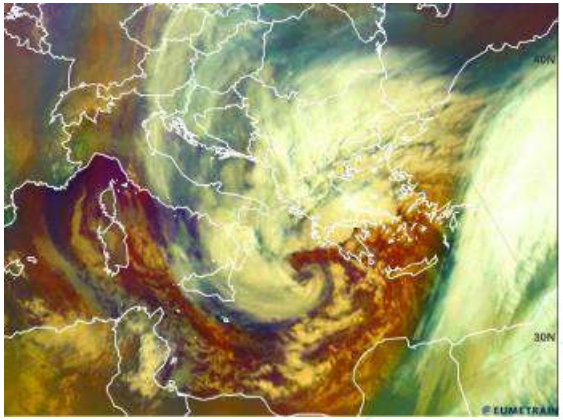
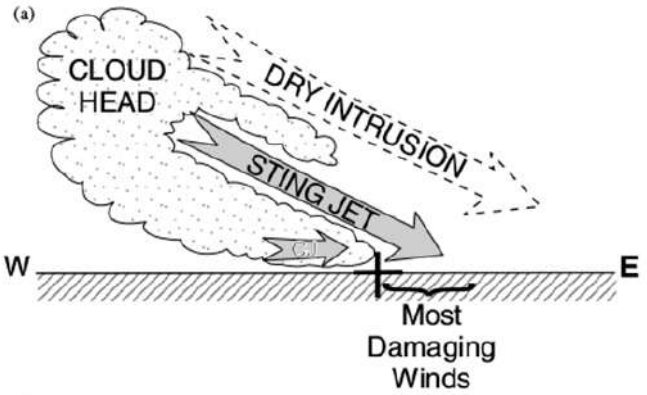
Sting jets in Mediterranean cyclones?





Working towards their identification using high-resolution simulations

Ambrogio Volonté and Manos Flaounas, with many thanks to Sue Gray

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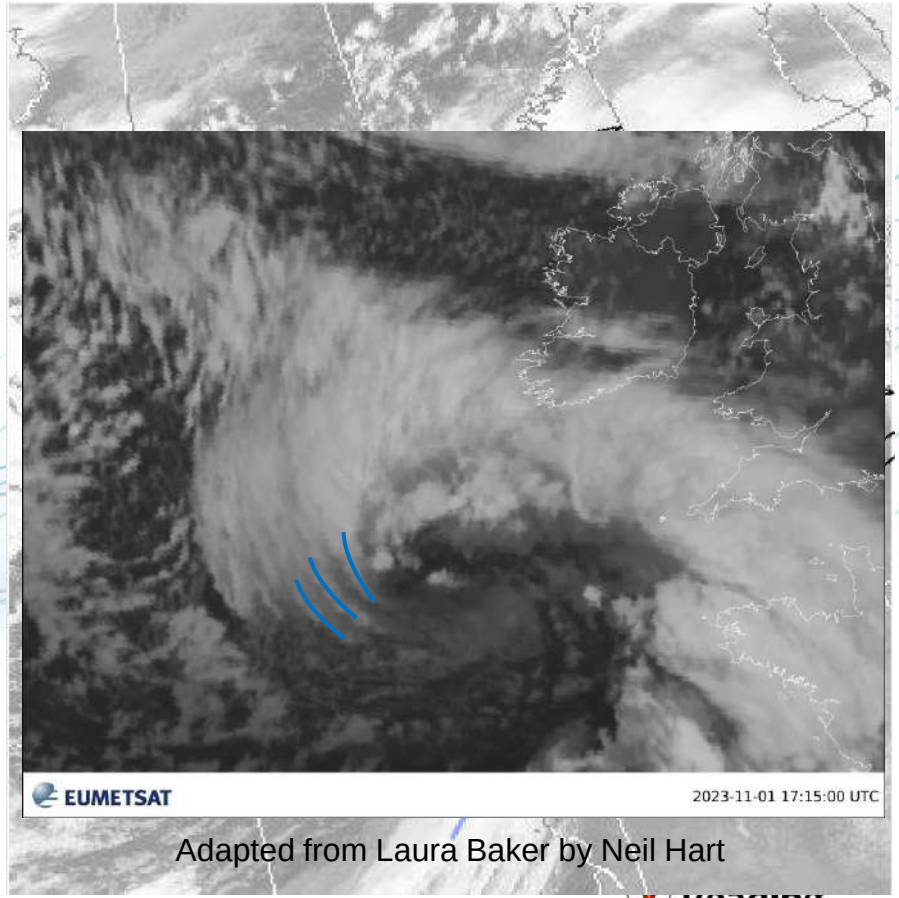
Sting jets: an introduction

- Transient (few hours), mesoscale (~50km spread) jets of air descending from the tip of the hooked cloud head in the frontal-fracture regions of some extratropical storms
- Coined “the sting at the end of the tail” by Browning (2004) in his study of the Great October storm of 1987
- Found in most of the recent damaging windstorms over UK / NW Europe
- Recent studies indicate their presence in all the major mid-latitude basins (Gray et al., under review for WCD) and in cyclones that in their early stages are more diabatically than baroclinically driven (e.g. Storm Ciarán)
- Can we find sting jets in Mediterranean cyclones?



Adapted from Laura Baker by Neil Hart

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SYSTRA-SJ:
Systematic trajectory identification of sting jets in WRF simulations of Mediterranean Cyclones

- Activity awarded a Virtual Mobility Grant in the EU COST Action MedCyclones

- Can sting jets occur in Mediterranean cyclones? If so, how do they compare against their extratropical (North Atlantic and beyond) counterparts?

- WRF moving-nest convection-permitting simulations part of Flaounas's ECMWF Special Project:

"Understanding dynamics and impacts of cyclone systems through a comprehensive dataset of convection-permitting simulations"

- 200 Mediterranean cyclones in the dataset + 178 North Atlantic cyclones.

- Simulations include on-line trajectories starting at every grid point in the inner domain, released every 12 hours throughout the evolution of the cyclone and computed forward and backward to the start and end of the run, where possible

- Applying criteria based on thresholds of wind speed, pressure and moisture change on these trajectories to identify strong winds airstreams and, if present, sting jets.

