COST Action WG1+2 Meeting
22-23 February 2012

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Liquid detrainment in convection embedded in a cold front

Oscar Martínez-Alvarado
Bob Plant

Department of Meteorology
University of Reading

DIAMET project

DIAbatic influences on Mesoscale structures in ExTratropical storms

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- Consortium constituted by four UK universities (Manchester, Leeds, Reading and East Anglia) and the Met Office
- Three Work Packages
  - WP A. Structure of mesoscale anomalies and their wide-scale consequences
  - **WP B. Physical processes and their parameterisation**
  - WP C. Predictability

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  - WP A. Structure of mesoscale anomalies and their wide-scale consequences
  - **WP B. Physical processes and their parameterisation**
    1. **Improving convective parameterisation**
    2. Air-sea fluxes and their influence on storm development
    3. Microphysical processes
  - WP C. Predictability

1. Lagrangian moisture budget diagnostics

- Moisture and potential temperature tracers (affected by advection)
- Budgets decomposed by parameterised processes:

$$\Delta\theta(x,t) = \sum_{i=\text{proc}} \Delta\theta_i(x,t)$$

$$\Delta q(x,t) = \sum_{i=\text{proc}} \Delta q_i(x,t)$$

proc = {convection, boundary layer, microphysics,…}

- Current field configuration given by

$$\theta = \theta_0 + \Delta\theta_0 + \Delta\theta$$

Initial field at t=0

Change in initial field due to advection only

2. Spectral decomposition of bulk mass flux parameterisation output

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- Spectral decomposition using entrainment ε as single parameter.
  1. Construction of a plume ensemble consistent with the model sounding
  2. Solve

$$\min \left| M(z^{\alpha}) - \sum_i c_i M_i(z^{\alpha}) \right|, c_i \geq 0$$

z^a : a-th height level

M: bulk mass flux

M_i : i-th plume mass flux

c_i : i-th coefficient

Analysis method: Motivation Plant (2010)

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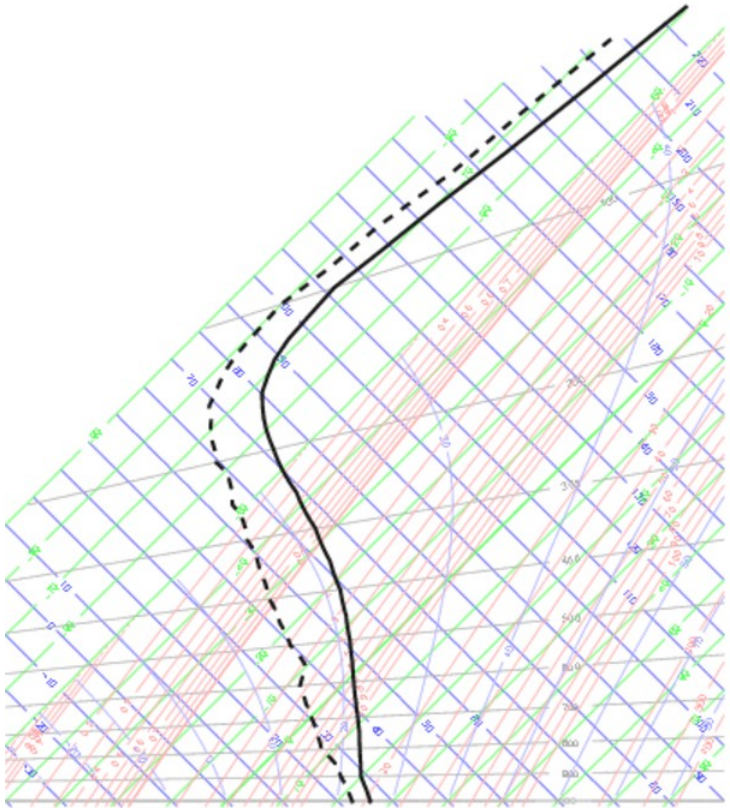
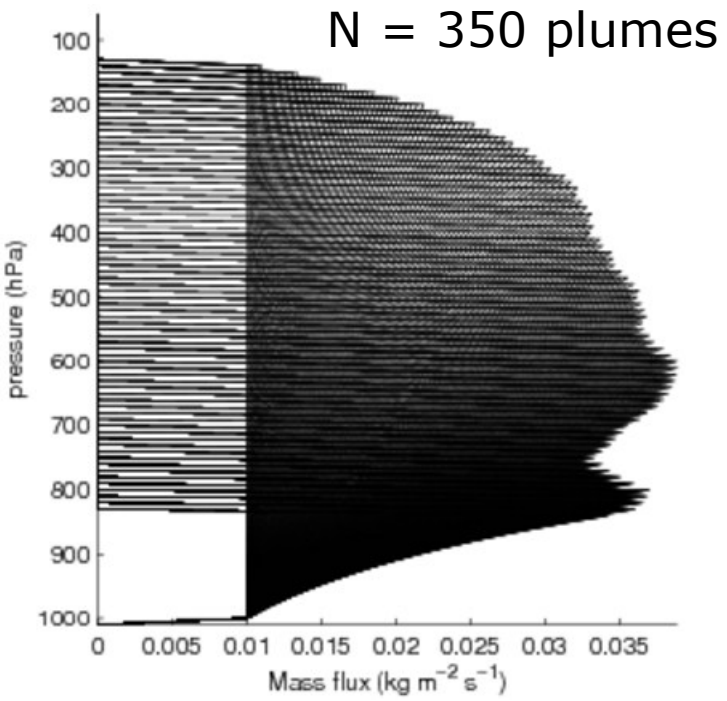


