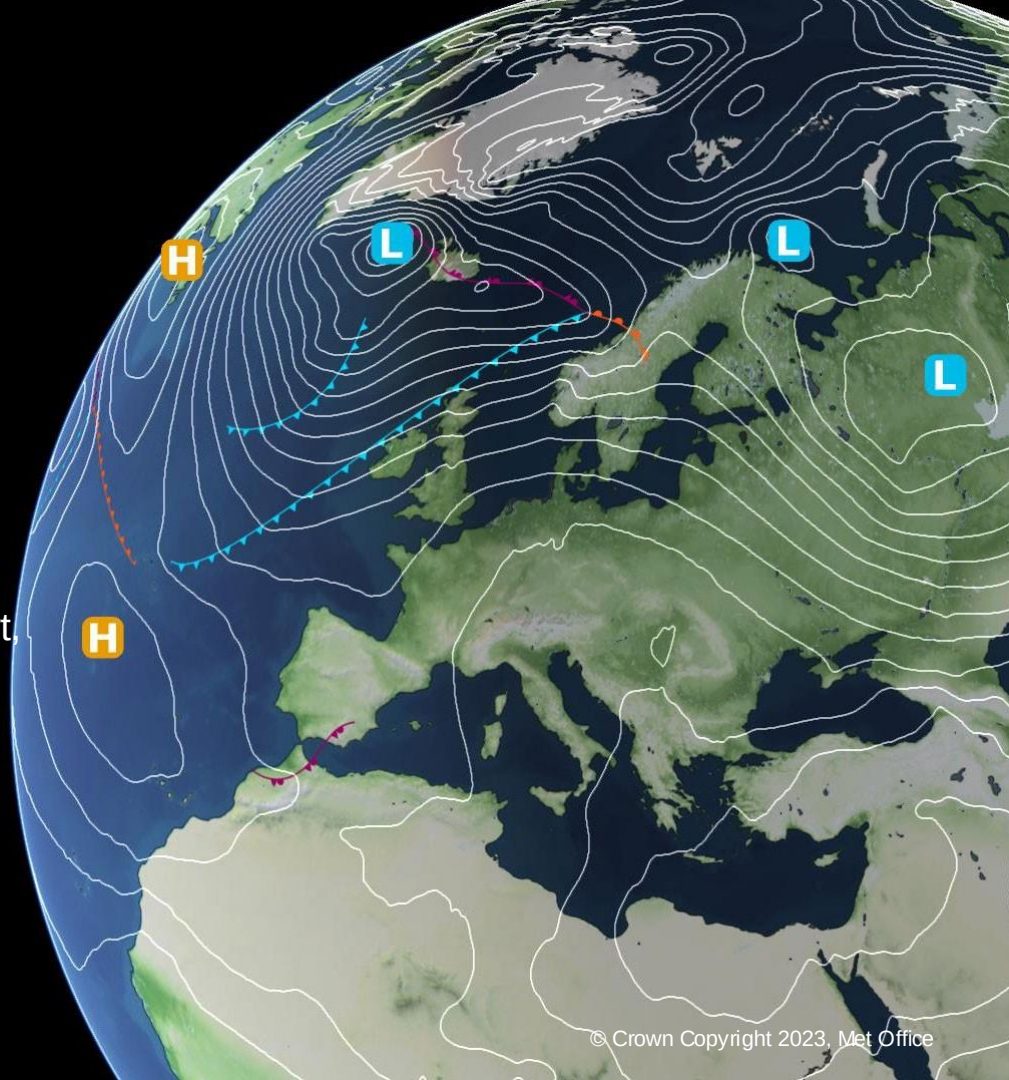
Development of Novel Methods for Predicting Convective Hazards

David Flack

with thanks to:

Humphrey Lean, Steve Willington, Matthew Lehnert, Chris Lattimore, Tom Crabtree, Mark Seltzer, Mike Silverstone, Neil Armstrong, Sylvia Bohnenstengel, Aurore Porson, Jon Petch, Sue Gray, Peter Clark, John Marsham and Doug Parker