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SYSTRA-SJ:
Systematic trajectory identification of sting jets in WRF simulations of Mediterranean Cyclones

Methods and thresholds used to identify potential sting jets in Mediterranean cyclones:

12-hr backward trajectories starting between 750 and 1000hPa are constructed for each time (hour) in the cyclone evolution by using subsets of the original, longer, trajectories

12-hr backward trajectories are selected and saved into “potential sting jet” trajectory files if:

- Wind speed>30m/s at release time (t=0)
- Descent >120hPa between t=0 and t=-6 (hours)
- Relative humidity>80% at t=-6

Focusing on the largest trajectory file for each cyclone, two cyclones stand out as having a sizeable number of trajectories meeting these constraints*

*admittedly quite strict, but we wanted to start identifying cases with clear airstreams rather than including “transitional” trajectories

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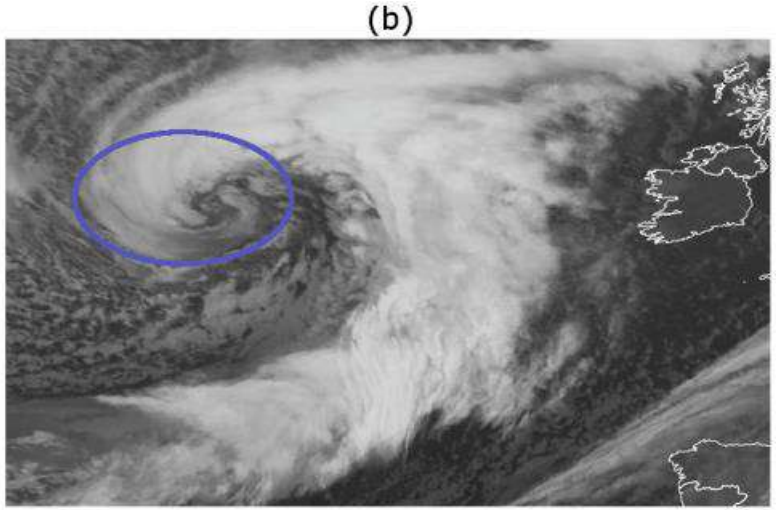
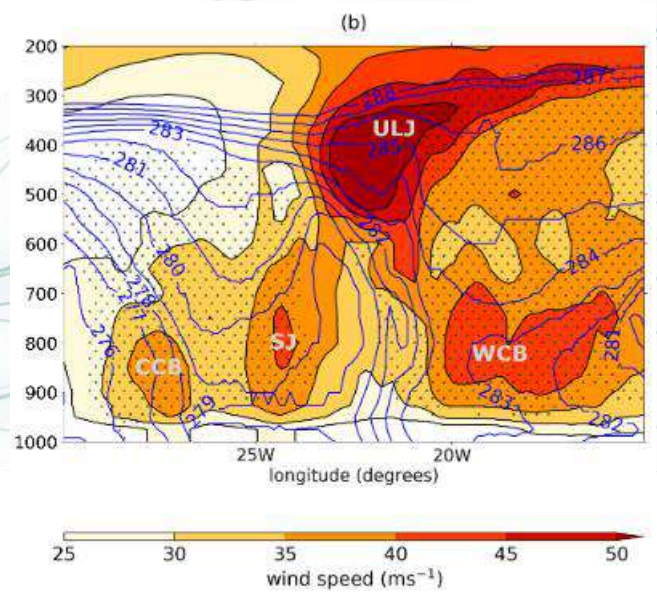
Storm Brendan (TRACK 0002)

We first look at output of the WRF simulations for Storm Brendan, a N Atlantic cyclone with a confirmed sting jet, to provide some context for the results of the two “suspected” sting-jet Mediterranean cyclone cases





See Gray et al. (2021), Weather

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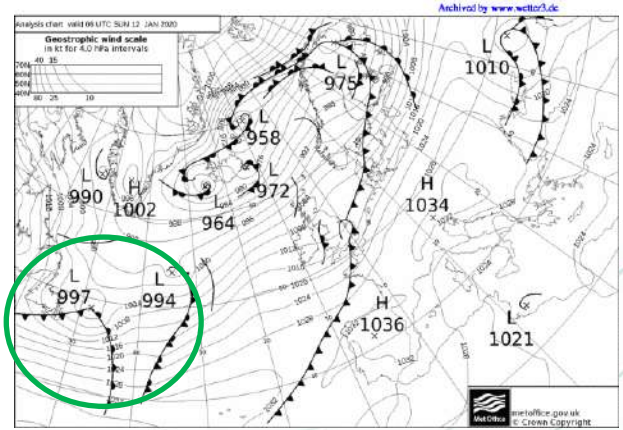
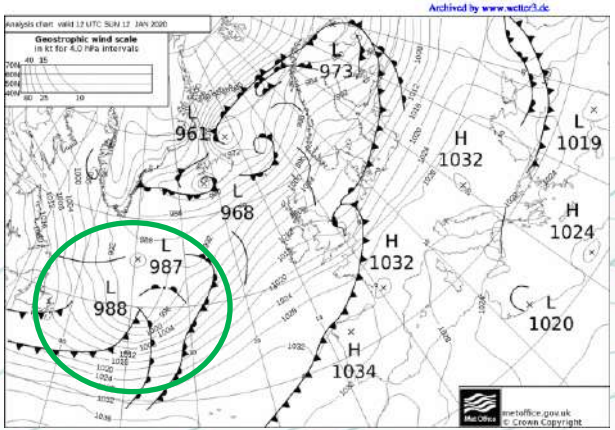
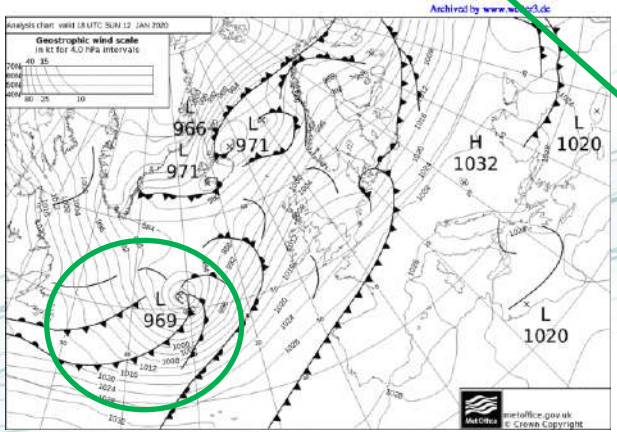
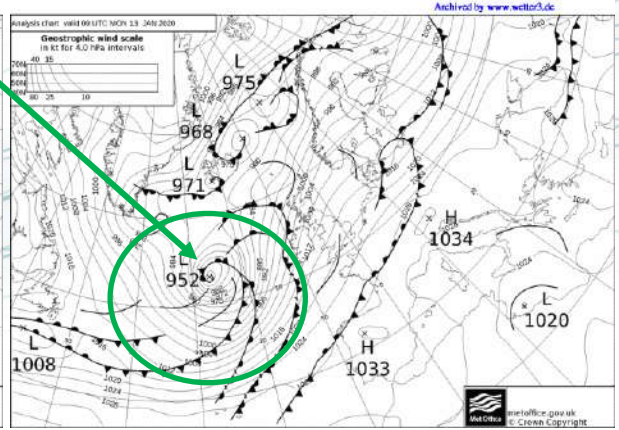
Storm Brendan