Mean West Indies sounding data for "hurricane season" (Jordan 1958)



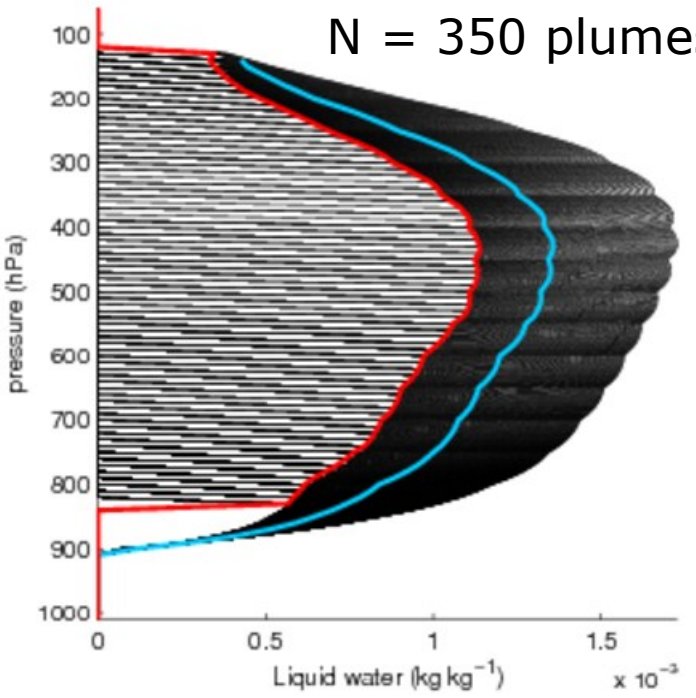
Vertical profiles of mass flux in ensemble (after Plant 2010)

Analysis method: Motivation Plant (2010)

Bulk parameterisation schemes ansatz (Yanai et al. 1973)

The liquid water detrained from each individual plume is given by the bulk value:

$$l_{D_i} = l_i = l_B = \frac{\sum_i M_i l_i}{\sum_i M_i}$$



Ensemble detrained liquid water

Bulk liquid water

(after Plant 2010)

Preliminary results

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- Case from DIAMET first field campaign:
  - 30 September 2011
  - Low-pressure system centred to the south-west of Iceland
  - Long trailing active cold front
- Model:
  - Met Office Unified Model (MetUM) version 7.3
  - North-Atlantic—Europe (NAE) domain
  - Grid spacing 0.11^{o} (~12 km)
  - 38 vertical levels (lid ~40 km)
  - (MetUM Modified) Gregory—Rowntree convection scheme

