DIAMET

DIAbatic influences on Mesoscale structures in Extratropical sTorms

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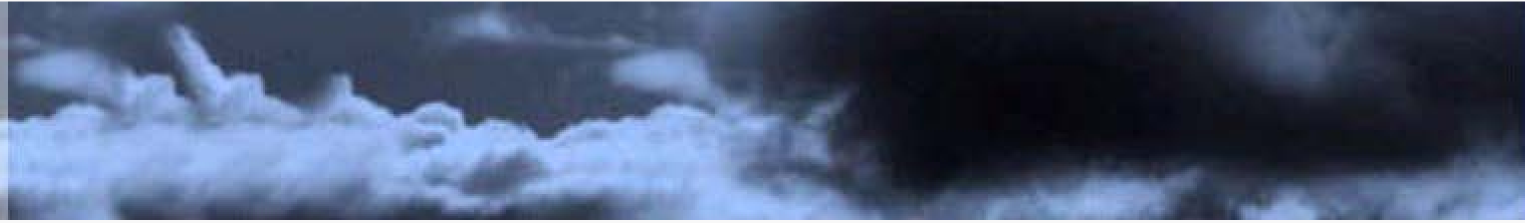
Storm risk mitigation



DIAMET is part of NERC Storm Risk Mitigation Programme

http://www.bgs.ac.uk/stormrm/home.html

- NERC strategic research activity to improve forecasting of storms and their impacts on catchments and coasts
- £4.9M from 2010-2014

DIAMET - Lead PI, Geraint Vaughan, Manchester

weather ♣ observation, process-level understanding and high-resolution weather prediction

TEMPEST - Lead PI, Len Shaffrey, Reading

climate ♦ representation of cyclones and stormtracks in climate models and their interaction with climate change

DEMON - Lead PI, Paul Bates, Bristol

flooding ♥ improving ability to forecast floods using a cascade of models from NWP rainfall $\Rightarrow$ hydrology $\Rightarrow$ inundation (street scale)

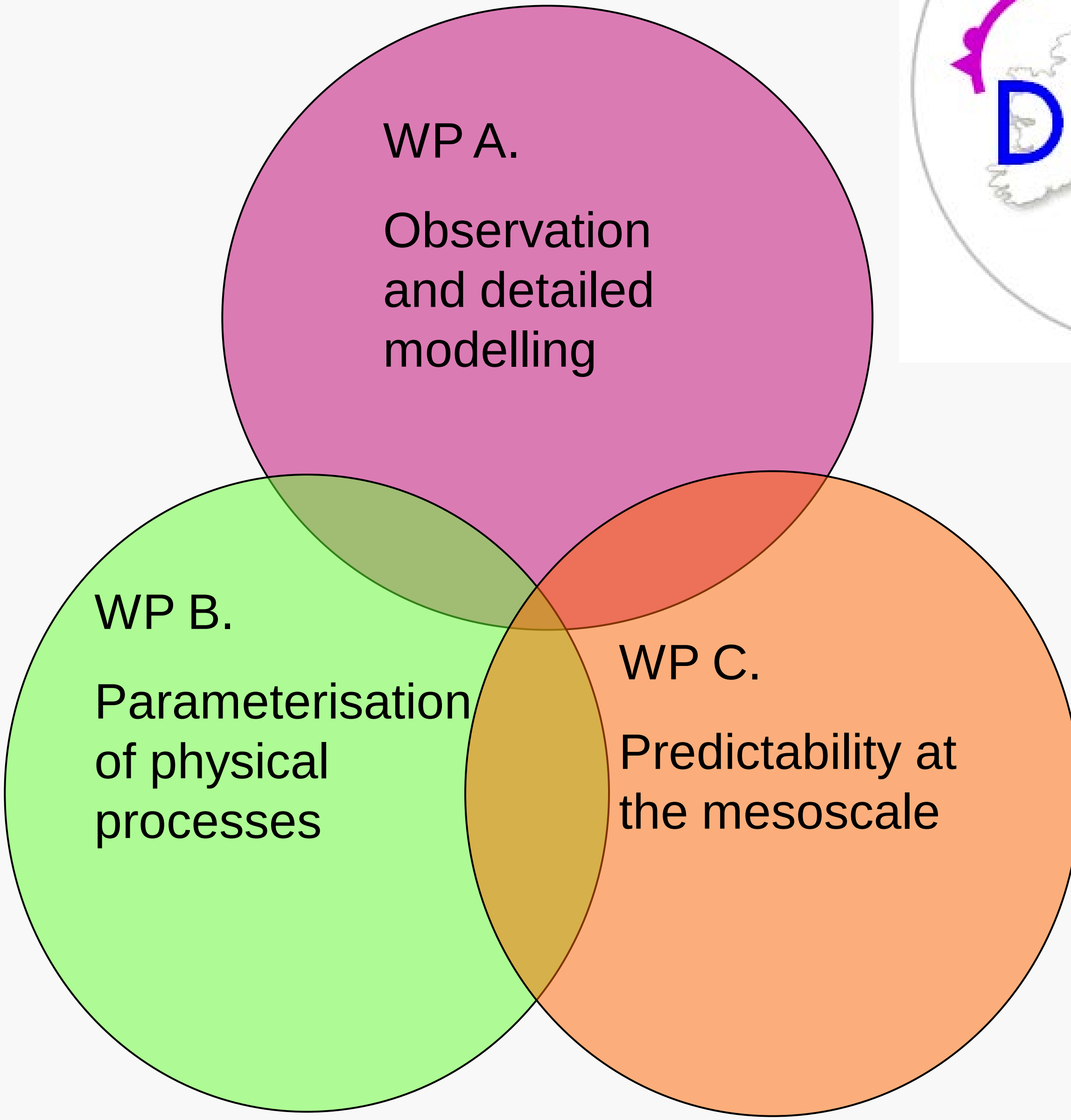
DIAMET Aims

- To describe the structure, origin and dynamical consequences of heating (condensation/evaporation on the mesoscale – e.g., fronts).