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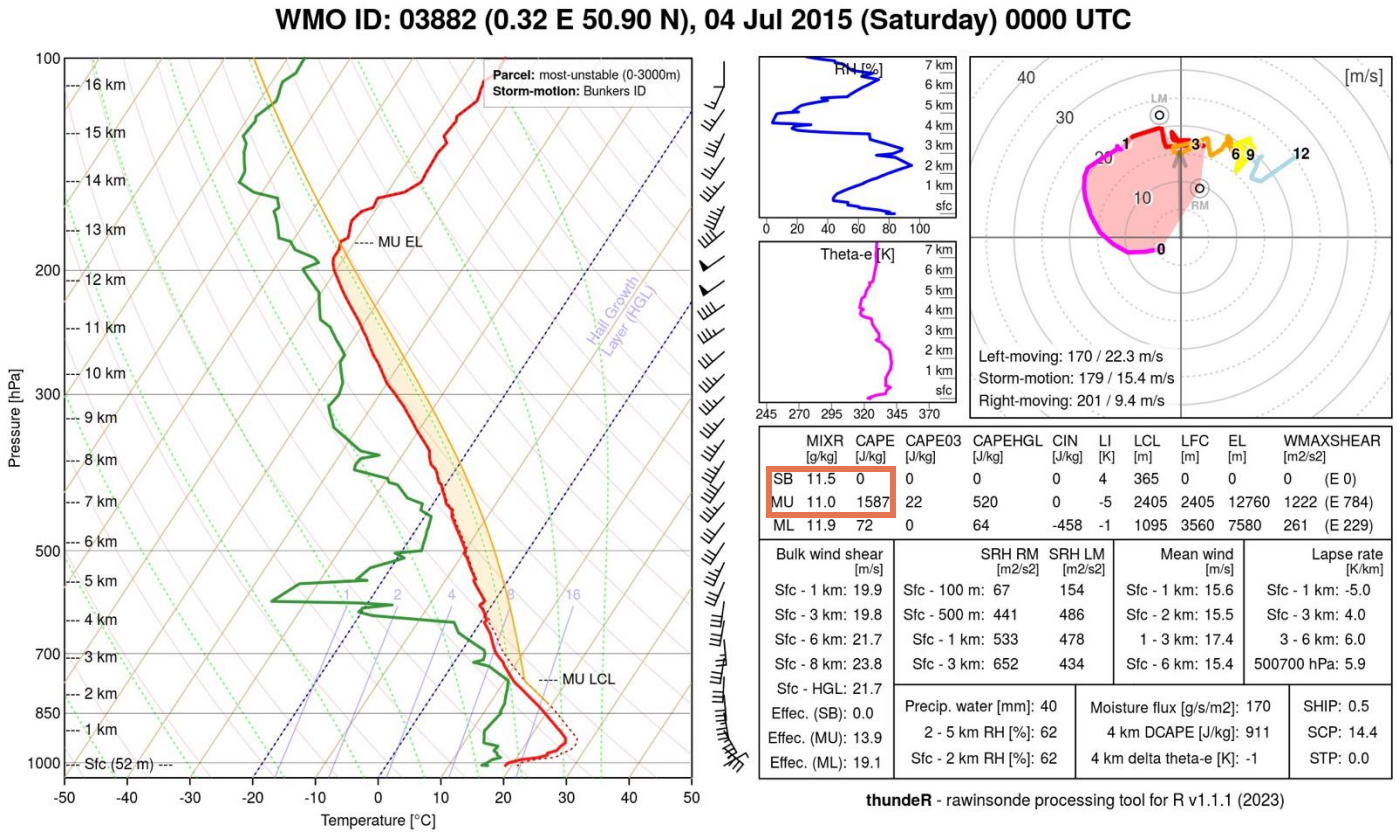
What is elevated convection?

- Convection in which the origin of the air parcels is above the boundary layer (e.g. Berry et al. 1945, Corfidi et al. 2008)



Ascent from Herstmonceux (www.rawinsonde.com)

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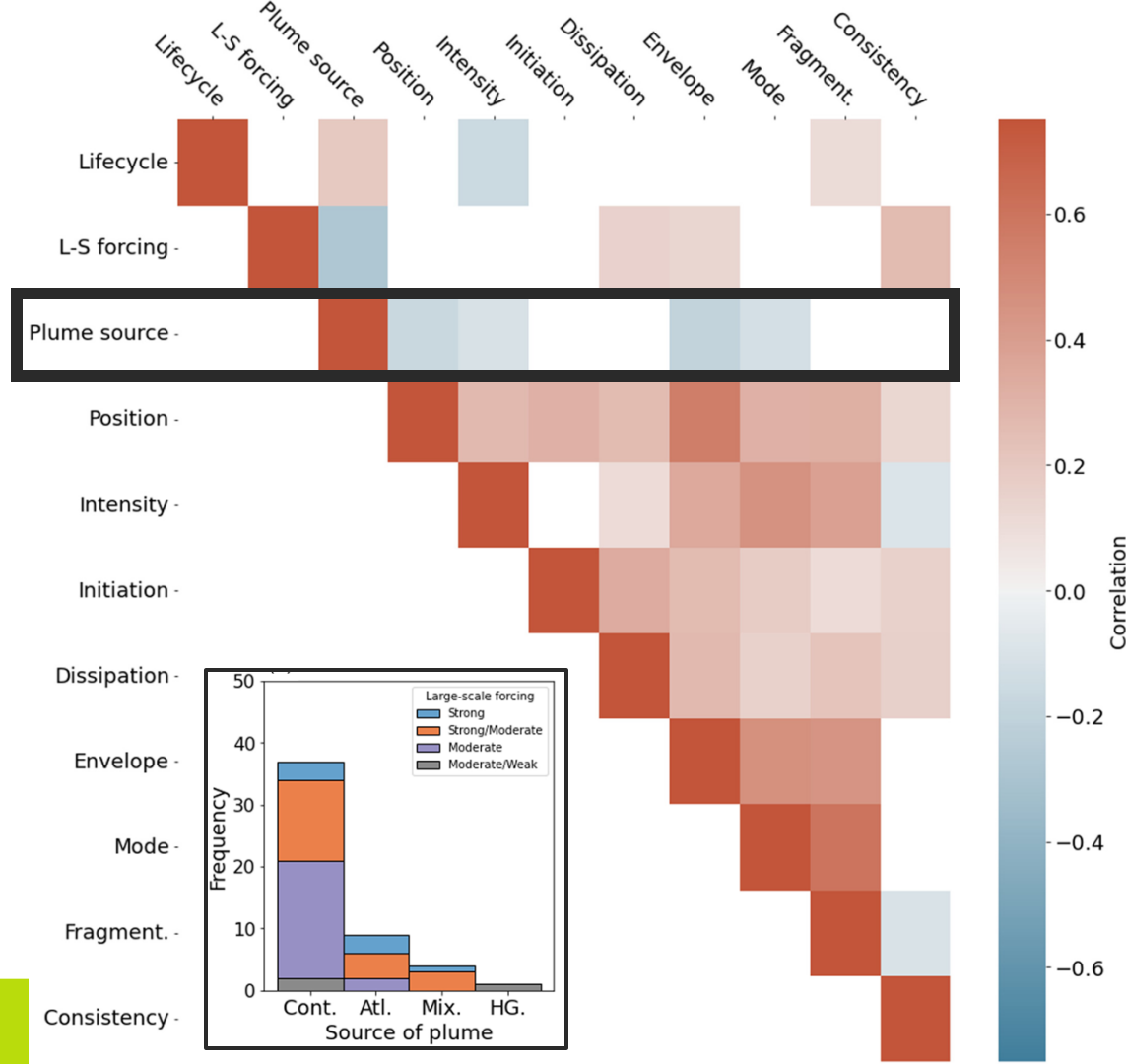
Operational Meteorologists notice problems with elevated events

