RMetS Student Conference 04/07/19

Thermals in deep convection

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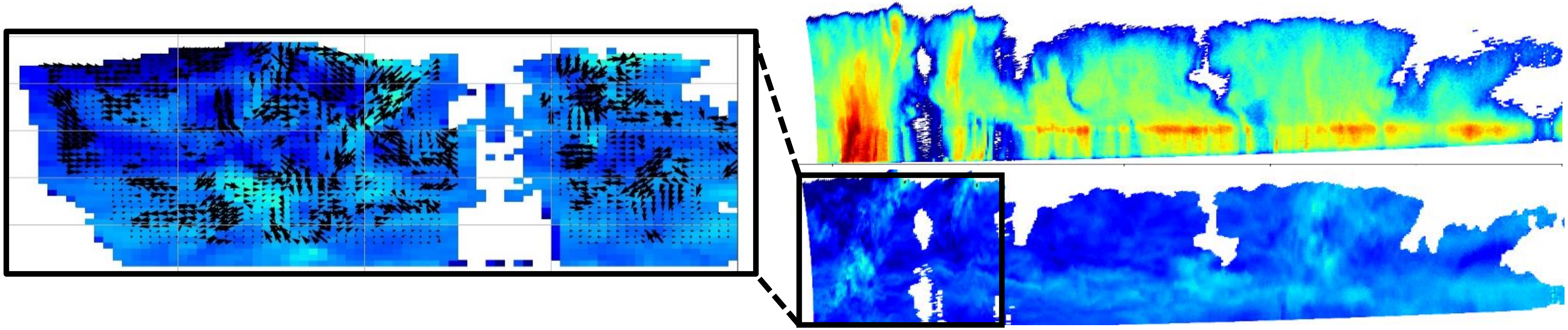