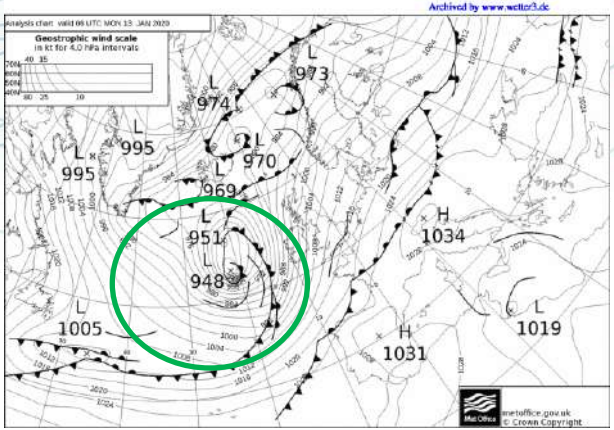
- Intense extratropical cyclone (explosively deepening, 35 hPa / 12 h)
- Development of a bent-back front at around 00UTC 13 Jan











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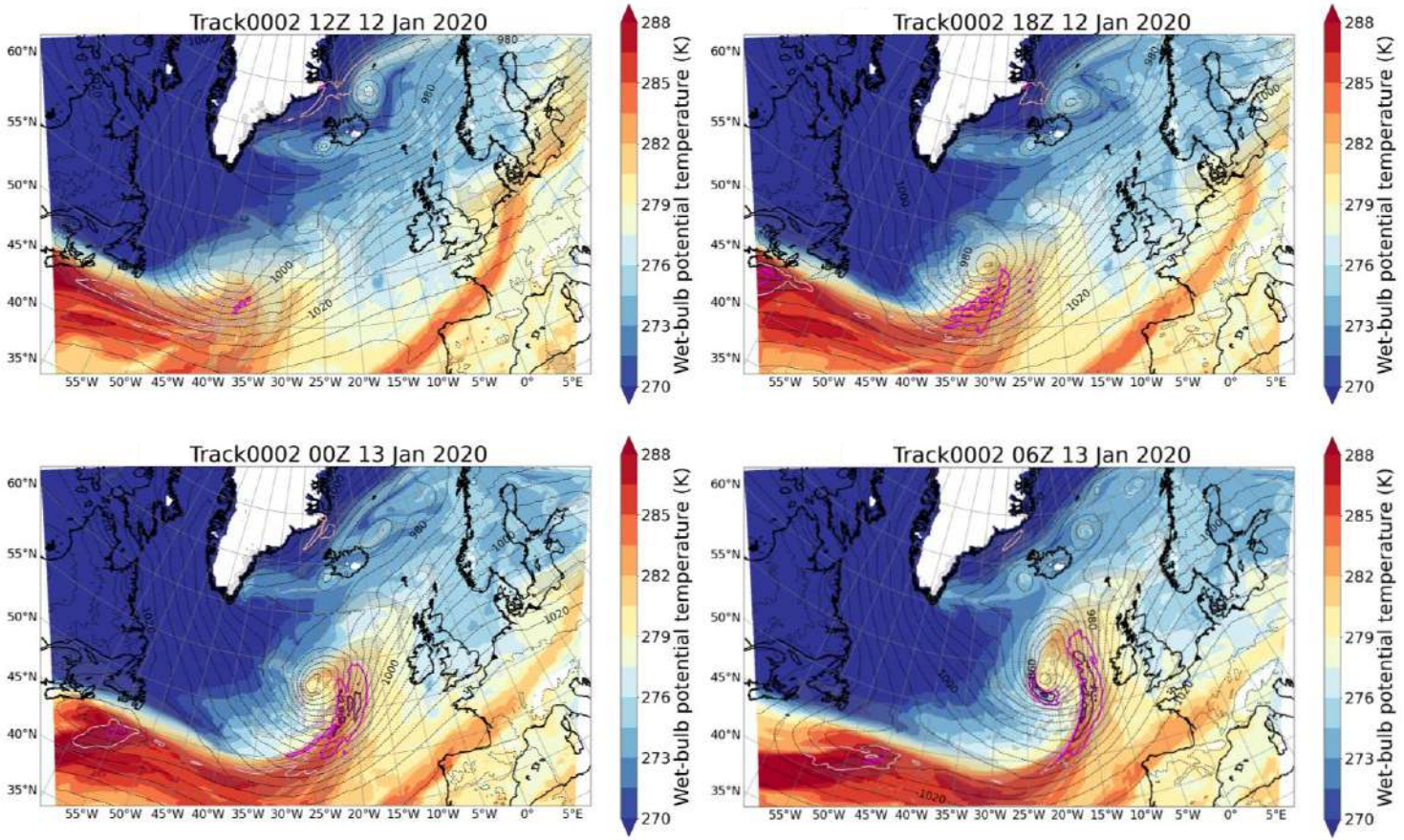
Storm Brendan



- The driving model (WRF, ~10 km grid spacing) correctly simulates the evolution,
- Strong winds at 850hPa are present in the early hours of 13 Jan in the warm sector (WCB) and to the south of the low centre (CCB/SJ?)