DIAMET field campaign
0600 UTC 30 September 2011

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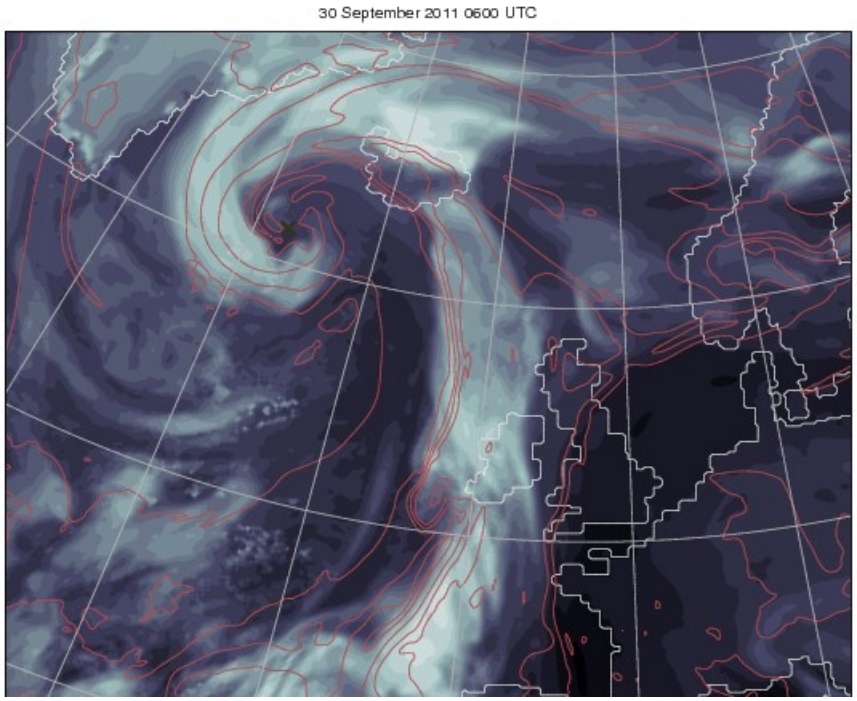
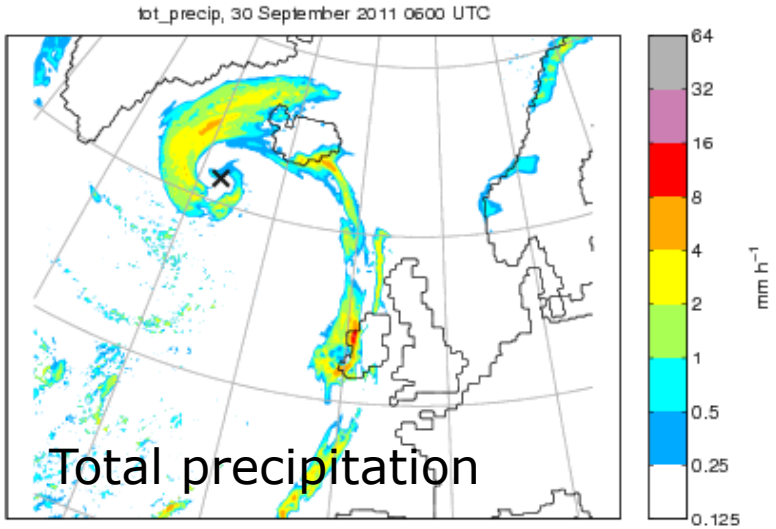
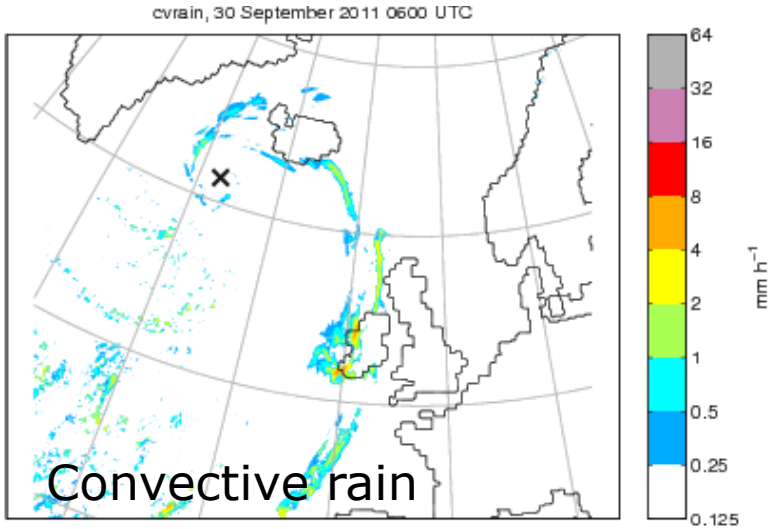
Model-derived OLR



850-hPa equivalent potential temperature





Lagrangian budget diagnostic

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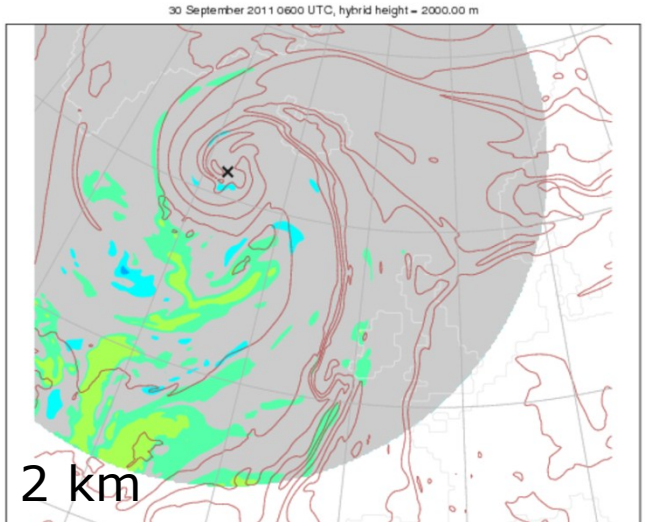
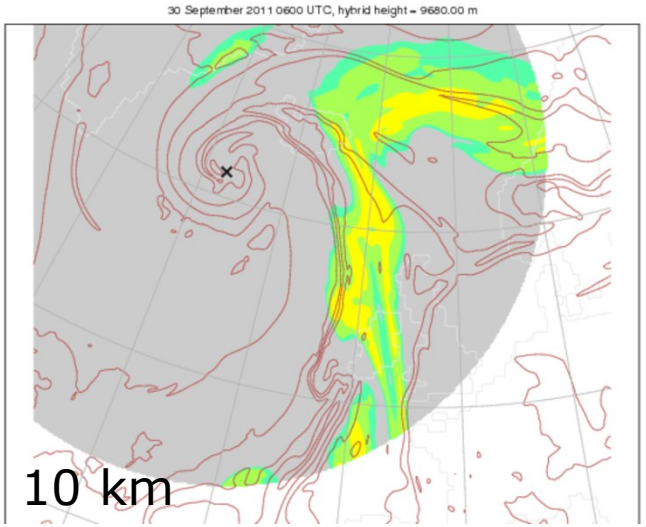
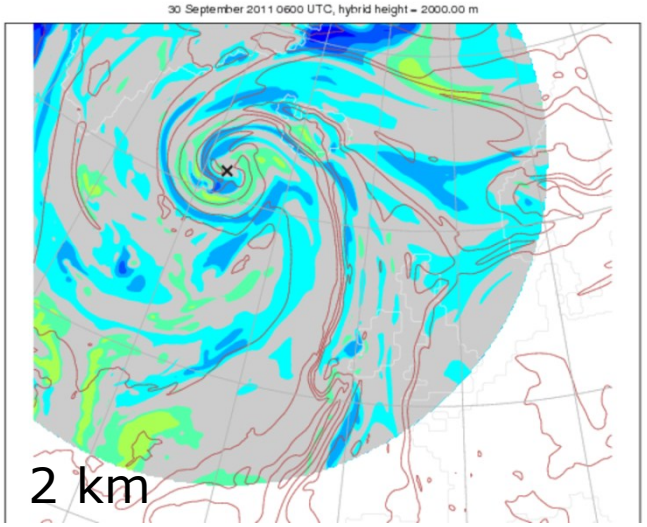
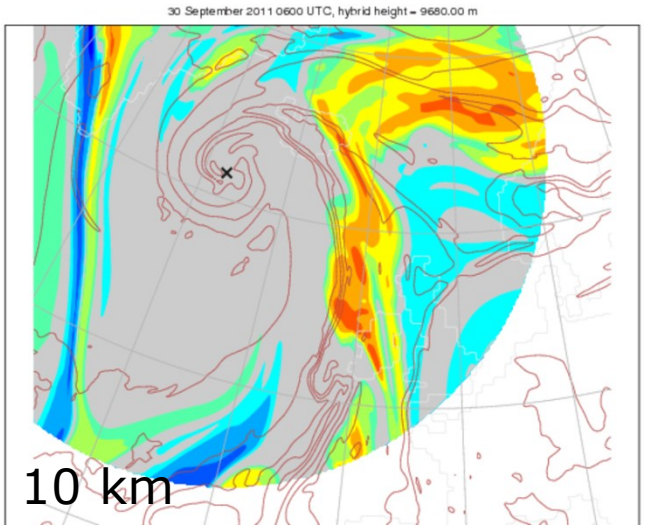
Change in theta due to convection





