Numerical simulations of a COPE-type case

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My PhD Project

University of Reading

- *Quasi-stationary convective systems in the UK*
- Motivation
  - Numerous case studies of QSCS from USA and Mediterranean region; comparatively little work from the UK
  - Want to improve understanding of and ability to forecast QSCSs
- Key project questions:
  1. How common are QSCSs in the UK and how does their occurrence vary seasonally, geographically and with synoptic conditions?
  2. What are the typical mechanisms by which QSCSs in the UK form?
  3. How well are QSCSs represented in a high-resolution operational NWP model (MetUM, UKV)?

Climatology

Case studies

Southwest Peninsula Convective Bands

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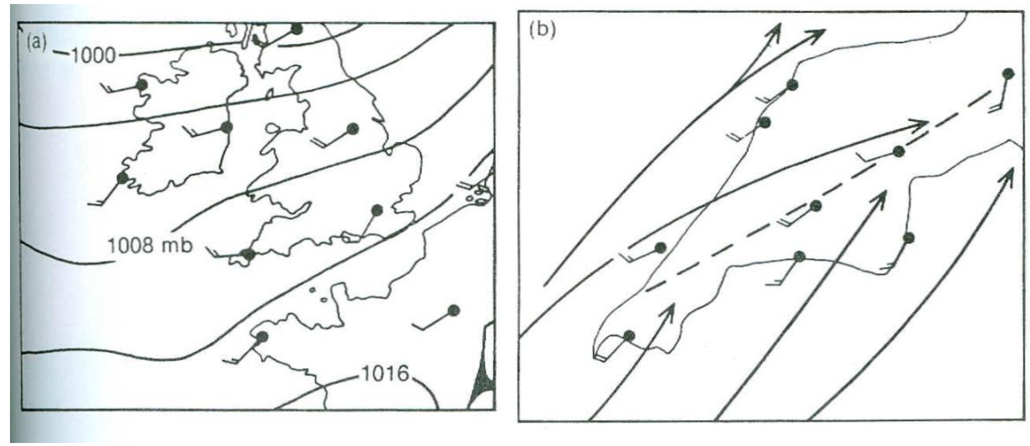
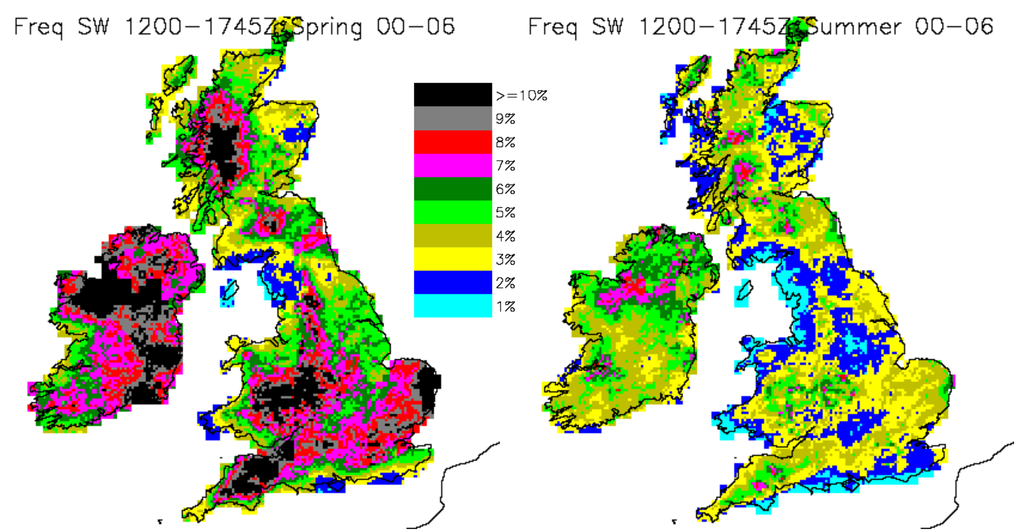
- Frequently observed under conditions of southwesterly flow
- Not always associated with precipitation
- Cloud is co-located with a well-defined boundary layer convergence line
- Most common during Spring and Summer → suggests importance of differential land and sea surface temperatures

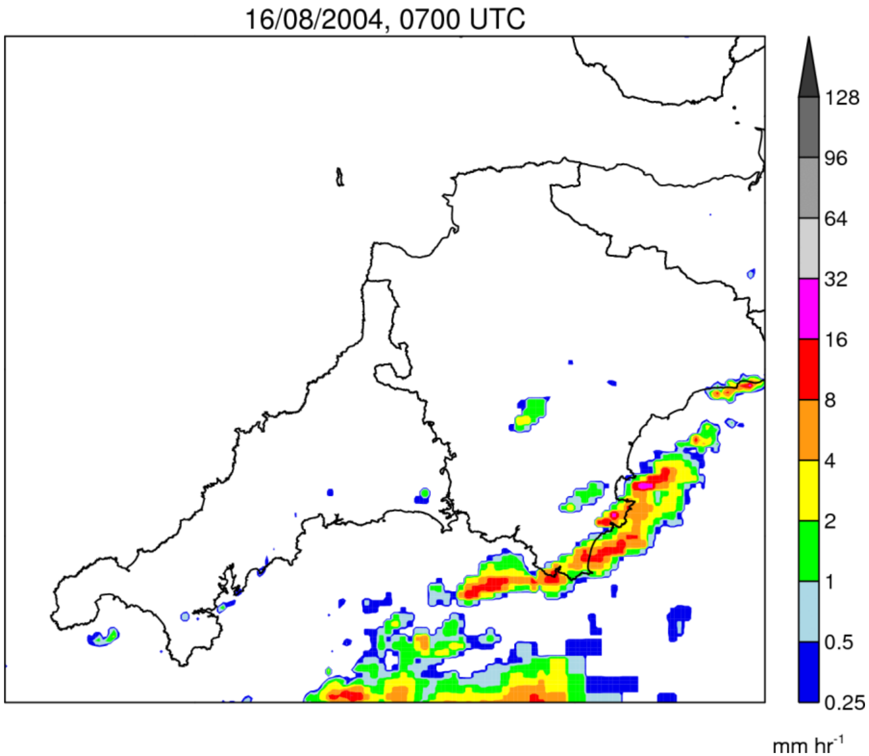


Monk (1987)

