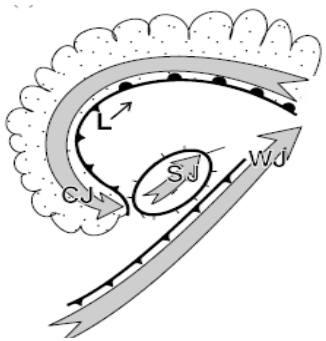
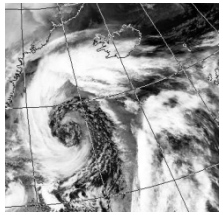




A regional climatology of sting jets and the extratropical cyclones in which they occur

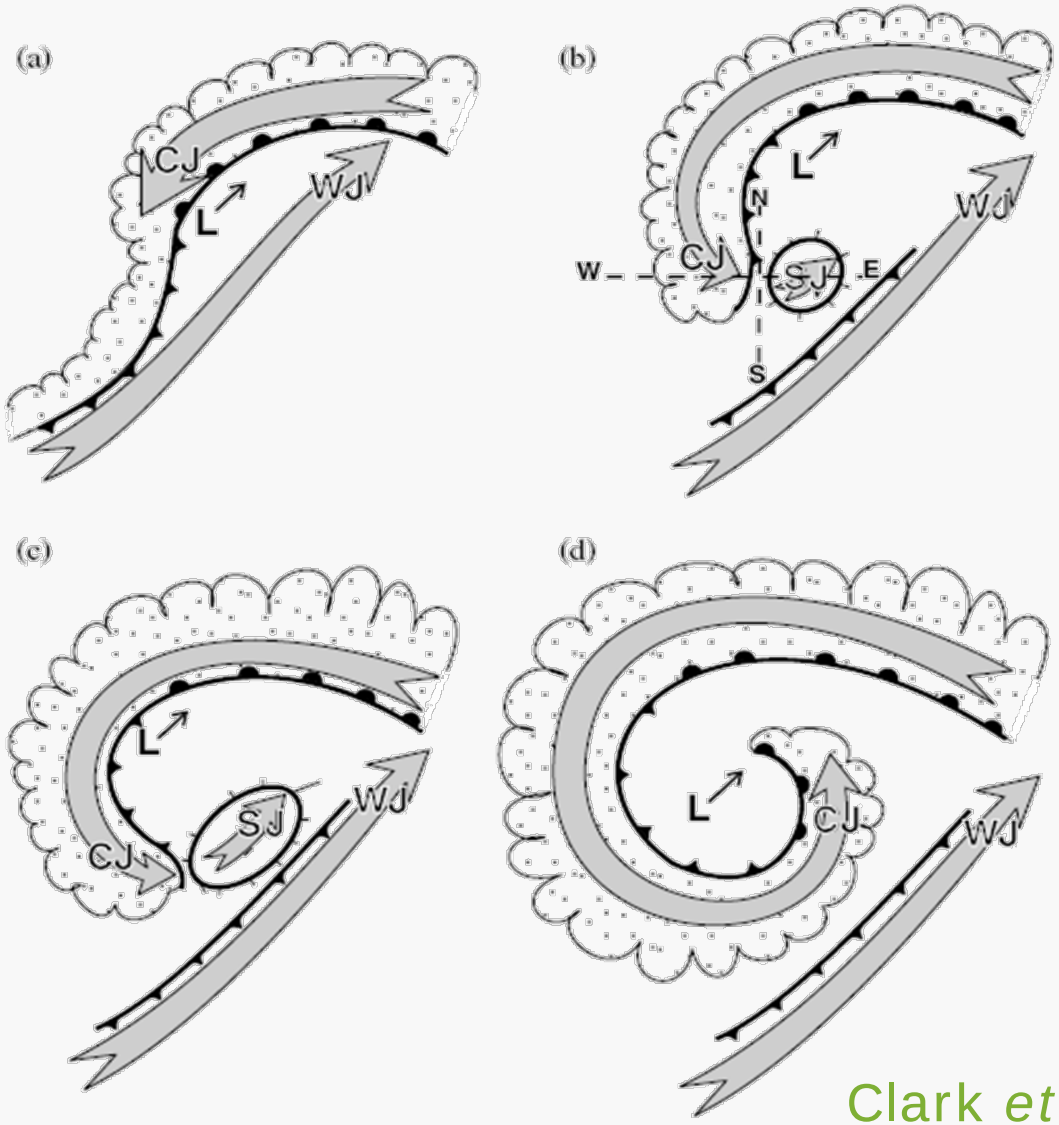
Suzanne Gray,

Oscar Martinez-Alvarado, (Univ. of Reading), Peter Clark (Univ. Of Surrey), and Jennifer Catto (Univ. Monash)

