Mesoscale Applications for Microscale Model?

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(With thanks to Sue Gray)

(Also K. Browning, C. Morcrette, A. Agusti-Panareda, M. Pizzamei, M. Valente)

Microscale Model Meeting

16th December 2003

Blatant but Shameless Advertisement

We are planning a UWERN meeting to review the current state of mesoscale modelling in the UK.

The probable date is…

Friday 13th February, 2004.

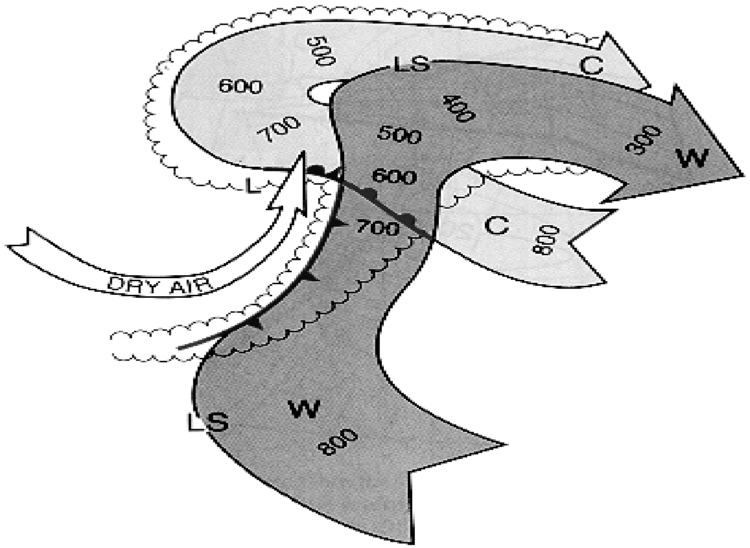
Example Meso/Microscale Projects

Studies that might…

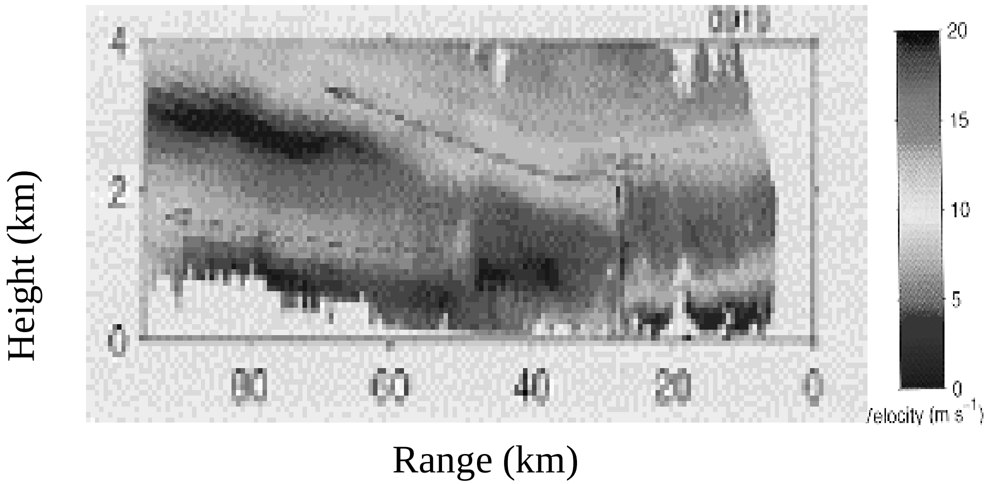
- benefit from the microscale model.
- require certain things from the microscale model.

- Boundary layer ventilation.
- Slantwise convection.
- The sting jet.

Boundary Layer Ventilation



Bader et al. (1995)



Browning et al. (2001)

How much polluted air is transported to free troposphere by:

- warm and cold conveyor belts
- stacked slantwise convective circulations
- upright convection
- shear instability and turbulent mixing

When and where are these processes important?