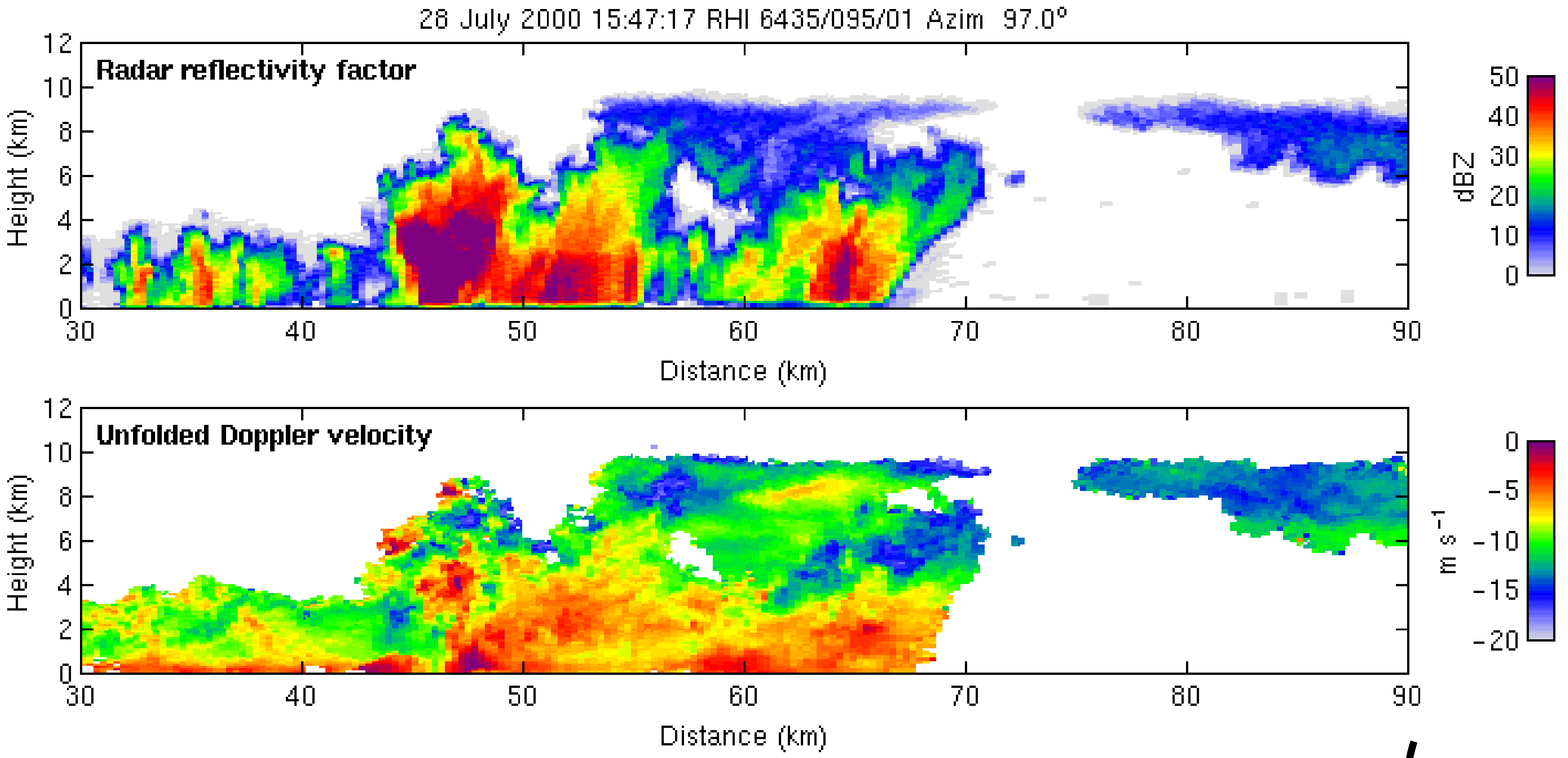
Motivation

- Convective storms can produce severe weather such as: heavy rain, hail, lightning and strong winds.
- Forecasting cloud evolution and intensity is challenging where cloud evolution can be too slow or fast (Lean et al. 2008; Clark et al 2016).
- Updrafts drive cloud evolution and interact with microphysics, distribute heat and moisture and lightning production and precipitation formation depends on them. Updraft evolution is also difficult to represent.

Thunderstorm impacts from May 2018. Taken from BirminghamLive at https://www.birminghammail.co.uk/news/midlands-news/met-office-thunderstorm-weather-warning-16451476

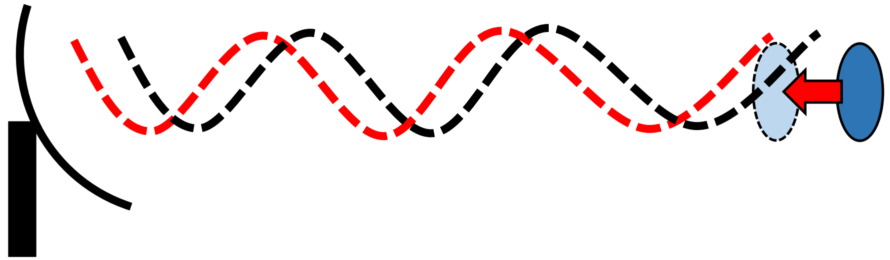
Motivation

Animation of storms over Gatwick. Courtesy of Robin Hogan. Taken from http://www.met.rdg.ac.uk/radar/overview/storms.html