- Poorer performance in continental flows for
  - Location (position and convective envelope)
  - Convective mode
  - Intensity
  - For plume source red implies good scores for continental plumes; blue implies bad scores for continental plumes but good scores for Atlantic plumes
- Main question:
  - Will an event be maintained as it crosses the English Channel?



(Flack et al. 2024)

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Making Elevated Convection Diagnostics Operational

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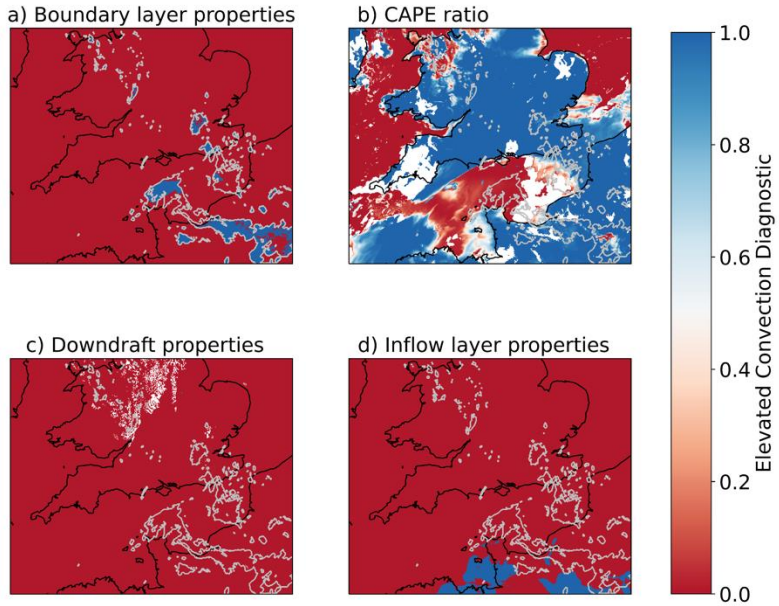
Diagnostics to Identify Elevated Convection

Diagnostic	binary/continuous	Maximum value	Equation	Value for elevated convection
Boundary layer properties	binary	1	BL type = stable and Max. Col. Ref. > 30 dBZ	1
CAPE ratios	continuous	1	1 – (SBCAPE/MUCAPE)	1
Downdraft properties	continuous	infinite	DCIN/DCAPE	> 1
Inflow layer properties	binary	1	Effective inflow layer base > BL height	1

Corfidi et al. (2008), Clark et al. (2012), Market et al. (2017), Thompson et al. (2007)

Typical UK case study event: 14 September 2021



(Flack et al. 2023)

