Sting Jets

Ambrogio Volonté
University of Reading
RMetS Careers information day

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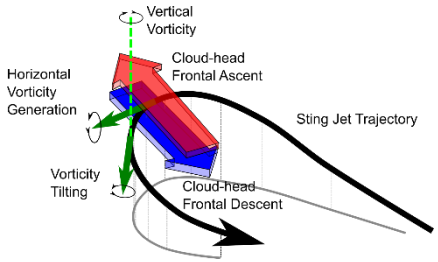
Royal Meteorological Society

University of Reading

- Why am I talking about Sting Jets?

Well, this is what I've been studying for almost 4 years in my PhD!



- What did I do before?

Undergrad and Master degree in Physics at University of Milan and a little bit of secondary school teaching/tutoring

- What am I doing now? (and in the near future…)

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INCOMPASS project
part of the NERC/MoES Monsoons Programme 2015-2018

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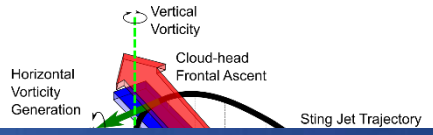

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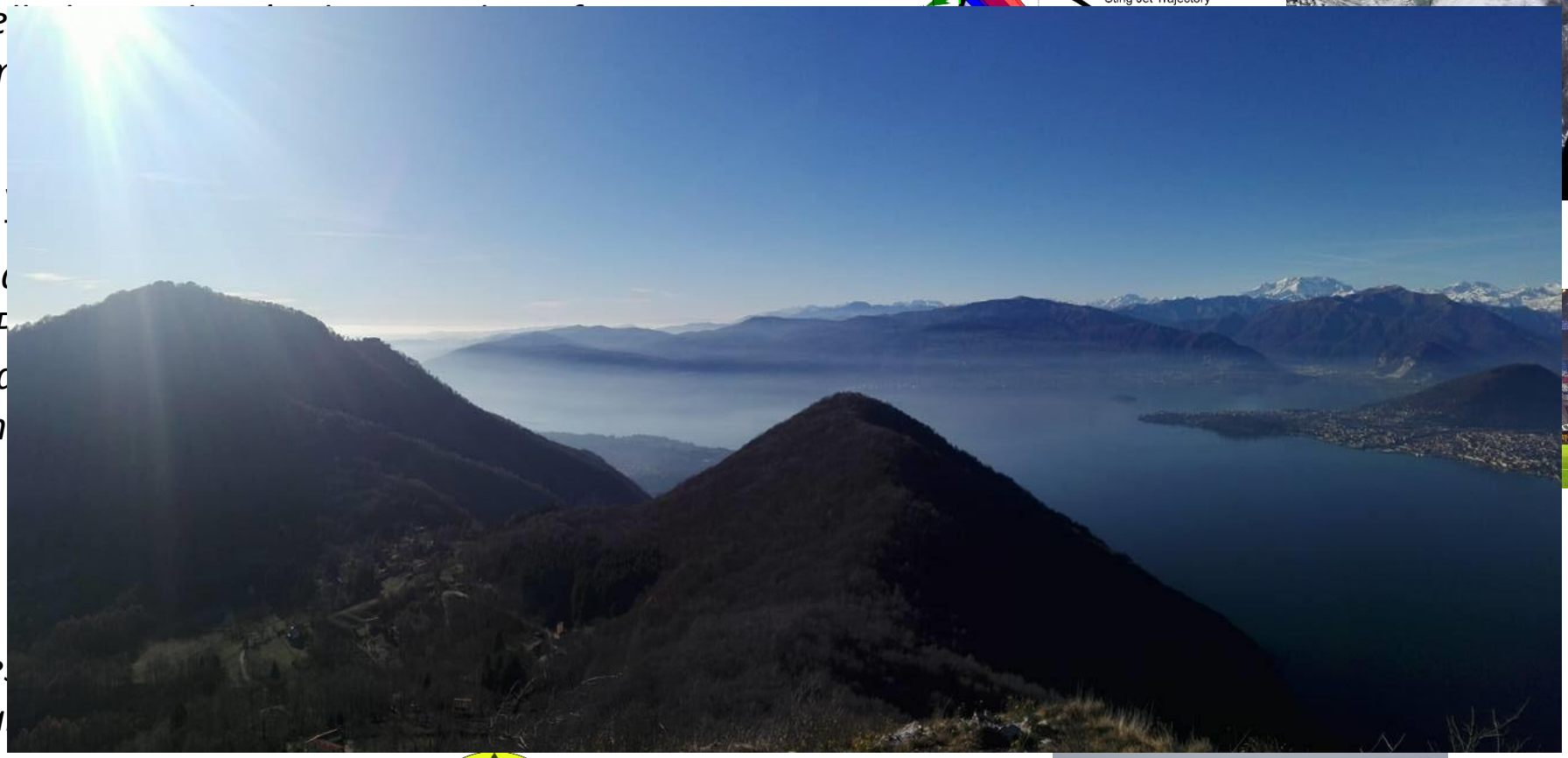

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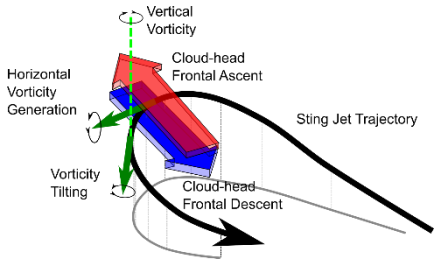

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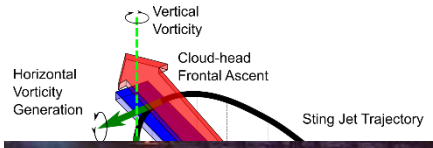

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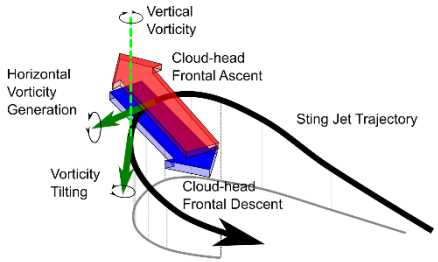

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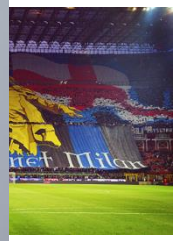

