DIAME\[\text{\textsuperscript{T}}\]

DIAbatic influences on Mesoscale structures in Extratropical sTorms

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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 ⇒ hydrology ⇒ 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

WP A. Observation and detailed modelling

WP B. Parameterisation of physical processes

WP C. Predictability at the mesoscale
Structure of project

WP A.
Obs campaign in 4 phases
Sept, Nov/Dec 2011
May, July/Aug 2012

WP B.
Convection in cyclones
Ocean BL fluxes
Phase changes in clouds

WP C.
Ensembles and data assimilation
Balances at small scales
Link to precip
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

<table>
<thead>
<tr>
<th>Date</th>
<th>IOP</th>
<th>Event</th>
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<tbody>
<tr>
<td>16 Sept</td>
<td>1</td>
<td>Convective band ahead of upper-level PV max</td>
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<tr>
<td>20 Sept</td>
<td>2</td>
<td>Baroclinic waves propagating on long trailing cold front</td>
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<tr>
<td>23 Sept</td>
<td>3</td>
<td>Ascent in warm conveyor belt</td>
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<tr>
<td>26 Nov</td>
<td>4</td>
<td>Surface fluxes</td>
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<tr>
<td>28 Nov</td>
<td>5a</td>
<td>Double cold front in Atlantic (dropsonde flight)</td>
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<tr>
<td>29 Nov</td>
<td>5b</td>
<td>Cold front passage over Exeter and Chilbolton</td>
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<tr>
<td>1 Dec</td>
<td>6</td>
<td>Bent back warm front near Shetland + surface fluxes</td>
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<tr>
<td>5 Dec</td>
<td>7</td>
<td>Organised convection west of Scotland</td>
</tr>
<tr>
<td>8 Dec</td>
<td>8</td>
<td>Bent back warm front: Windstorm over Scotland</td>
</tr>
<tr>
<td>12 Dec</td>
<td>9</td>
<td>Warm front approaching UK from the west</td>
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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
The flight track
Wind speed (m s\(^{-1}\))
Cold front to cyclone centre

"sting jet"?

Dropsondes 1-10

NAE model forecast

Cold front  \rightarrow  Cyclone centre

Oscar Martinez-Alvarado
Trajectory analysis 1200 UTC

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