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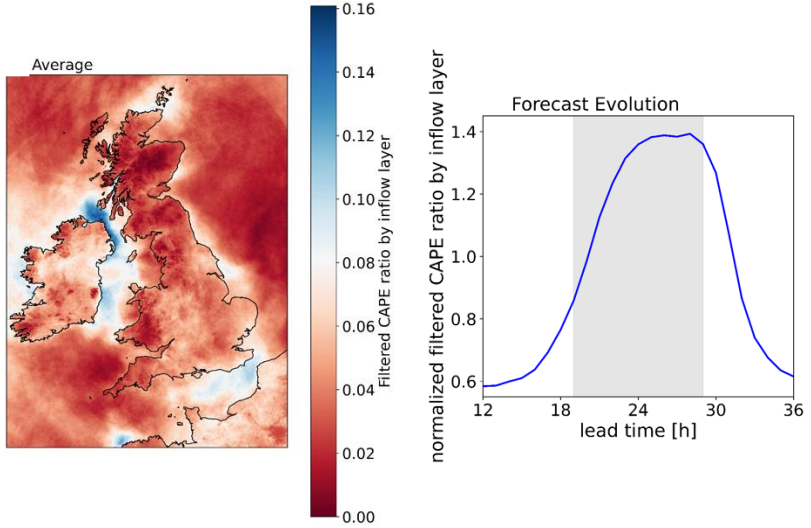
A Combined Diagnostic

- Preferred diagnostics are the CAPE ratio and Inflow layer properties from UK Testbed Summer 2021

- CAPE ratio filtered by the inflow layer properties
  - Only “meaningful” values of CAPE indicated



(Flack et al. 2023)

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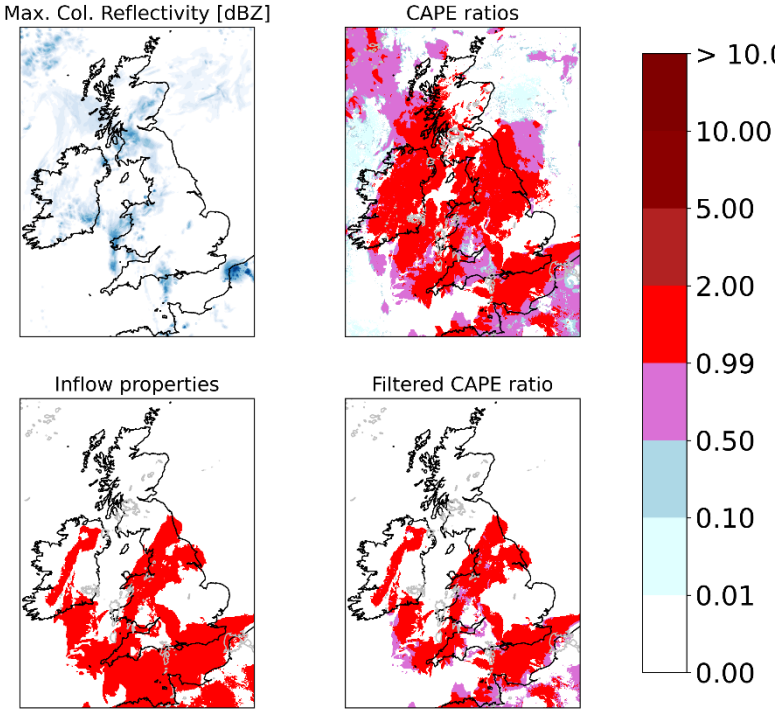
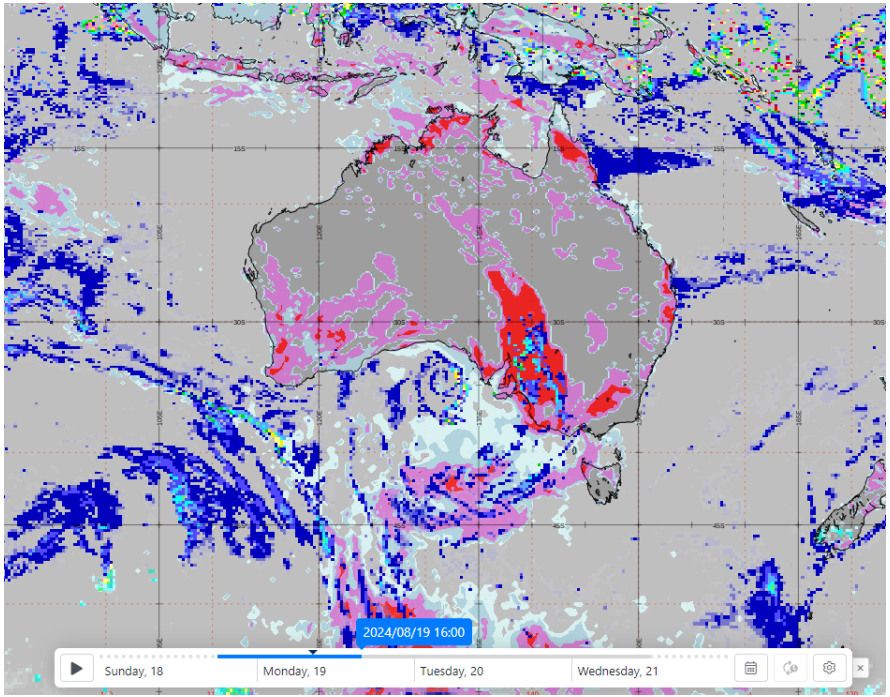
0000 UTC 01 August 2024 (T + 000)





CAPE Ratio applied in OnlineWeather: 19 August 2024 - GM (courtesy of Neil Armstrong)