Radar Reflectivity Factor (Z) ∝ D^6

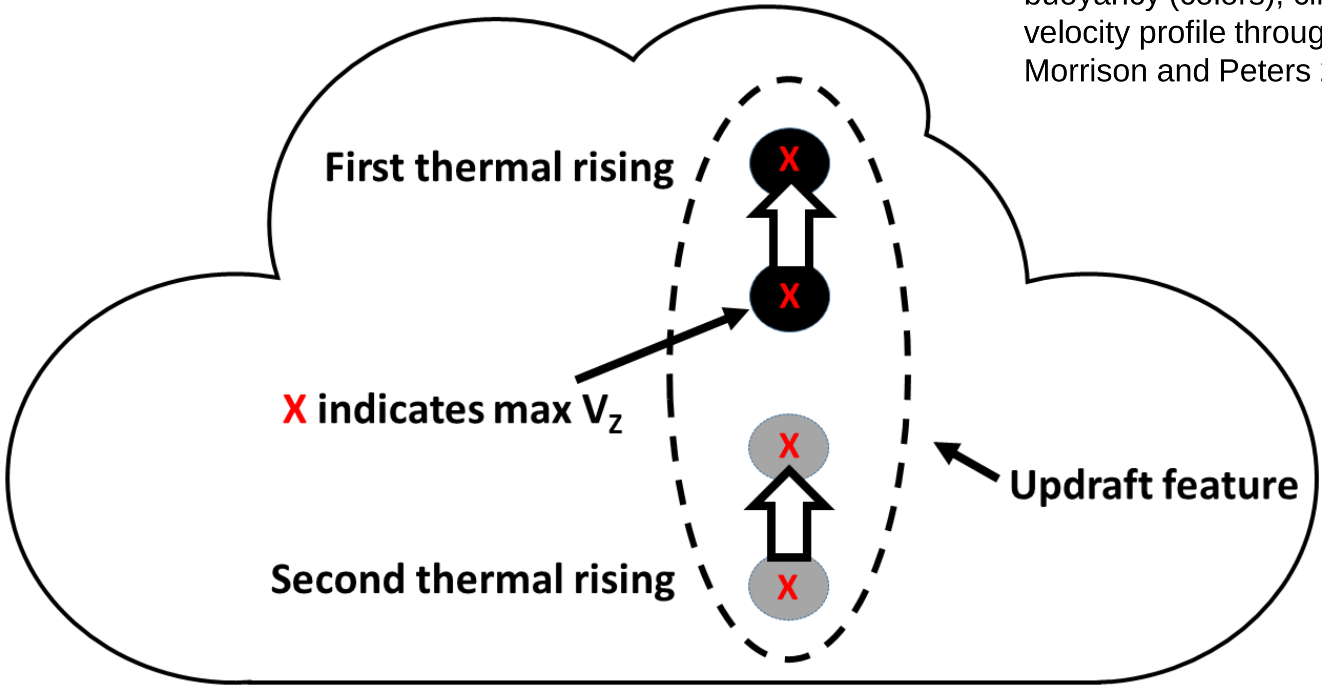
Measure phase shift between two pulses



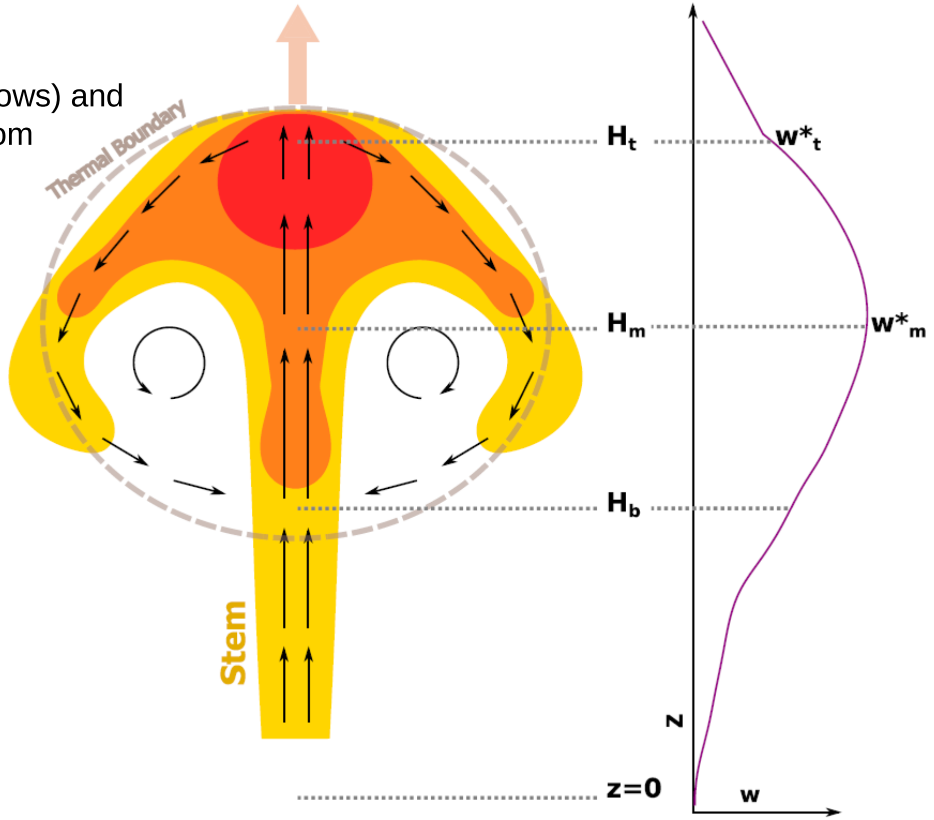
Limited observations of thermals in deep convection using ground based radar (Yuter & Houze 1995; Hogan et al. 2008).

Thermals in convection

- Thermals in convection can impact:
  - Fluxes of moisture and mass (Morrison and Peters 2018).
  - Hydrometeor transport (Damiani et al. 2006, 2007).
  - Entrainment (Blyth et al. 1988, 2005; Damiani et al. 2006, 2007; Moser and Lasher-Trapp 2017).
  - Therefore updraft and cloud evolution.