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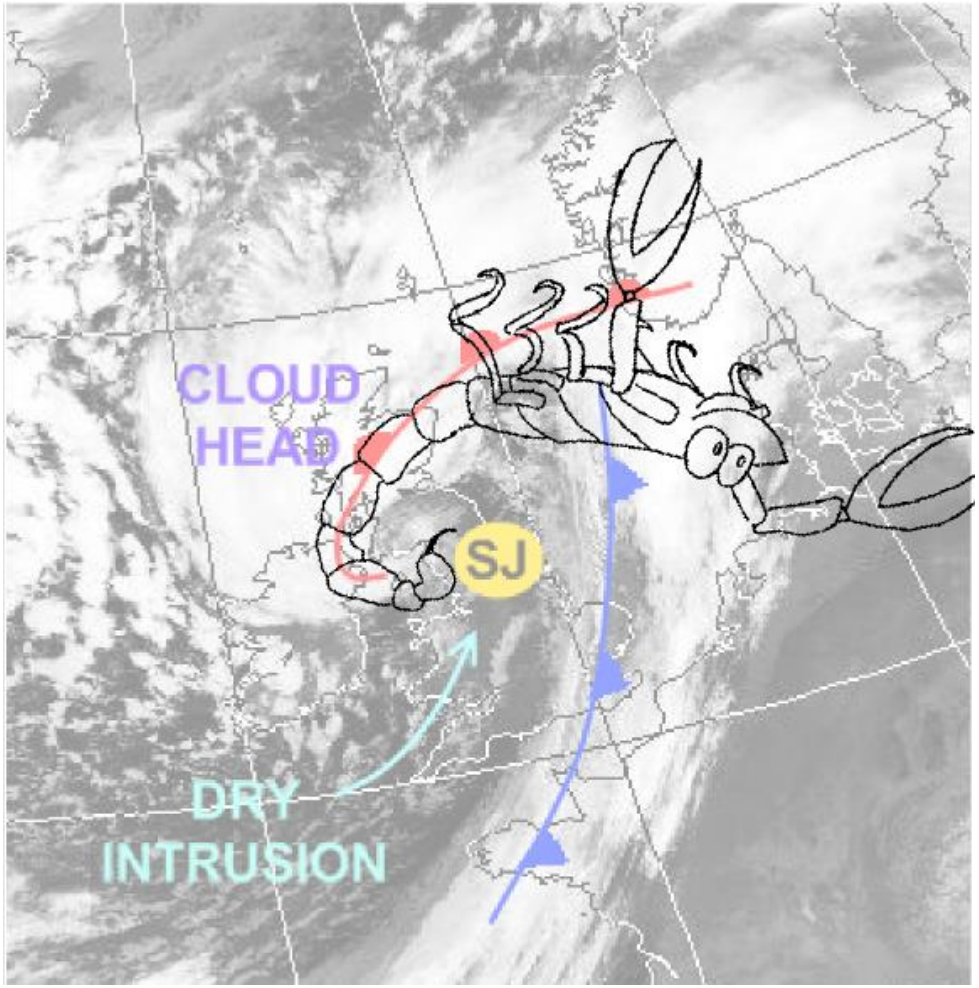
So , the “Sting Jet”… a poisonous sting at the end of the tail!

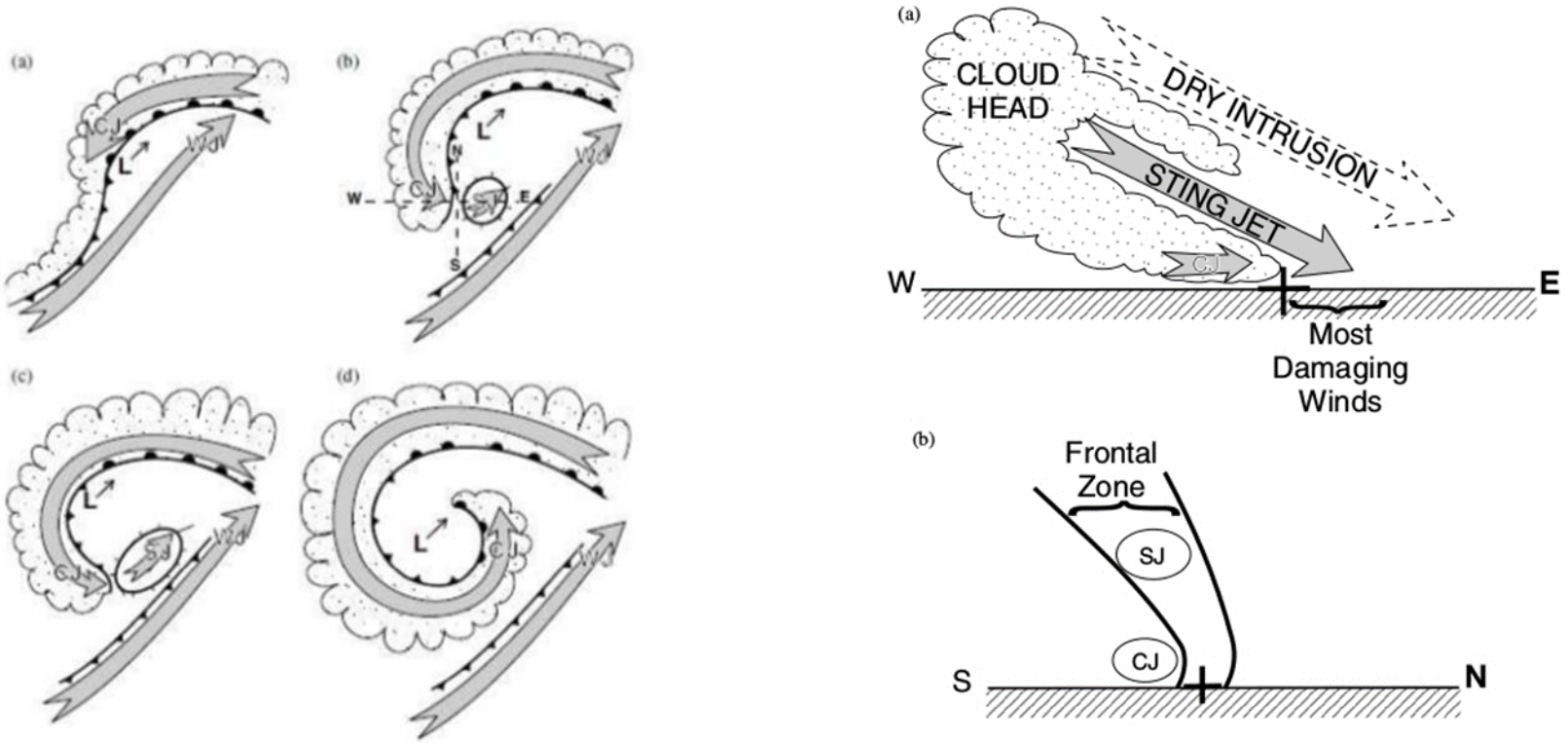


Adapted from Laura Baker by Neil Hart.