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Next steps

- Feedback from the summer from the operational meteorologists
  - Addressing any immediate feedback to improve the diagnostics (where possible)
  - May need to extend this given the weather over the summer…
- Development of “use cases” to allow for prioritisation in operational implementation planning
- Operational implementation

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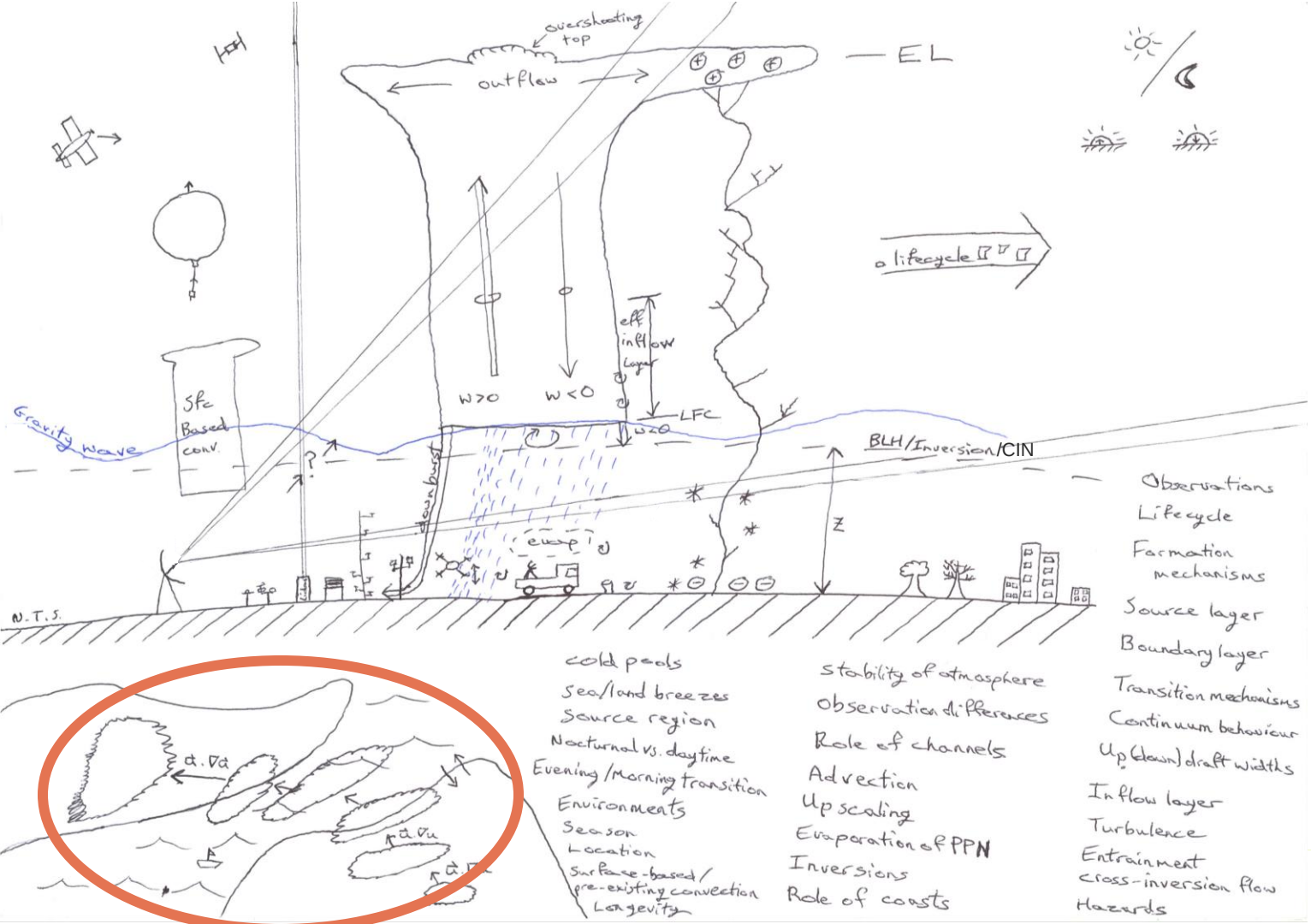
Development of a method to predict the maintenance of convection in unfavourable environments



Elevated Convection: What is the problem?

Will it be maintained as it crosses the English Channel?