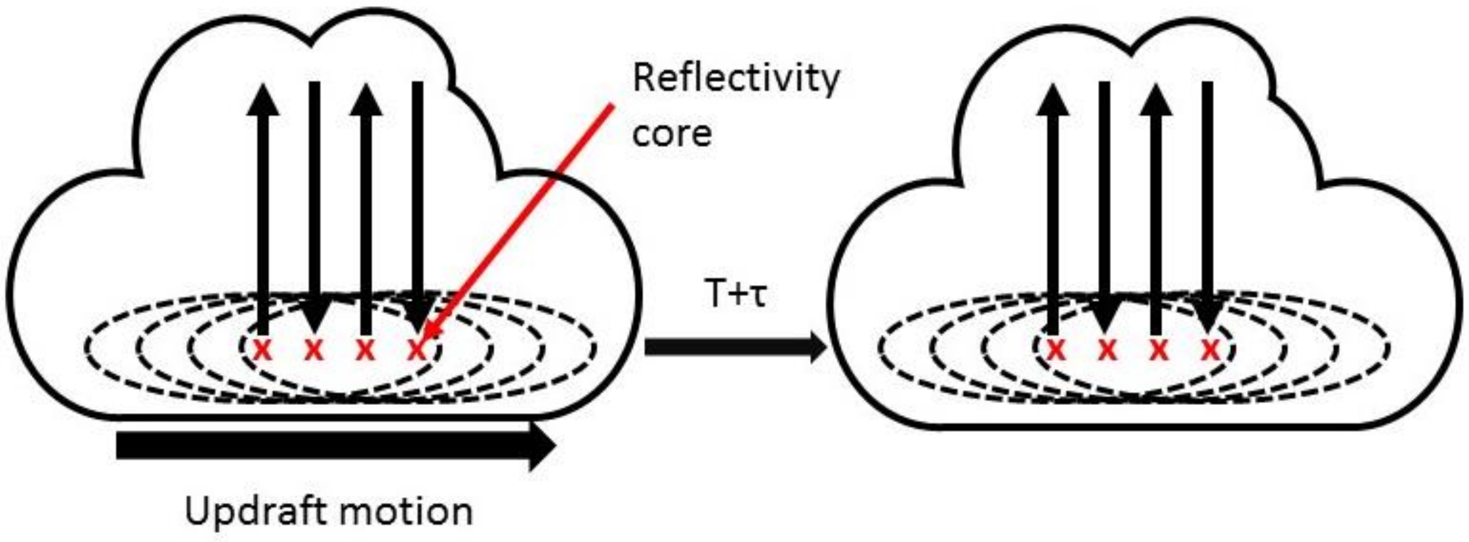


Conceptual diagram of thermal showing buoyancy (colors), circulations (black arrows) and velocity profile through thermal. Taken from Morrison and Peters 2018.