(Agusti-Panareda, Gray, Belcher)

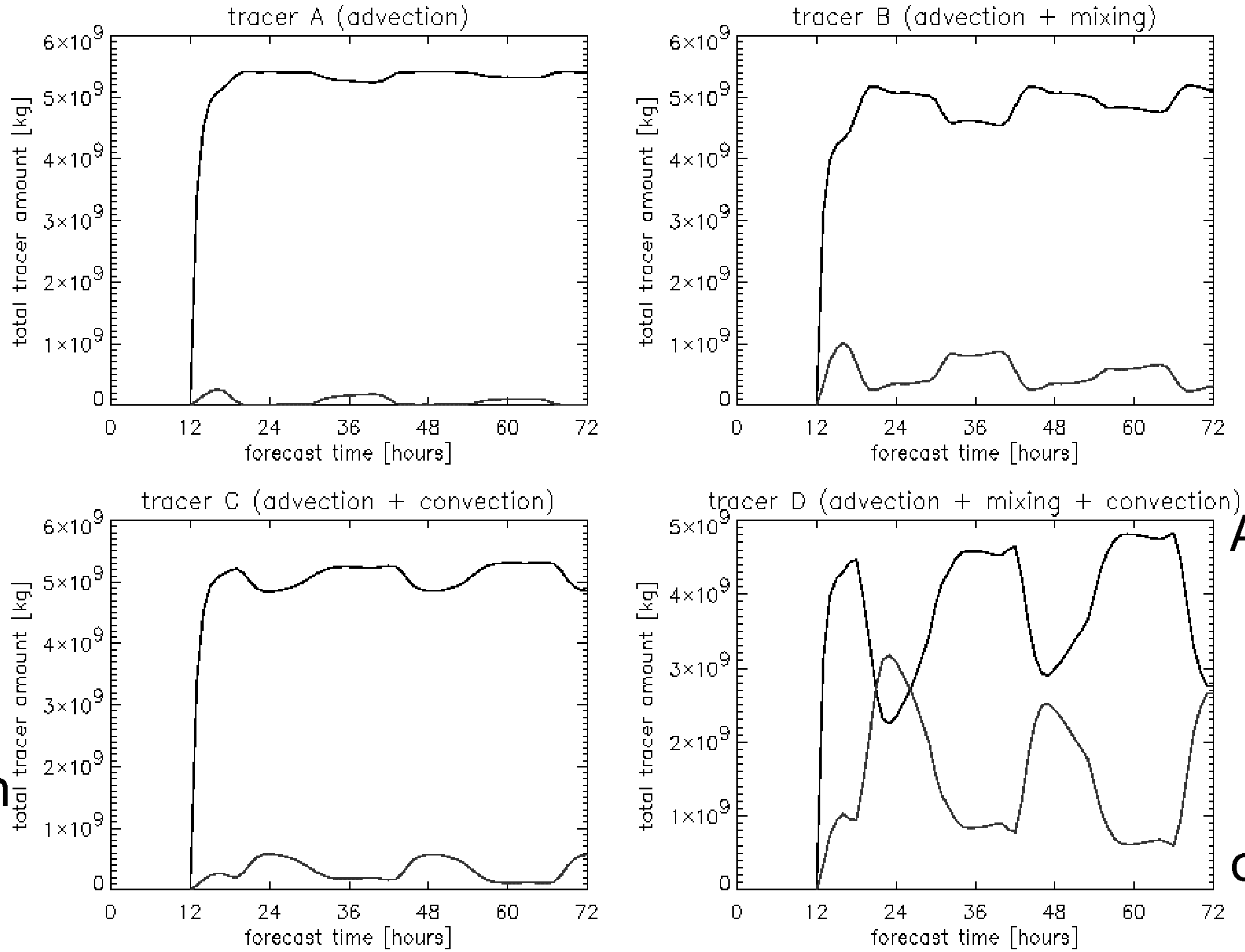
UM domain-integrated free-tropospheric tracer (Tracer lifetime is 1hr)