September 2011

www.met.reading.ac.uk/~sws98slg

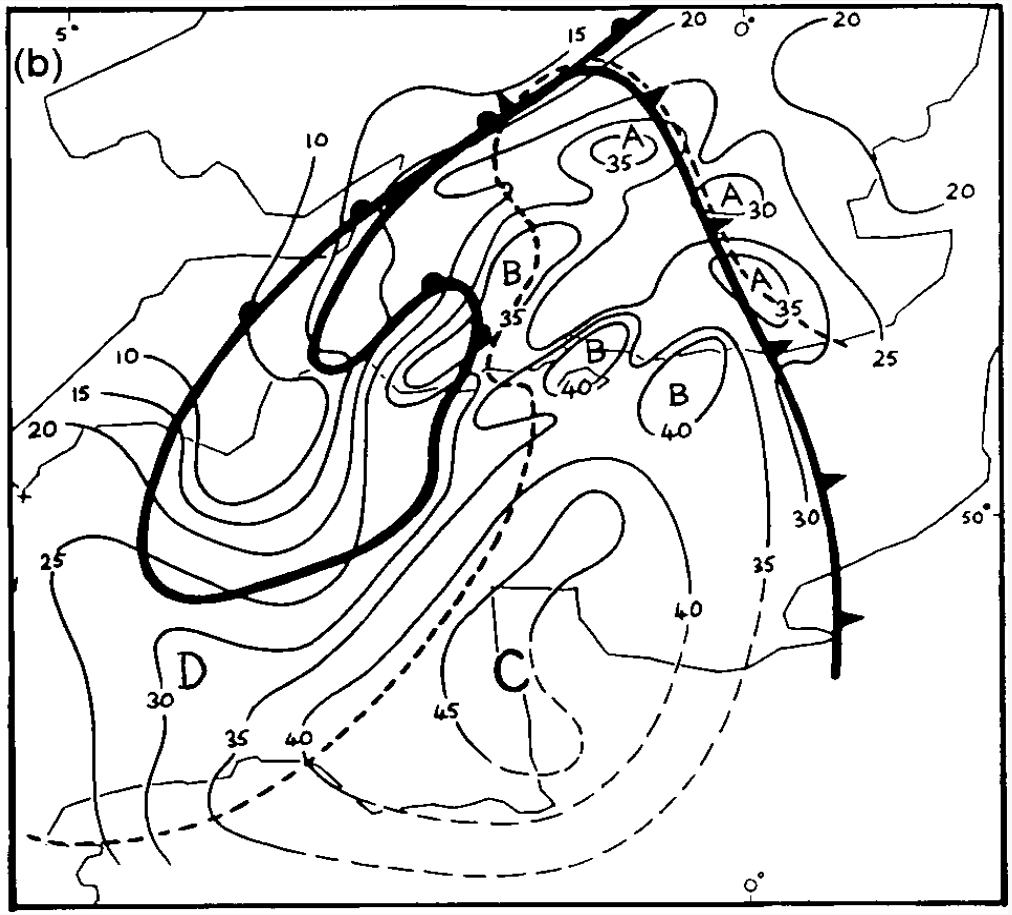
Review: conceptual model



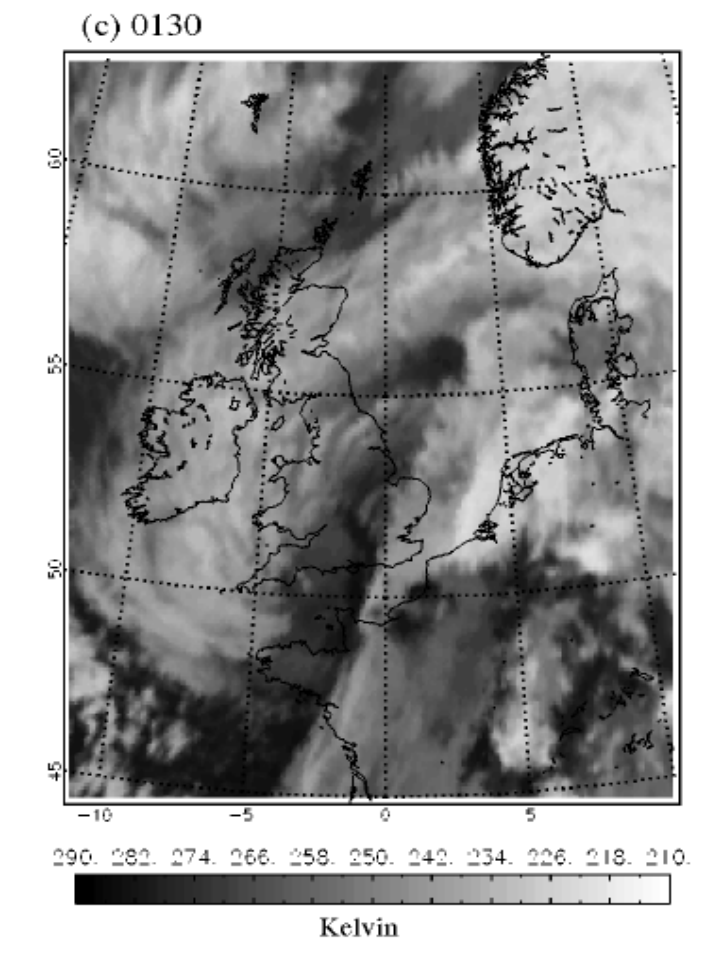
The Sting jet is a transient mesoscale feature that sometimes occurs during the process of frontal fracture in Shapiro-Keyser cyclones

Clark *et al.* (2005)