Total change in theta





Rain

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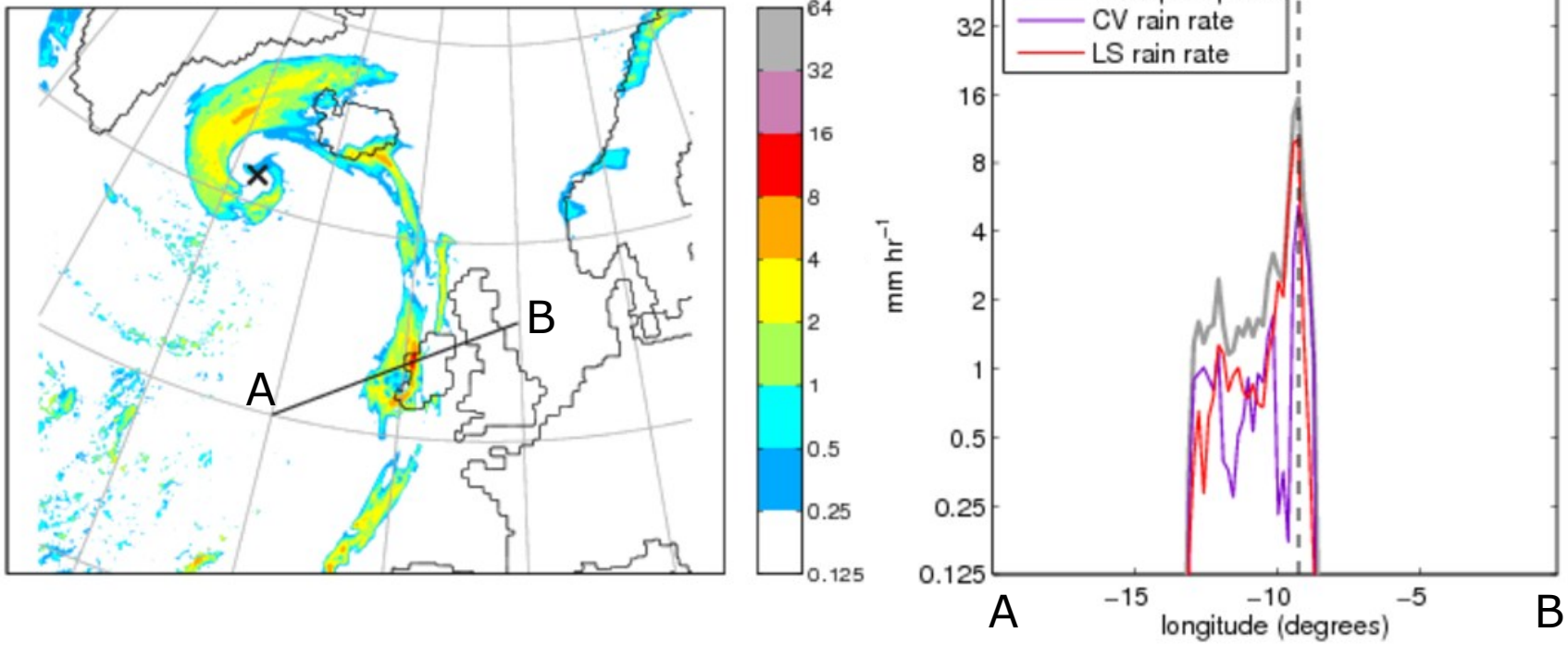
Total precipitation