16 October 1987: The Great Storm

"Earlier on today, apparently, a woman rang the BBC and said she heard there was a hurricane on the way... well, if you're watching, don't worry, there isn't!". That evening, the worst storm to hit SE England for three centuries caused record damage and killed 19 people

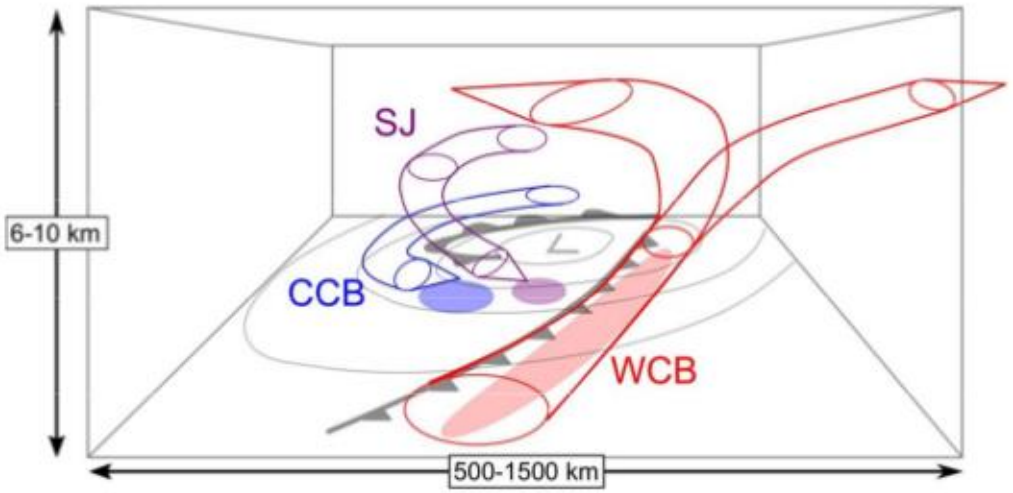
What is a Sting Jet?



From Clark et al. (2005)

- Intense extratropical cyclones with an opening frontal fracture (Shapiro-Keyser)
- Jet exiting the tip of cloud head in mid-troposphere and descending into that region
- Airstream accelerating and drying out during its descent: strong winds at low levels
- Transient (few hours) and mesoscale (~50-100 km spread) phenomenon

What is a Sting Jet?



From Clark and Gray (2018)

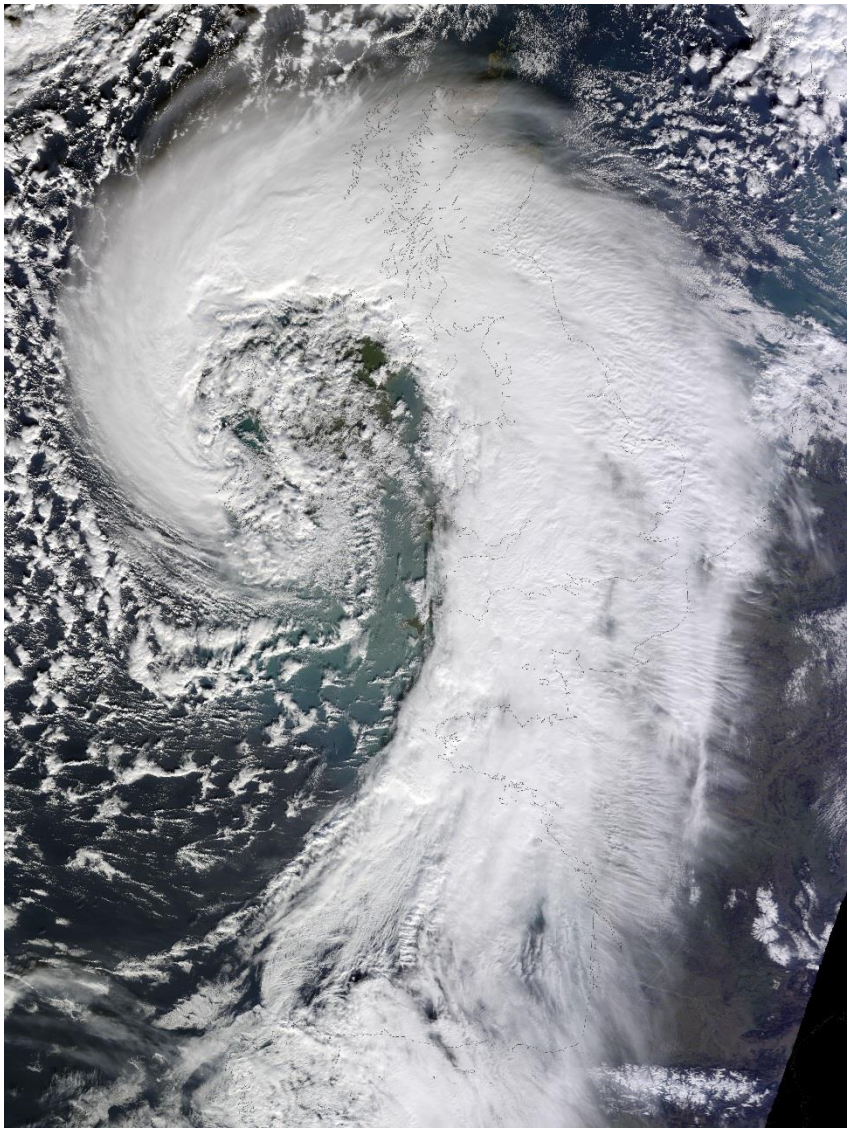
State-of-the-art definition (Clark and Gray, 2018):

- The SJ is defined as a distinct region of stronger winds that descends from mid-levels inside the cloud head into the frontal-fracture region of a Shapiro-Keyser cyclone over a period of a few hours.
- It lies above the CCB during some stage its life, but, at least in some cases, descends to reach the boundary layer ahead of the CCB.
- It is not attributed to a specific mechanism in this definition.

Windstorm Tini

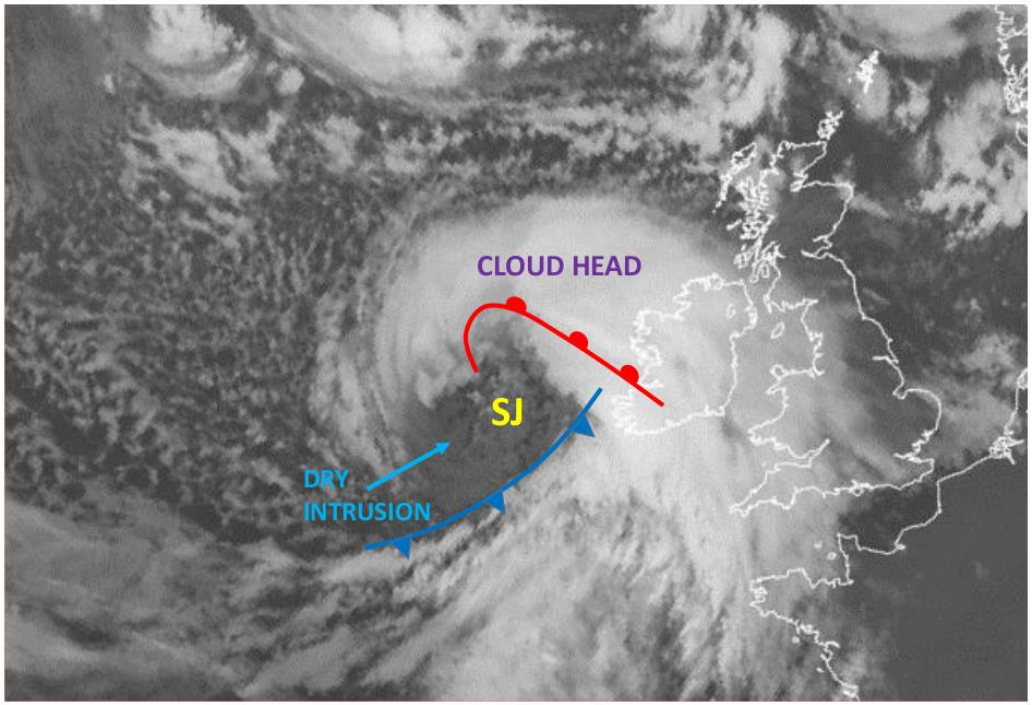
12 February 2014: Shapiro-Keyser extratropical cyclone passes over UK and Ireland with well defined bent-back front and frontal fracture