Advection

Advection + mixing

Advection + convection

Advection + mixing + convection



FT tracer   BL tracer

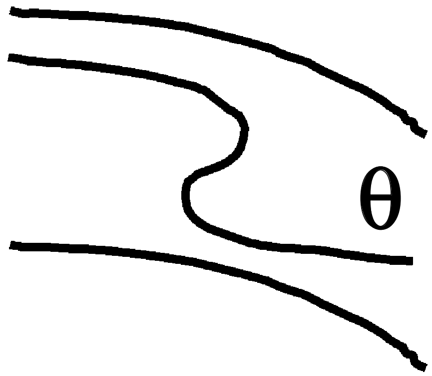
Boundary Layer Ventilation

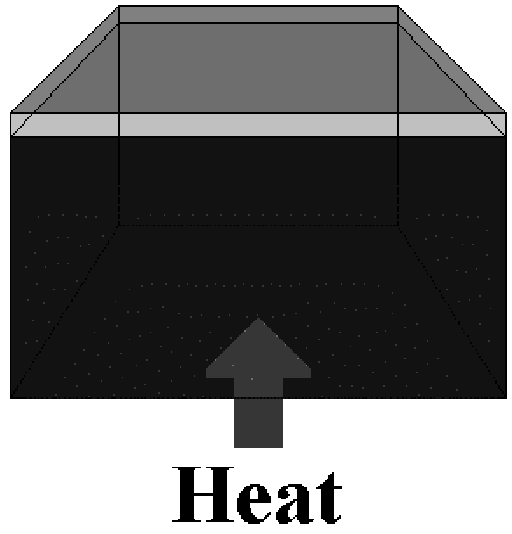
Desirable features for modelling:

- code for tracers
- weak numerical diffusion
- good boundary layer scheme
- coupling to mesoscale model (UM?) to allow for representation of fronts, conveyor belts etc.

Upright convection

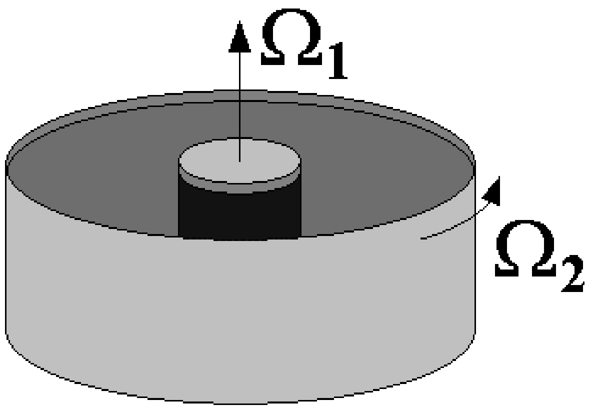
- Driven by gravitational fore.
- Due to unstable temperature distribution.
- Causes vertical motio

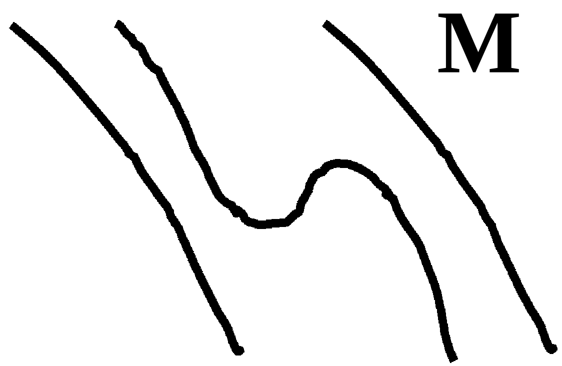


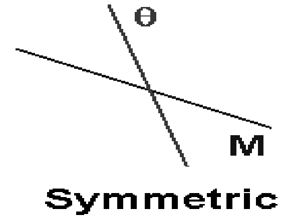


Inertial convection

- Driven by centrifugal fore.
- Due to unstable angular momentum distribution.
- Causes radial motion.