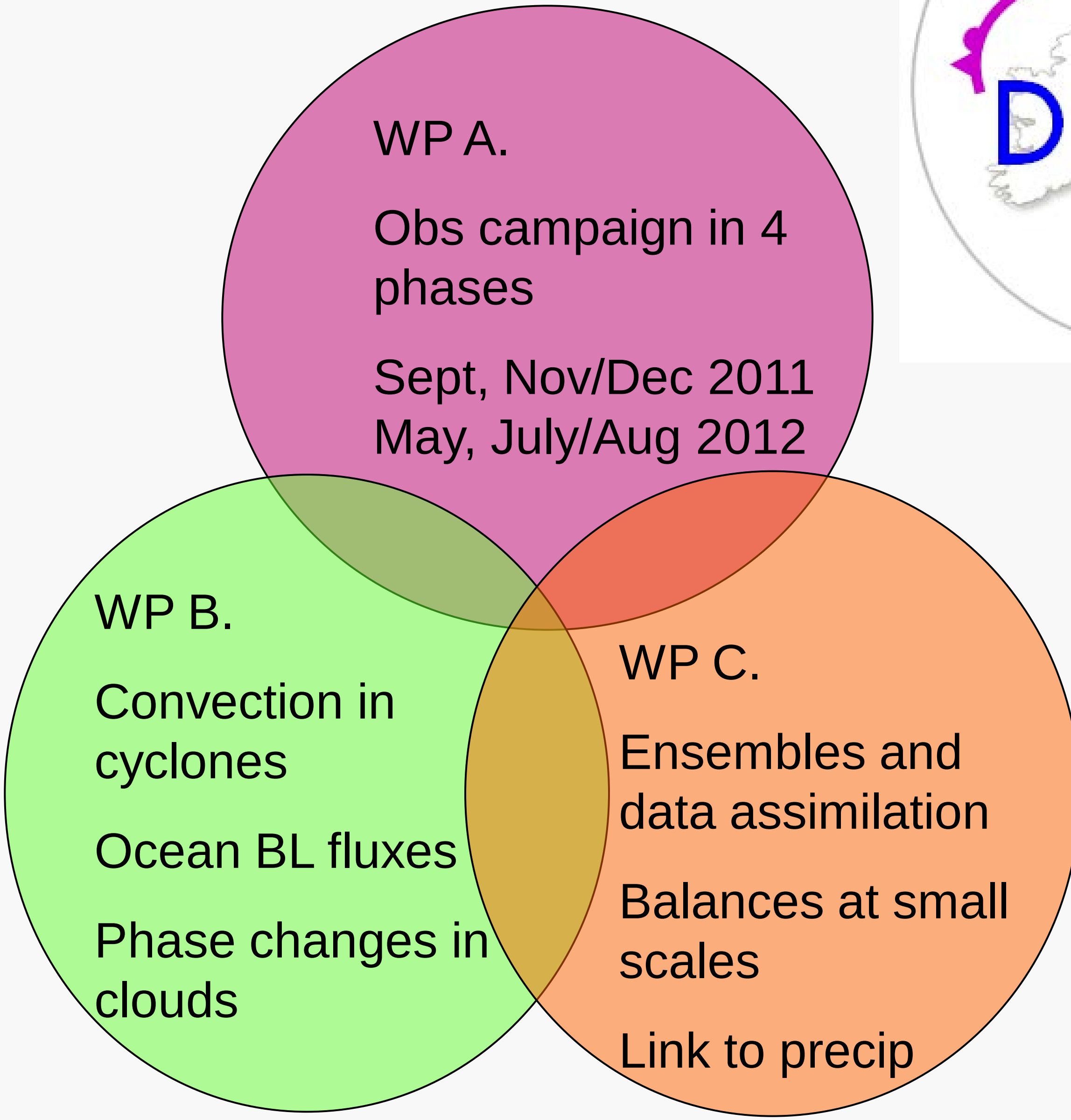
- To make a link between the simulation of mesoscale structure and forecasts of surface weather (high winds and precipitation).

- To investigate the implications for predictability and the skill of numerical weather prediction
  - Especially convection-resolving forecasts (1-2 days)

Structure of project



Structure of project



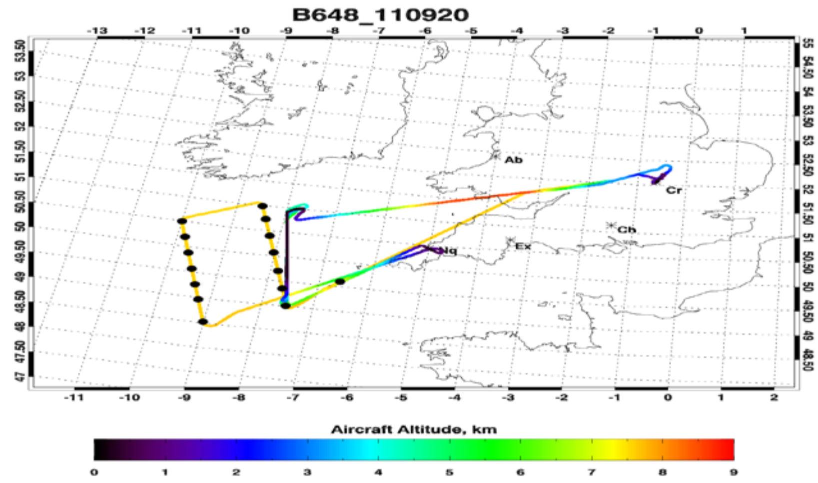
Overarching scientific questions for DIAMET

- What role do diabatic processes play in generating mesoscale potential vorticity (PV) and moisture anomalies in cyclonic storms?
- What are the consequences of those anomalies for the weather (rainfall and surface winds)?

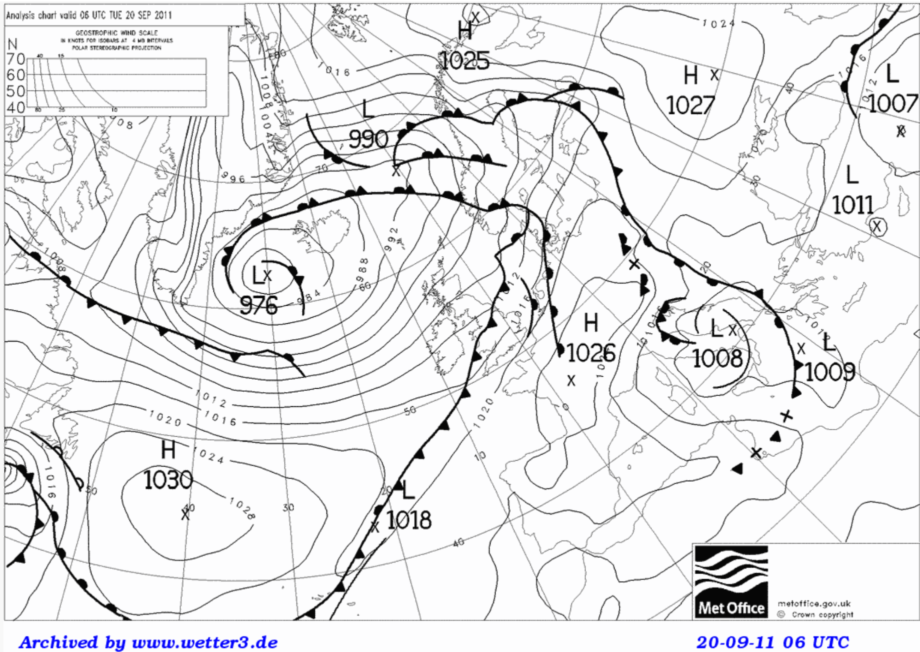
We focus on two key diabatic processes: latent heating/cooling and air-sea fluxes of heat and moisture.