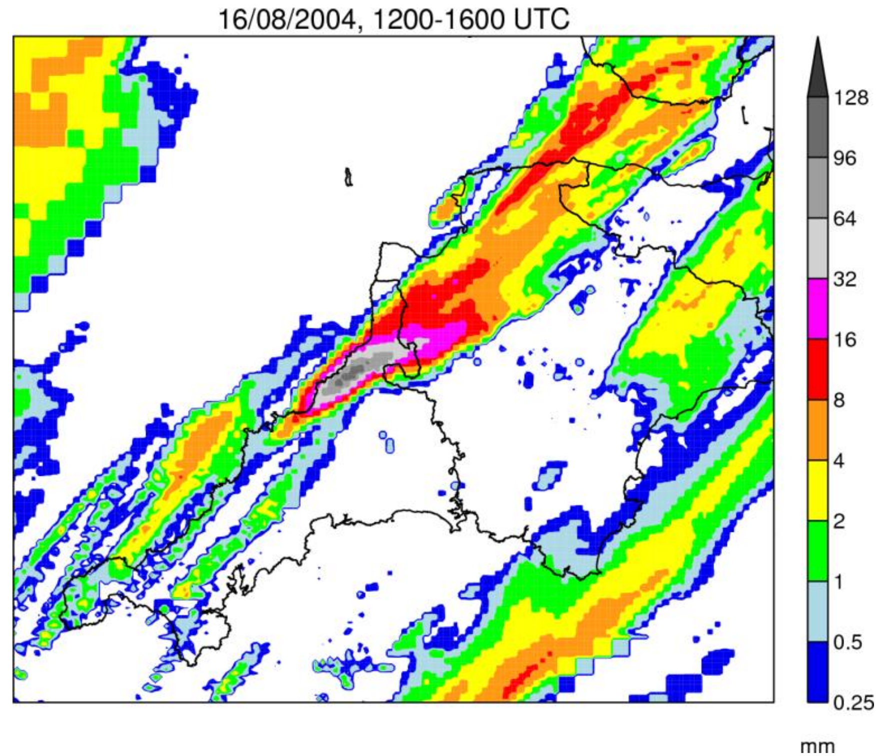


Hand (2005)

The Boscastle Case: 16/08/2004



Rain Rate
0700–1900 UTC



Rain Accumulation
1200–1600 UTC

Our Case Study: 21 July 2010

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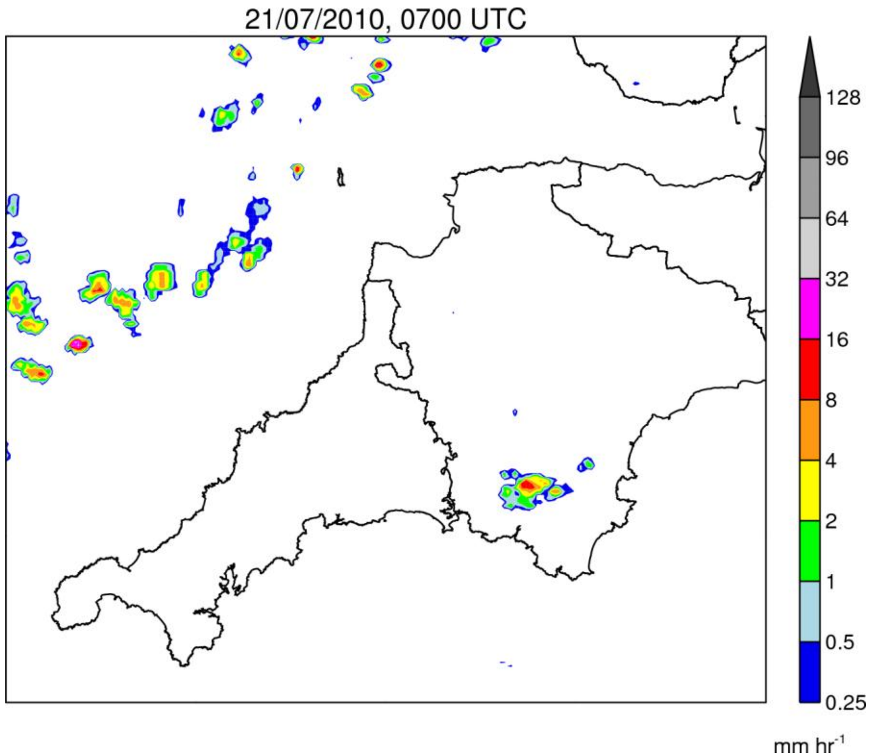
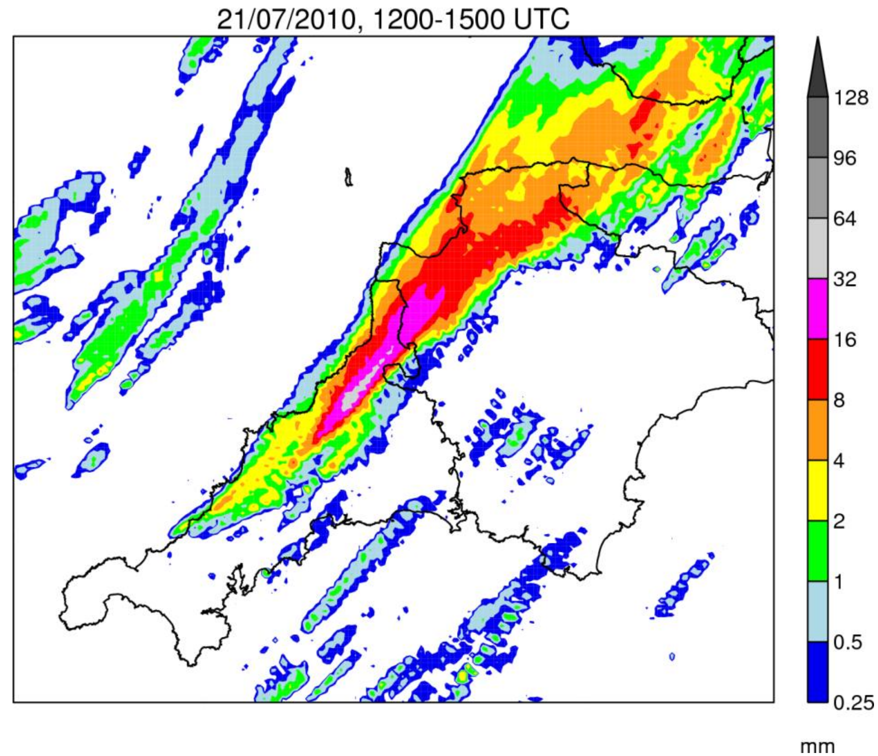