Updraught mass flux

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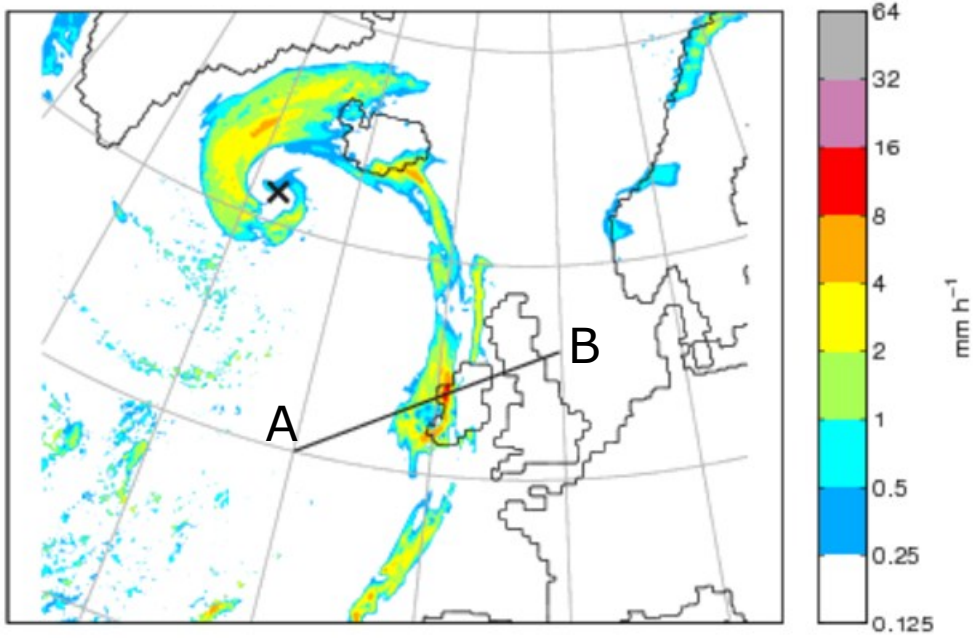
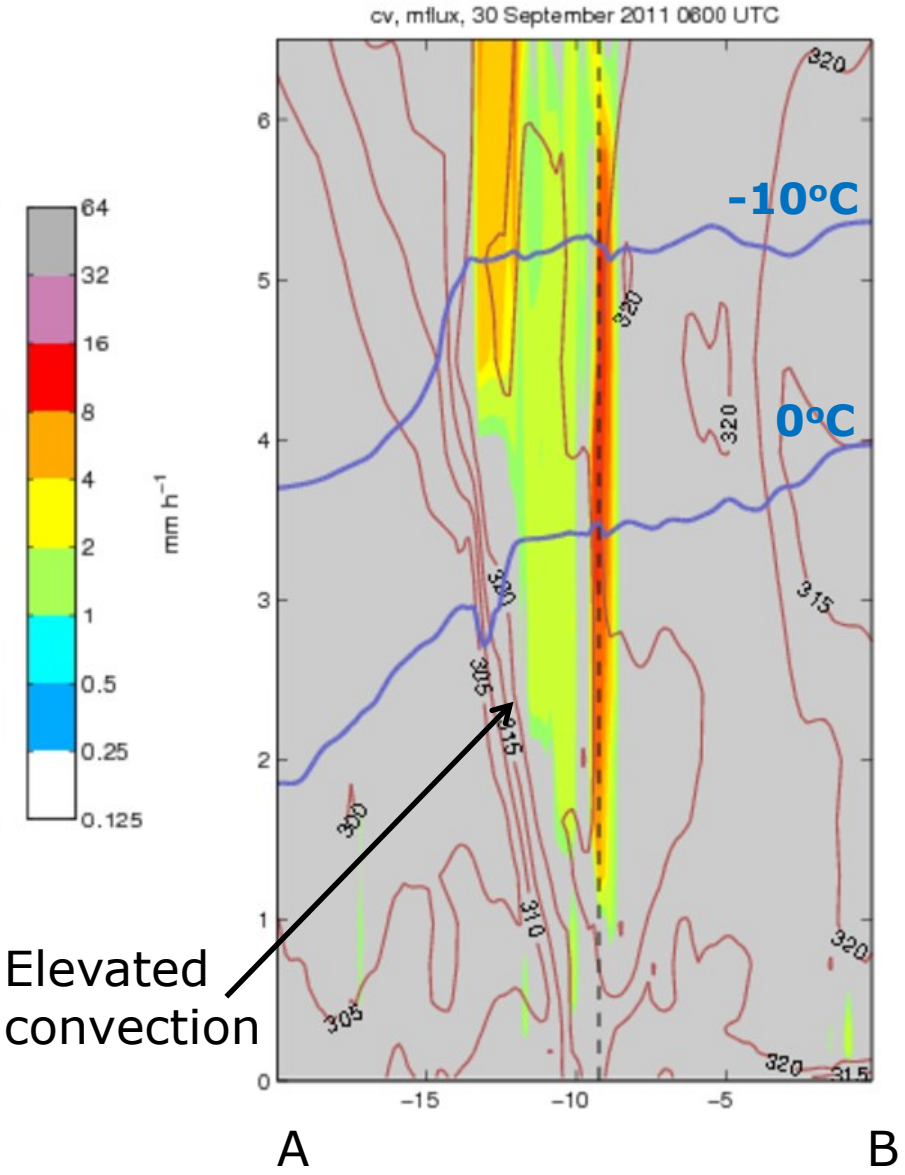
Total precipitation