Review – example case: October 1987 storm, observations



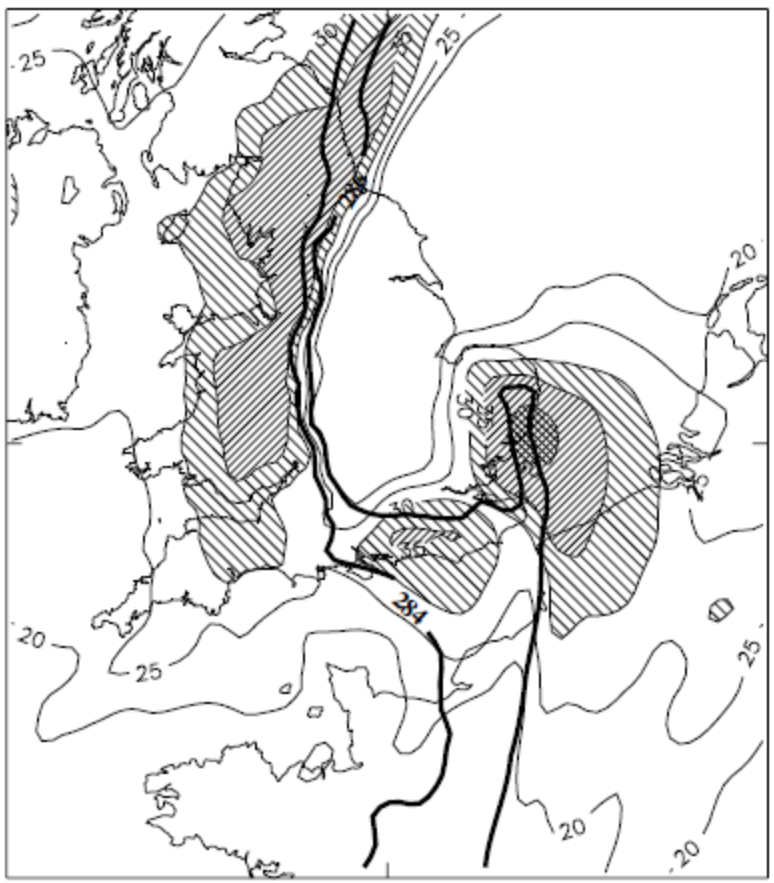
Mesoanalysis



IR imagery

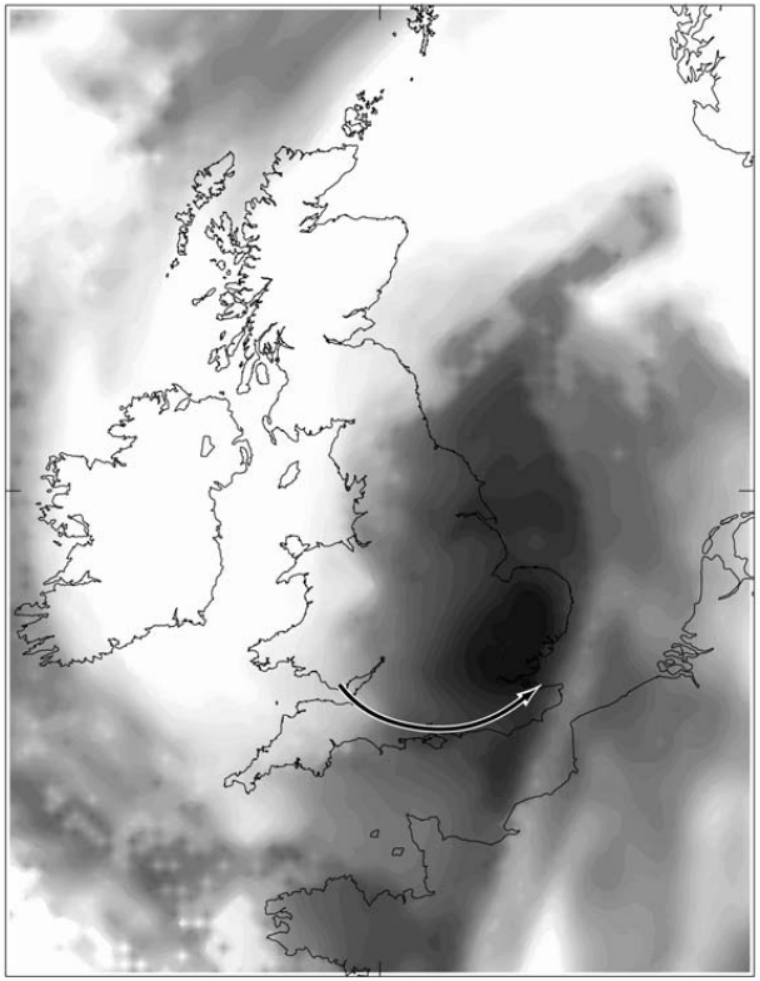
Browning (2004)

Review – example case: October 1987 storm, modelling



Model system-relative 825hPa windspeed at 0300 UTC

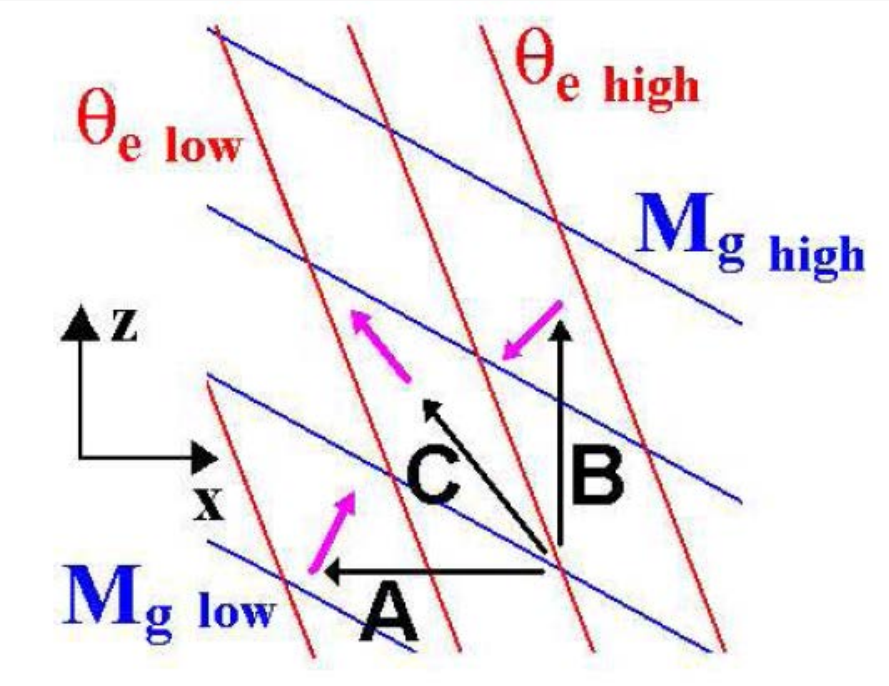
Clark *et al.* (2005)