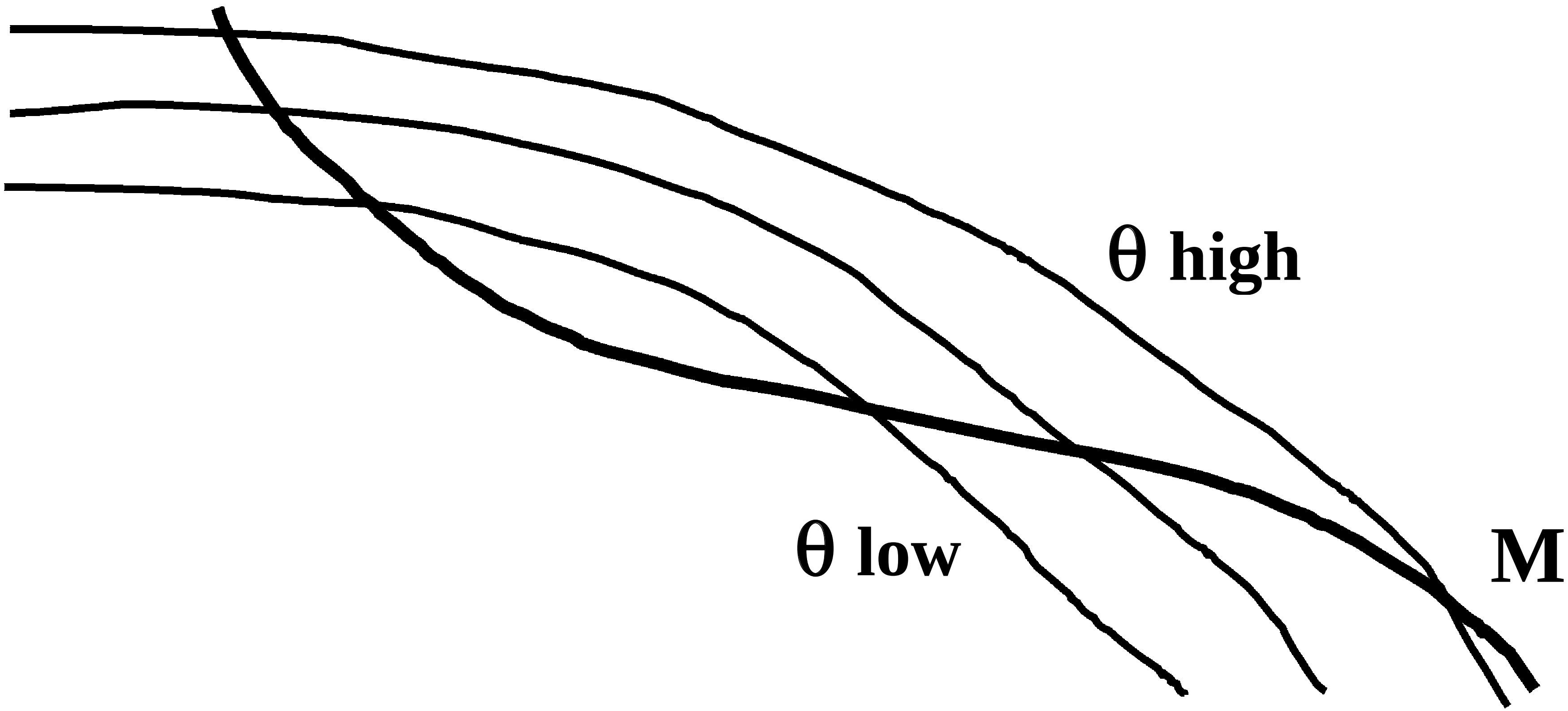


Symmetric Instability (SI)

(Bennetts and Hoskins, 1979)

Parcel can be stable to both upright and inertial convection but unstable to slantwise convection.

If parcel perturbed at an angle between the M and θ lines, it will accelerate from its initial position on a slantwise trajectory.