Field Measurements

BAe 146 aircraft



Chilbolton radar



Radiosondes and MST (wind profiling) radar

Poster no.20

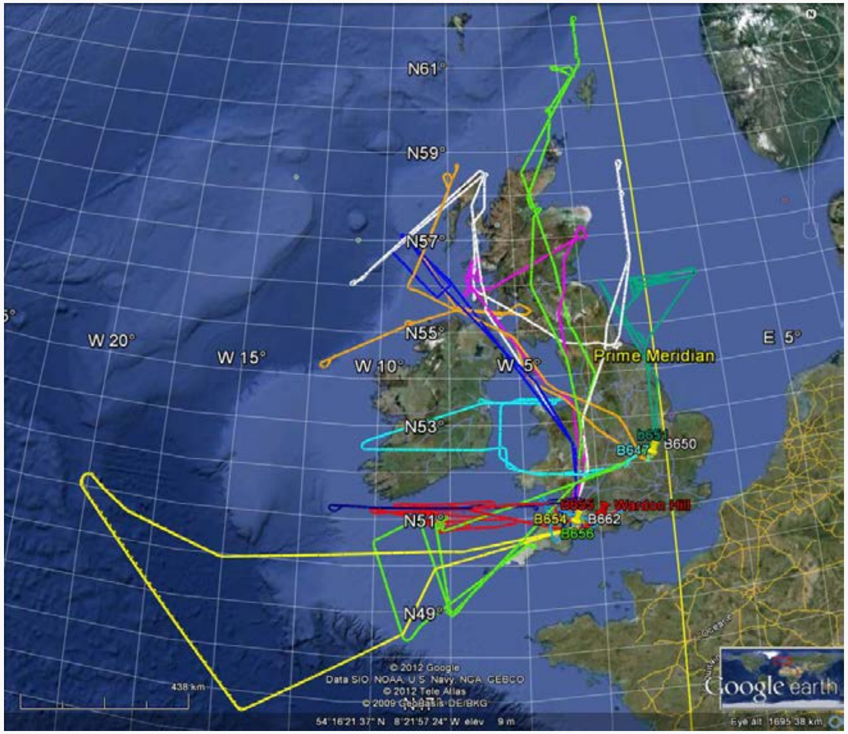
Periods of interest for case studies

- DIAMET field campaigns
  - 16-30 Sep 2011
    - Frontal waves across UK
  - 25 Nov – 15 Dec 2011
    - Severe cyclone sequence across Scotland (into Jan 2012)
  - 1 – 16 May 2012
    - Drier break between extremely wet April and June in UK
  - 9 Jul – 16 Aug 2012
    - Several summer cyclones with persistent rainfall

- PANDOWAE case study focus (German/Swiss THORPEX Project)
  - 11 Sep 2011
    - Extratropical transition and downstream development
  - 7-10 Oct 2011
    - Downstream development and extreme precip (N. Alps)
  - 7-8 Nov 2011
    - “Medicane” and extreme precip (S. Alps)

Field Campaigns in 2011

Date	IOP	Event
16 Sept	1	Convective band ahead of upper-level PV max
20 Sept	2	Baroclinic waves propagating on long trailing cold front
23 Sept	3	Ascent in warm conveyor belt
26 Nov	4	Surface fluxes
28 Nov	5a	Double cold front in Atlantic (dropsonde flight)
29 Nov	5b	Cold front passage over Exeter and Chilbolton
1 Dec	6	Bent back warm front near Shetland + surface fluxes
5 Dec	7	Organised convection west of Scotland
8 Dec	8	Bent back warm front: Windstorm over Scotland
12 Dec	9	Warm front approaching UK from the west



DIAMET IOP-8
Cyclone Friedhelm – 8th Dec 2011

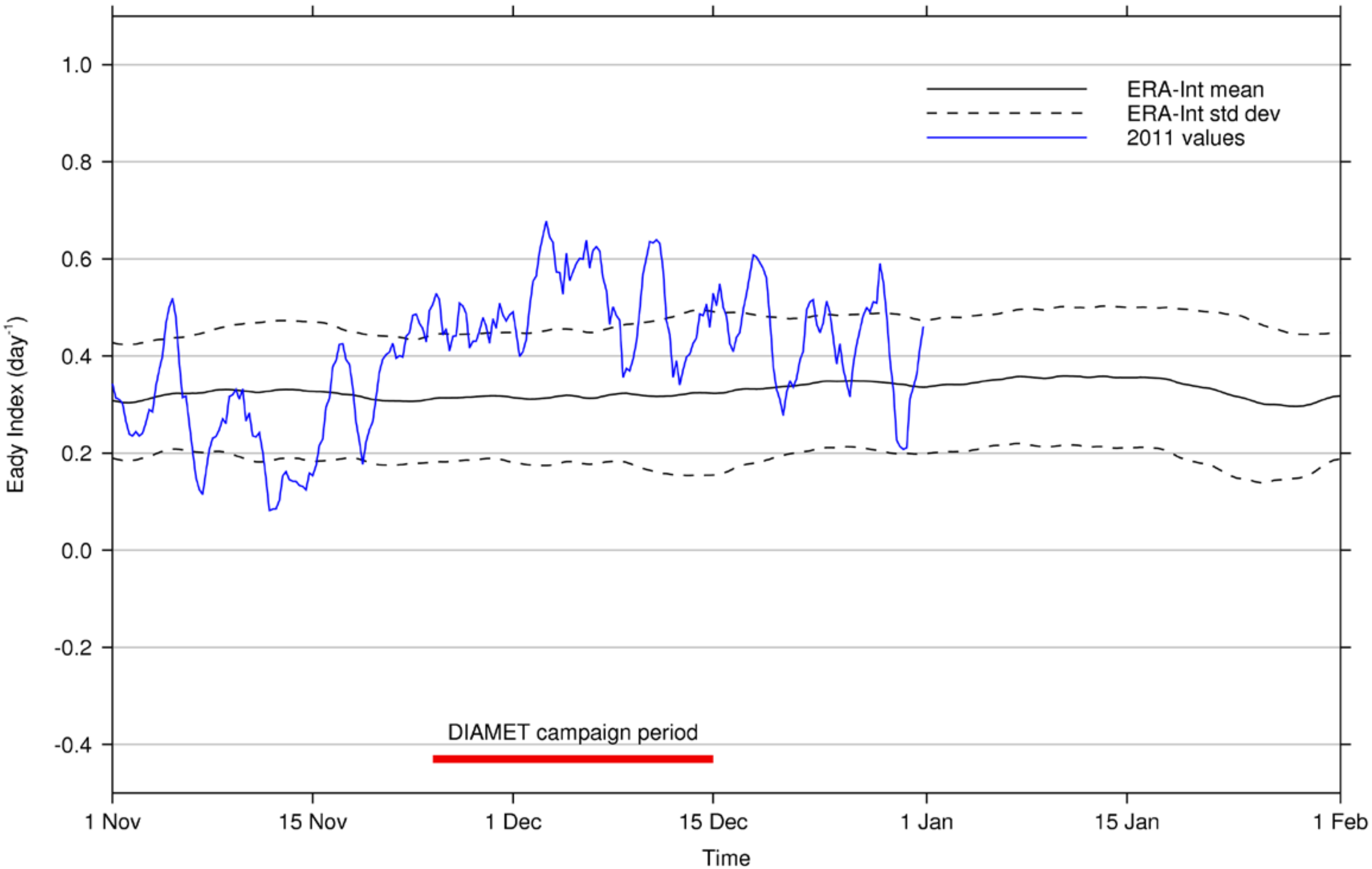
- Rapid development *(deepening 40hPa in 24 hours)*
- High system speed *(wave slowing as it matured)*
- Shapiro-Keyser structure at low levels
- All ingredients for severe surface winds
  - 165mph (gust) on Cairngorm
  - Considerable damage and disruption

