How does boundary layer variability affect cumulus and convective storm development?

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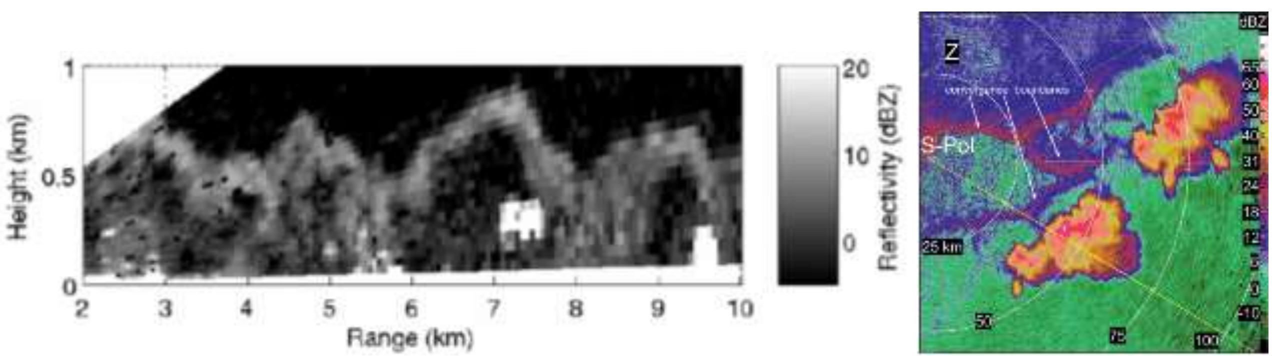
Accurate forecasting of convective storms in the UK remains a challenge. Modelling studies have demonstrated that surface inhomogeneities introduce boundary-layer variability in terms of humidity and vertical motion, which affects the evolution of subsequent clouds and convective storms. Such boundary-layer variability is notoriously difficult to observe due to a lack of instrumentation. Radar measurements help in two ways: (1) clear-air radar echoes can be used to identify convergence lines and (2) Bragg scatter from sharp humidity gradients near the tops and edges of developing clouds can indicate rising thermals (see Figures). This project will interpret these measurements with a view to relate the boundary-layer structures to subsequent cloud development and evaluate the inferred physical mechanisms and structures in high-resolution numerical weather prediction (NWP).



Left: Signatures of sharp humidity gradients are detected in a vertical radar scan, indicating rising thermals along the edges of clouds. We can see that individual cells are 2 km apart (Bennet et al. 2006). Right: Convergence boundaries are detected in a planar radar scan, with indicative scales of about 20 km (Hubbert et al., 2018).

This project complements the Wessex Summer Convection Experiment (WesCon, Barrett et al., 2021), an observational field programme funded by the Met Office and scheduled for summer 2023 involving the FAAM BAe146 research aircraft, a ground based super site, the Chilbolton Observatory and the Met Office Wardon Hill research radar. You will characterise the time and length scales of boundary-layer structures such as convergence lines using data from multiple radars and study subsequent cloud formation in satellite imagery and you will validate your findings against the aircraft observations. Using high-resolution NWP, you will evaluate whether forecast models develop similar boundary-layer structures as observed and what the consequences of model biases are for forecasting of convective storms.

Training opportunities:
Involvement with the WesCon field programme can range from assisting with launching radiosondes, to assisting or even running radar operations, and potentially joining a flight mission. You will have the opportunity to spend time at the Met Office in Exeter with the CASE supervisor, during which you receive further training into NWP

modelling, using high-performance computing resources, and NWP model development.

Student profile:
This is a project that combines use of observational data and sophisticated numerical models, so will suit a student with mathematical and computing skills. An interest in learning the relevant physics and meteorology is essential in order to interpret the results, but the project does not require a meteorological background.

Funding particulars:
This project comes with CASE funding from the Met Office.

References:

Barrett, P., Abel, S., Lean, H., Price, J., Stein, T., Stirling, A., and Darlington, T.: WesCon 2023: Wessex UK Summertime Convection Field Campaign, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-2357. https://doi.org/10.5194/egusphere-egu21-2357

Bennett, L.J., Browning, K.A., Blyth, A.M., Parker, D.J. and Clark, P.A. (2006), A review of the initiation of precipitating convection in the United Kingdom. Q.J.R. Meteorol. Soc., 132: 1001-1020. https://doi.org/10.1256/qj.05.54

Hubbert, J. C., Wilson, J. W., Weckwerth, T. M., Ellis, S. M., Dixon, M., and Loew, E. (2018). S-Pol's Polarimetric Data Reveal Detailed Storm Features (and Insect Behavior), Bulletin of the American Meteorological Society, 99(10), 2045-2060. https://doi.org/10.1175/BAMS-D-17-0317.1

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