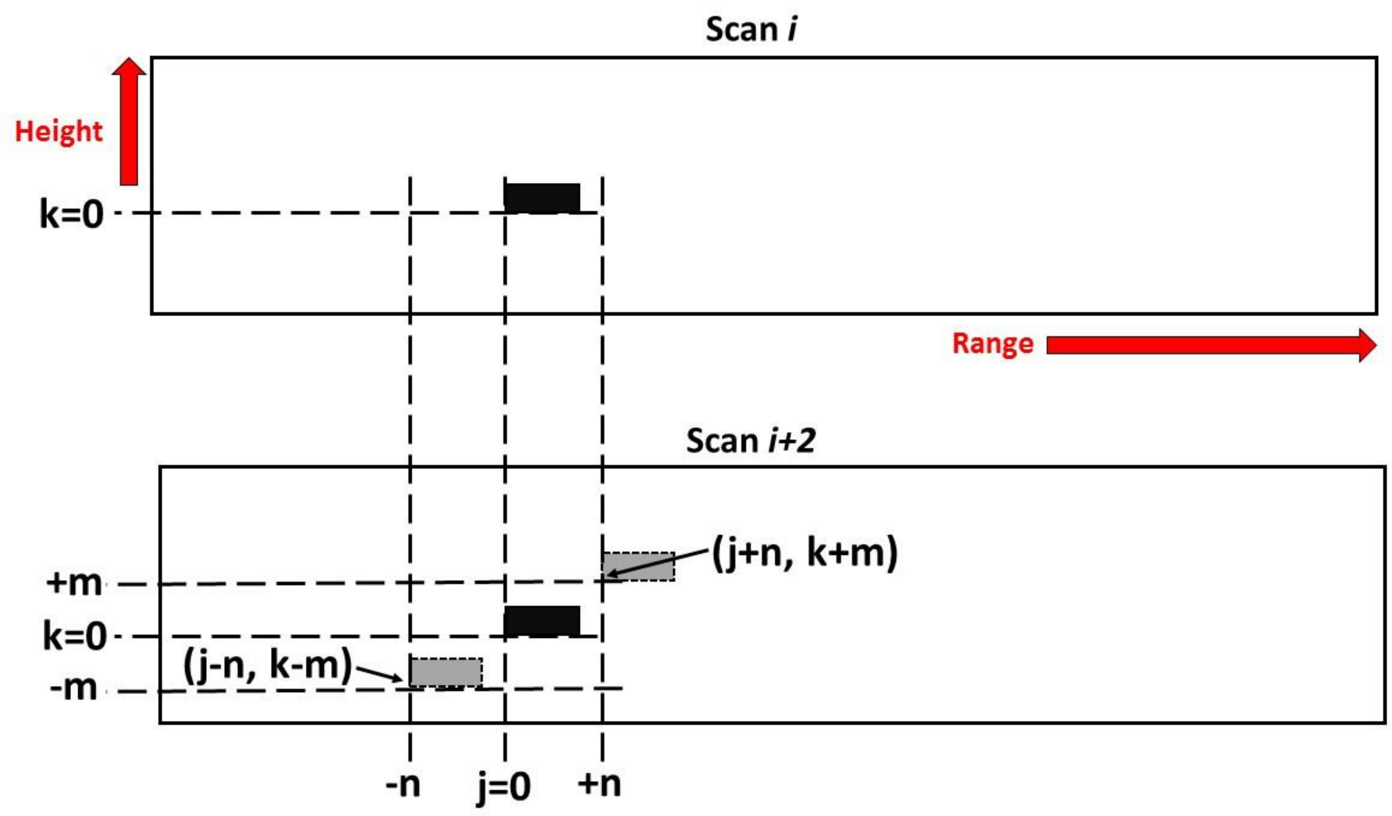
Radar Data

- Chilbolton Advanced Meteorological Radar (CAMRa) -
  - 3 GHz (10 cm) radar.
  - 300 m range gates and 0.28° beamwidth.
  - Target clouds using slow vertical scanning rate to obtain high vertical resolution.