Updraught mass flux

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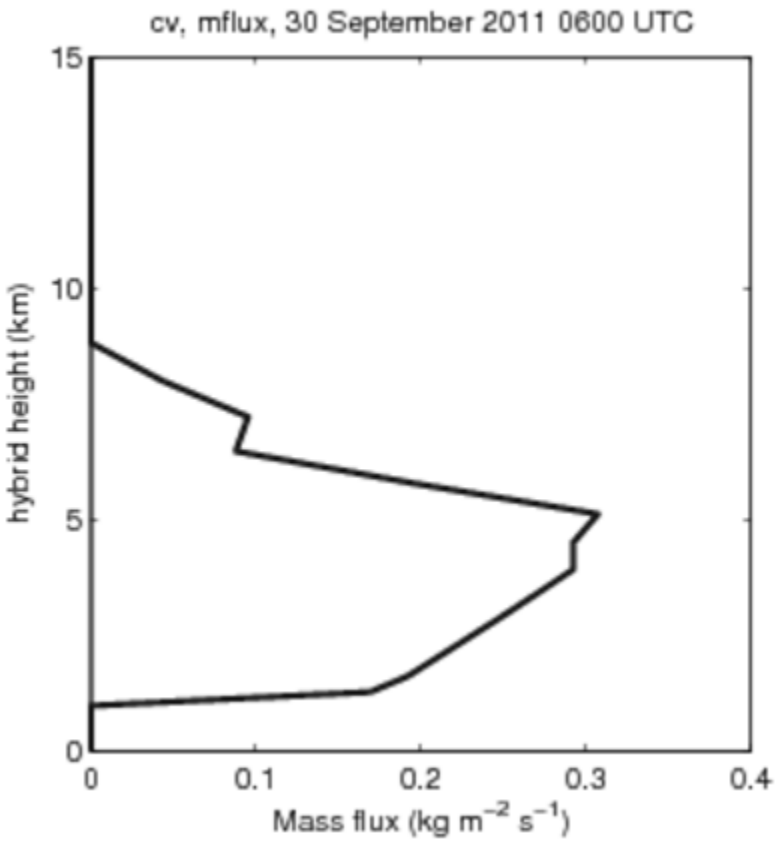