Pseudo-IR at 0300 UTC and system-relative track of the maximum descending trajectory

Review – mechanisms: 1. conditional symmetric instability

- CSI is the due to the combination of inertial and conditional instability (gravitational instability) for air parcels displaced along a slantwise path.
- It will only be released if the atmosphere is inertially stable to horizontal displacements and conditionally stable to vertical displacements.



Morcrette (2004)

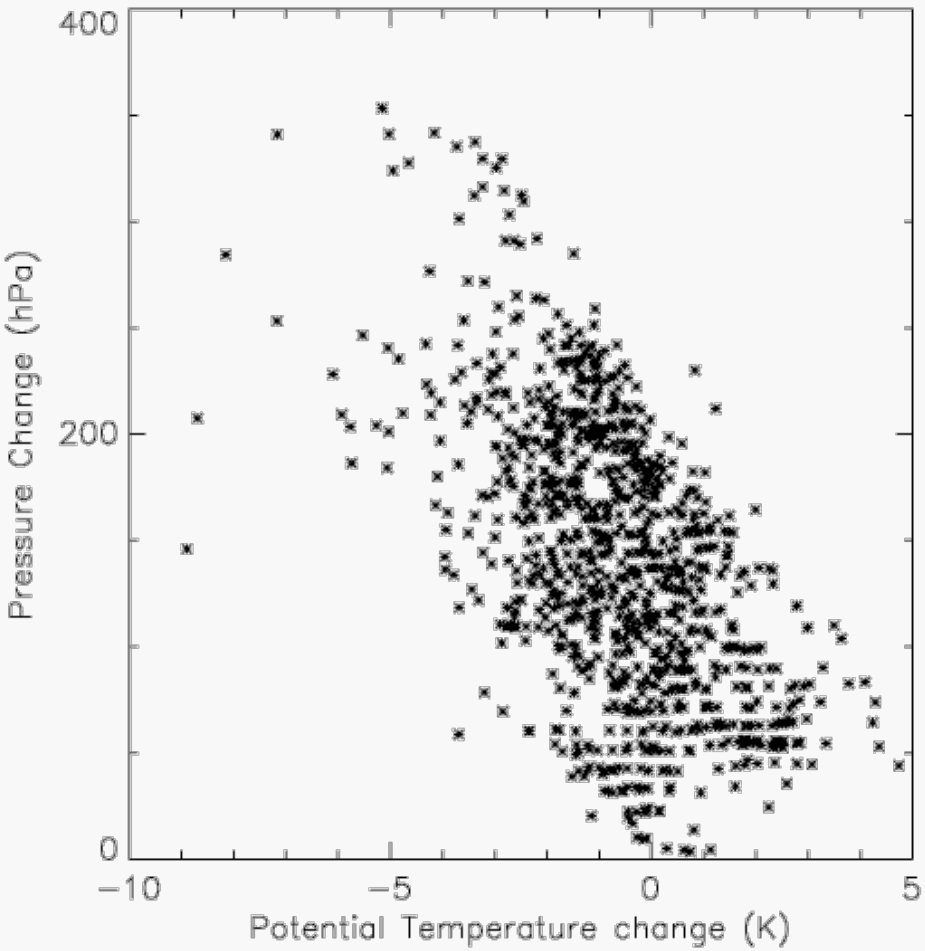
Review – mechanisms: 2. evaporative cooling

Enhancement of surface winds by

i. Intensifying the slantwise circulations and so amplifying the latent heat sources and sinks on the mesoscale.

ii. Reducing the static stability in the dry slot and/or closer to the cloud head so leading to turbulent momentum transfer or upright convection.

(Browning 1994)



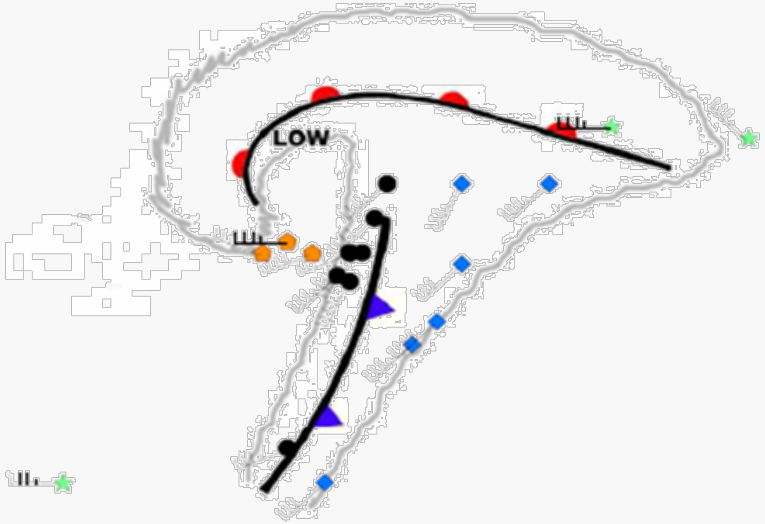
Clark *et al.* (2005)