Science Questions

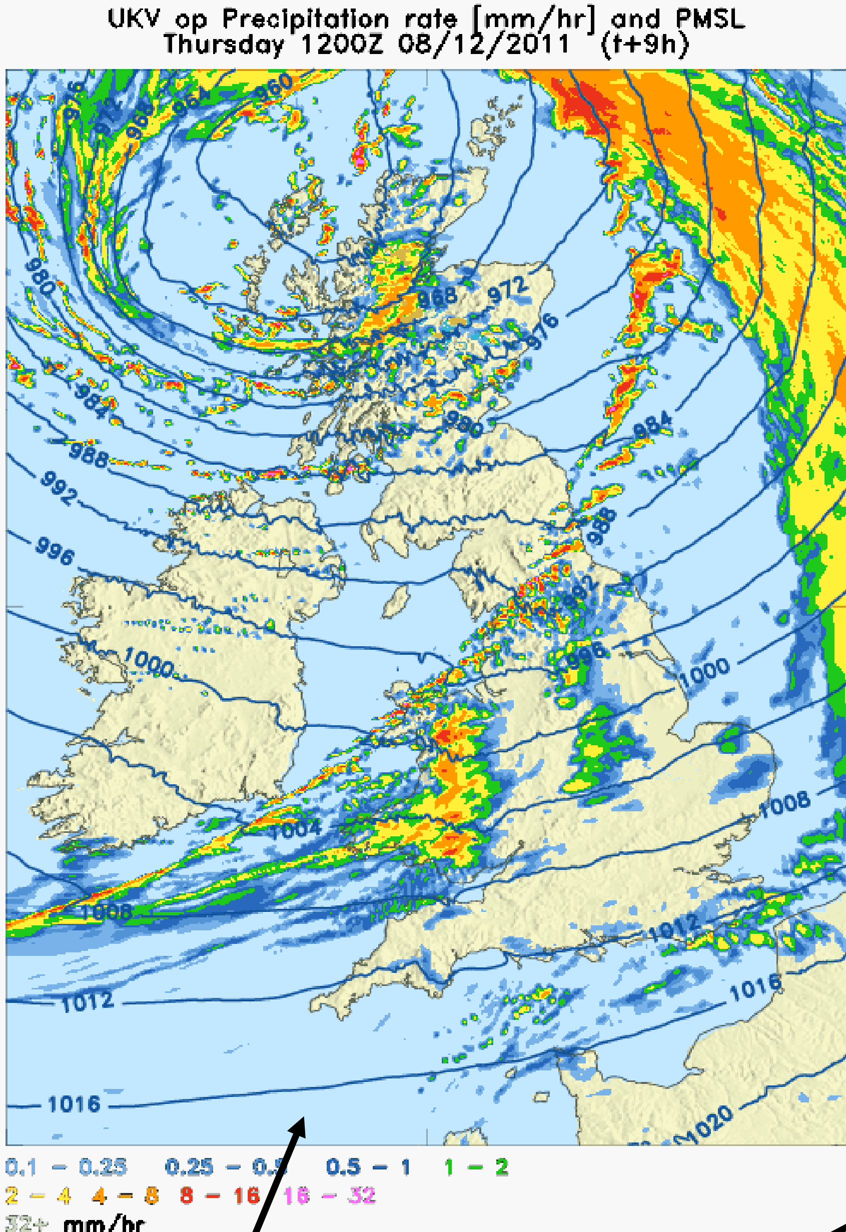
- Were the low-level winds well forecast (structure + strength)?
- Nature of **cloud banding** around cyclone centre
- Role of ice evaporation ⇒ **diabatic cooling** ⇒ enhanced descent and **stronger winds** at BL top

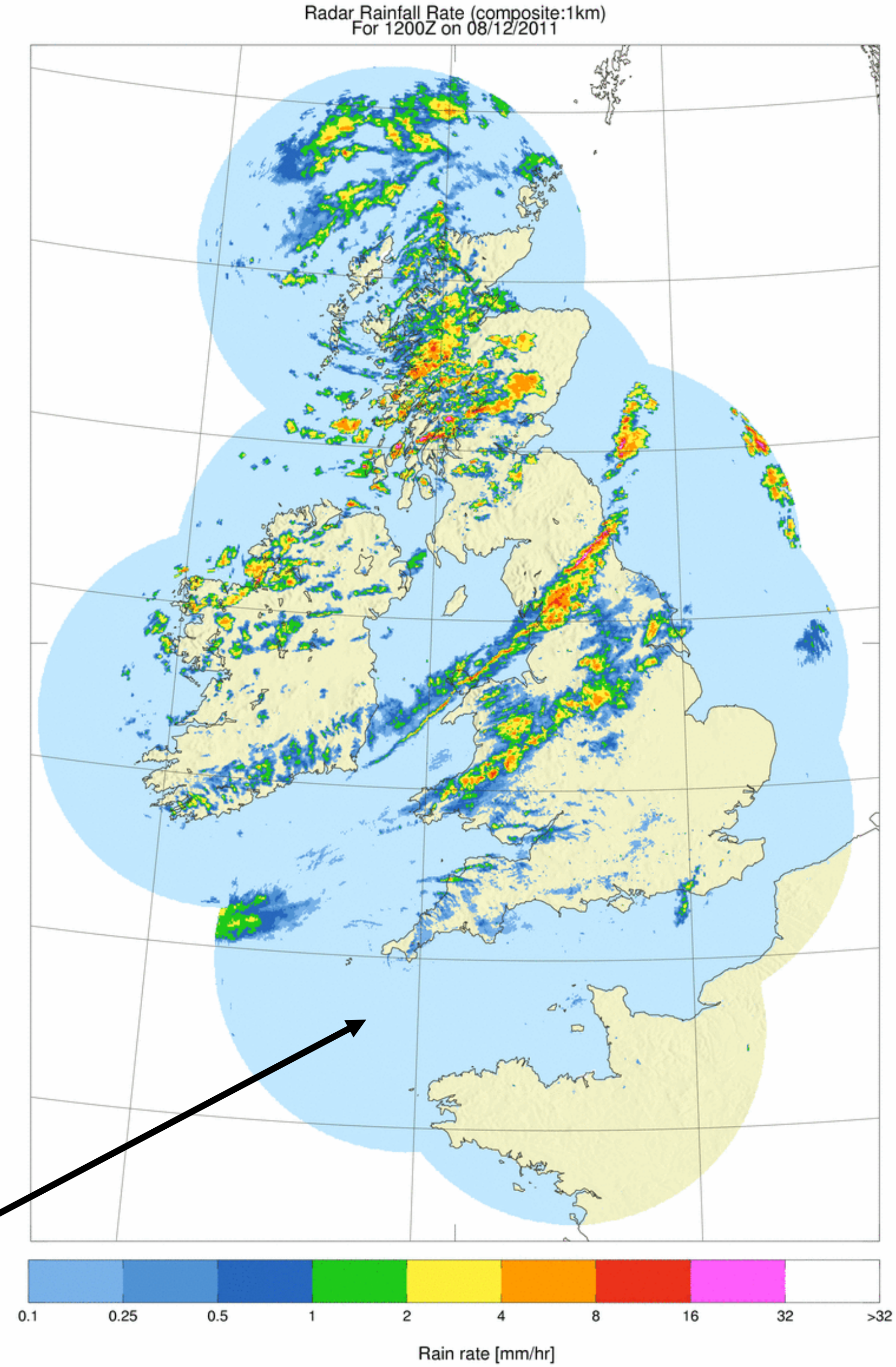
Eady growth rate index Nov/Dec 2011

Average Eady index across N. Atlantic was extremely high.
Most positive NAO for Dec (from CPC 1950-2011).