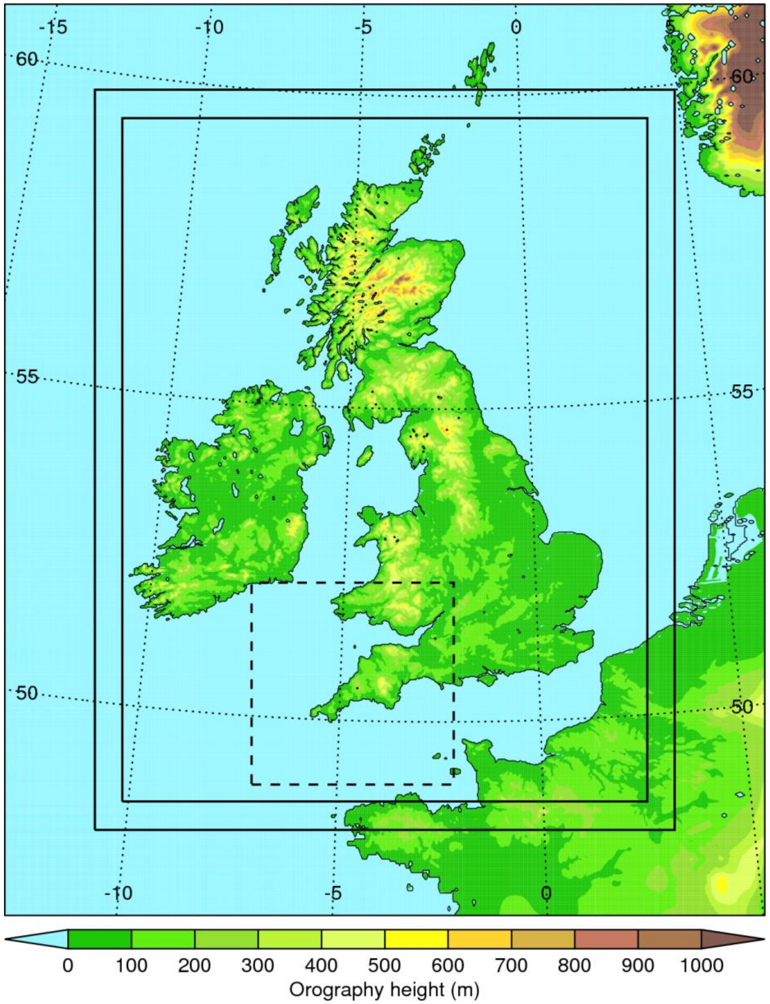
Rain Rate
0700–1900 UTC



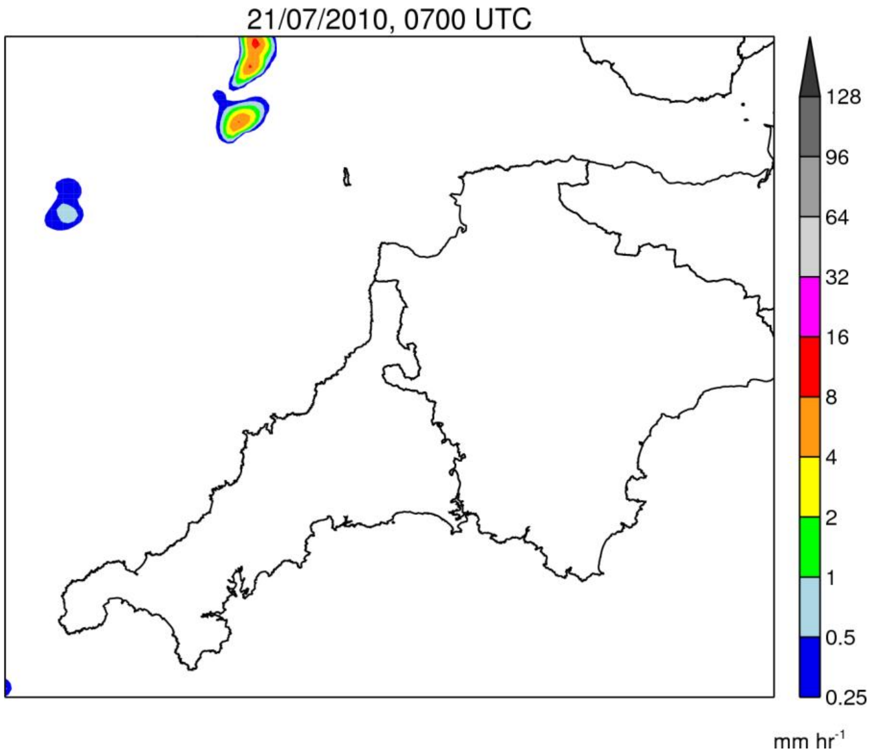
Rain Accumulation
1200–1500 UTC

Simulation Strategy

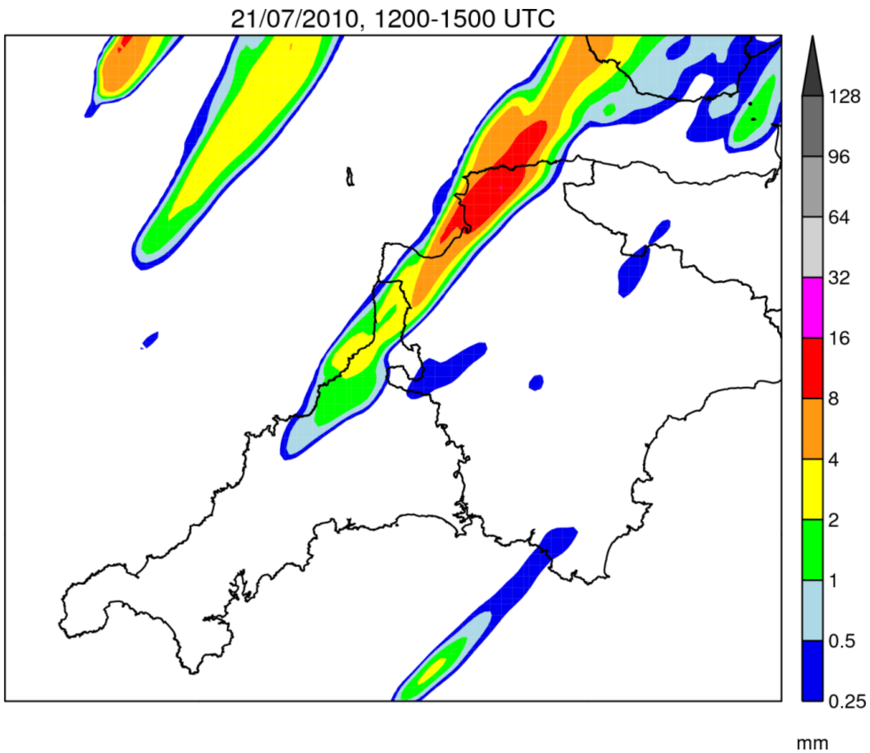
- MetUM - UKV model:
  - Grid spacing: 1.5-km inner domain stretching to 4-km outer domain
  - Explicit convection
  - 70 vertical levels
- Initialised from operational 0400 UTC UKV analysis
- LBCs from operational NAE run
- Smaller domain with same resolution nested within UKV to reduce expense