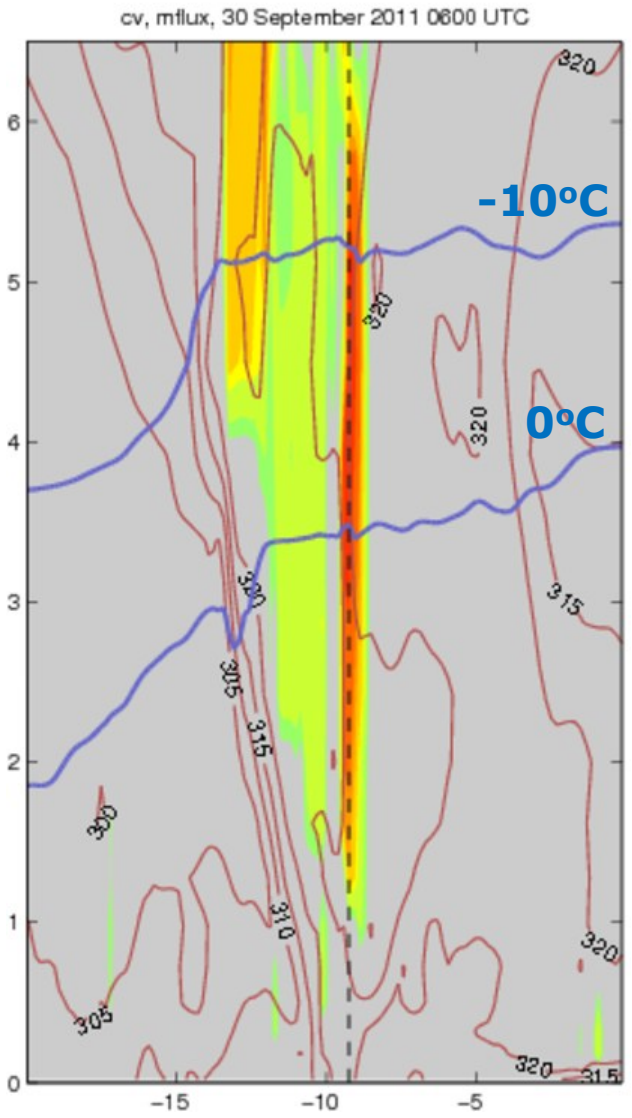

A B

T-φ-gram and plume ensemble

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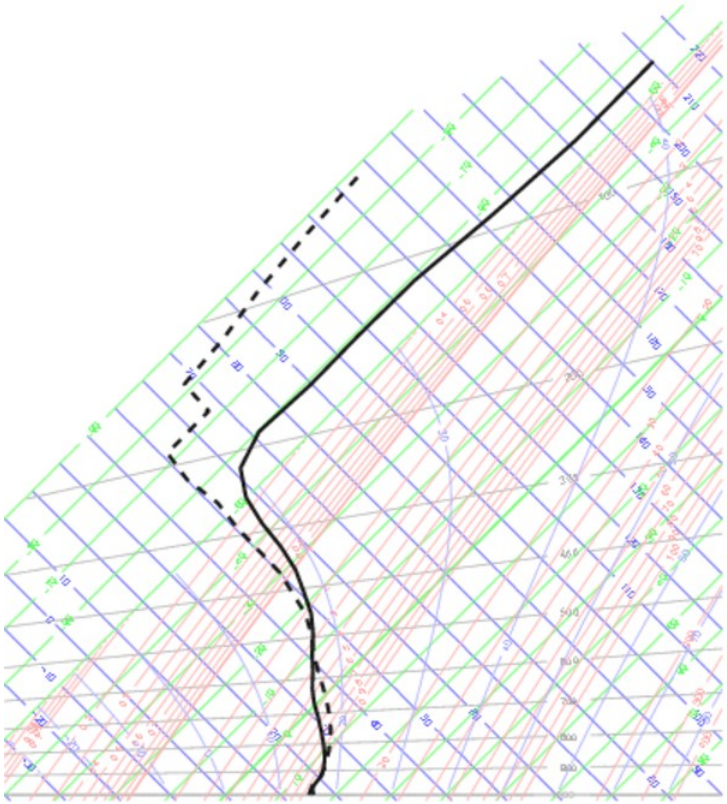
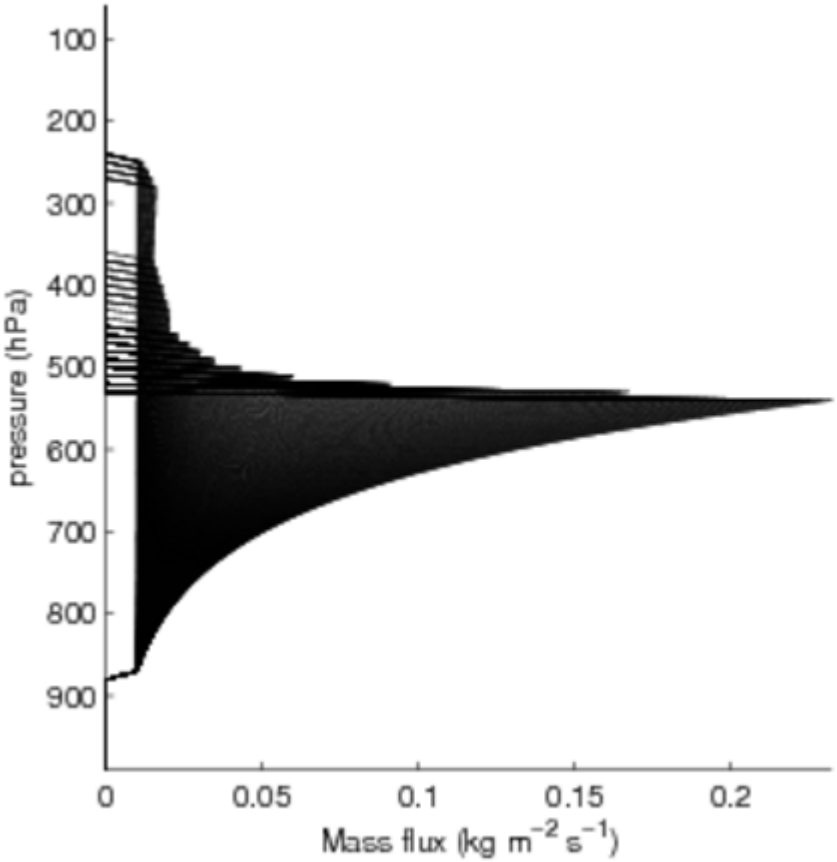