- Deep and fast cyclogenesis
- Δp ~ -40 hPa in 18 hours
- Surface gusts close to 100 kt in Wales

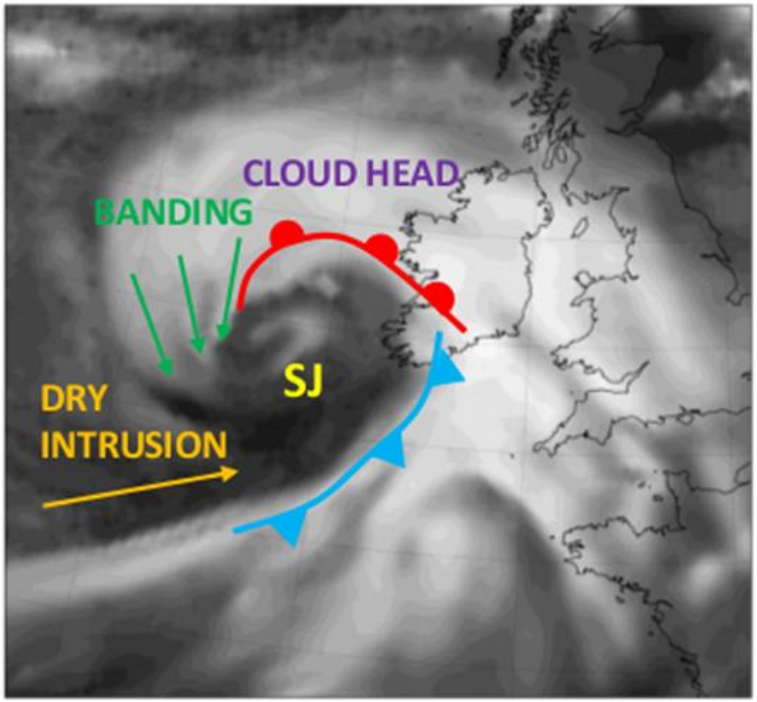


Observations: Hints of a SJ?

- banding at cloud-head tip suggests presence of instability
- Features present also in our simulations (Met Office Unified Model)
- horizontal resolution ~12 km
- vertical resolution ~200 m at 2-3 km height



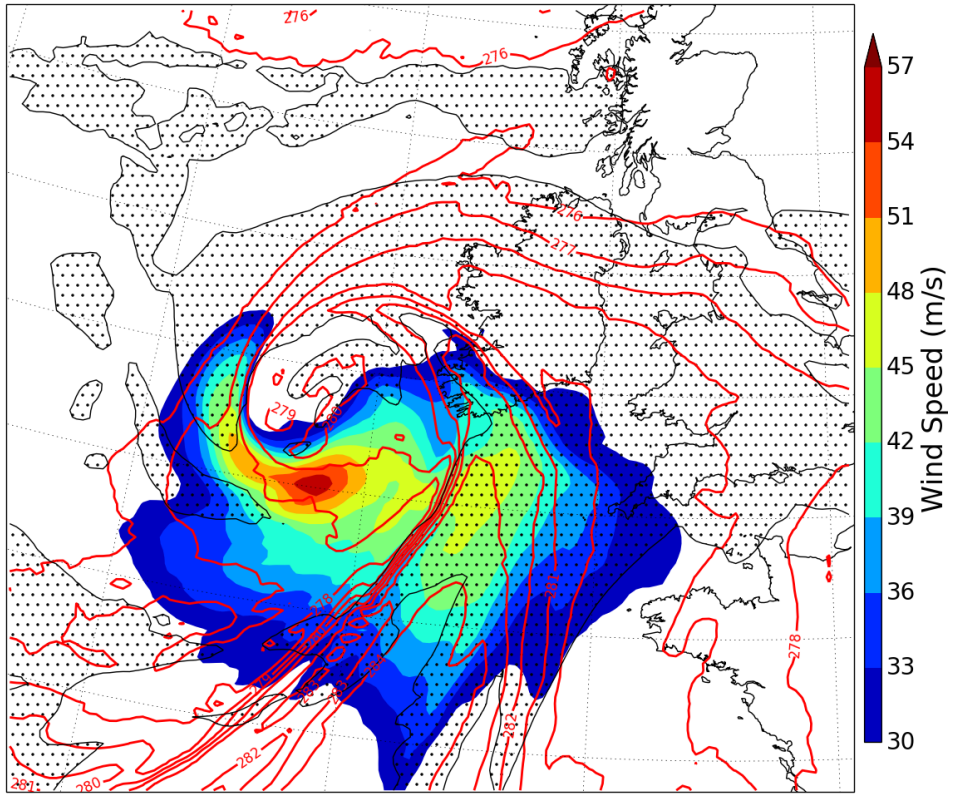
- Meteosat infrared satellite image of windstorm Tini at 06 UTC



- Simulated-satellite image (using brightness cloud-top temperature) referred to 07 UTC

An additional airstream

- 07 UTC – wind speed and θ_w at 850 hPa (clouds at 700 hPa)

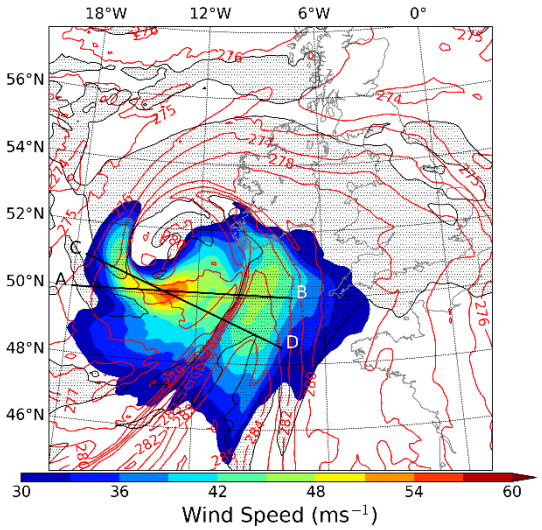


There is an evident wind maximum in the frontal-fracture region, the SJ!