Control simulation: Rainfall

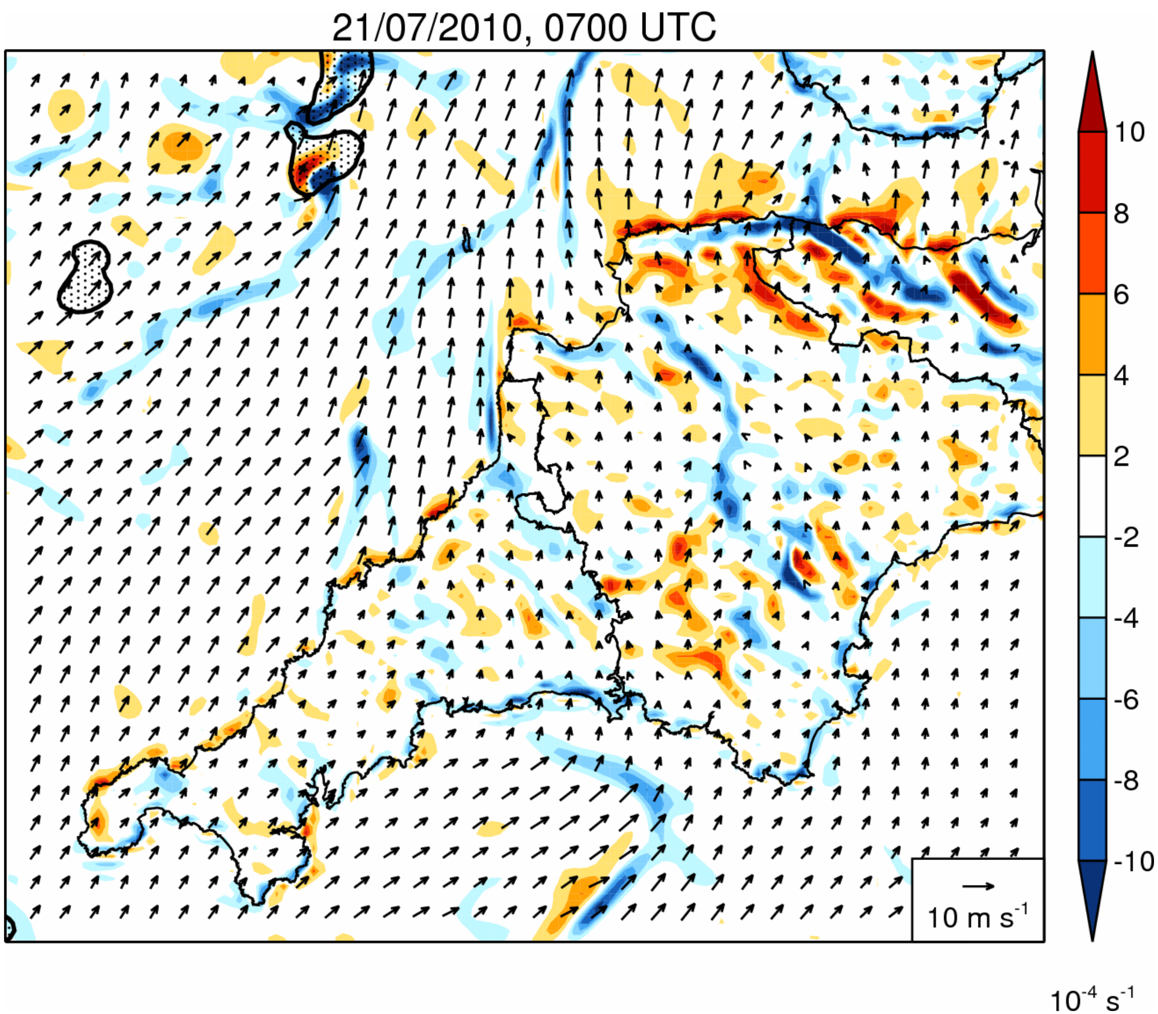


Rain Rate
0700–1900 UTC

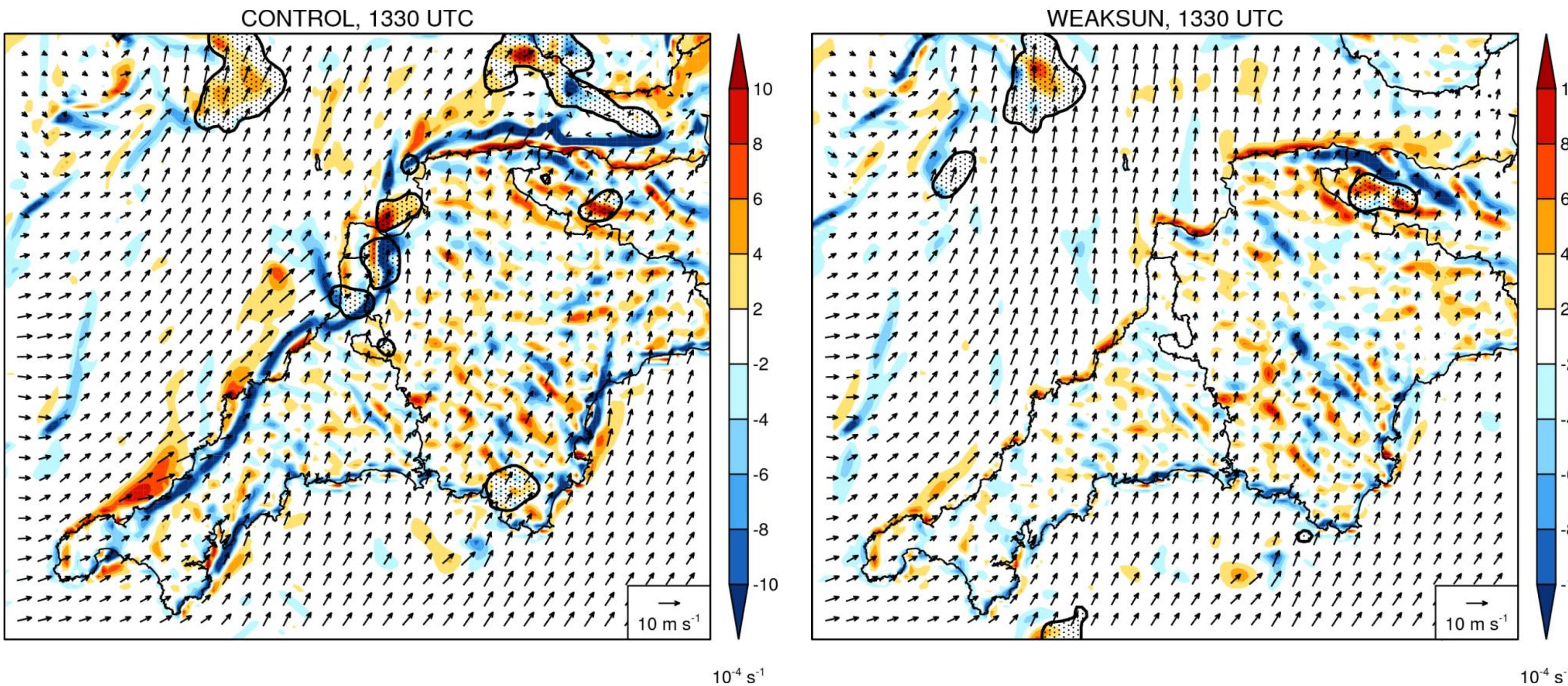


Rain Accumulation
1200–1500 UTC

Control simulation: Divergence

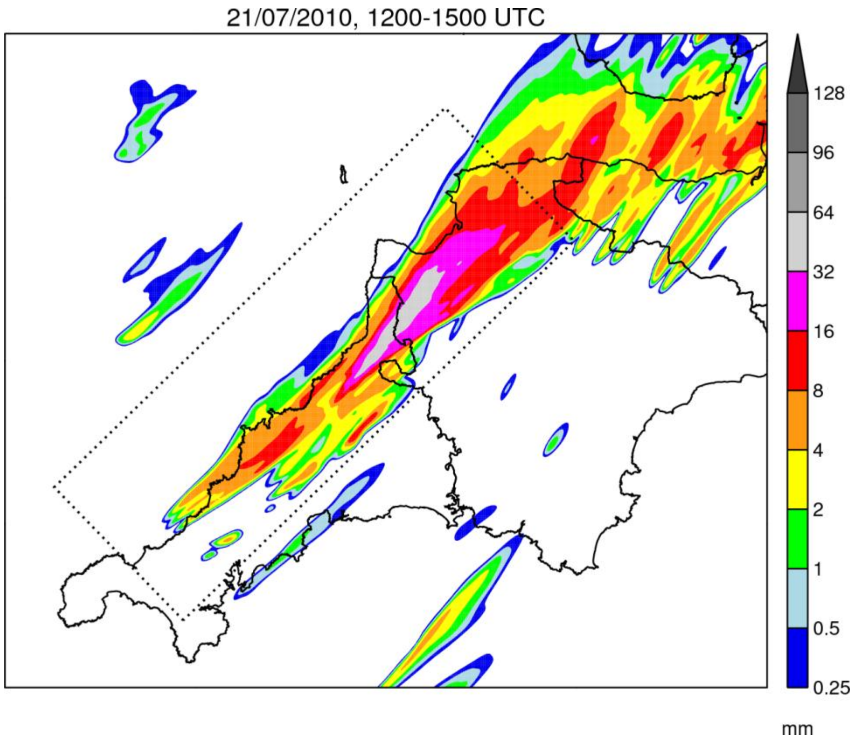


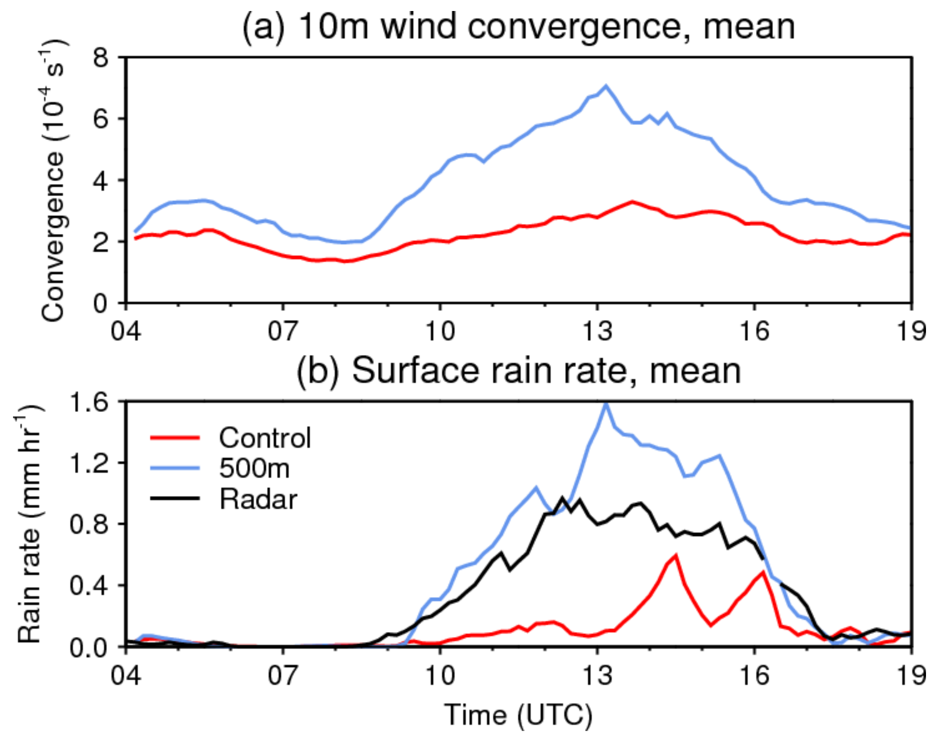
Sensitivity tests



- Differential surface heating is a necessary condition for the convergence line to form → convergence line was a sea-breeze
- Orography, differential surface roughness and cold pools not found to be important in this case

500m Simulation

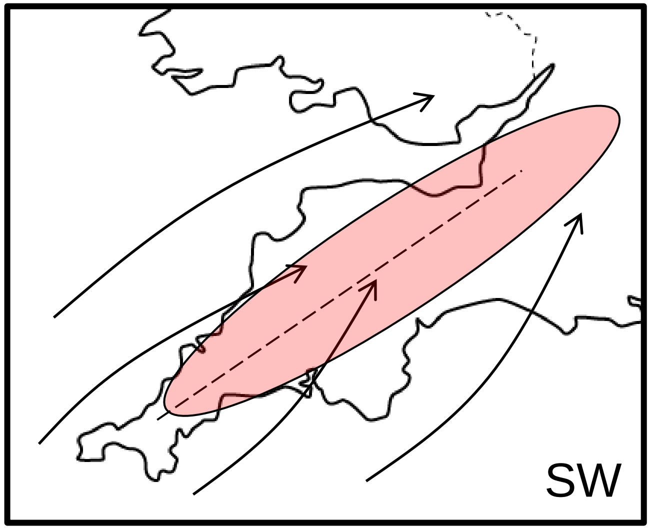


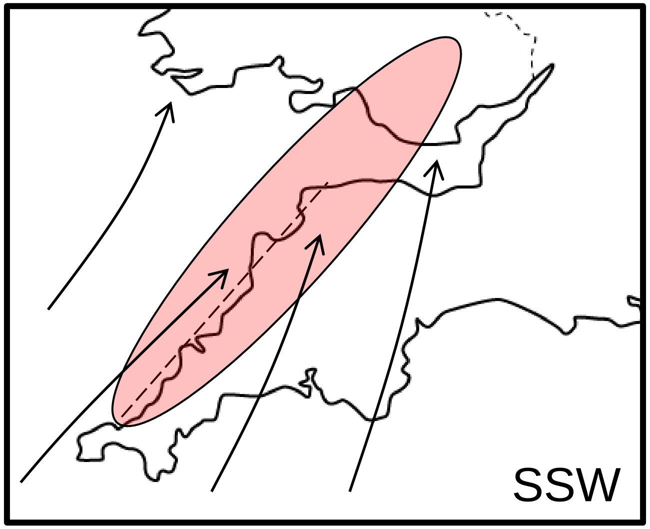


- Convergence line is better resolved with 500m grid-spacing → timing and pattern of convective initiation is significantly improved

Perspectives for COPE

- Would expect convergence line to form under WSW / SW / SSW flow provided $T_{land} > T_{sea}$
- Hypothesised dependence of convergence line on flow direction:
  - For SW flow, sea breeze effect on both coasts may be important → convergence line along centreline of peninsula
  - For SSW flow, sea breeze effect on south coast 'washed out' by onshore flow → convergence line along west coast of peninsula
- N.B. UKV model may give a poor representation of convective initiation and organisation in these cases