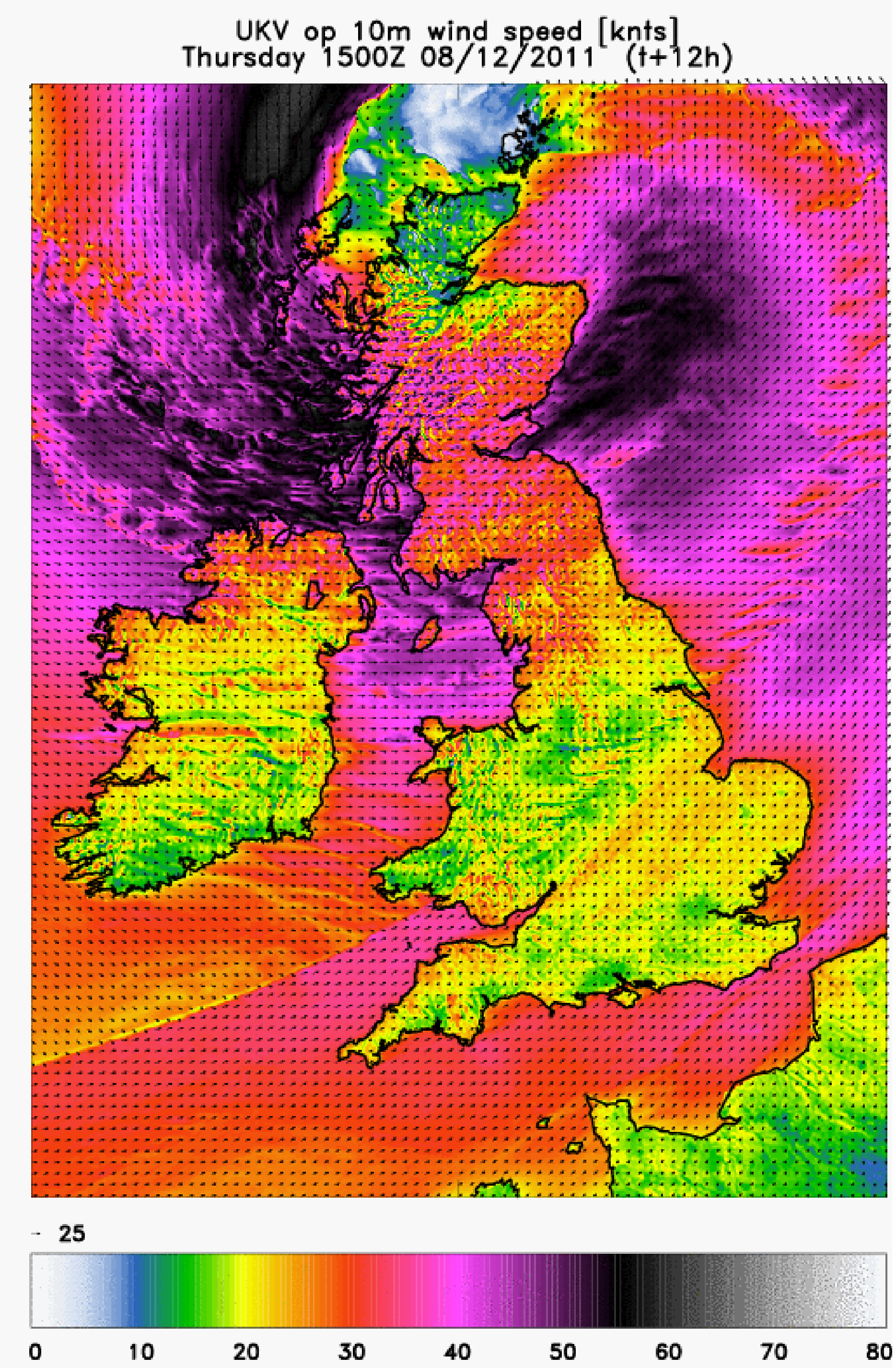
Ben Harvey, U. Reading

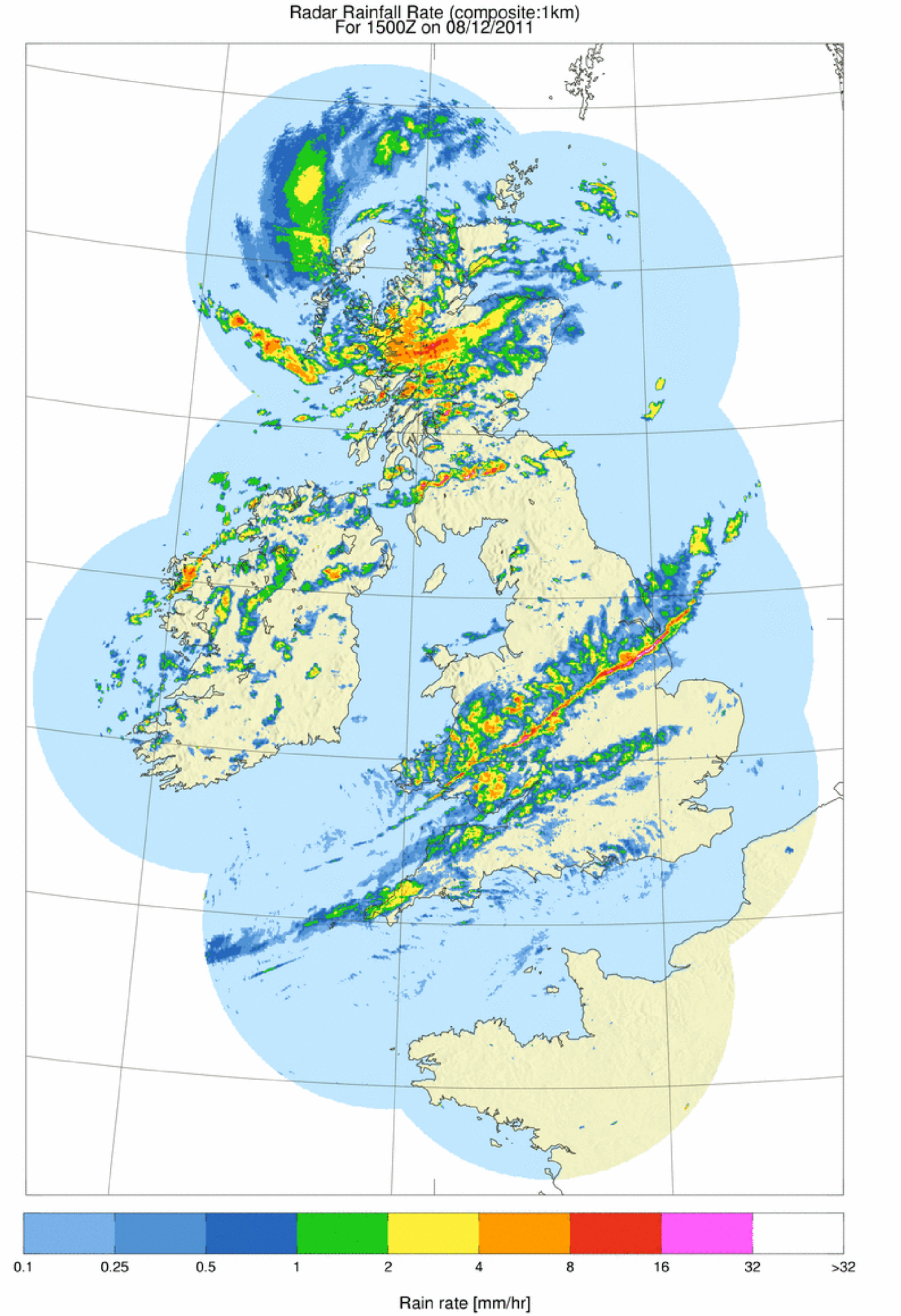




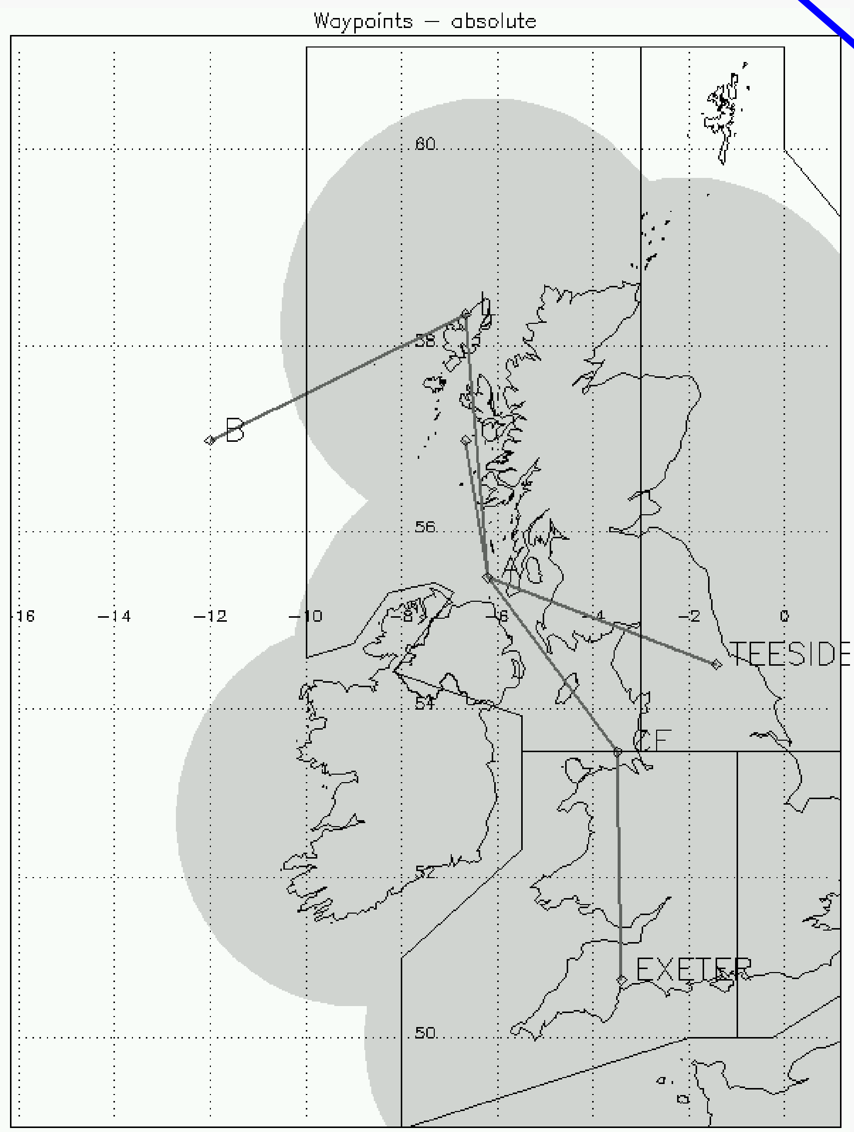