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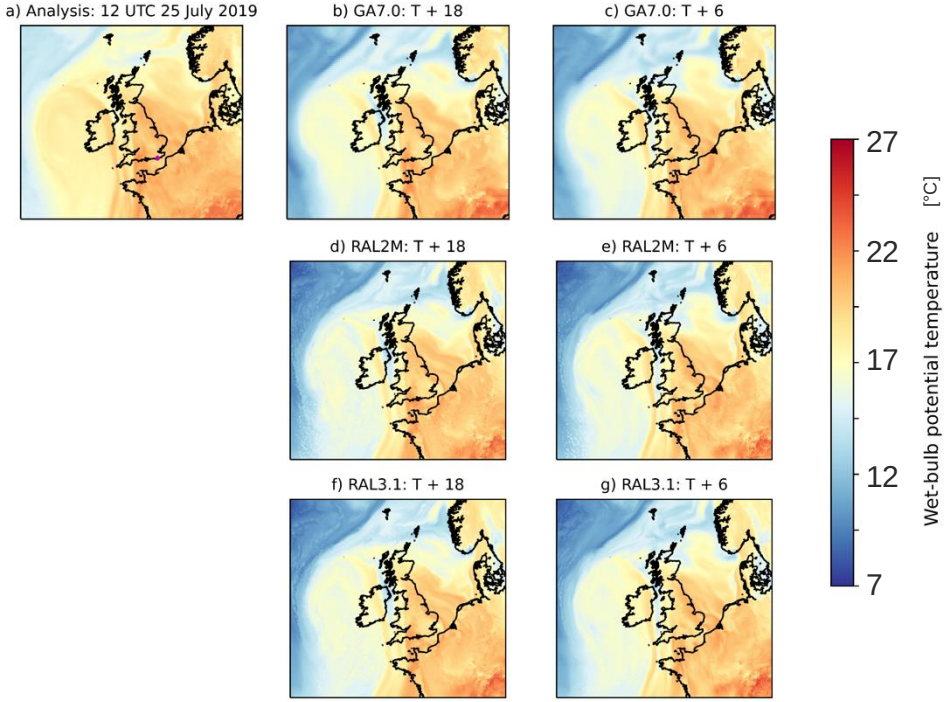
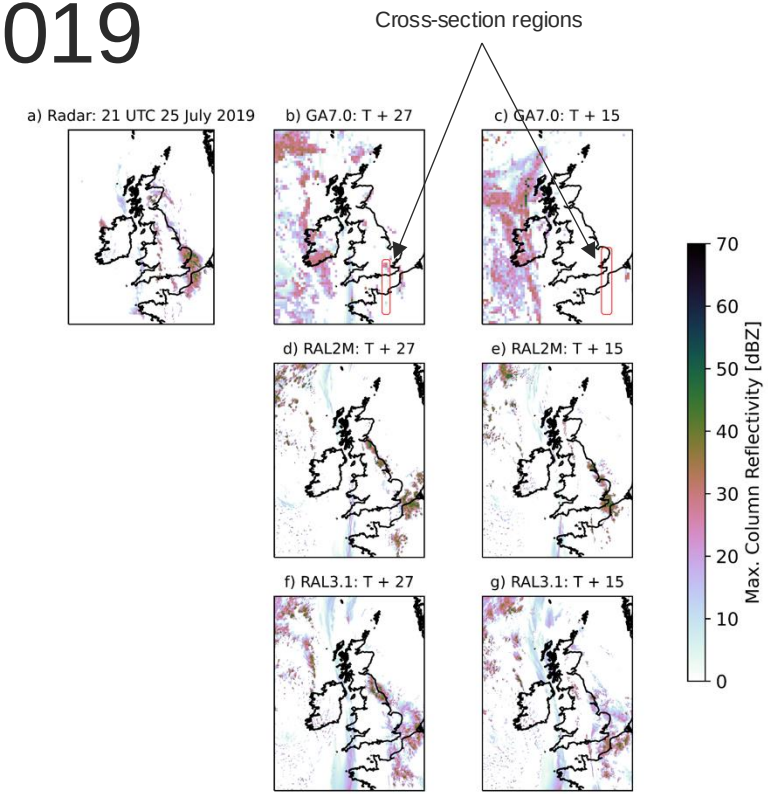
Case Study: 25 – 26 July 2019





(Flack et al. in prep)

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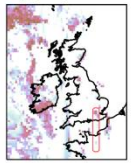
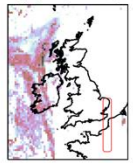
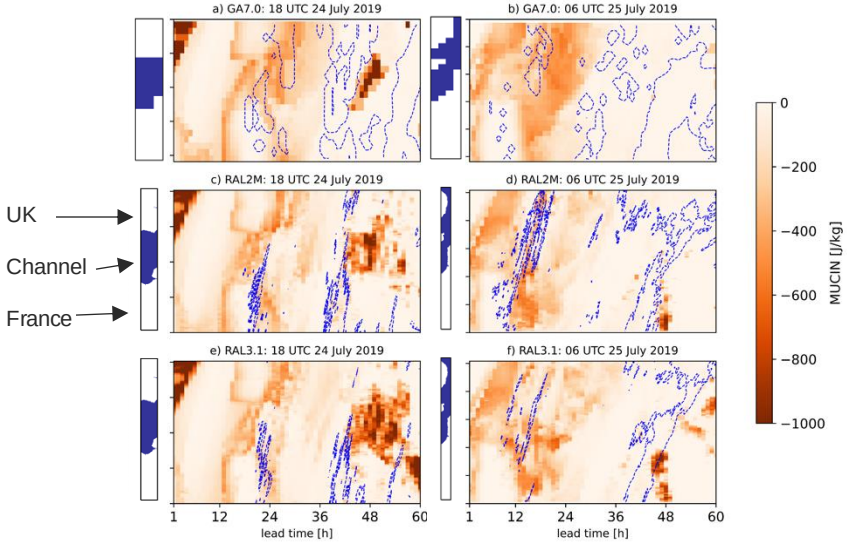