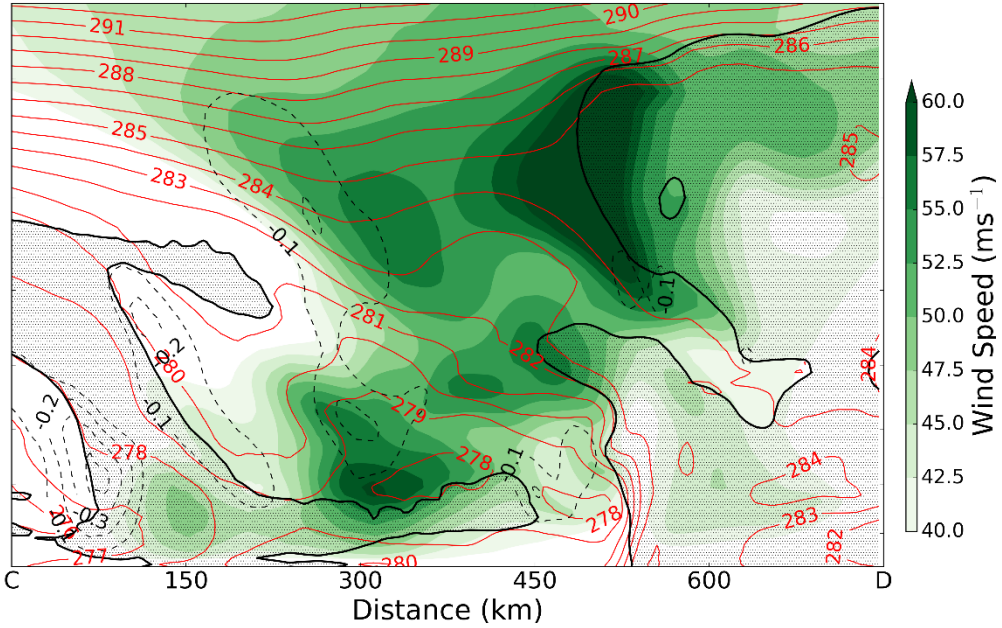
A descending airstream

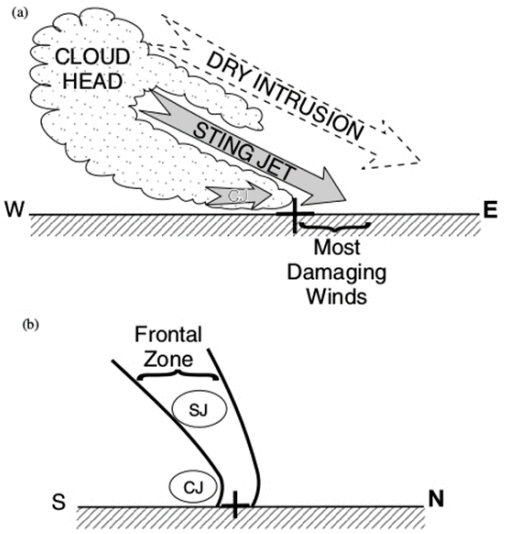
Cross section along the frontal fracture shows:

- In an area of descent there are folds in wet-bulb potential temperature
- Indication of a moist-adiabatic descent of an airstream
- Strong wind speed maximum at low-levels