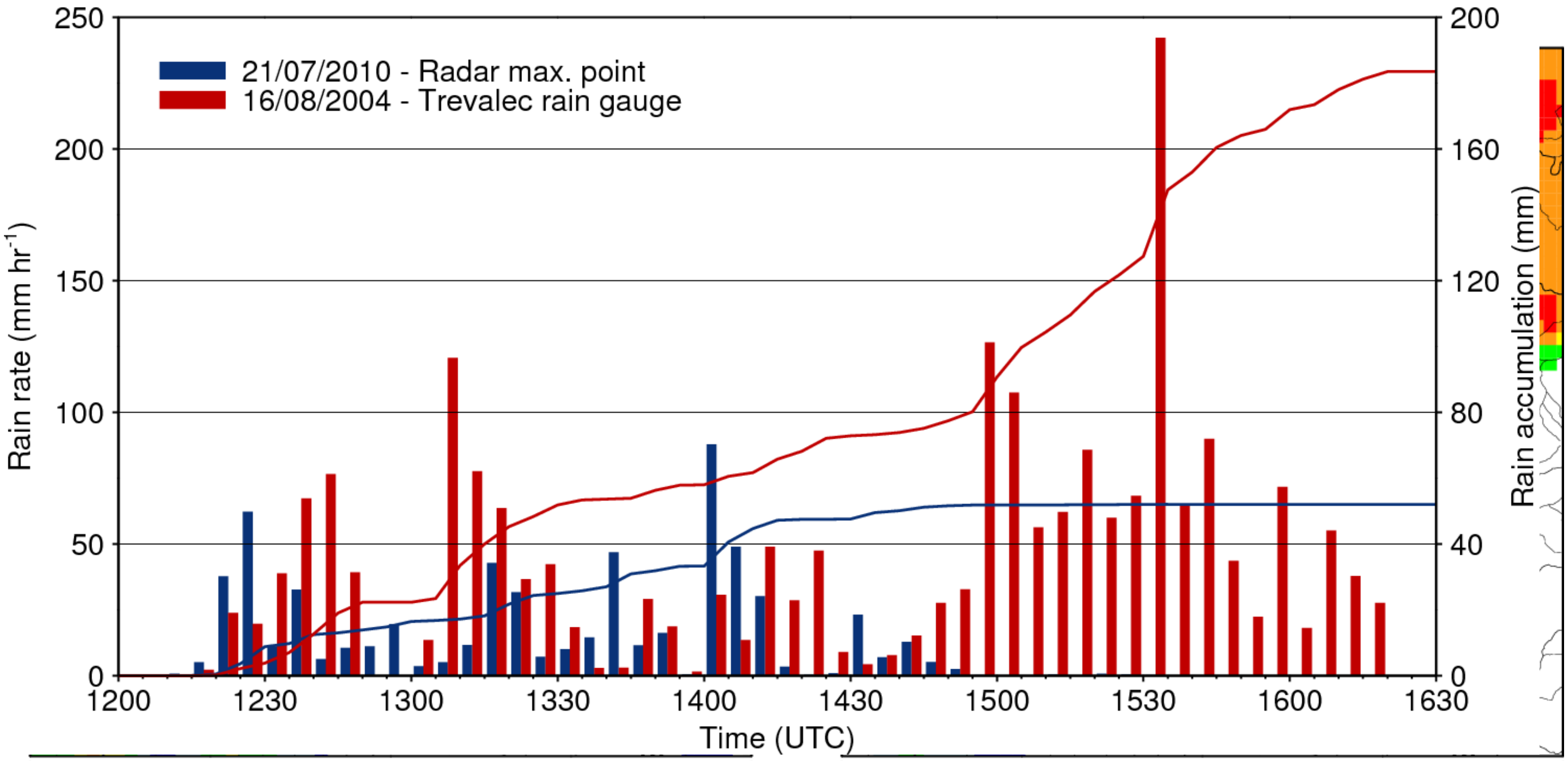




Perspectives for COPE

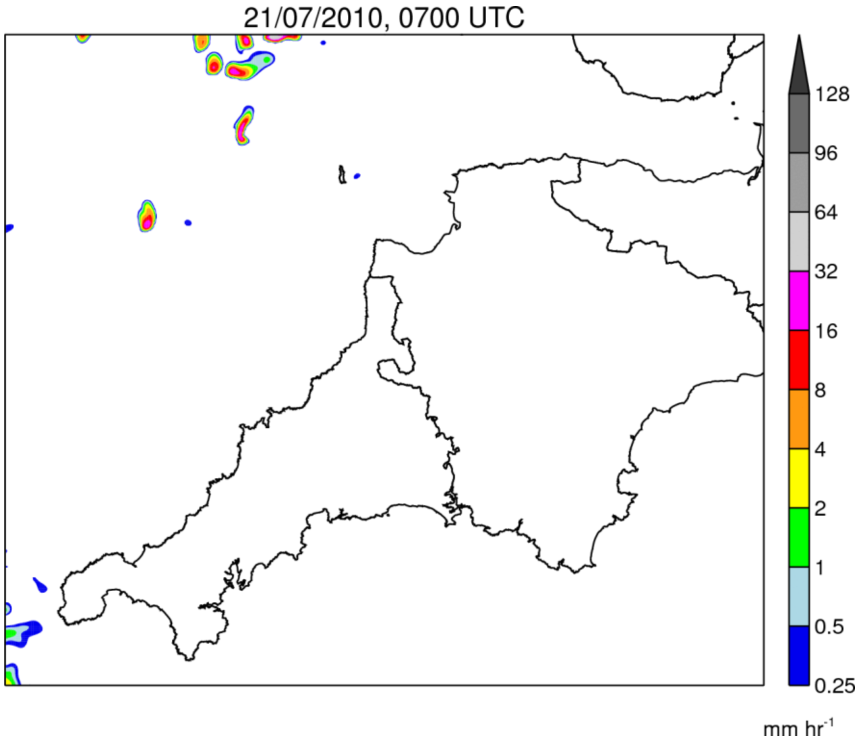
- Useful observations for this type of event:
  - Land-sea temperature contrast
  - Convergence lines: location, intensity, and width
  - Sea breeze circulation
  - Low-level flow around Land’s End and Lizard peninsulas
  - Convective initiation
  - Convective downdraughts and their effect on the convergence line

Comparison with Boscastle Storm

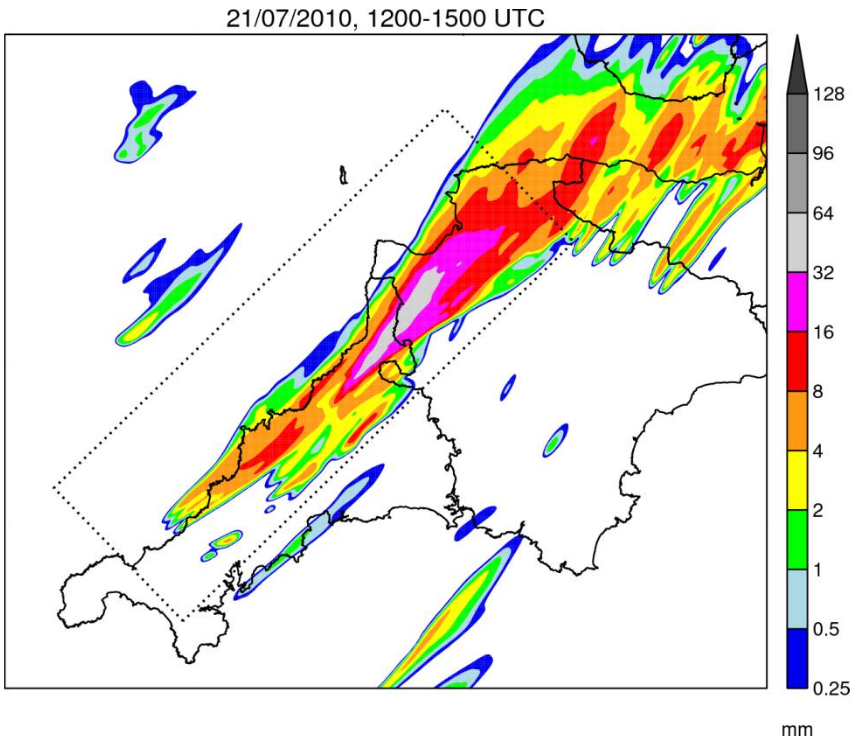


- Warmer, moister atmospheric column → higher rain rates
- Slow evolution of large-scale flow → more stationary system