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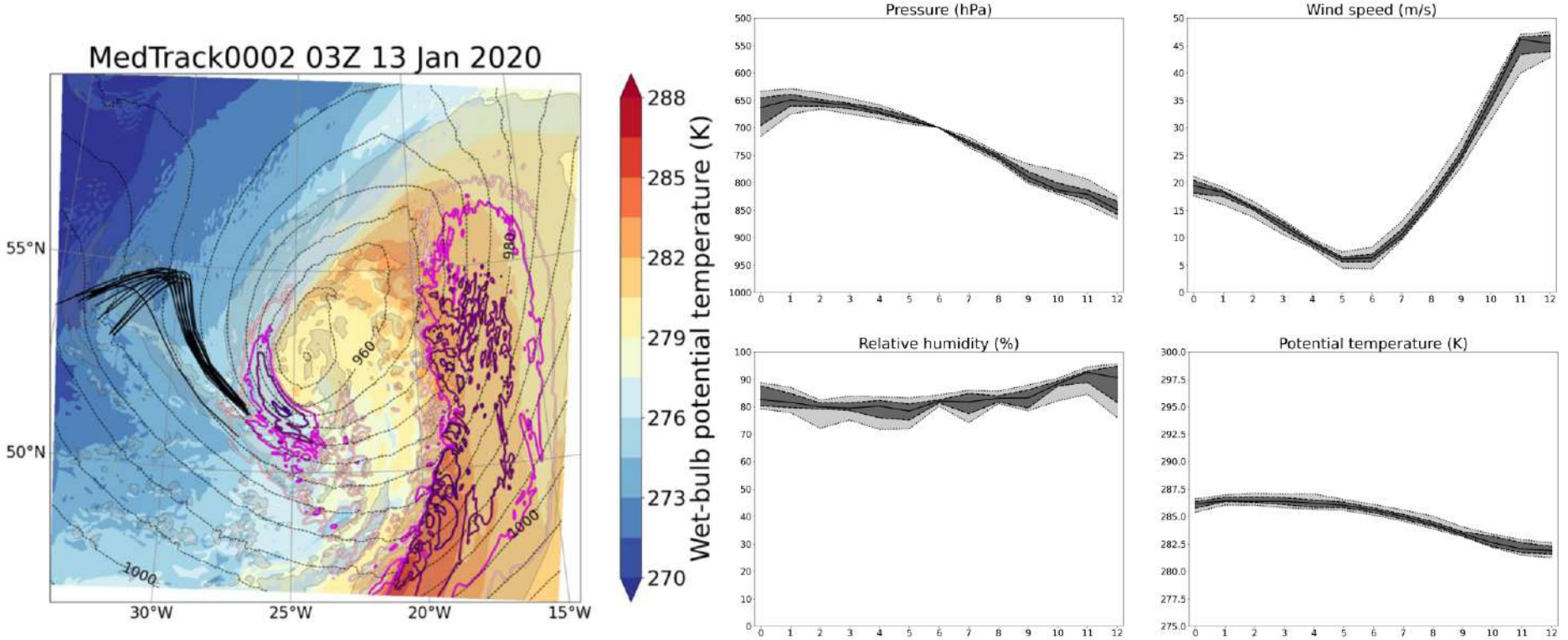
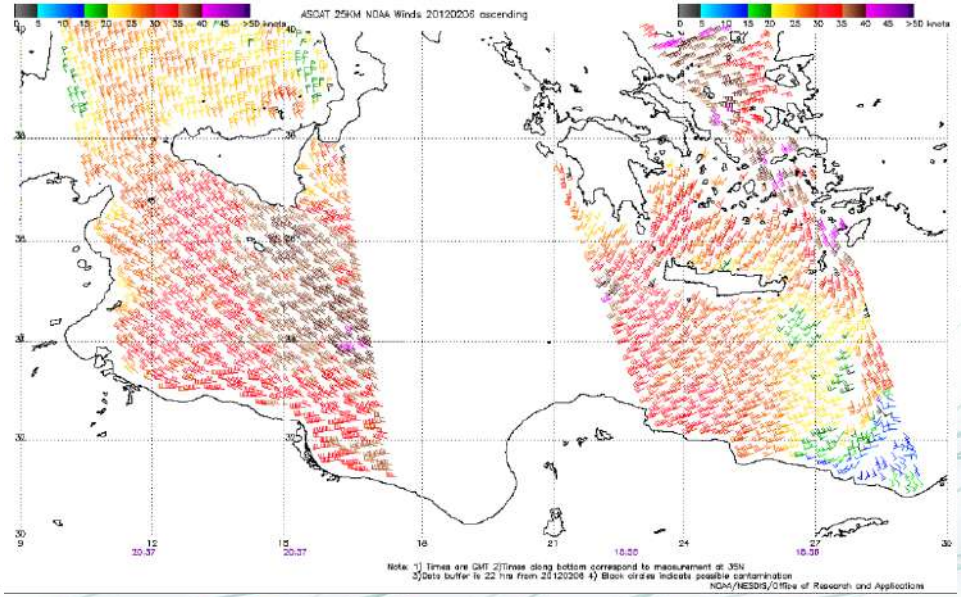
Storm Brendan

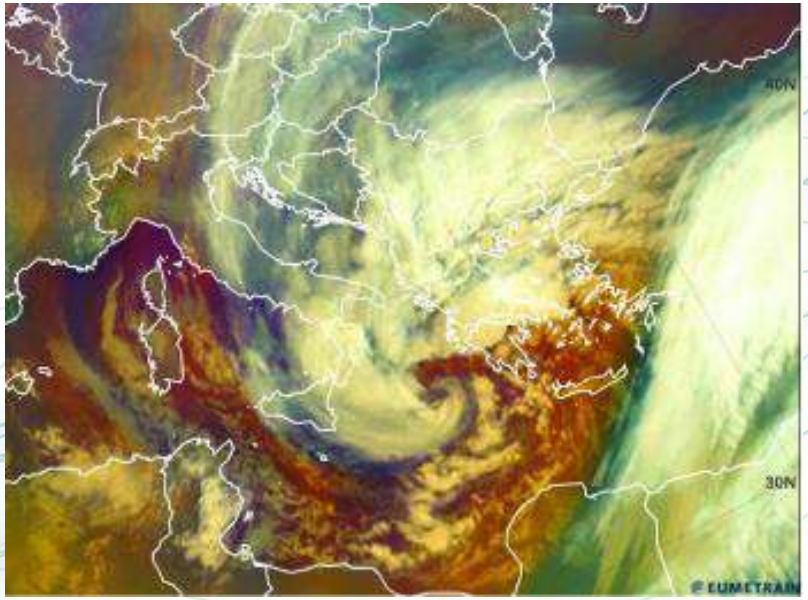
- The nested model (WRF, 3.3 km grid spacing) shows max wind > 50 m/s at 850hPa at 3 UTC 13 Jan at the tip of the cloud head and at the edge of the frontal-fracture region

- Threshold-meeting trajectories highlight descent and acceleration of the airstream, consistent with it being a SJ



Cyclone Julia (medTRACK 0007)