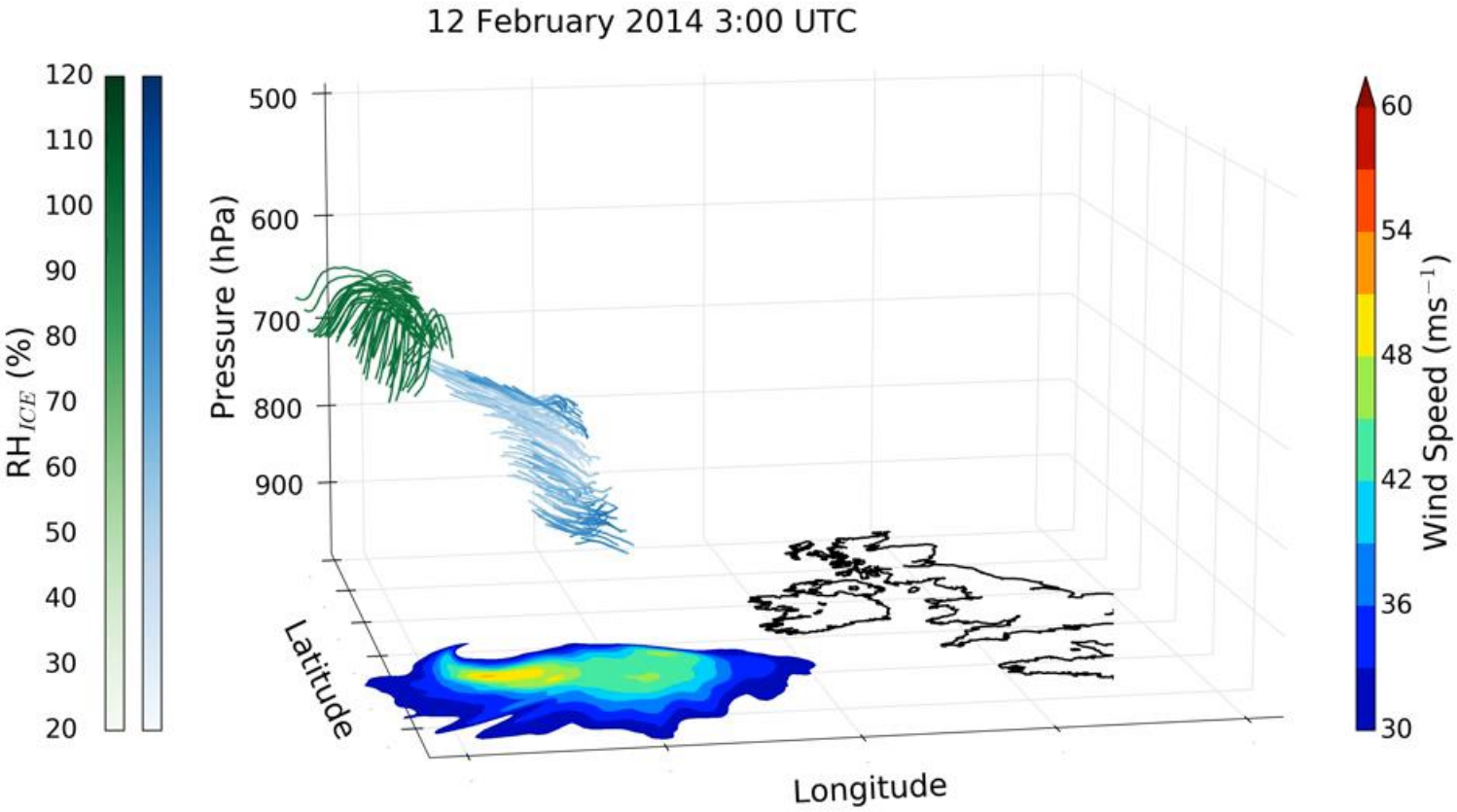


See the similarities with the schematics





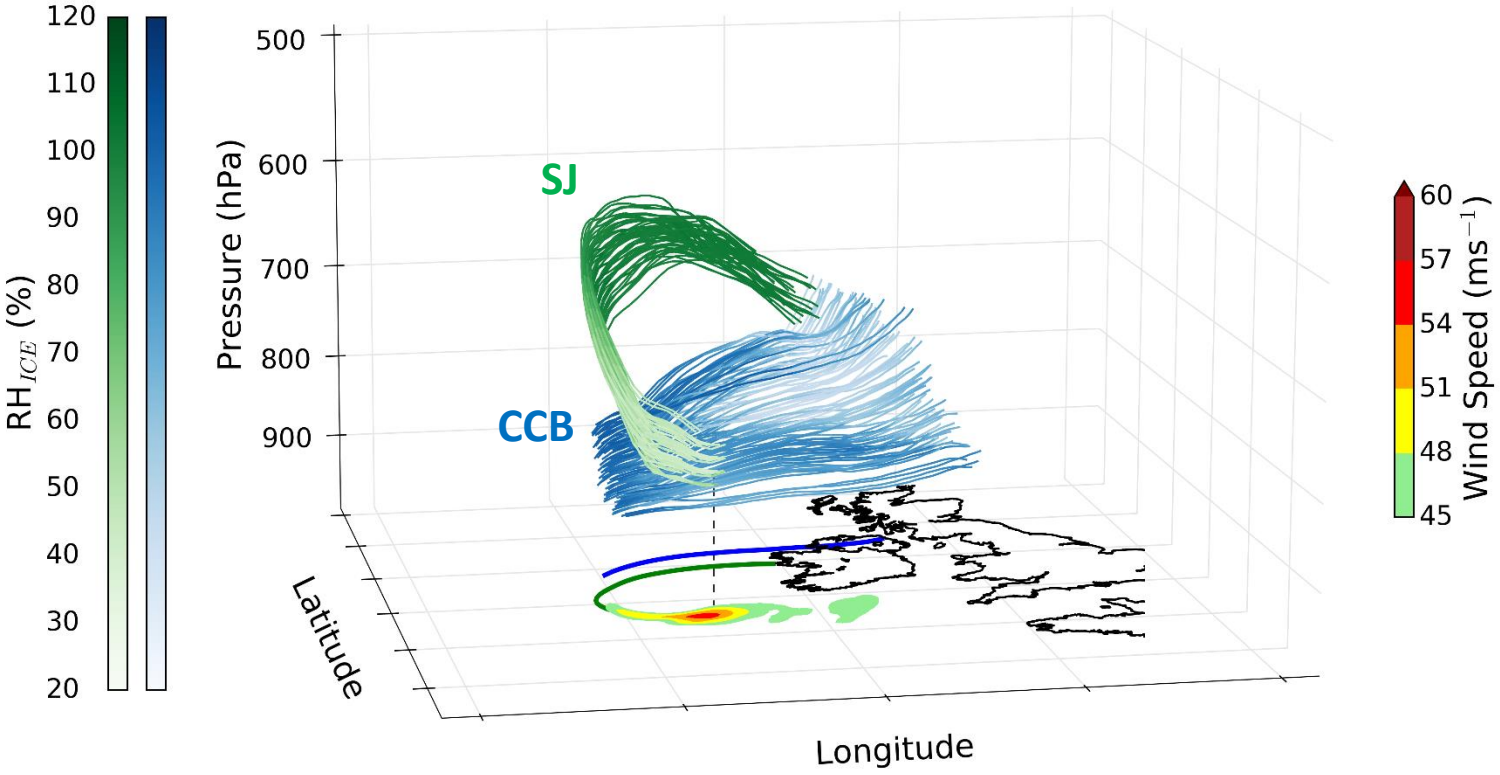
A distinct airstream



- Lagrangian trajectory analysis on the identified SJ and CCB: trajectories from 22 UTC on 11 Feb to 10 UTC on 12 Feb
- SJ is a different airmass with respect to CCB, undergoing to its own evolution

A distinct airstream

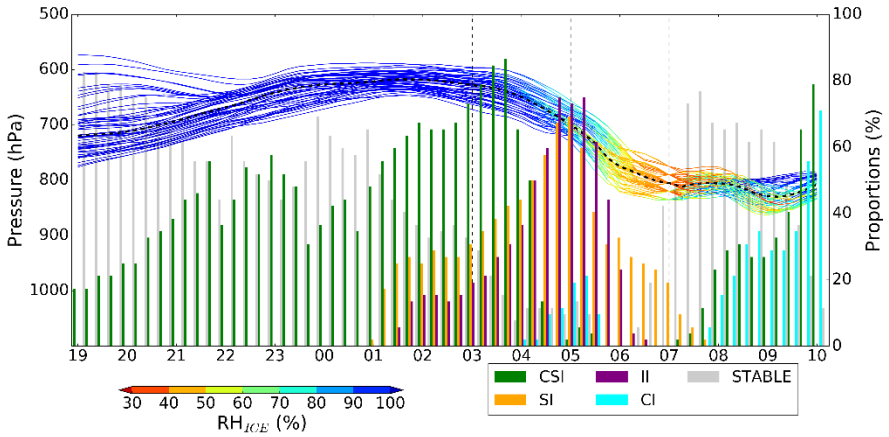
(system-relative reference frame)

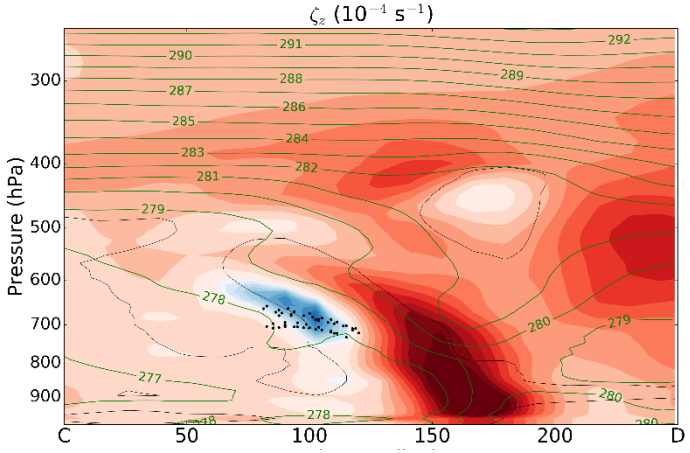


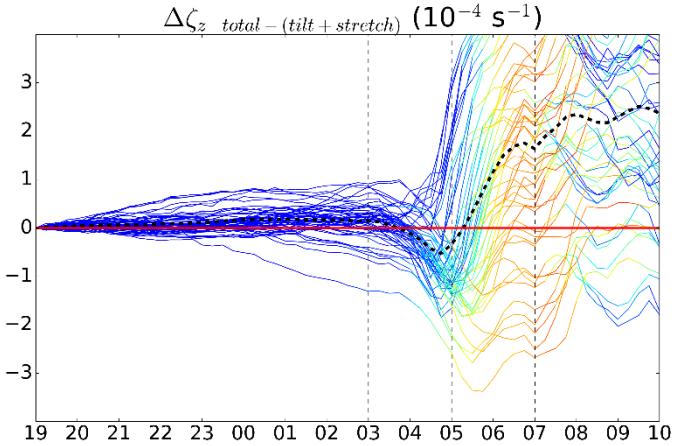
- Lagrangian trajectory analysis on the identified SJ and CCB: trajectories from 22 UTC on 11 Feb to 10 UTC on 12 Feb
- SJ is a different airmass with respect to CCB, undergoing to its own evolution