Review – climatological importance

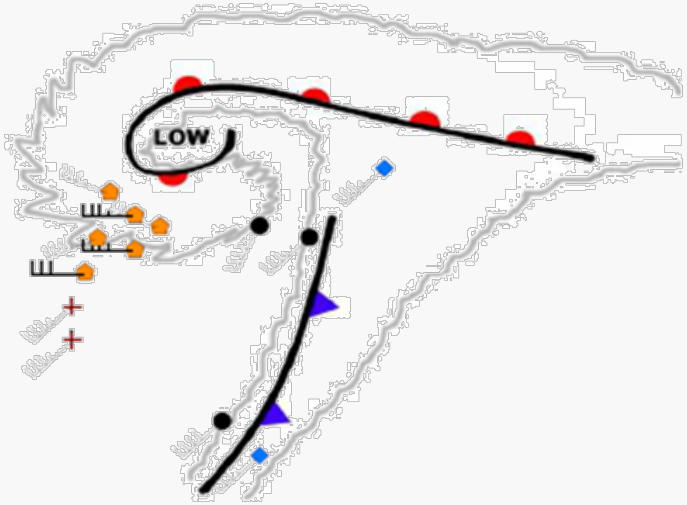
Algorithm developed to extract mesoscale strong wind events from MST radar data – classified by structure and synoptic setting

9 potential sting jets passed over radar (in 7 years)

Parton et al. (2010)



(f) Shapiro-Keyser Model Stage III



(h) Shapiro-Keyser Model Stage IV

AIM

to develop a regional climatology of sting jets and sting jet cyclones

PROBLEM

observational datasets do not provide sufficient temporal resolution over the oceans to allow exhaustive identification of sting jets and sting jets are not resolved in multi-year re-analysis datasets