The role of CIN reservoirs and convective history



precipitation contoured

(Flack et al. in prep)

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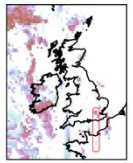

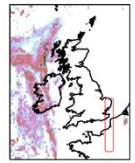

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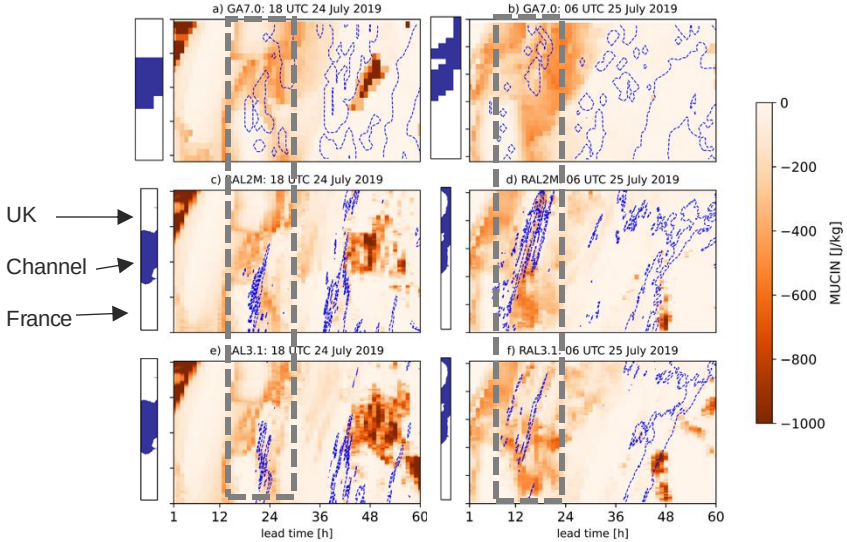

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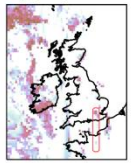

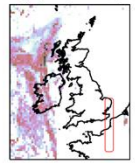

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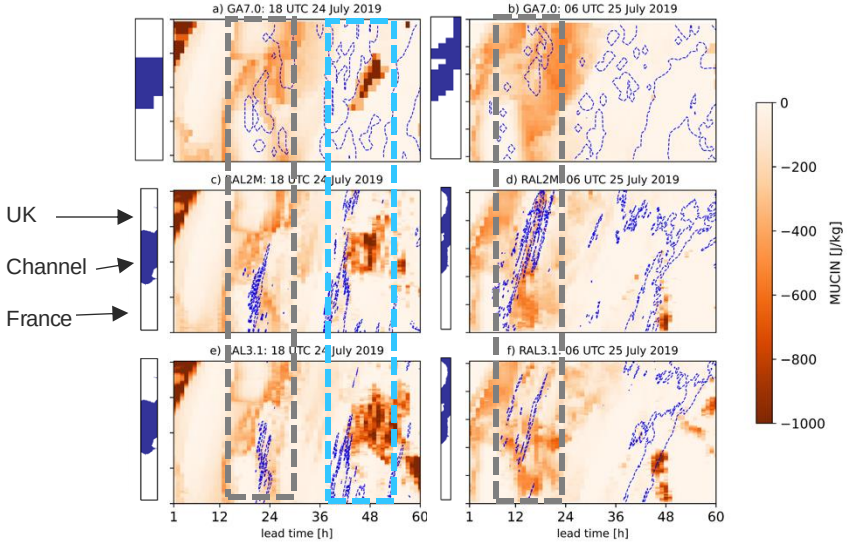

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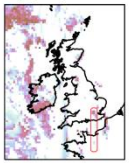

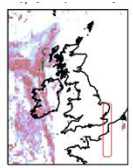

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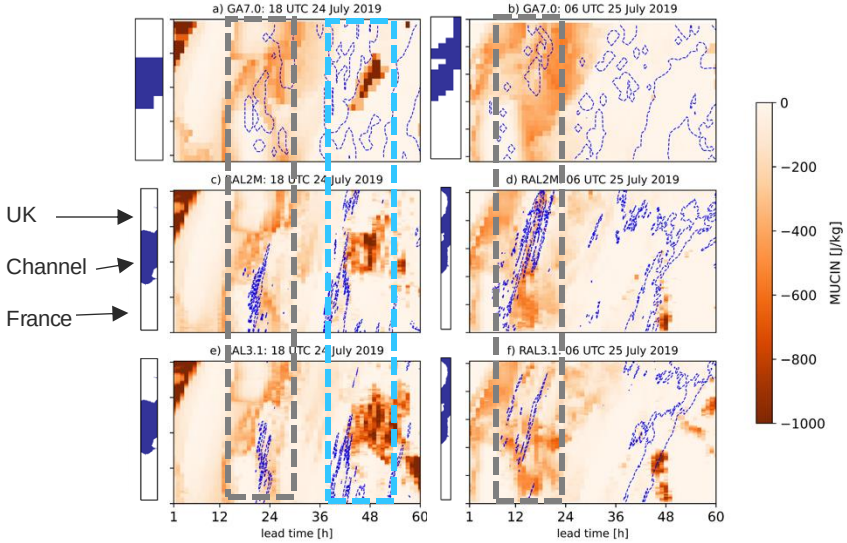