UKV T+9 forecast

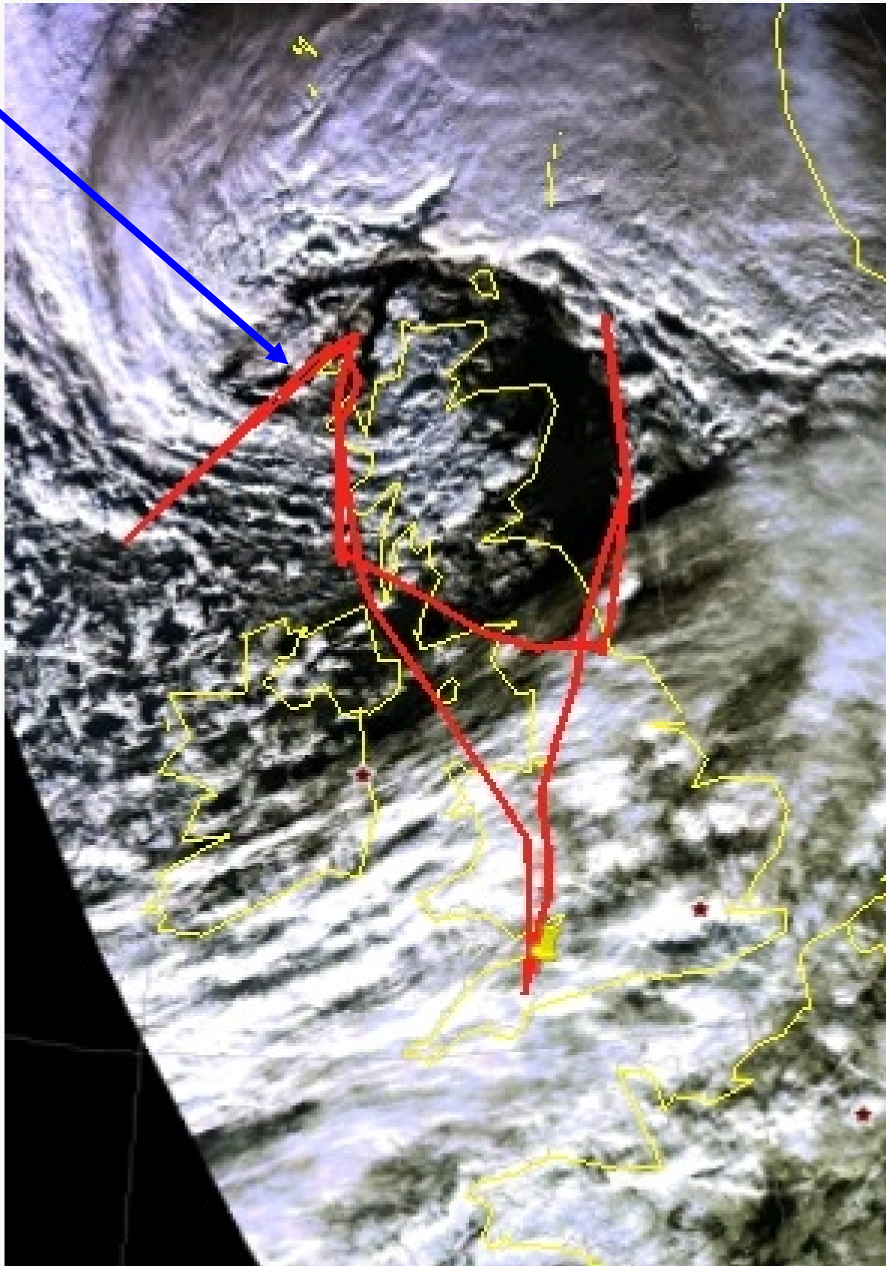
Radar image


UKV op 10m wind speed [knts]
Thursday 1500Z 08/12/2011 (t+12h)
25
0
10
20
30
40
50
60
70
80


