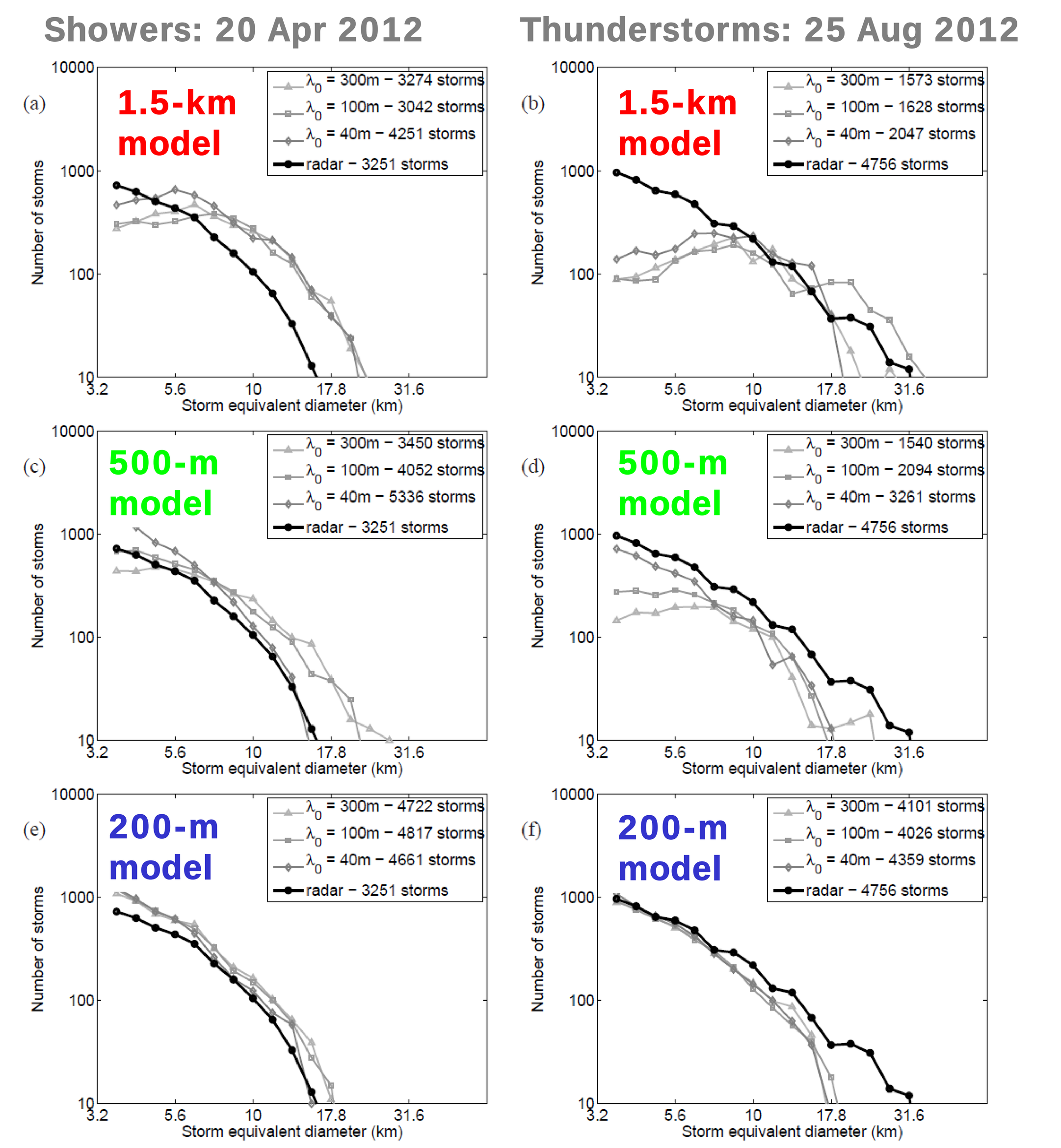
2. Surface rainfall comparison

- Surface rain rate snapshots (mm h[-1]) from radar and two model resolutions for two contrasting cases:



3. Effect of mixing length

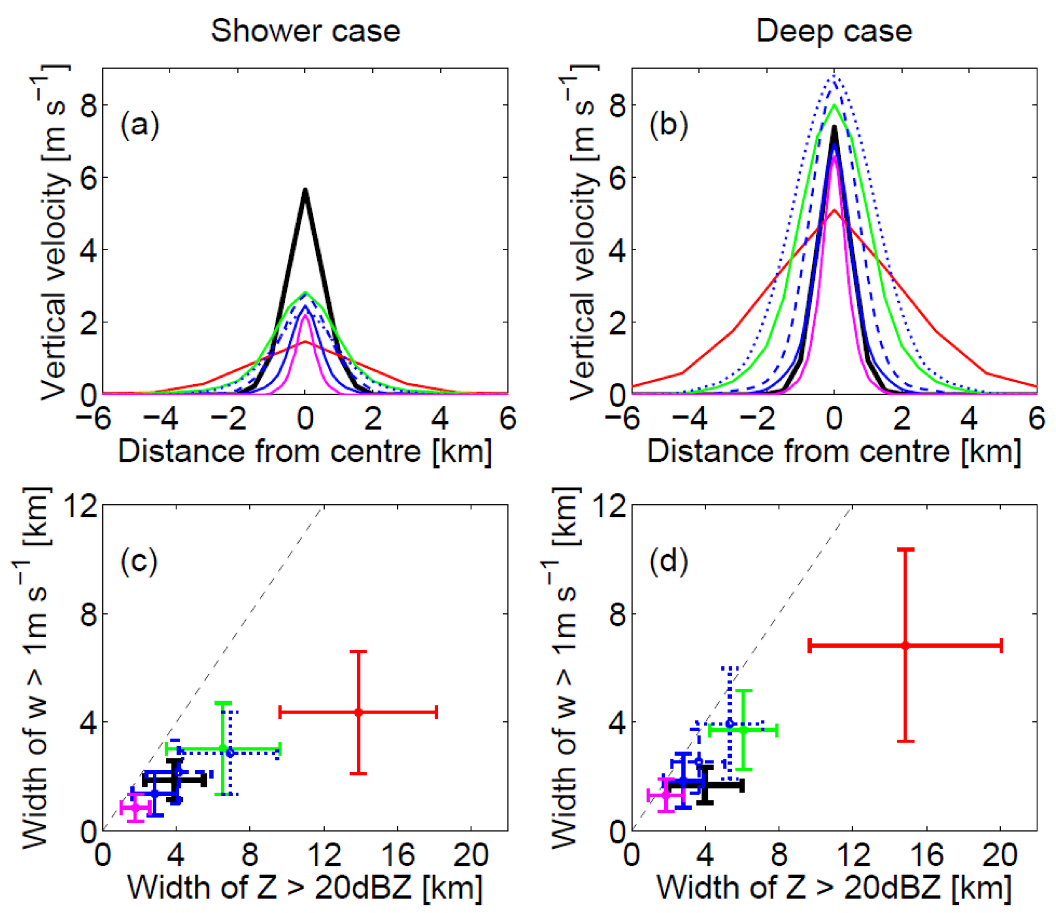
- Model uses LES-type Smagorinsky mixing length normally 0.2 times horizontal grid-length.



- *More mixing kills small storms; little effect on large*
- *No one value works well for all cases*