Metheniti (2012), Eumetsat report

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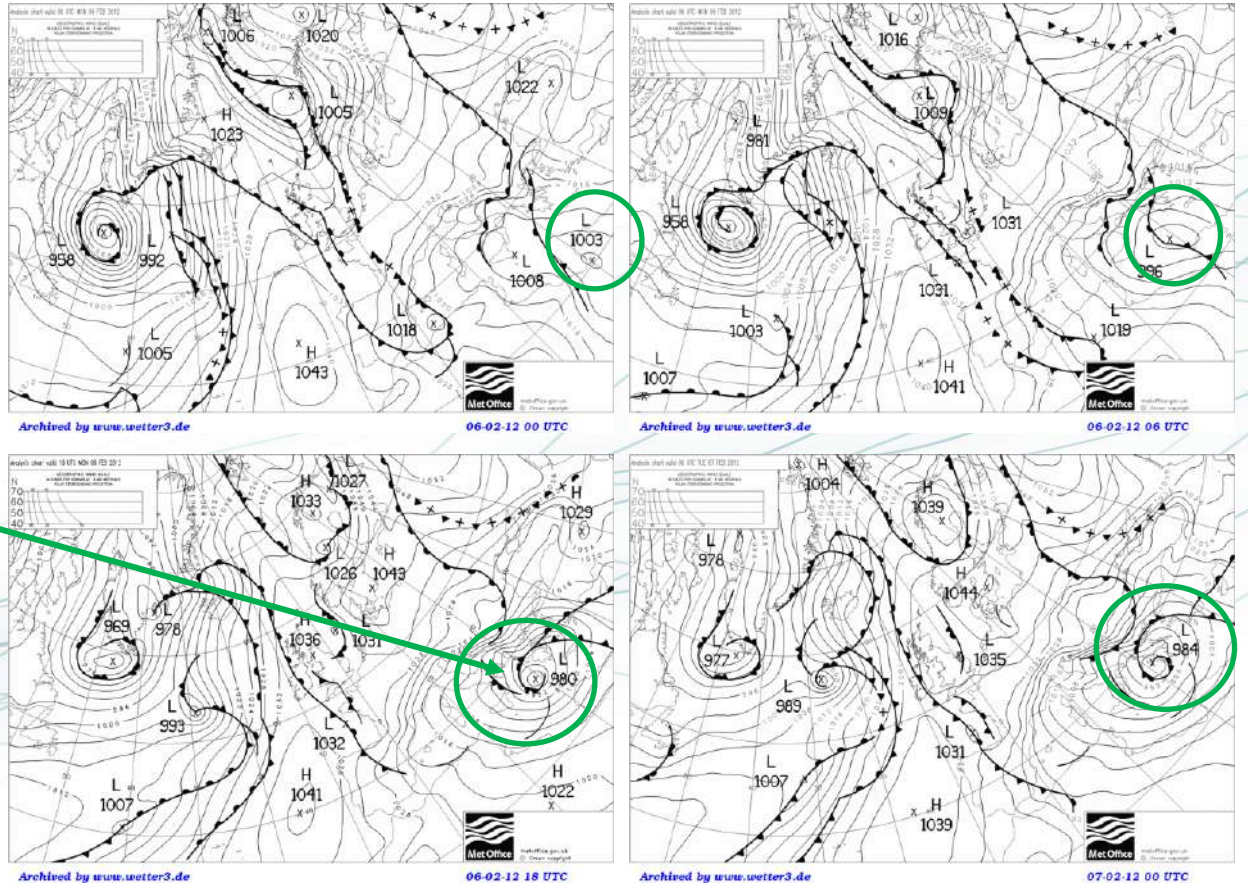
Cyclone Julia

- Rapidly deepening Med cyclone (23 hPa / 18 h), moving N from Gulf of Sidra to the Ionian Sea
- Development of a bent-back front and possible frontal-fracture region late on 6 Feb



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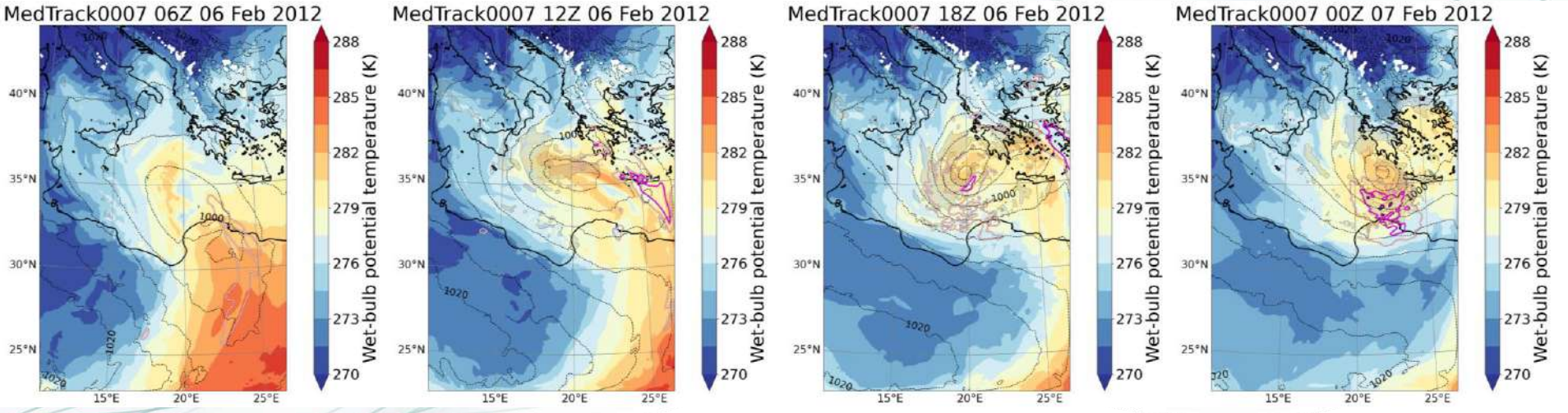
Cyclone Julia

- The driving model shows the formation of a warm seclusion at the cyclone centre as the cold front moves E
- Strong winds at 850hPa are present late on 6 Feb to the south of the low centre



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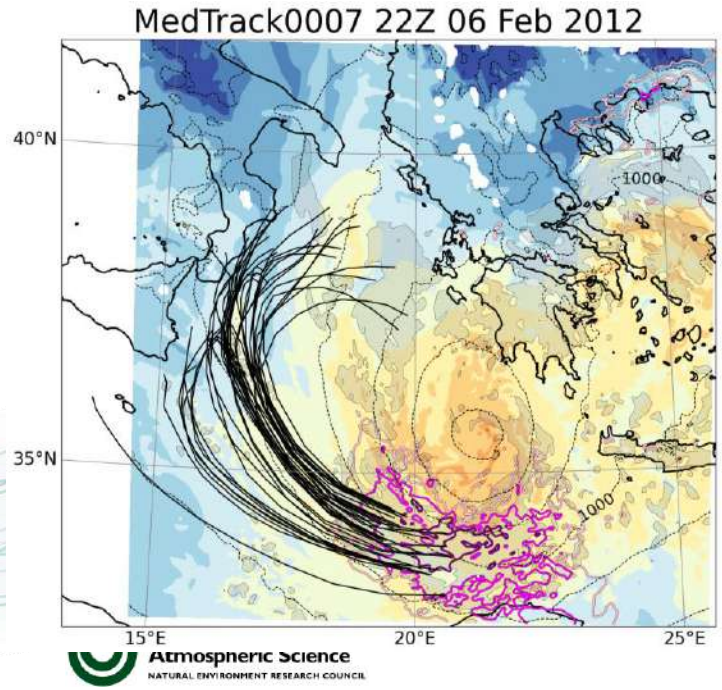
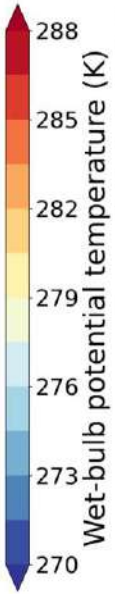
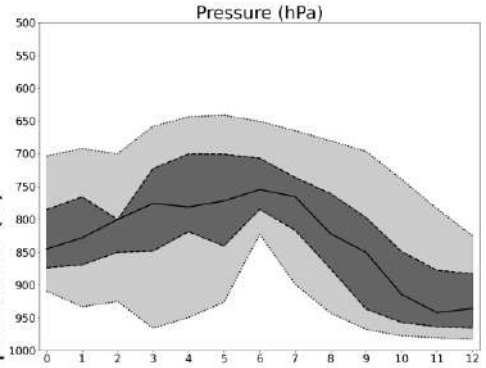
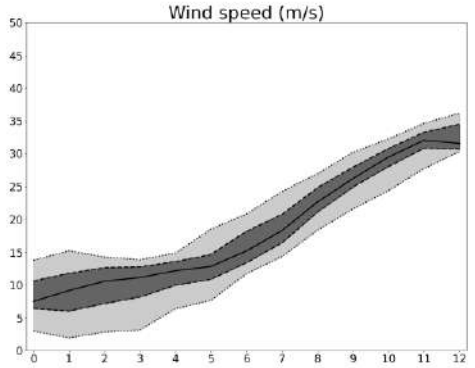
Cyclone Julia