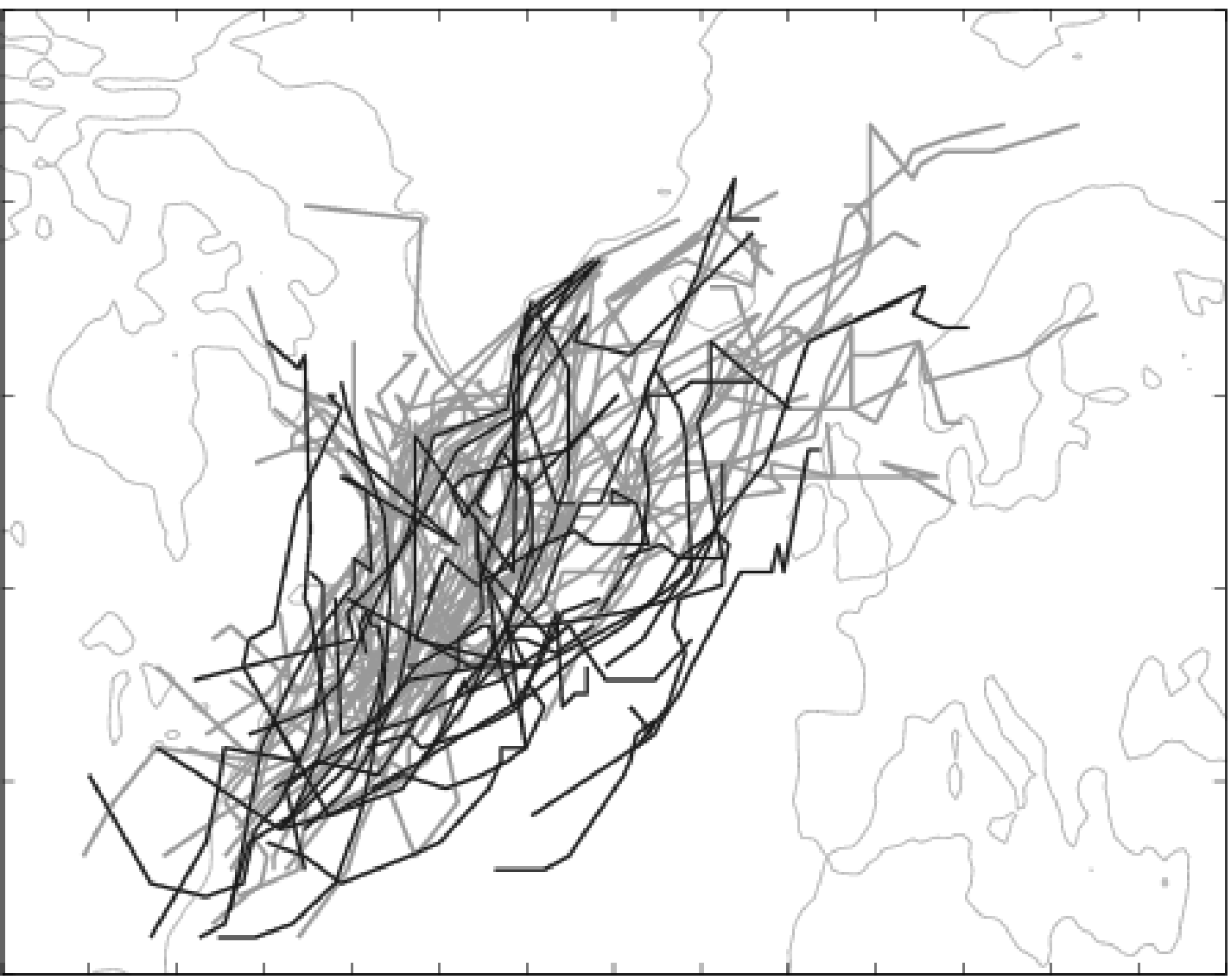
SOLUTION

- We have developed a diagnostic to diagnose sting jet precursor regions in re-analysis datasets (Martinez-Alvarado et al. 2011).
- The diagnostic detects downdraught CSI (via a metric called DSCAPE) in the moist frontal fracture zone.
- DSCAPE is present in cyclones that have sting jets but not present in other, equally intense, cyclones that do not have sting jets (Gray et al., 2011).
- Low resolution does not inhibit the accumulation of CSI, just its release to generate a sting jet.

Methods

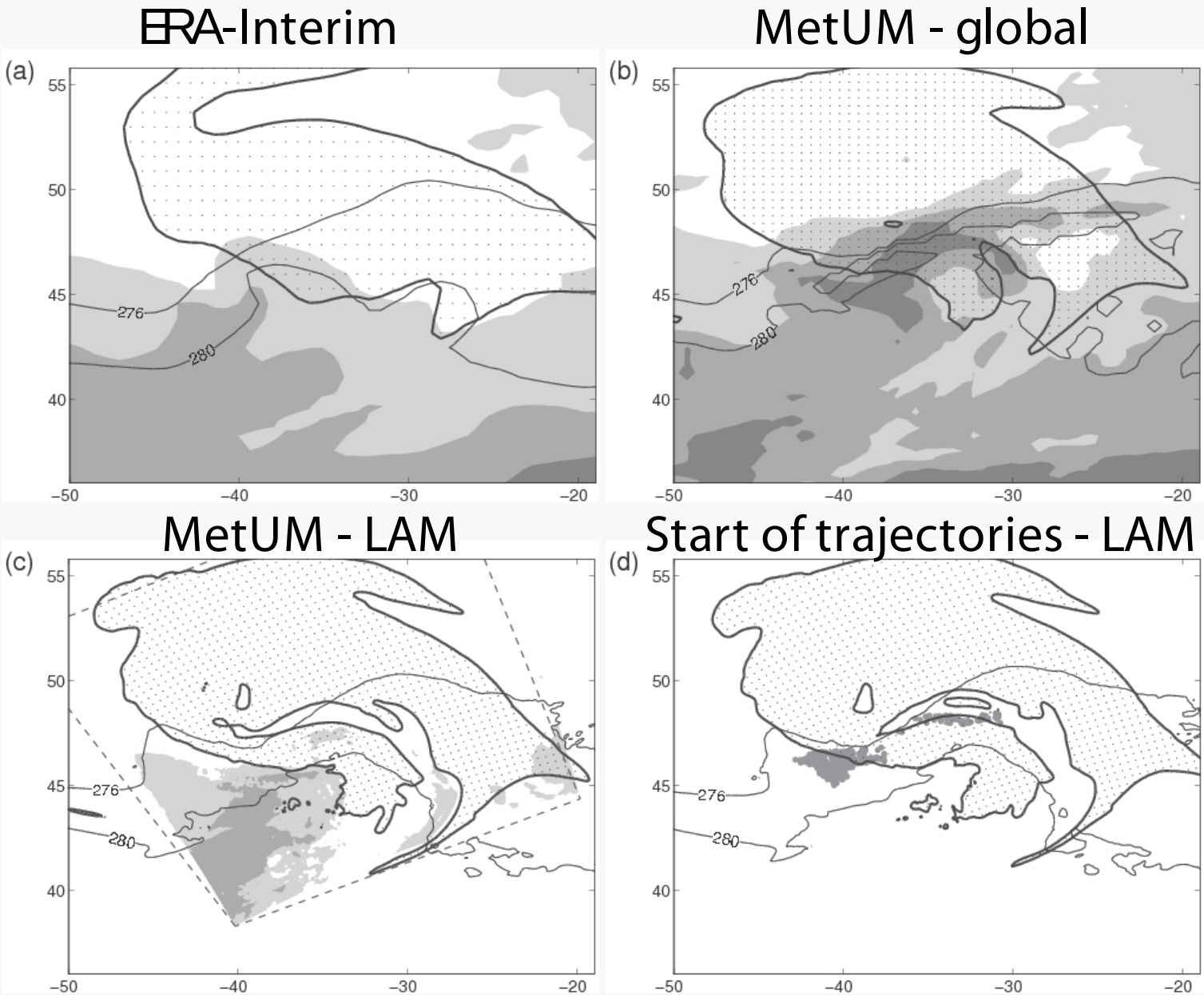
- The 100 most intense winter cyclones in ERA-Interim data (DJF 1989-2009) over the North Atlantic are identified by applying an objective feature tracking algorithm (Hodges, 1994).
- The sting jet precursor diagnostic is applied to each cyclone over 3 days straddling the time of maximum intensity.
- Verification of a subset of cases (15) is performed using high resolution (sting-jet resolving) model simulations with the Met Office Unified Model.
- Sting jets are identified in these simulations using established trajectory methods.