4. Updrafts

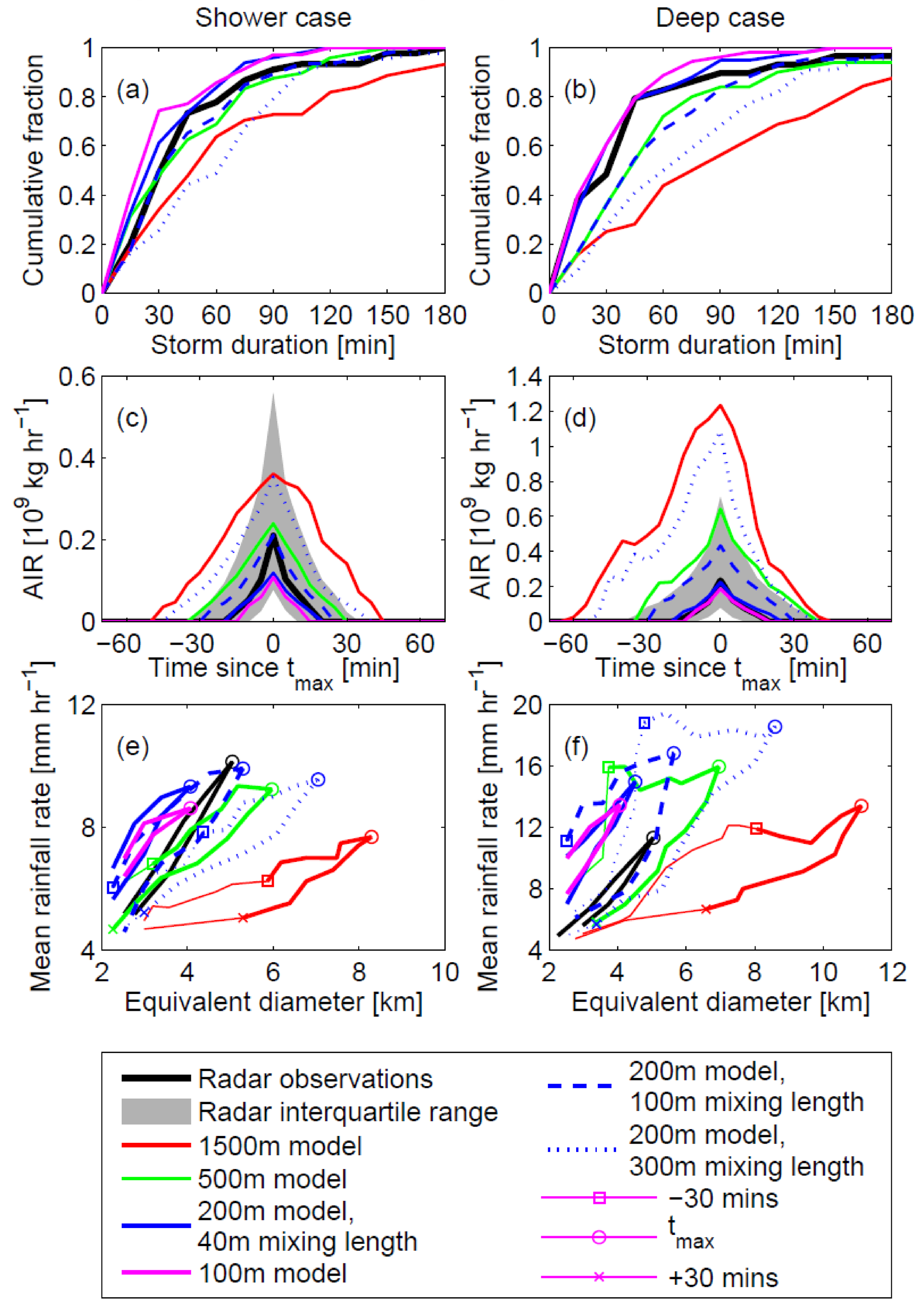
- Estimate vertical velocity by applying continuity equation to radial winds from single RHIs.
- Not perfect but sufficient to characterize mean updraft behaviour when applied to many cases.



- *1.5-km model over-predicts per-updraft mass flux by at least an order of magnitude.*
- *Updraft size increases steadily with grid size.*
- *200-m model has updrafts of around the right width, but intensity not always right.*
- *Increased mixing-length widens updrafts.*

5. Storm lifecycles

- Compare storms tracked in 5-min rainfall data.
- Characterize the lifecycle in terms of the **Area Integrated Rainfall (AIR)**



- *Storms in the 1.5-km model evolve too slowly.*
- *200-m model clouds evolve well, are around right size, but can produce too much rain for their size.*
- *Models exaggerate difference between growing and decaying part of the lifecycle.*

DYMECS References

Hanley, K. E., R. S. Plant, T. H. M. Stein, R. J. Hogan, J. C. Nicol, H. W. Lean, C. Halliwell and P. A. Clark, 2014: Mixing length controls on high resolution simulations of convective storms. *Q. J. R. Meteorol. Soc.*, in press.

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