Radar Rainfall Rate (composite:1km)
For 1500Z on 08/12/2011
0.1
0.25
0.5
1
2
4
8
16
32
>32
Rain rate [mm/hr]

The flight track

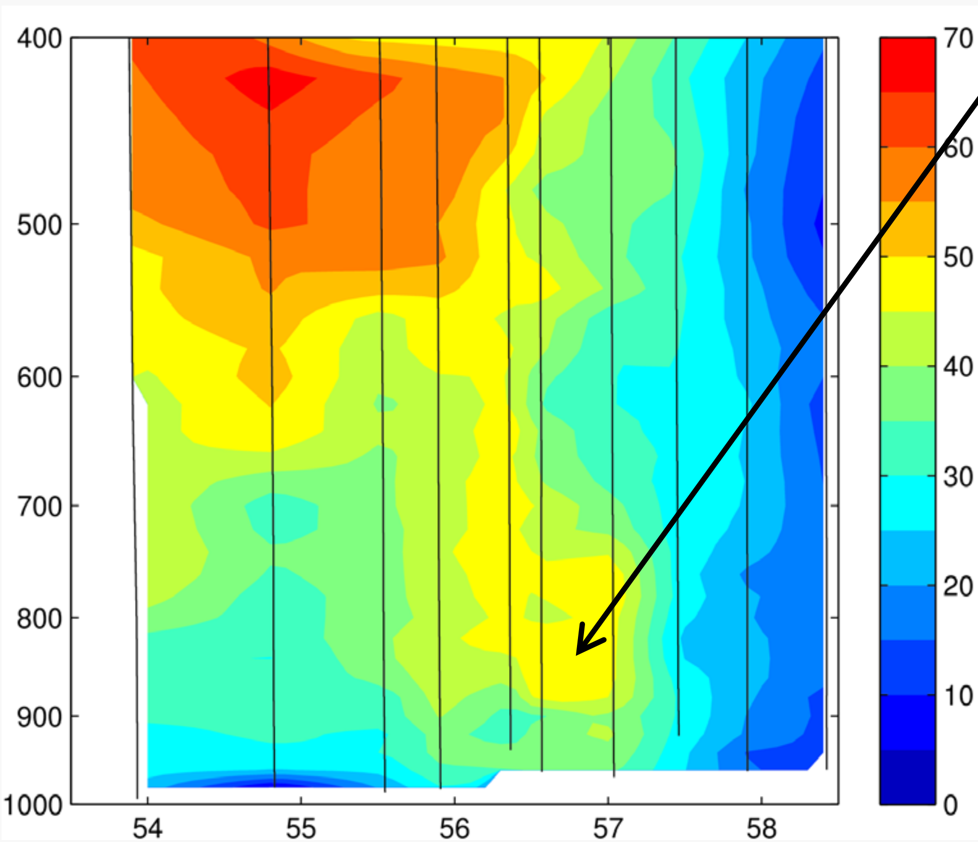




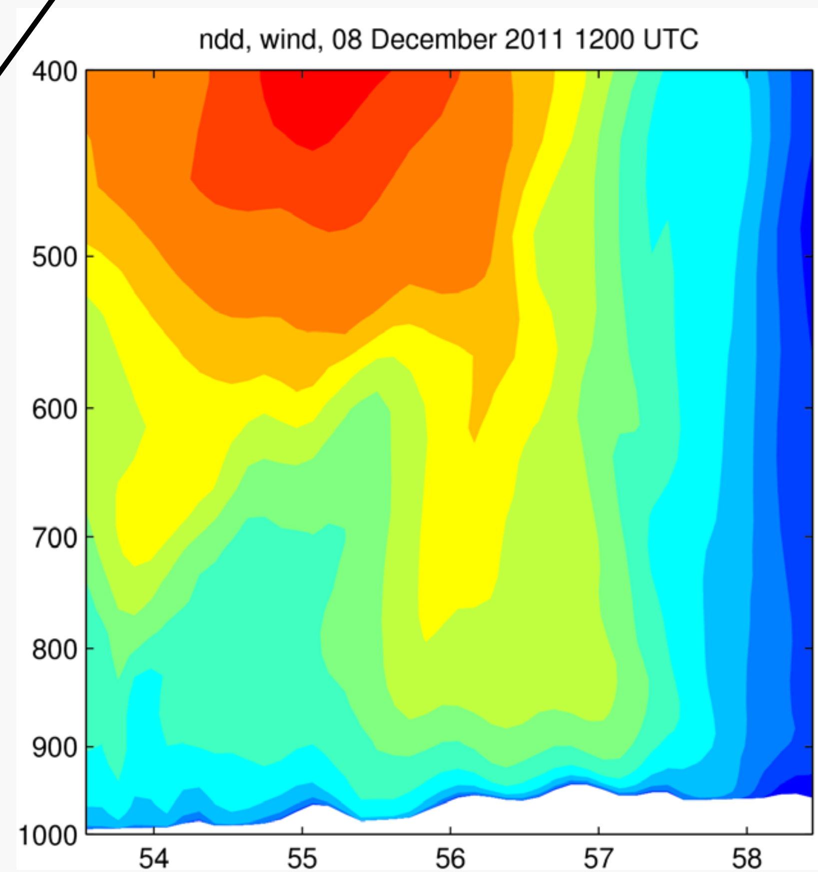
Wind speed (m s^{-1})
Cold front to cyclone centre

“sting jet”?