Tracks



100 most intense cyclones – 31 cyclones with sting jet precursor regions in black

Example of DSCAPE structure

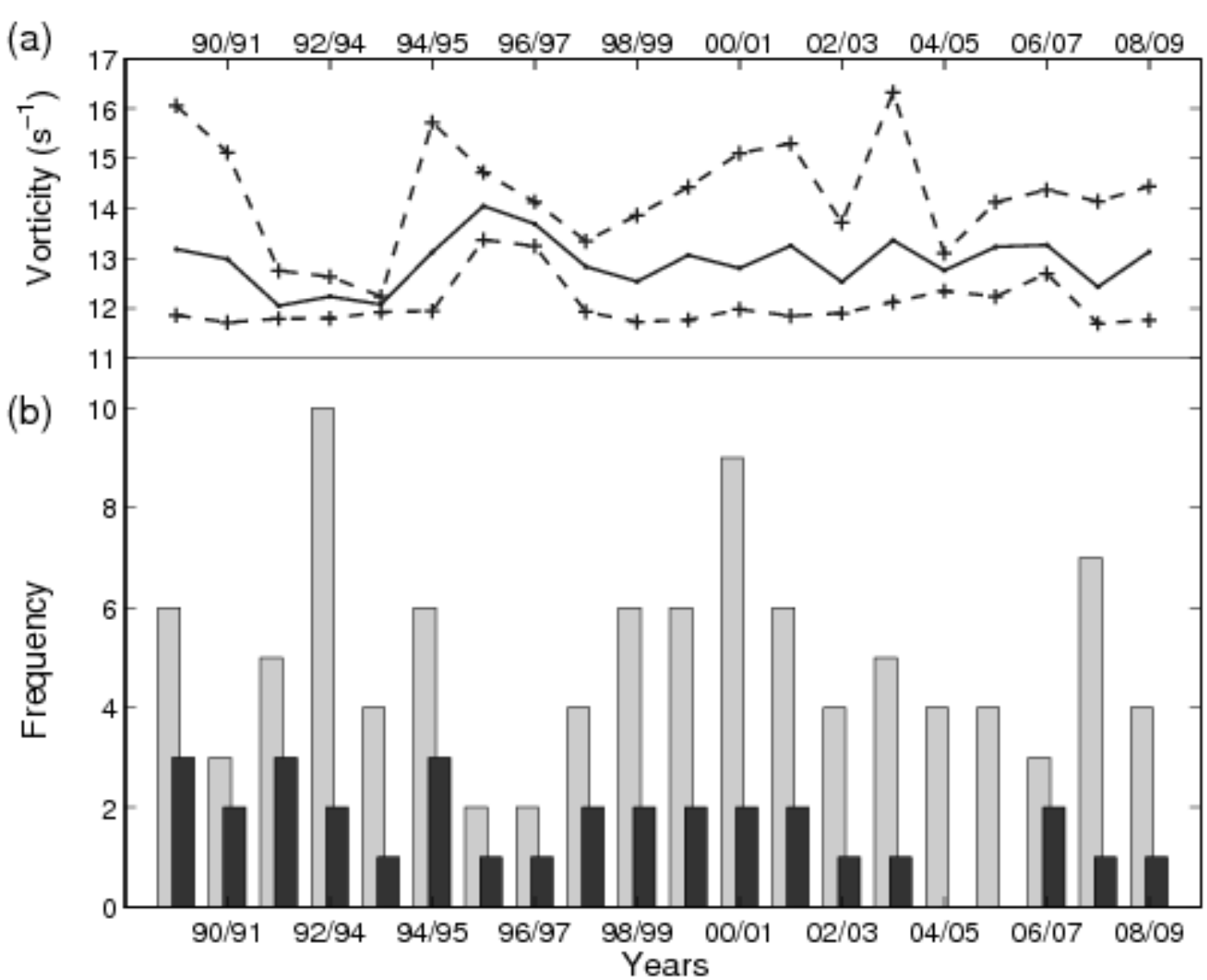


DSCAPE:
Light grey 200-500 Jkg^{-1}
Mid grey 500-800 Jkg^{-1}
Dark grey >800 Jkg^{-1}

Stippled regions: cloud at 550 hPa

Contours: 825 hPa-θ_w isolines

Inter-annual variability of frequency and intensity

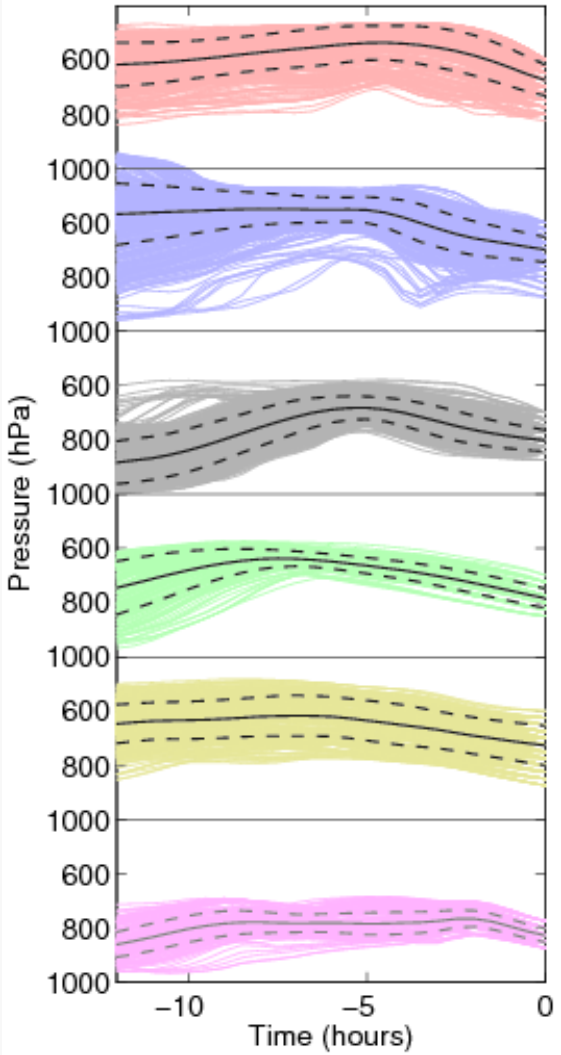


(a) Time series of max intensity (vorticity) during cyclone life cycle.