T-φ-gram before convection



Vertical profiles of mass flux in ensemble

T-φ-gram and plume ensemble

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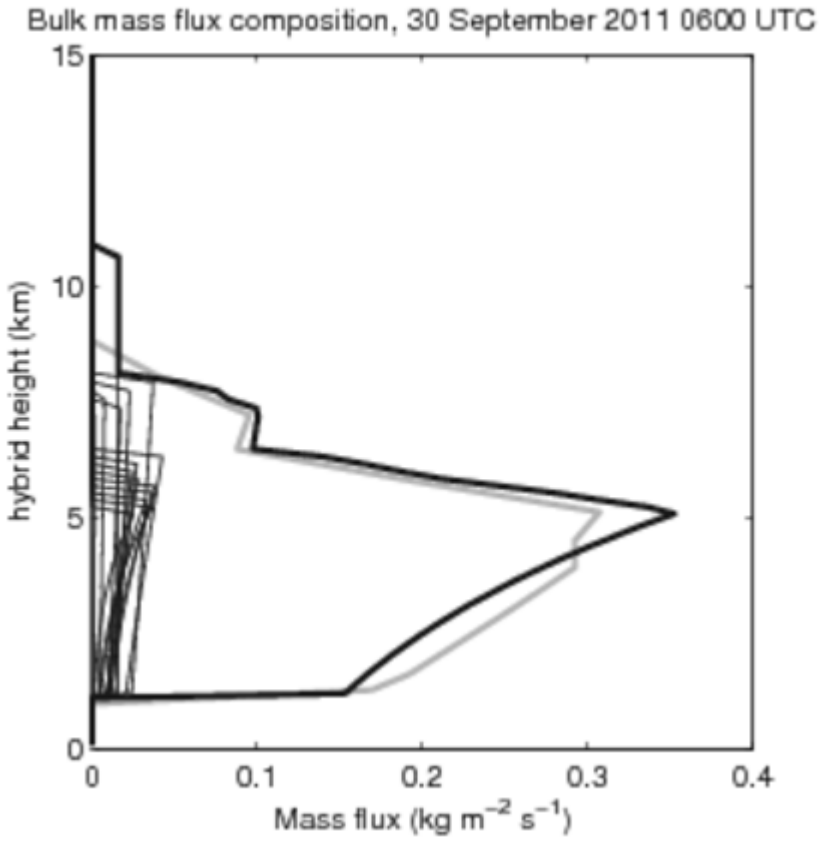
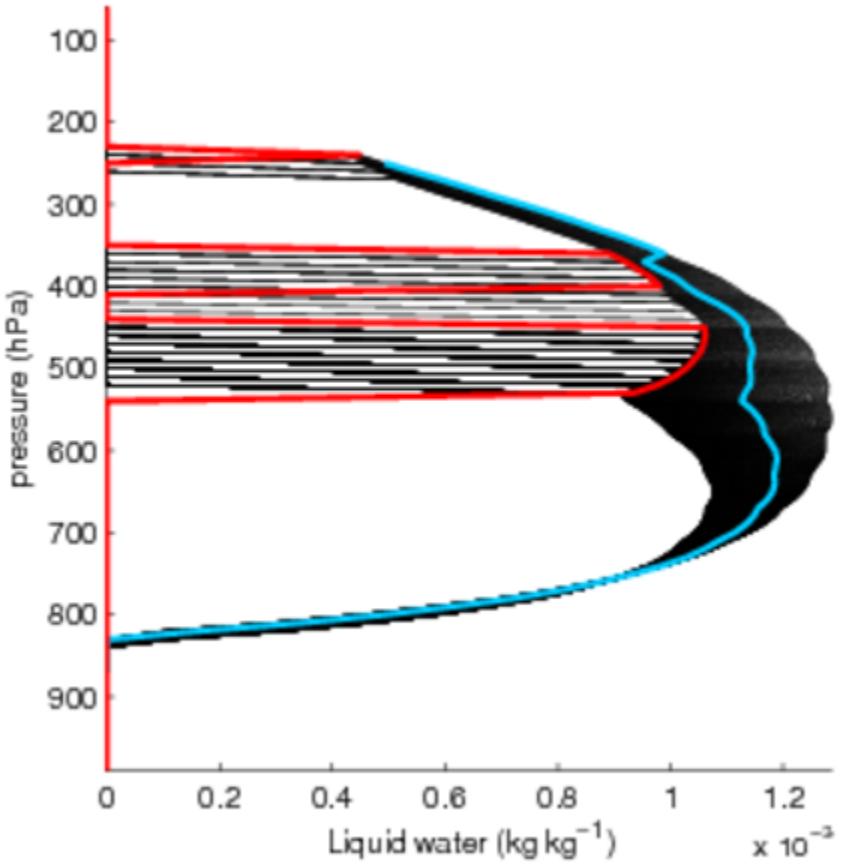


Bulk mass flux (MetUM)
Spectral component plumes (thin)
Spectral mass flux (bold)



Ensemble detrained liquid water
Bulk liquid water

Summary and conclusions

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- Two tools for the analysis of convection in bulk mass flux models have been developed
  1. Spectral decomposition of bulk mass flux convection
  2. Lagrangian budget of energy (heating/cooling) and moisture (drying/moistening)
- These tools are being applied to a realistic case involving an active cold front.
- Preliminary analysis shows discrepancies between spectral and mass flux approaches

On-going work

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- Quantification of the effect of discrepancies between spectral and bulk convective scheme formulations on the large-scale circulation
- Use of Lagrangian budget method to determine origin and downstream impact of moisture and energy sources/sinks from convection (and other parameterised processes)

References

- Jordan, C. L. 1958 Mean soundings for the West Indies area, *J. Meteorol.* **15**, 91—97.
- Plant, R. S. 2010 A review of the theoretical basis for bulk mass flux convective parameterization, *Atmos. Chem. Phys.* **10**, 3529—3544.
- Yanai, M., Esbensen, S. and Chu, J.-H. 1973 Determination of bulk properties of tropical cloud clusters from large-scale heat and moisture budgets, *J. Atmos. Sci.* **30**, 611—627.