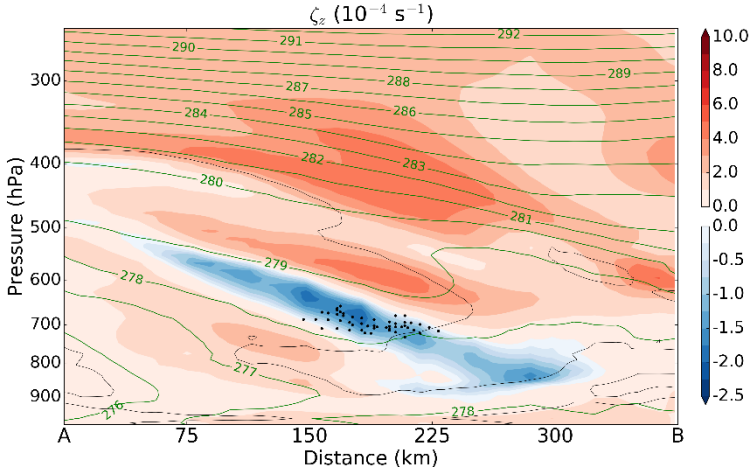
An in-depth analysis is needed to understand how the SJ descends and accelerates!

…these plots are too technical for today's talk so let's move to the overall result…



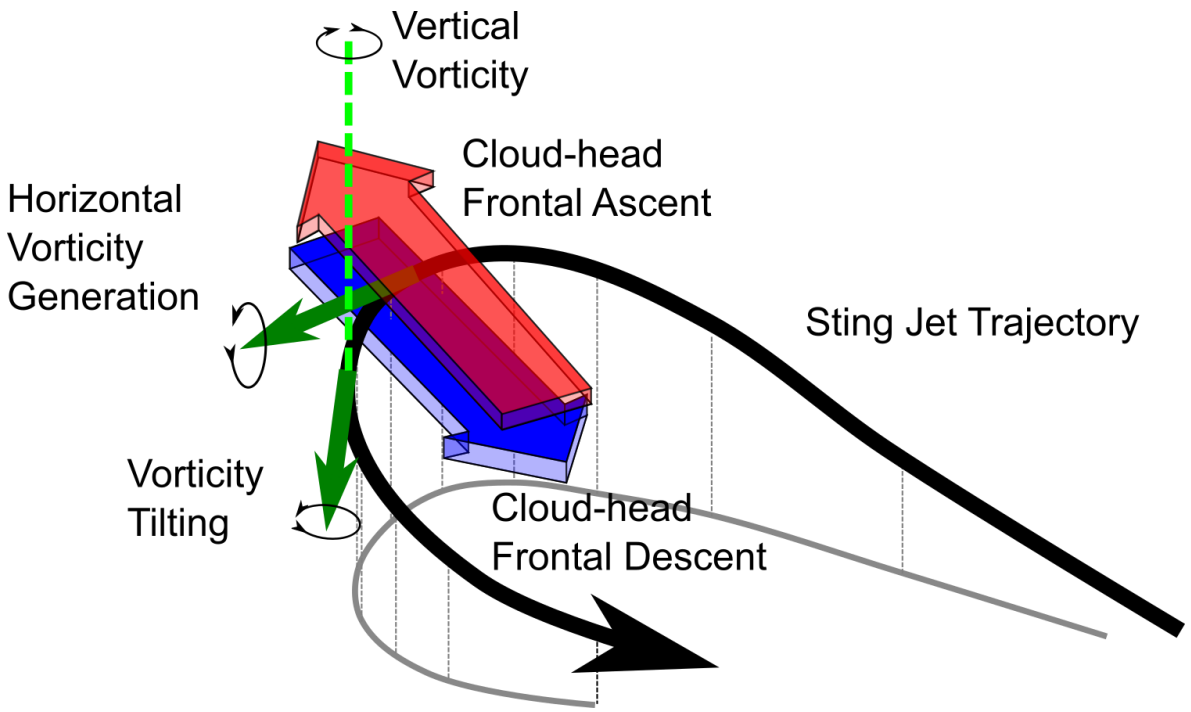






From Volonté et al. (2018), as most of the other images in here

Mechanism of SJ strengthening



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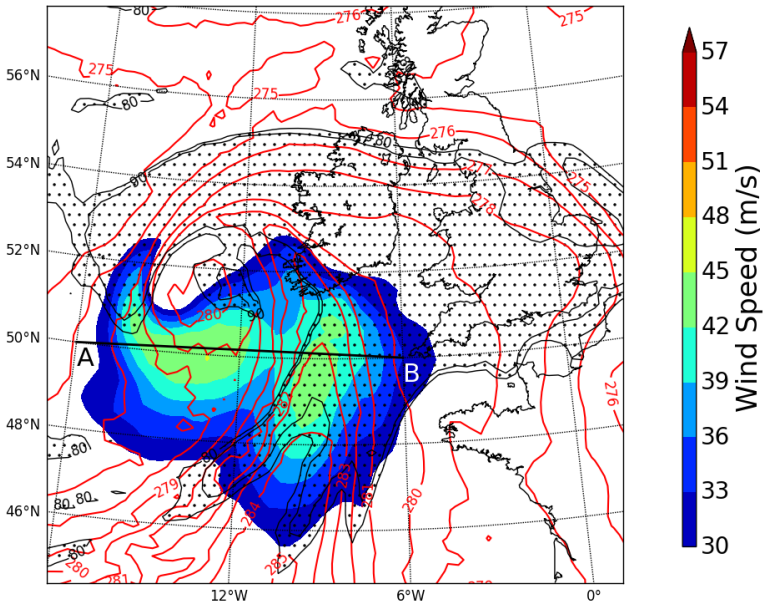
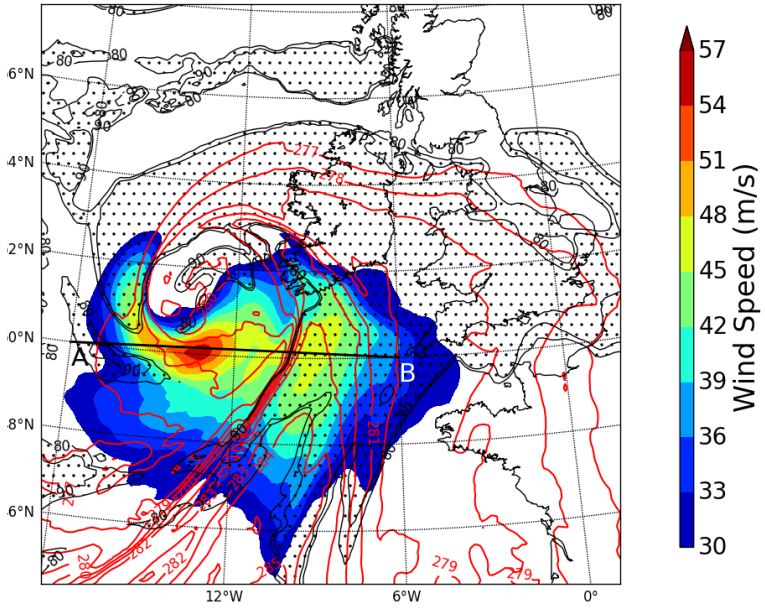
Comparison with a coarser model

So, there is a local mechanism strengthening the SJ. Are our models able to simulate it?