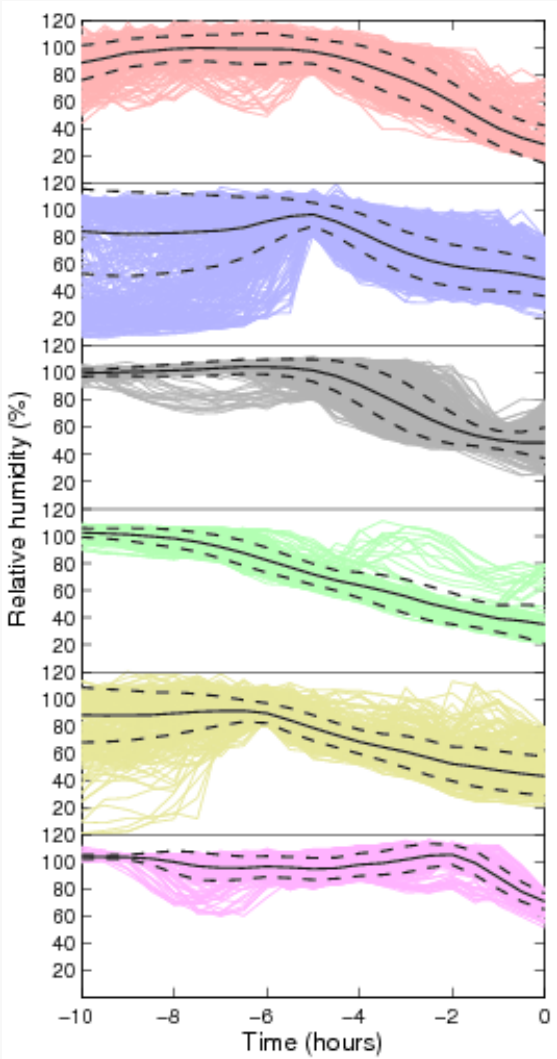
(b) Time series for frequency of the 100 most intense cyclones (grey) and those with sting jet precursor regions (black).

Sting jet trajectories

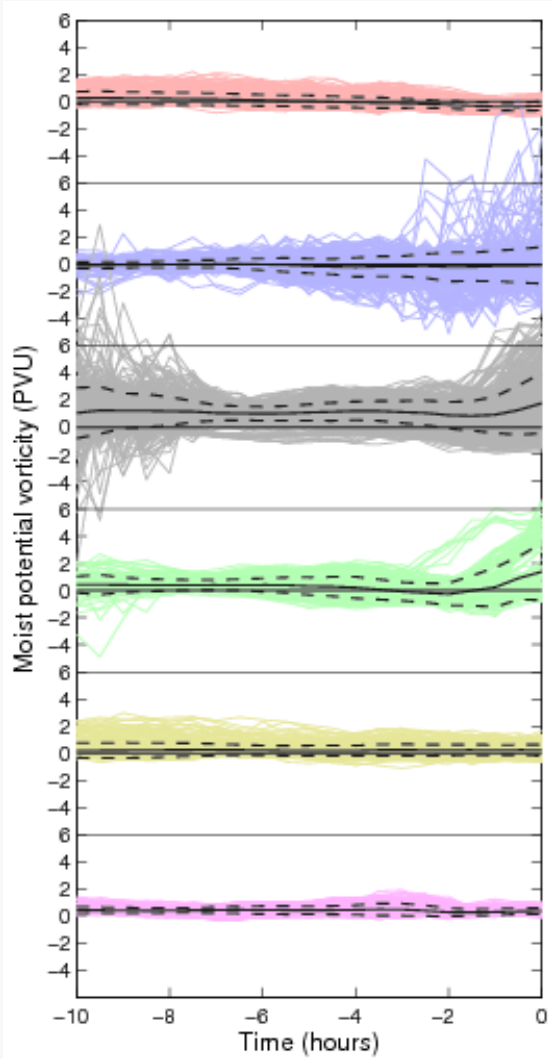
Pressure



Relative humidity



Saturated moist potential vorticty



Contingency table for 15 cases

	SJ observed	SJ not observed	
SJ Predicted	5	2	7
SJ not predicted	1	7	8
	6	9	15

p-value = 0.035 (using Fisher's exact test)

Conclusions

University of Reading

- The first regional climatology of sting jets has been developed.
- 31 out of the 100 most intense winter cyclones during the last two decades had sting jet precursor regions.
- Sting-jet resolving simulation of 15 cyclones demonstrates the reliability of the sting jet precursor diagnostic.
- The trajectories for all sting jets dried as they descended from the midtroposphere towards the top of the boundary layer although the depth of descent was less than in the October 1987 storm.
- All sting jets had at least some trajectories with negative saturated moist potential vorticity (and positive static stability and absolute vorticity); hence these trajectories are releasing conditional symmetric instability. There is little evidence for evaporative cooling.