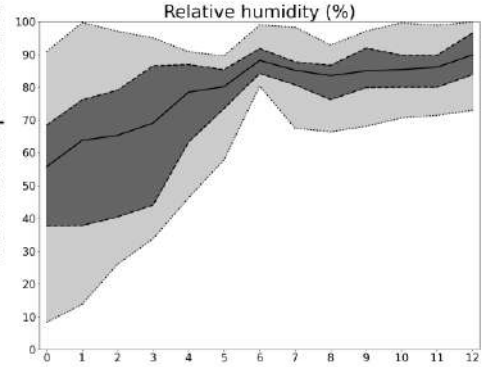
- The nested model shows max wind > 35 m/s at 22 UTC 6 Feb to the south of the warm-core low centre
- Threshold-meeting trajectories highlight ascent followed by descent and acceleration of the airstream, consistent with kinetic definition of a SJ

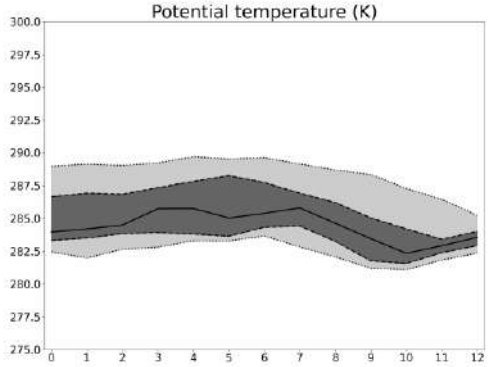




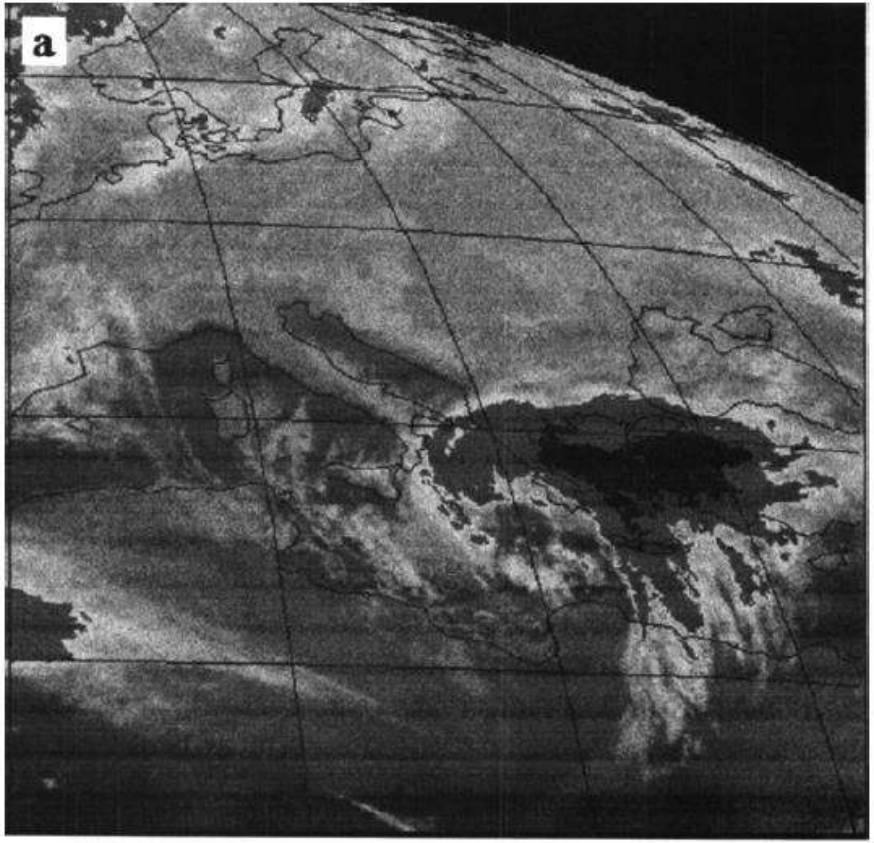








medTRACK 0088



From Lagouvardos et al. (2012), Weather

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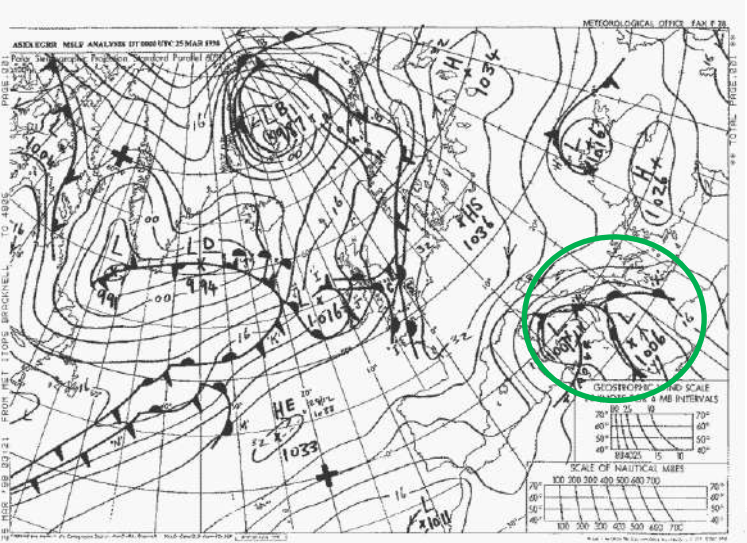
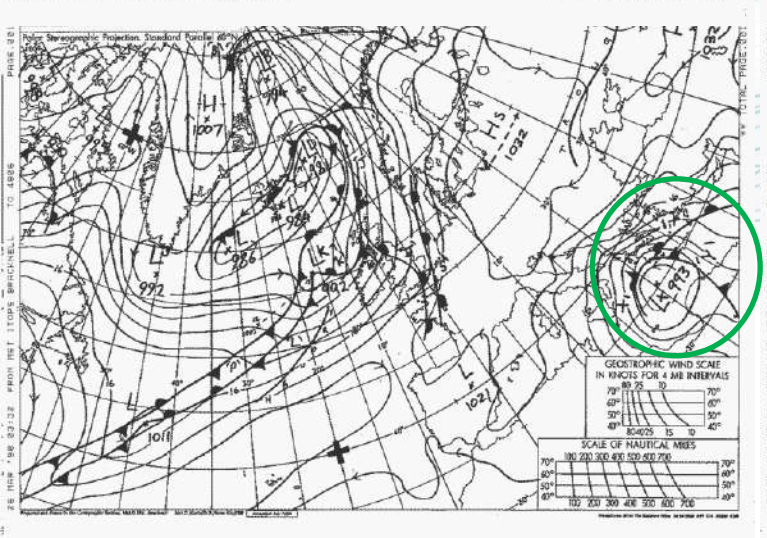
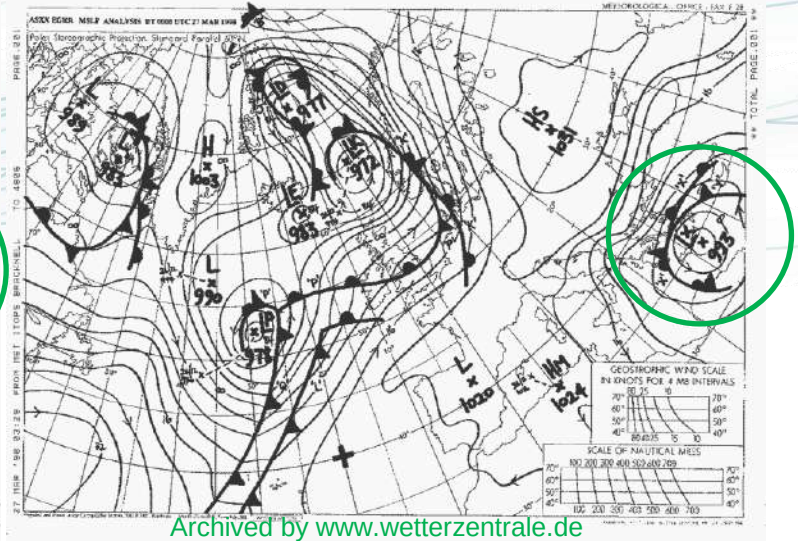
medTRACK 0088