25km horiz spacing



12km horiz spacing



The broad structure is the same but weakening of ‘SJ’ is evident

Comparison with a coarser model

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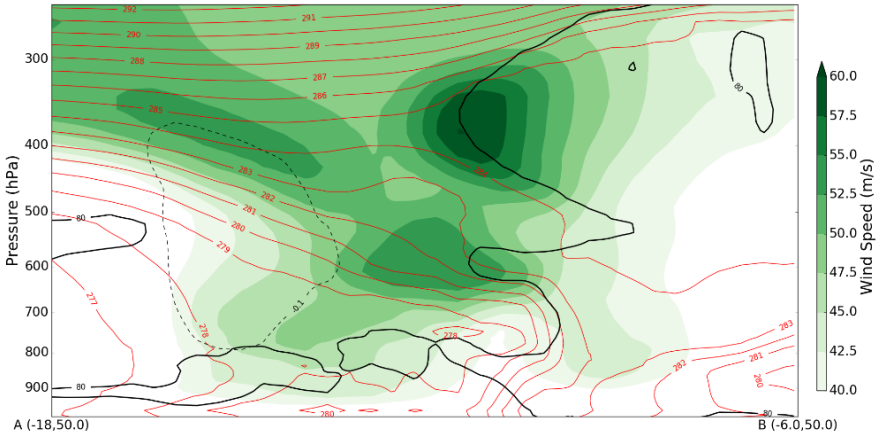

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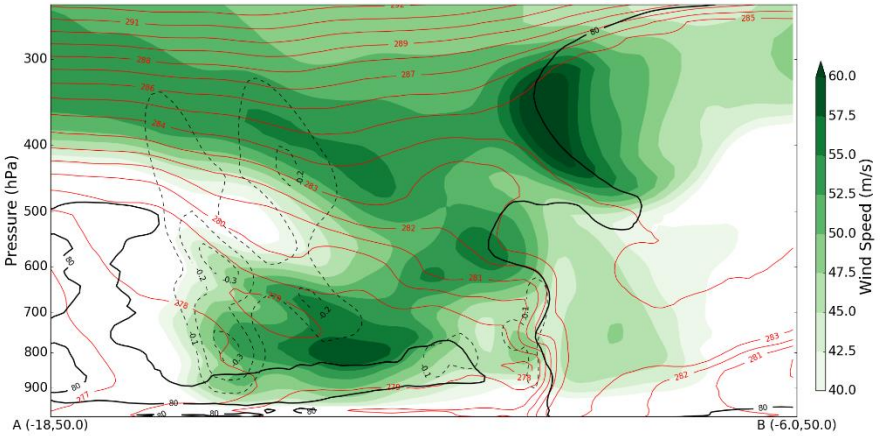
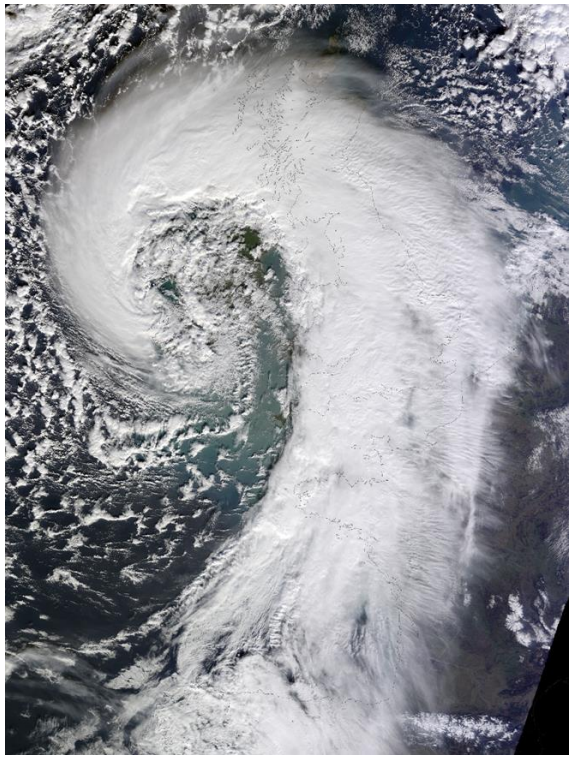


The broad structure is the same but weakening of 'SJ' is evident

Hence, high resolution is key when modelling SJs!

How are we moving forward in understanding SJs?

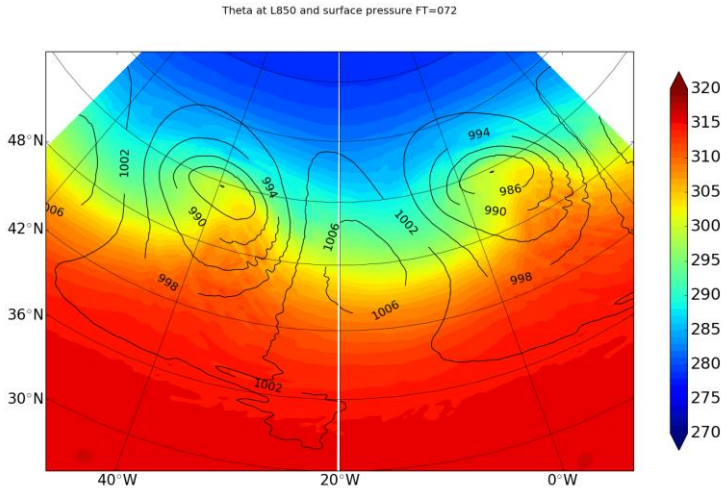


Challenges and open questions:

- Detailed dynamics behind the release of mesoscale instability
- Link between SJ dynamics and moist processes in the cloud head
- SJ predictability and link with climate
- Interaction with boundary layer and propagation to the surface

Tools:

- Case studies
- Idealised simulations
- Observations



How am I moving forward after a PhD on SJs?

Post-doc position:

- No money for further SJ projects in Reading after my PhD
- I looked around a bit, in Reading and elsewhere and I found some nice projects… eventually getting hired for one, on the dynamics of Indian Monsoon
- So… new topic, new challenges, still in Reading
- A lot to learn, some methods to bring!
- Trying out some teaching/supervision.. I like that!
- Future? Will see…