  - Doppler and dual polarisation capability.
- Doppler velocity is measured between -15 and 15 m s^{-1} with an accuracy of 0.15 m s^{-1}.



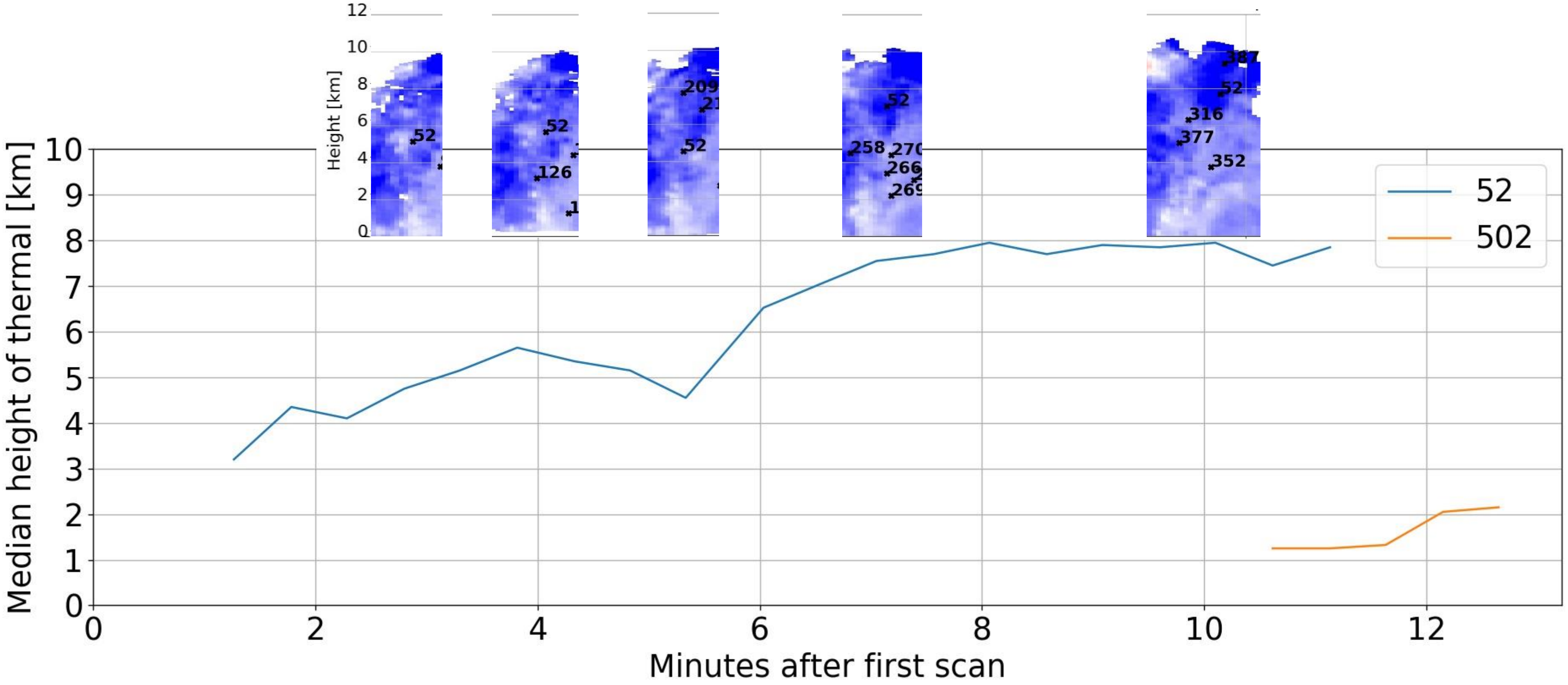
Chilbolton Advanced Meteorological Radar