Slantwise Convection

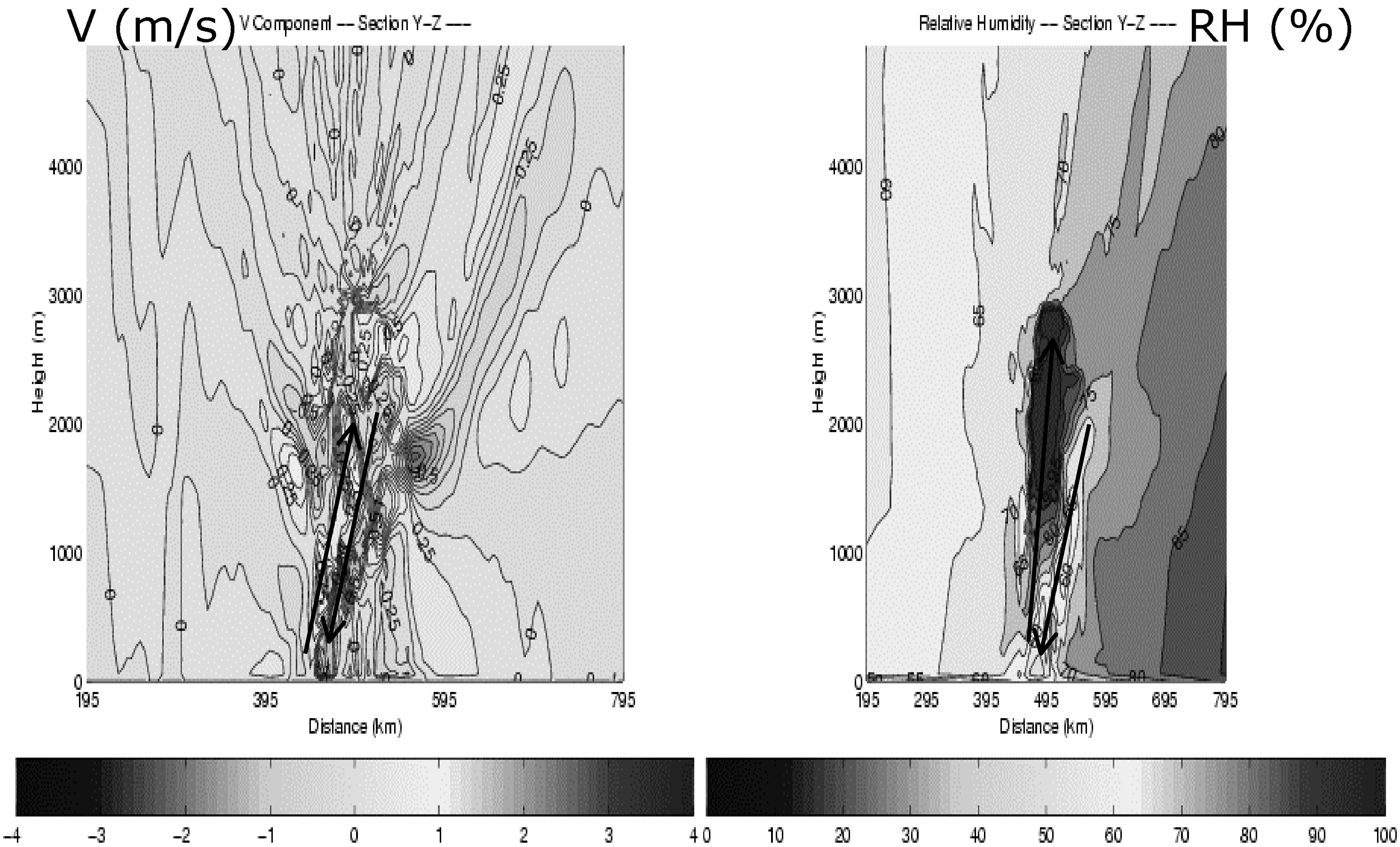
- What are the interactions between upright and slantwise convection in frontal regions?