Dropsondes 1-10



NAE model forecast

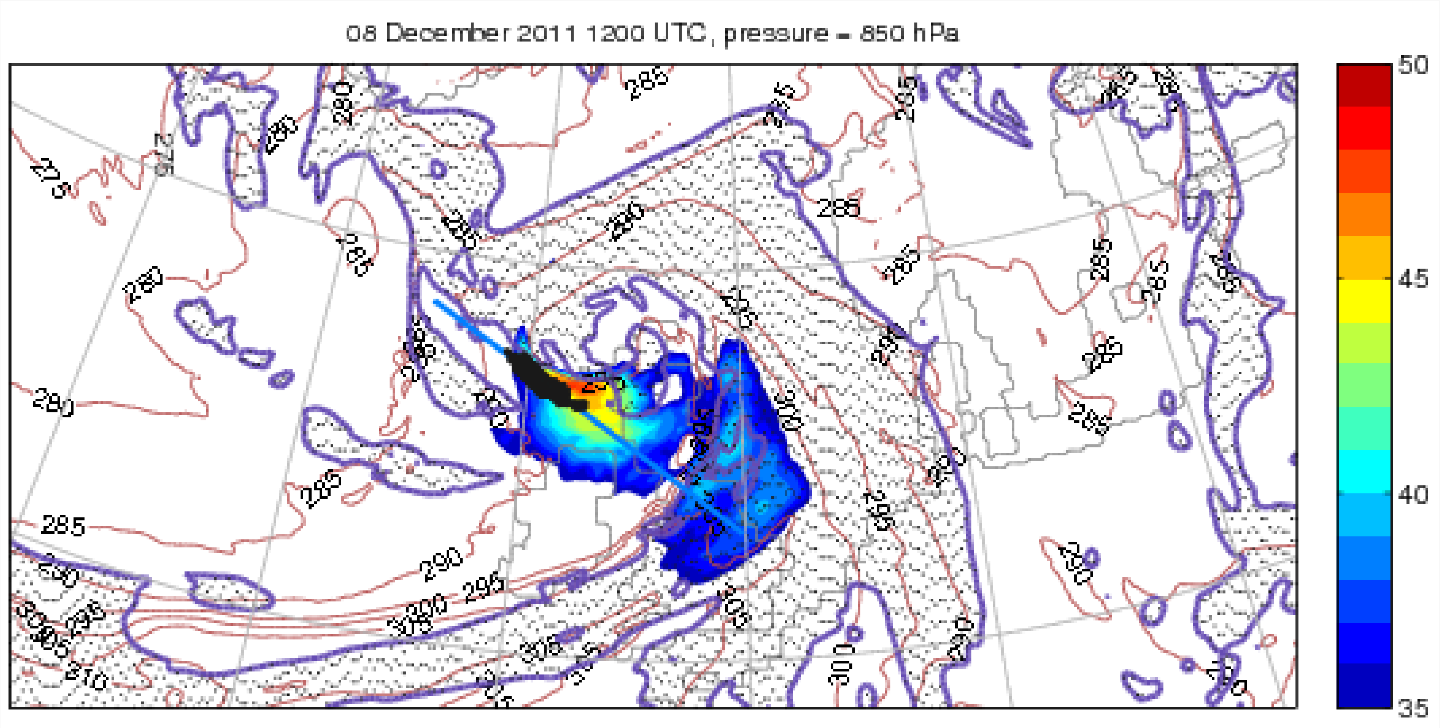


Cold front → Cyclone centre

Oscar Martinez-Alvarado

Trajectory analysis 1200 UTC

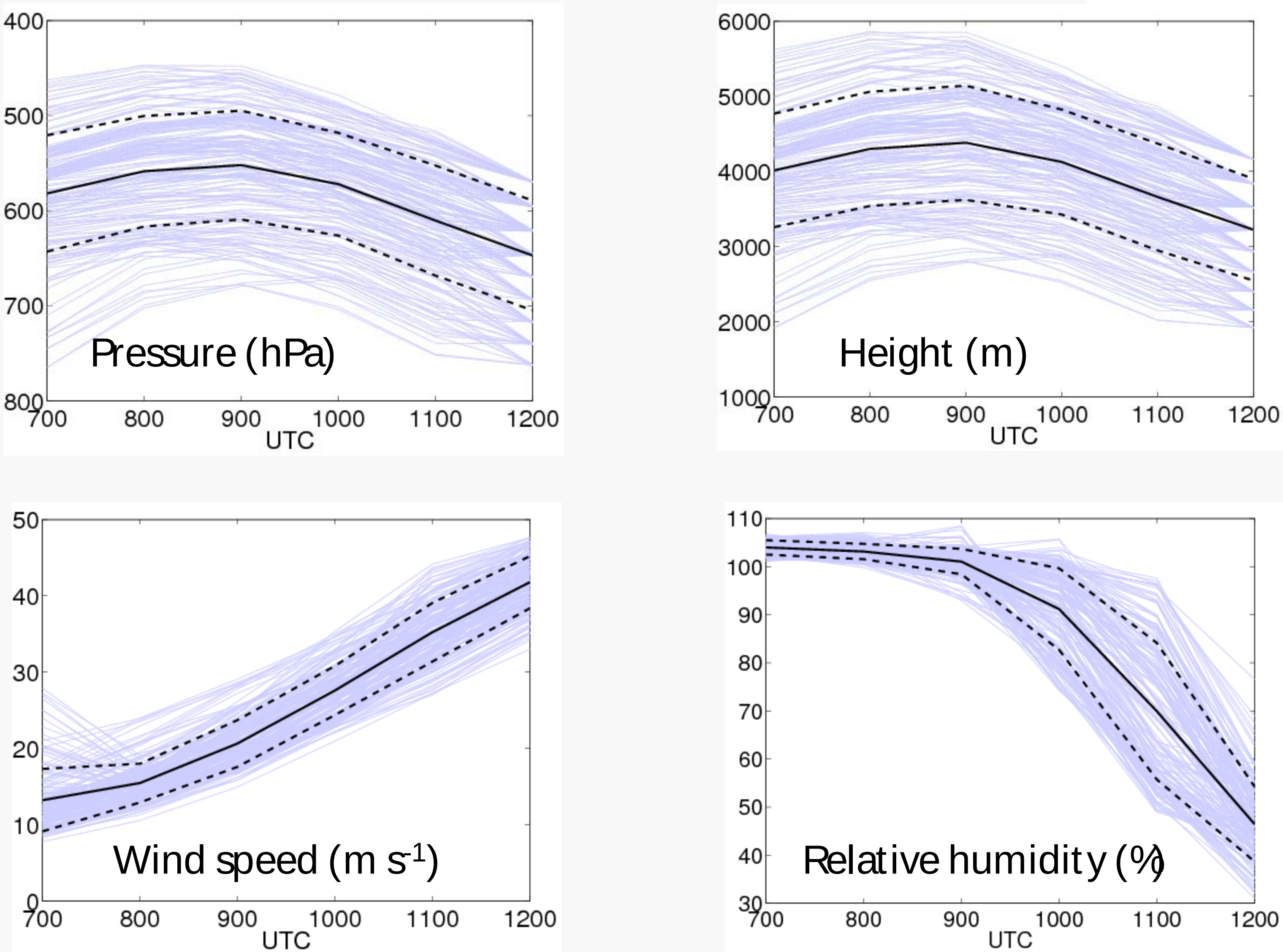
University of Reading



Wind speed (shading)
650-hPa Relative humidity (RH>80% stippled)
850-hPa Equivalent potential temperature
Trajectory position (black dots)

Oscar Martinez-Alvarado

Isolating “sting jet trajectories”



Early Conclusions from DIAMET

- Direct diabatic modification of PV at the tropopause is weak
  - Diabatic PV is positive above (above LW cooling at tpp)
  - Diabatic PV is negative below (LW and outflow from latent heating)
  - Ramifications for Rossby wave growth and propagation

- Field campaign phase has completed with cases relevant to:
  - Fronts and related severe weather: rainbands, tornados
  - Predictability of frontal waves and relation to diabatic processes
  - Rapidly moving winter cyclones with severe surface winds
  - Slow moving summer cyclones associated with widespread flooding

- E.g., first detailed microphysics obs through a sting jet cyclone
  - Is evaporation of ice essential for bringing sting jet winds towards ground?

DIAMET ongoing work

- Calculate diabatic PV in observed cases to infer contribution of diabatic processes to mesoscale structure
  - Relate to model representation of those processes, especially
    1. Ice microphysics
    2. Turbulent fluxes near ocean surface
    3. Convection in shear environment

- Invert diabatic PV tracers to quantify their indirect effect on tropopause

- Use convection-permitting ensembles to relate the predictive skill of mesoscale features to skill for precipitation field
  - Using new 12-member Met Office ensemble (2.2km grid)

- Use perturbed-physics ensembles to examine balance between variables and also model error
  - A few 100-member ensembles run for 12 hours (1.5km grid)