Feature tracking



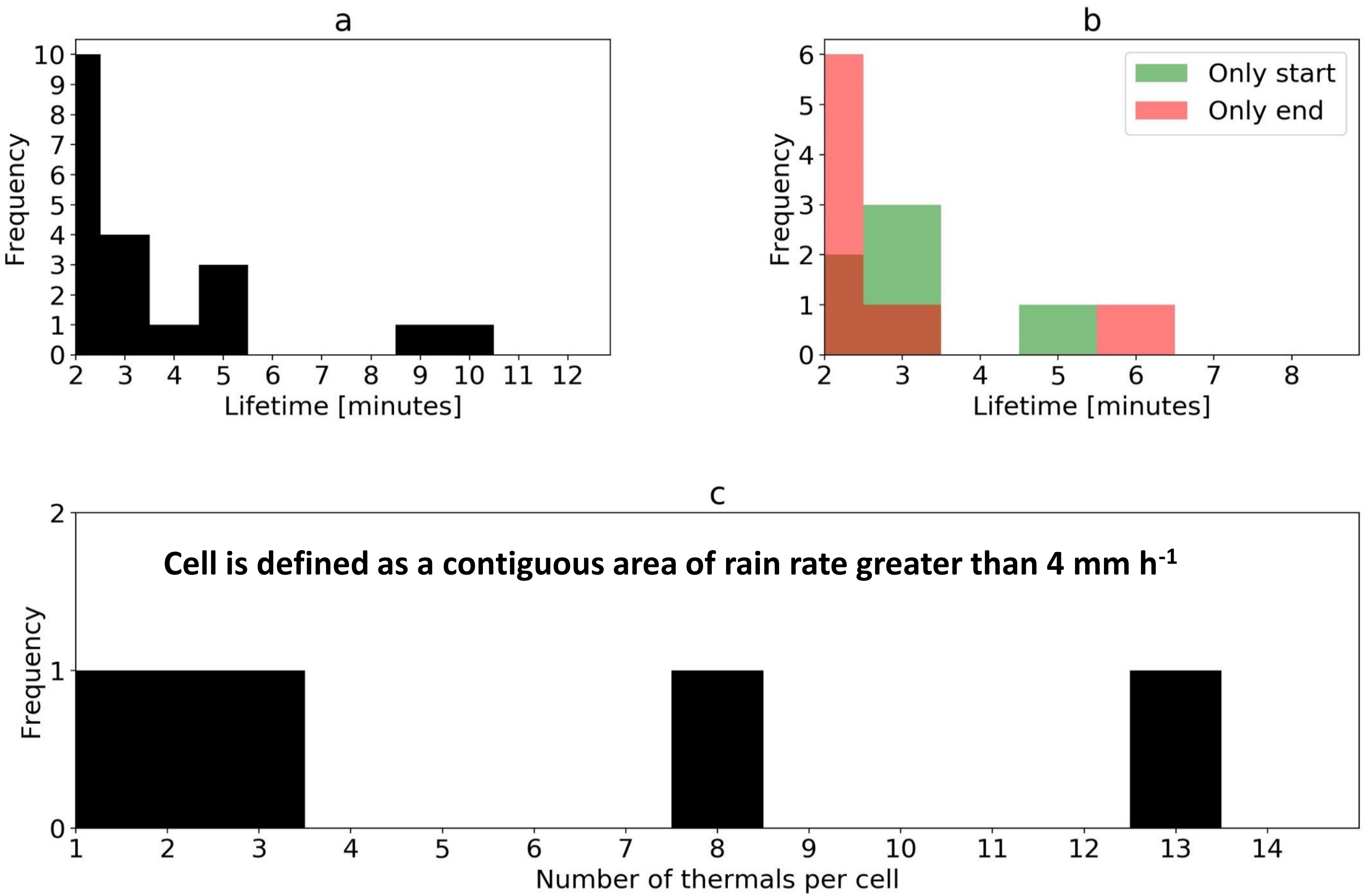
- Derive displacement by minimising a cost function between two scans at a particular scale (Hogan et al. (2008)).
- Box of 2 km width and 1 km height.
- Motion vectors calculated by dividing the displacement (black to gray box) by the time between scan *i* and scan *i*+2.