- What are the relative contributions of the release of conditional symmetric instability and ΔM adjustment to the slantwise component?

Difficult to model.

Some success with idealized LEM experiments…

Slantwise convection simulated by LEM



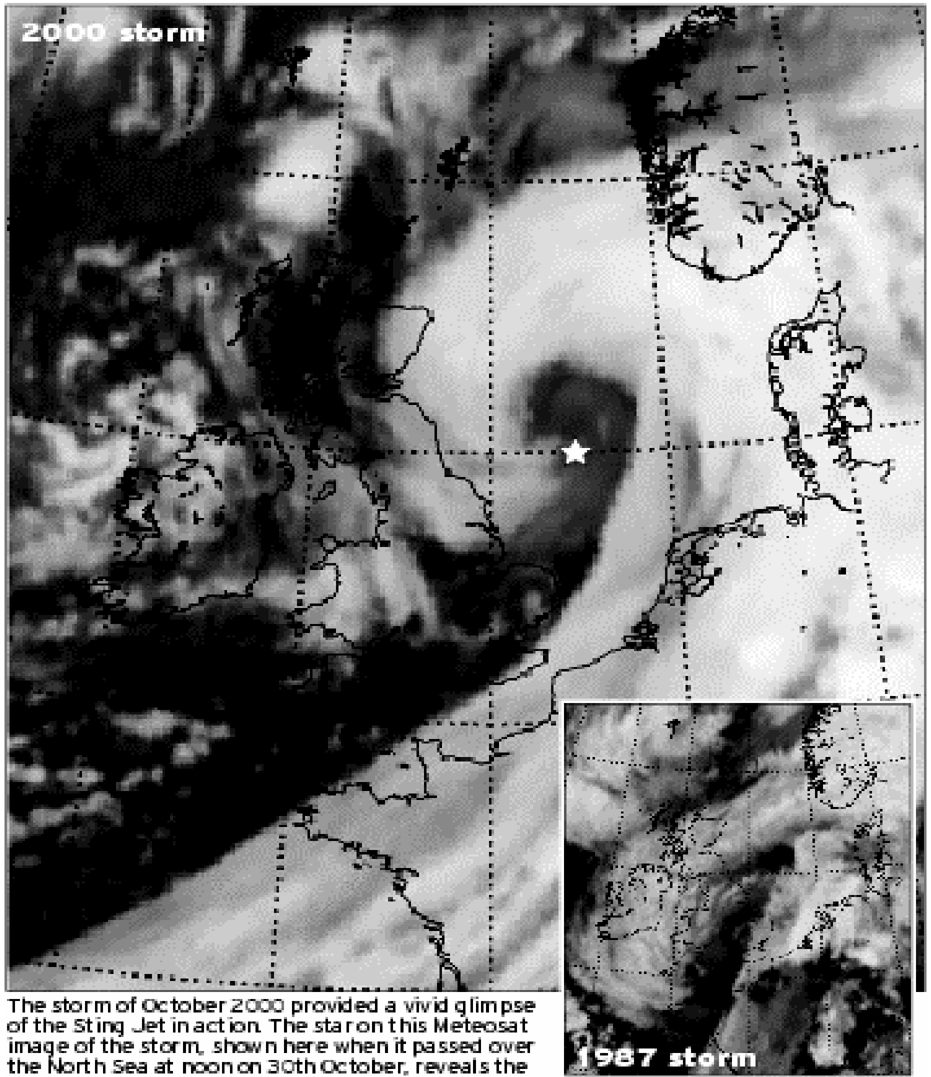
(Pizzamei, Gray)