- Cyclone developing in the central Mediterranean
- Possible development of a bent-back front?







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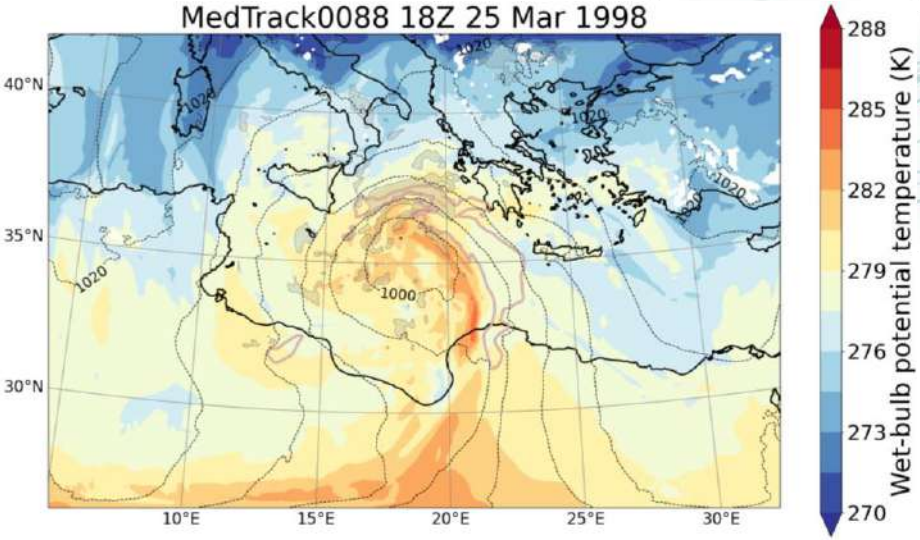
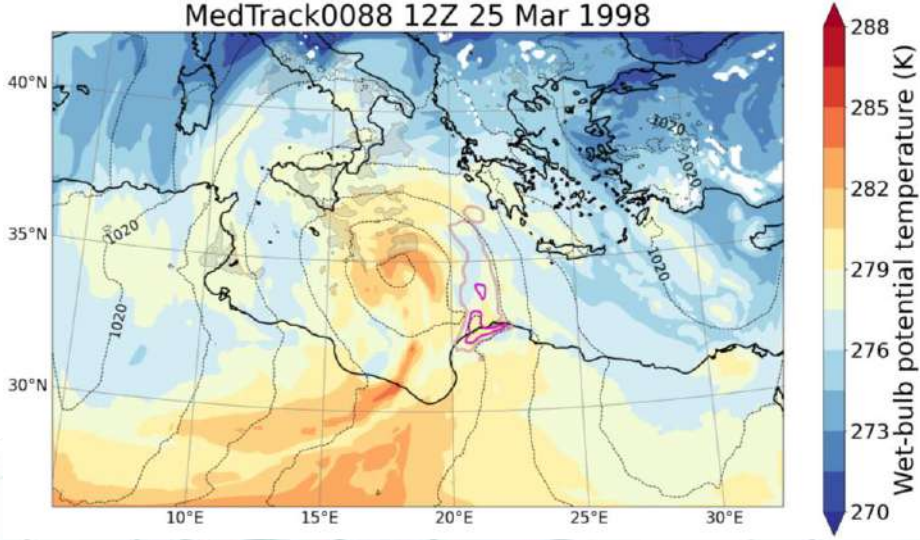
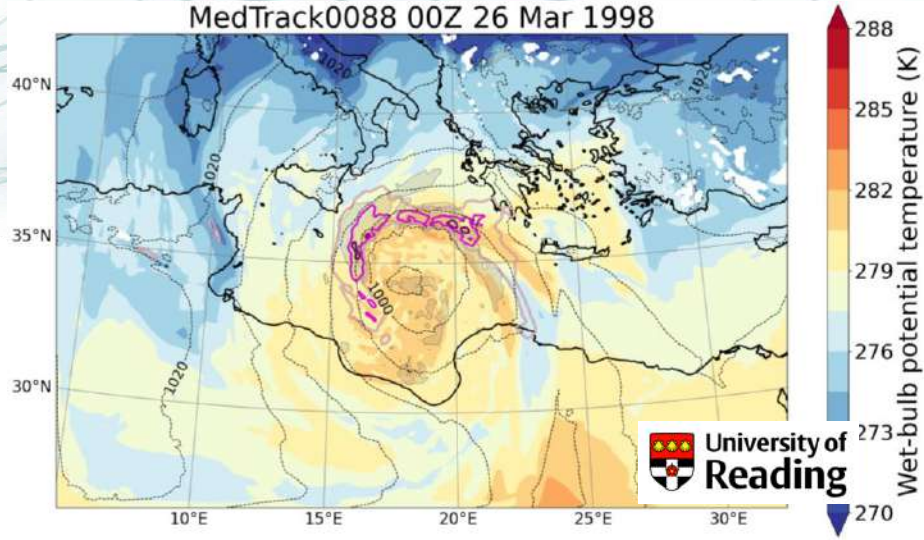
- Evolution less reminiscent of classic warm-seclusion ET cyclone, although clear warm core
- Cyclone almost stationary
- Strongest winds at 850hPa develop on the N side of the cyclone and flow around it (but not a classic cold conveyor belt!)