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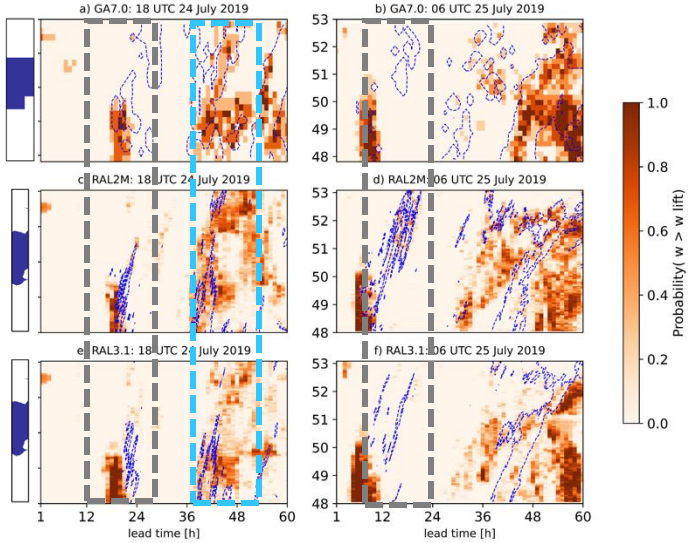
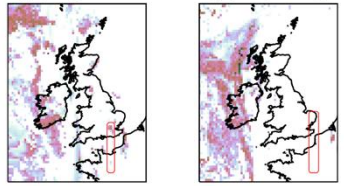
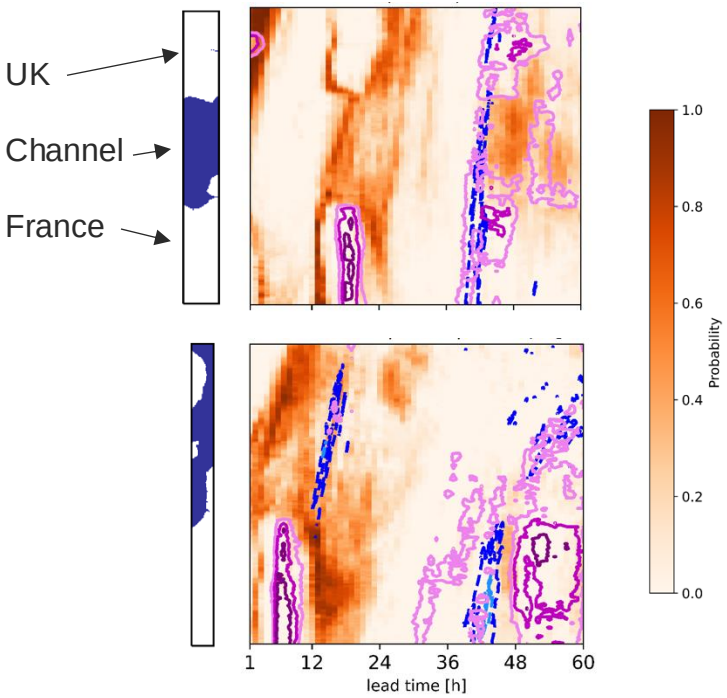


$$w_{lift} > \sqrt{2|MUCIN|}$$

(Flack et al. in prep)



Application in an ensemble



- How reasonable is this based on the ensemble?
  - Ensemble probabilities of
    - MUCIN < - 250 J kg^{-1} (shaded)
    - precipitation > 1 mm h^{-1} (blue contours)
    - $w_{max} > \sqrt{2}$ MUCIN (purple contours)
    - contours at 25%, 50%, and 75%
  - Good signal for the CIN reservoir
  - Harder to determine signal for the vertical velocity comparison, implying still uncertain within this forecast of whether it will be maintained as it crosses
  - Limitation of using an arbitrary threshold for identifying convective precipitation

(Flack et al. in prep)

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Next steps

- Test for multiple cases and more situations
- Test for different definitions of w more rigorously
- Consider expansion to included developed systems with slanted updrafts

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Summary

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Summary

- Elevated convection is one of the hardest challenges
  - Diagnosis of elevated convection
  - Maintenance of elevated convection (e.g. across English Channel)
- Three diagnostics are currently being tested at the Met Office to identify elevated convection to provide use cases for their operational implementation
- New method is being developed considering the updrafts required to overcome CIN to help determine if convection will be maintained across the English Channel
  - *The method could easily be applied to any convection and thus determine if convection could be maintained in unfavourable environments*