Slantwise Convection

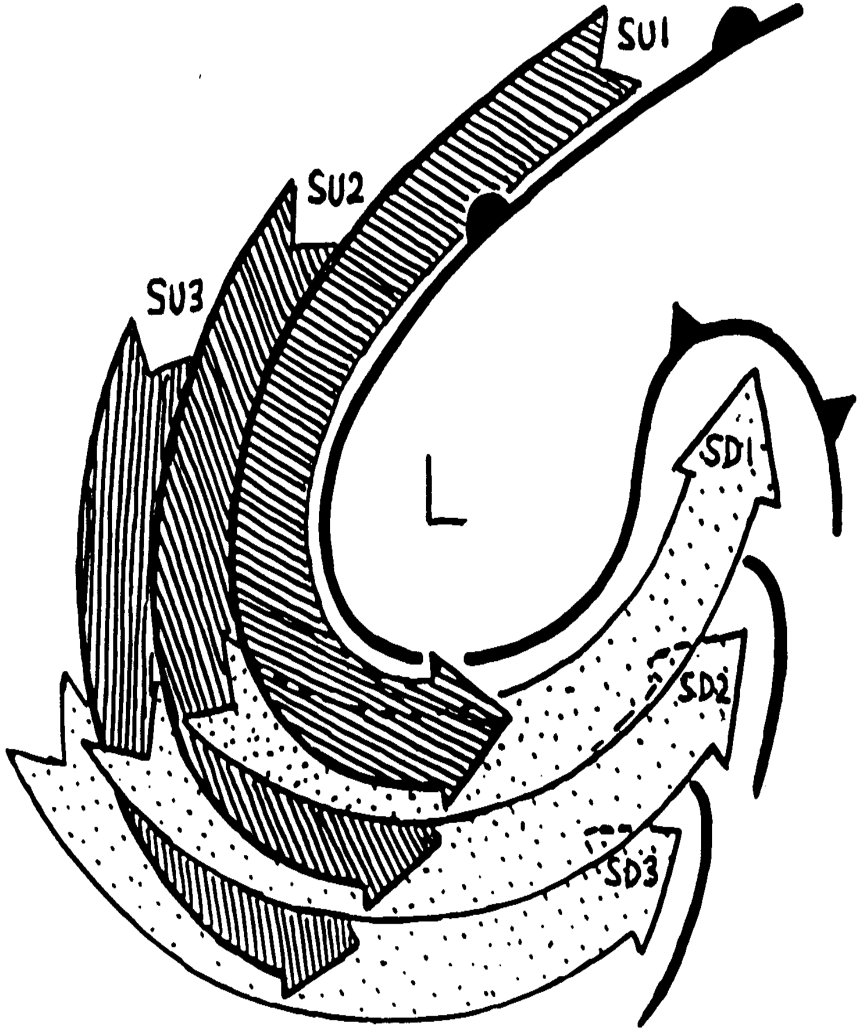
Desirable features for modelling:

- explicit treatment of upright convection
- good microphysics
- good vertical resolution
- coupling to mesoscale model (UM?) to allow for fully realistic simulations.

Sting Jet



The storm of October 2000 provided a vivid glimpse of the Sting Jet in action. The star on this Meteosat image of the storm, shown here when it passed over the North Sea at noon on 30th October, reveals the location of the Sting Jet, close to the tip of the hooked cloud feature. Inset: Satellite image of the Great Storm of 1987, when gusts of around 100 mph were battering the region around Jersey. These winds were caused by a Sting Jet that started in the southern tip of the hooked cloud feature that extends from Ireland, south and east into the English Channel. Credit K Browning, C Wang.



Sting Jet

- What are the dominant mechanisms leading to the intense winds in the dry slot region ahead of the hooked tail of the cloud head?

- What are the characteristics of cyclones exhibiting sting jets?

- What determines the locations of the regions of intense winds and their lifetime and propagation relative to the cyclone?

(Browning, Valente, Gray)

Sting Jet

Desirable features for modelling:

- good microphysics
- good vertical resolution
- coupling to mesoscale model (UM?) to allow for fully realistic simulations.

Difficult to model in the UM.

Use of Microscale Model

Some progress is being made with existing high-resolution tools.
(LEM/CRM, idealized UM)

Will the microscale model be a better vehicle for studying these mesoscale problems?
(Should it be?)

If so, how will it be better?