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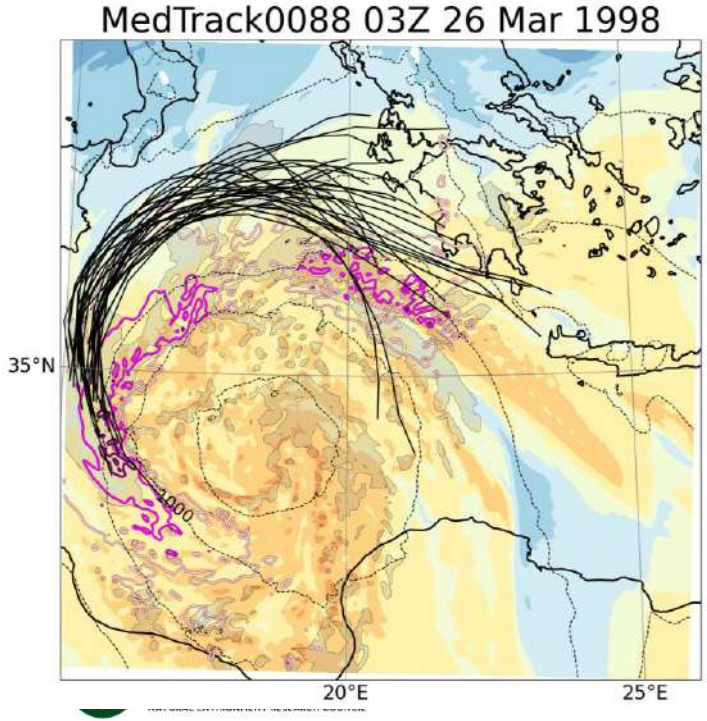
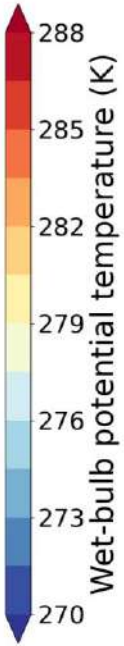
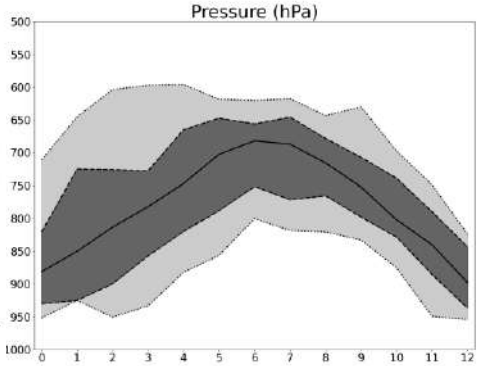
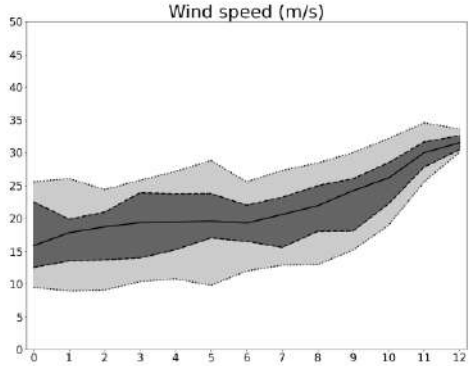
medTRACK 0088

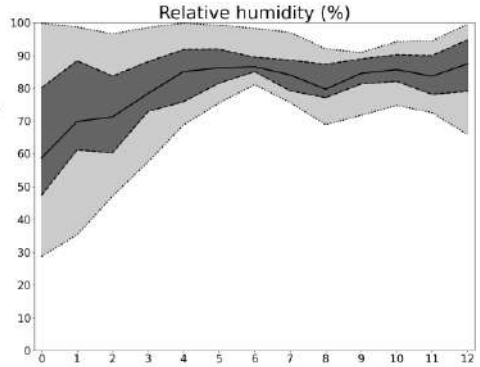
- The nested model shows max wind > 30 m/s at 3 UTC 26 Mar to the west of the warm-core low centre
- Threshold-meeting trajectories highlight ascent followed by descent and acceleration of the airstream, consistent with kinetic definition of a SJ

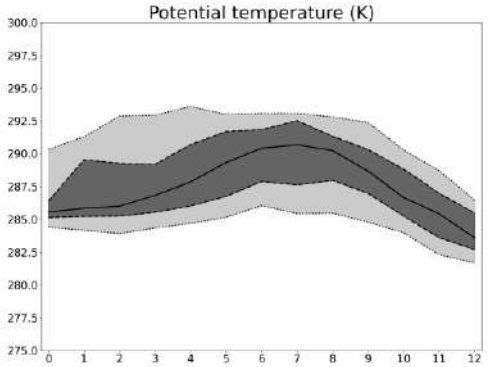










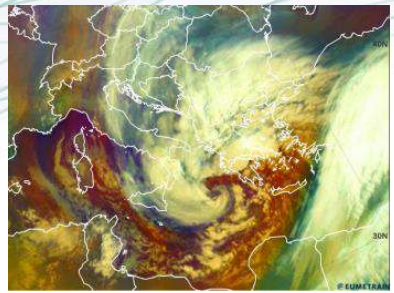


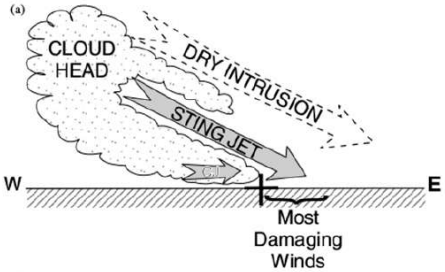
Summary and next steps

There are pieces of evidence of “SJ-like” airstreams associated with strong near-surface winds in convection-permitting simulations of Mediterranean cyclones

- Relevant observations need to be investigated to assess how realistic the model runs are
- More analysis is required to reveal their dynamics and compare/contrast against “canonical” mid-latitude SJs

The key question here is not about semantics / labelling, but rather about highlighting uncommon (but possible) pathways to the generation of damaging surface winds in Mediterranean cyclones





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Diabatic influences on current and future hazardous Mediterranean cyclones

- 3.5 years Post-doctoral research associate position at University of Reading
- PI: Sue Gray; Co-Is: Ambrogio Volonté, Ben Harvey; project partners: Manos Flaounas, UK Met Office (Claudio Sanchez, Ségolène Berthou)
- Influence of diabatic processes (air-sea fluxes, convection) on intense Mediterranean cyclones
- Changes in plausible worst case Mediterranean cyclones with future climate change
- Applications by 18 July!

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