500m simulation: Rainfall



Rain Rate
0700–1900 UTC



Rain Accumulation
1200–1500 UTC

500m simulation: Divergence

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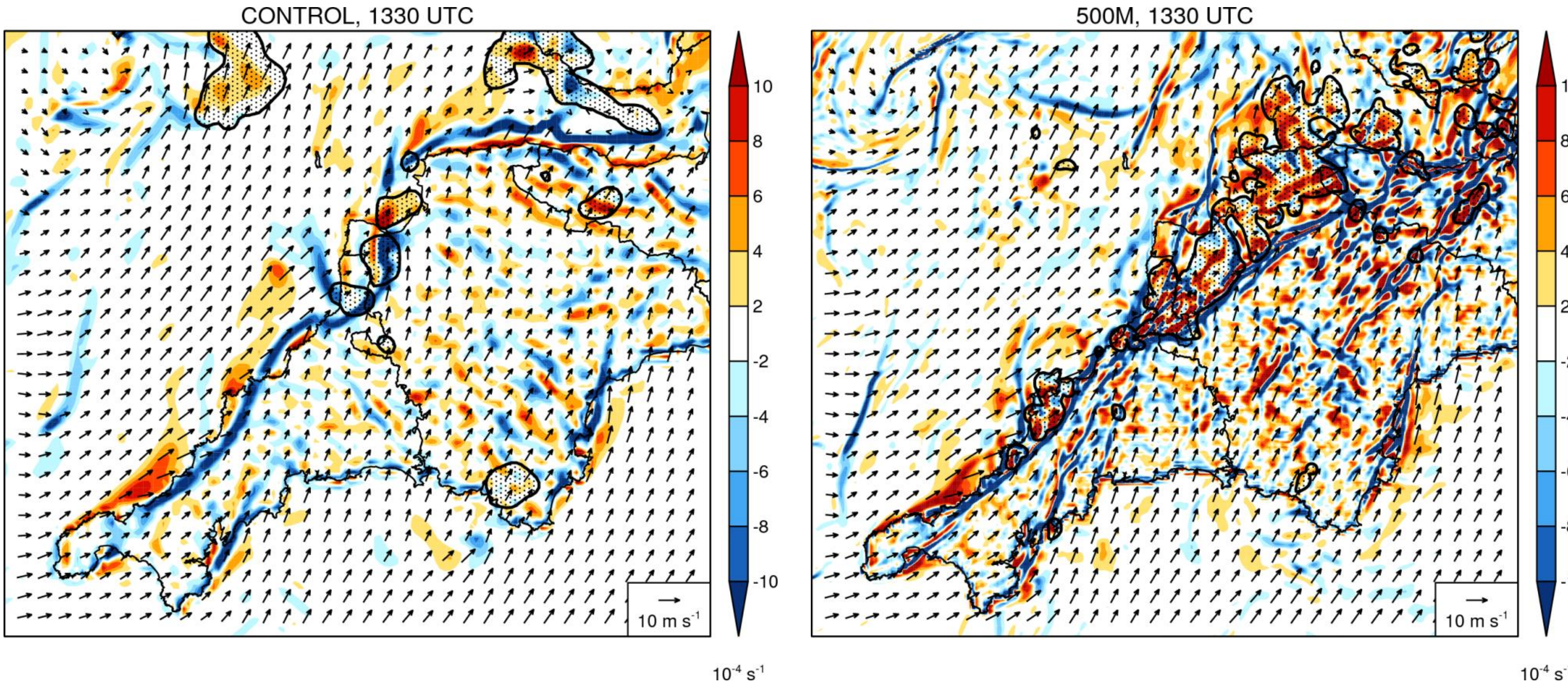

Synoptic setting comparison

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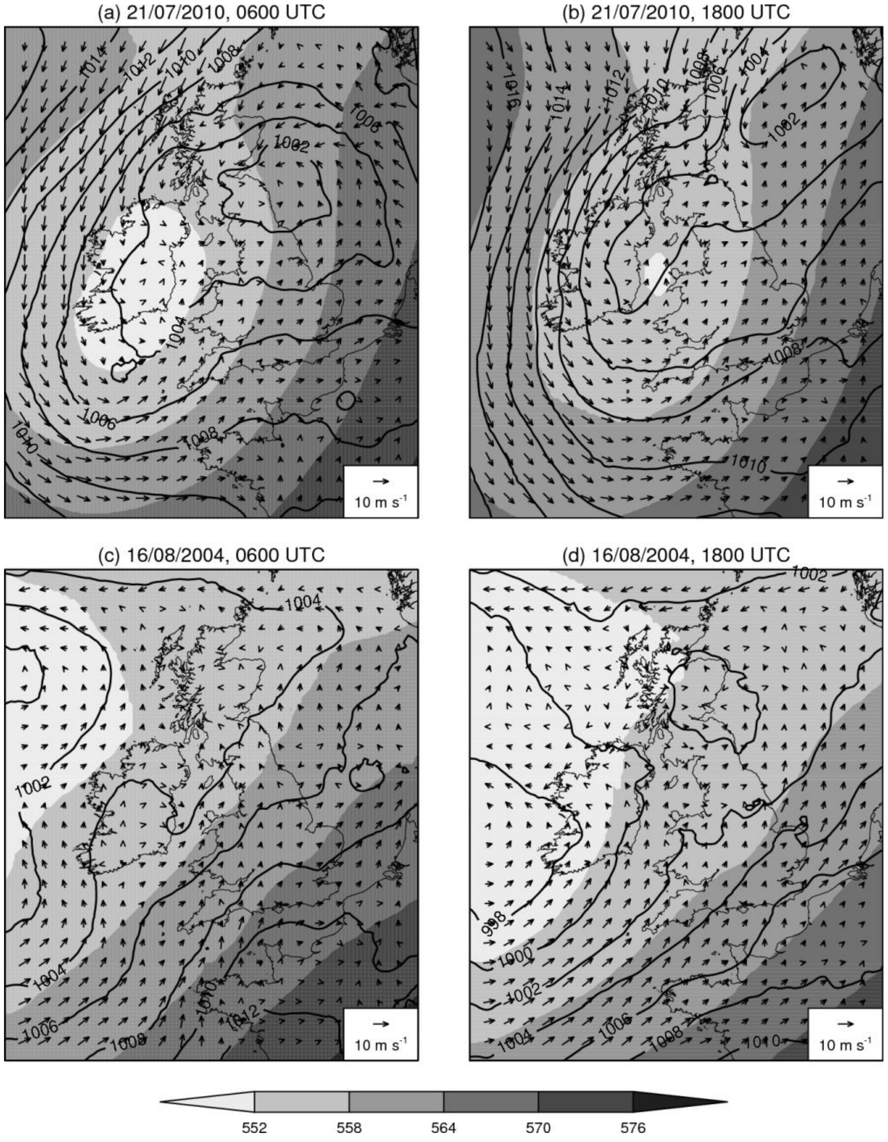
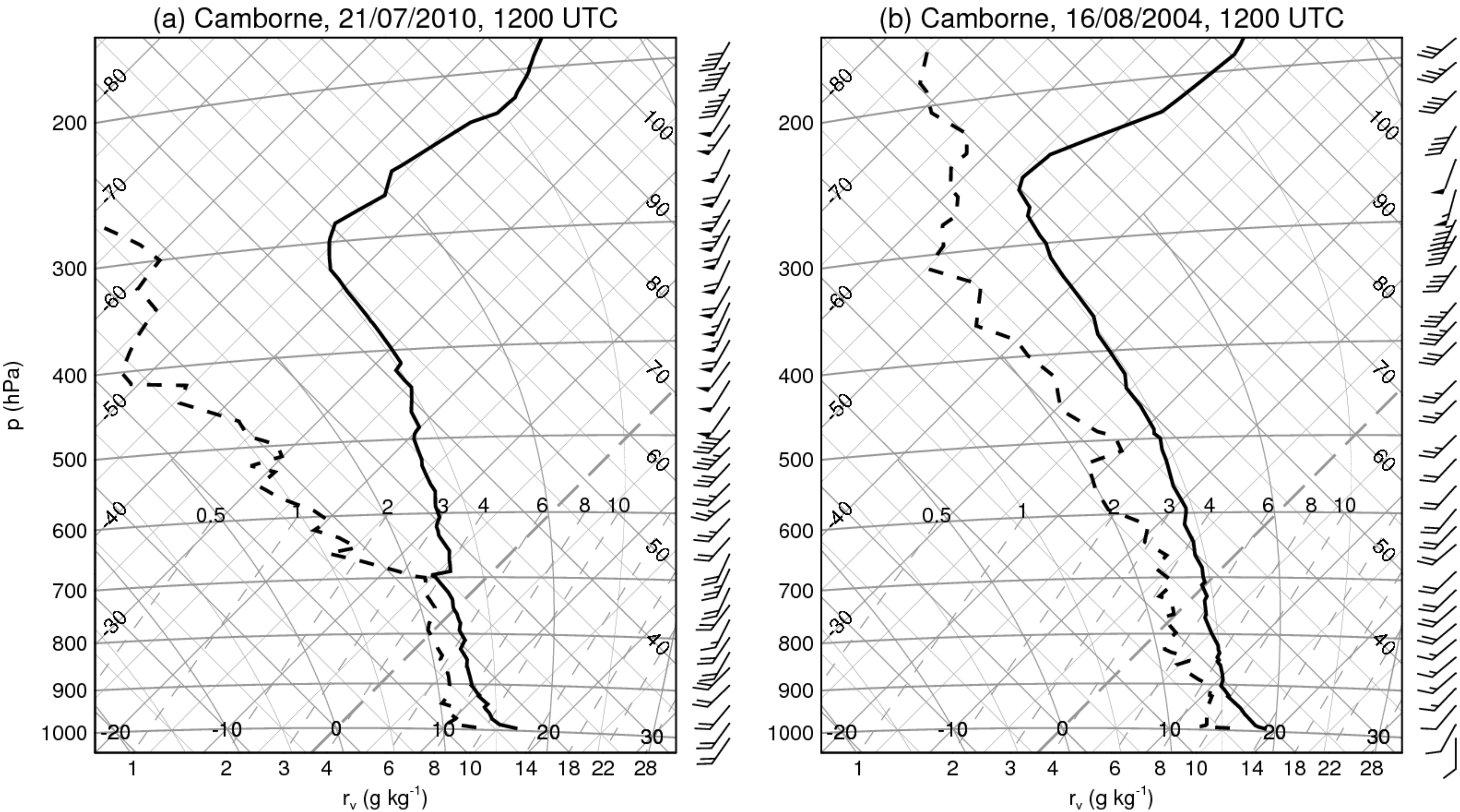