Thermal ascent

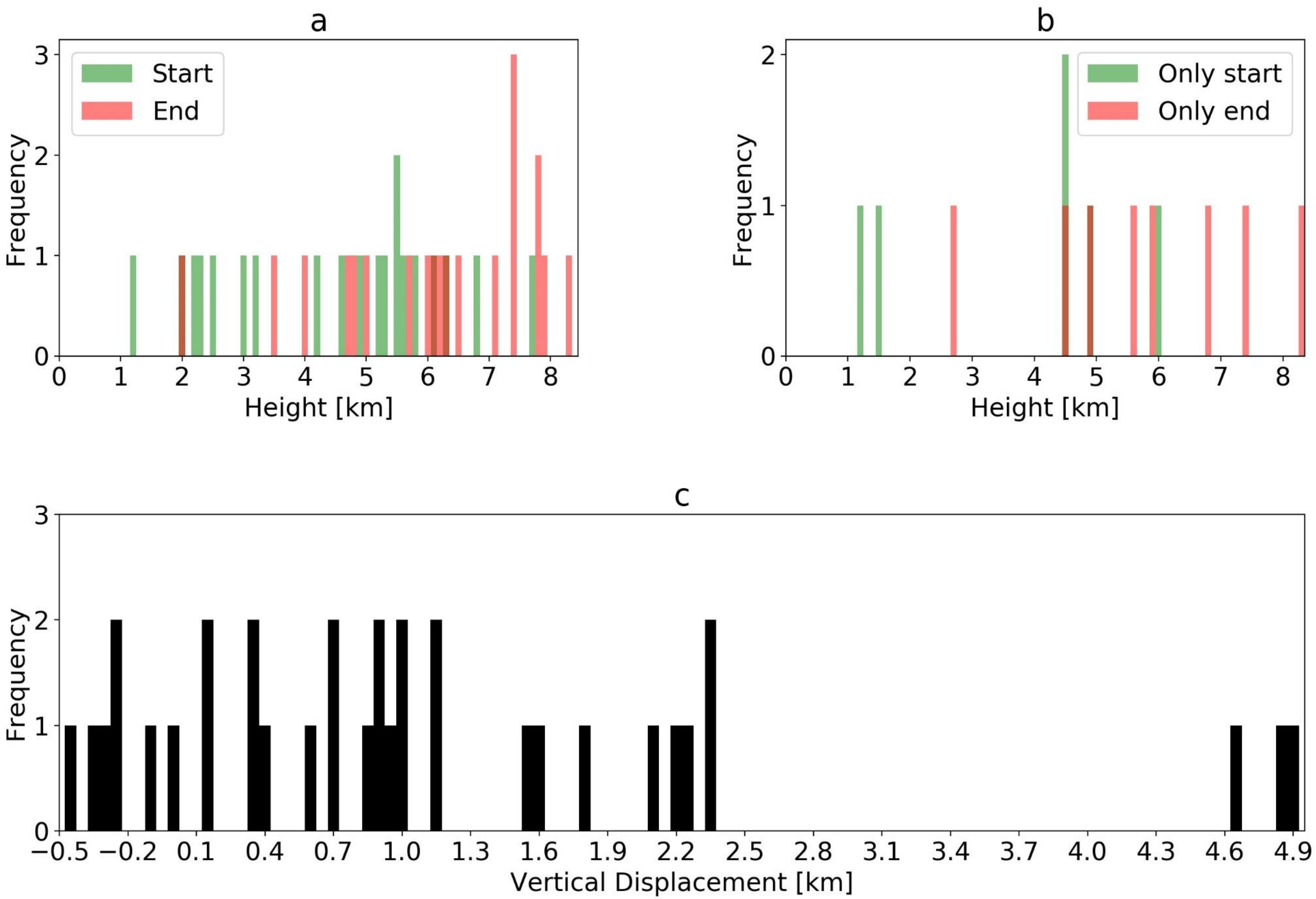


- Thermals defined as lasting longer than 2 minutes and a minimum width of 600 m and height of 250 m.
- Track thermals where a feature has moved at least 500 m between retrievals.
- Median thermal height over time for scans starting at 15:47 on 28th July 2000.

Thermal characteristics

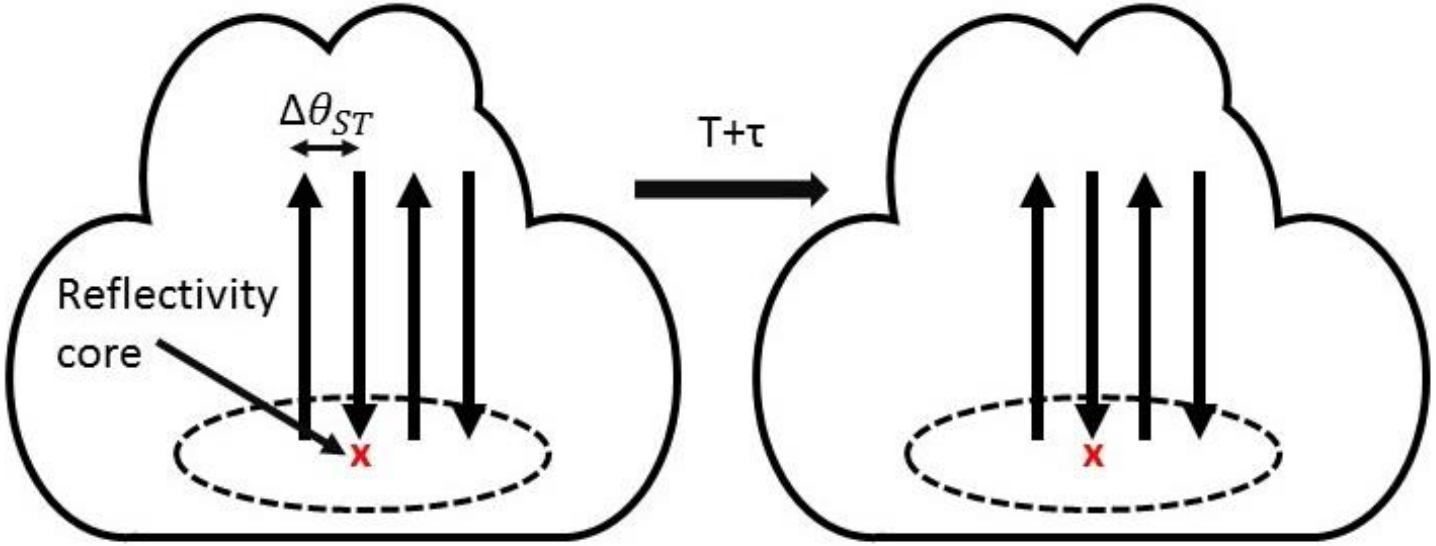


Thermal characteristics



Planned observations

- Collect new high resolution radar scans of convective storms at 75 m horizontal resolution.



- New scanning strategy to bracket core of cells
  - Accounts for uncertainty in core.
  - Gain spatial information in cross beam direction.
  - Information on occurrence of thermals with distance from core.

Summary

- Thermals are short lived and generally only a few per cell.
- Most only ascend a few hundred metres and originate and end at no specific region of clouds.
- Identify thermals characteristics such as ascent rates and see how this compares to updraft velocity.
- Collecting new high resolution radar scans to further investigate role of thermals on cloud evolution.

- **Larger thermal ascent rates and thermal number lead to longer lived storms.**

References

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