Tephigram comparison

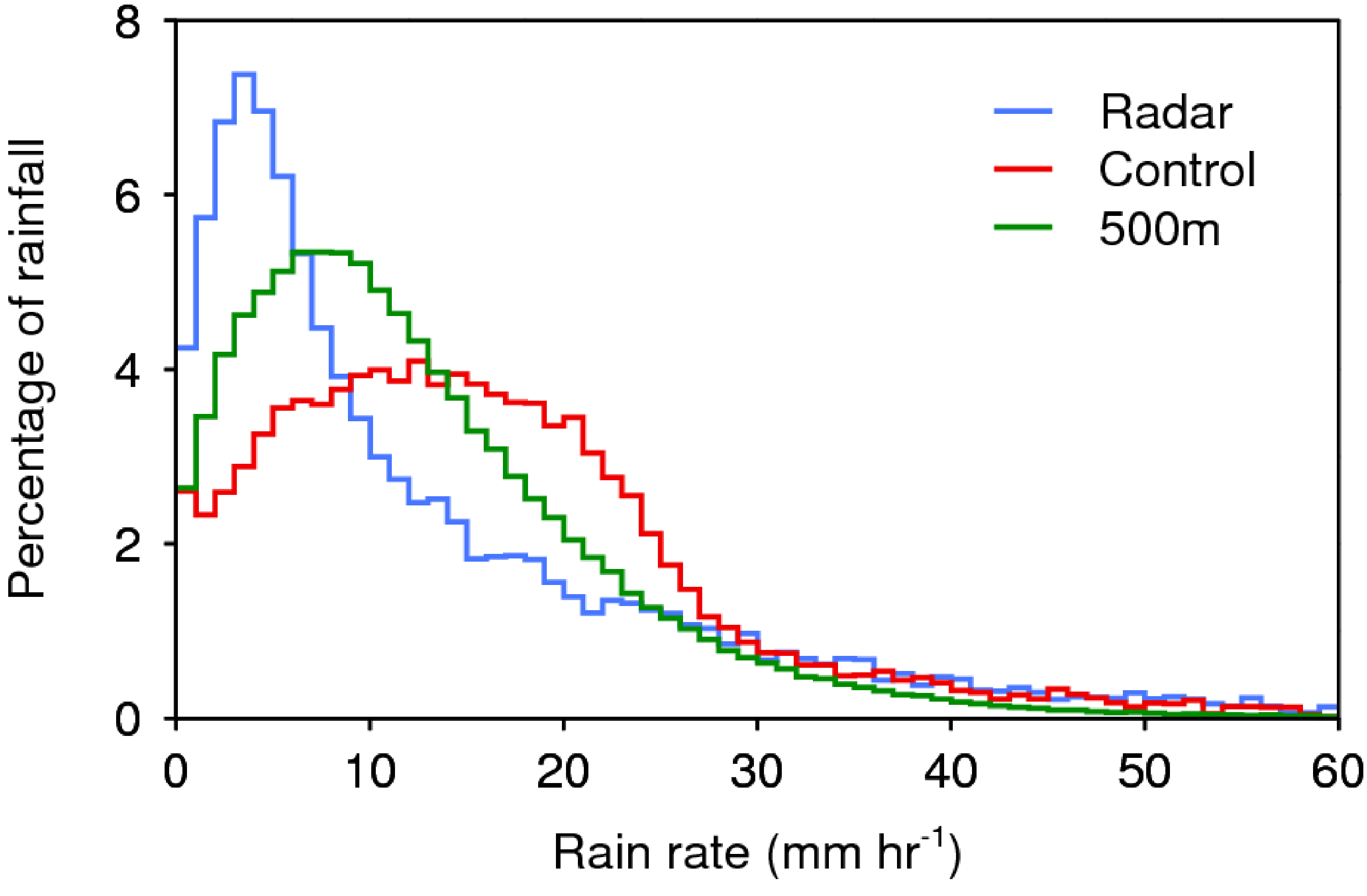


Sensitivity Tests

- Aim: To investigate the factors controlling the development and maintenance of the coastal convergence line

Name	Factor under investigation	Methodology
WEAKSUN	Differential surface heating	Solar constant reduced to 400 Wm^{-2}
SAMEROUGH	Differential surface roughness	Roughness length for momentum over land fixed to sea value
NOOROG	Orography	Land height over southwest peninsula set to zero
NOOUTFLOW	Convective outflow	Latent cooling in microphysics scheme switched off

Rain intensity bias



Control simulation: Divergence

Precipitation

Convergence line

Divergence offshore