



Lagrangian Diagnostics

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What is the model doing?



- The UM is a large and complicated creation
- It is not always easy to tell what its various components are up to!



What is the model doing?



- The UM is a large and complicated creation
- It is not always easy to tell what its various components are up to!
 - Is a particular parameterization important in my run?
 - Do I need to worry about my choices for process X ?
 - What impact is a parameterization having on the dynamics?
 - Are the parameterizations acting independently or in concert?



Why did that happen?



- How did some simulated feature in the results come about?

Was it from the action of...

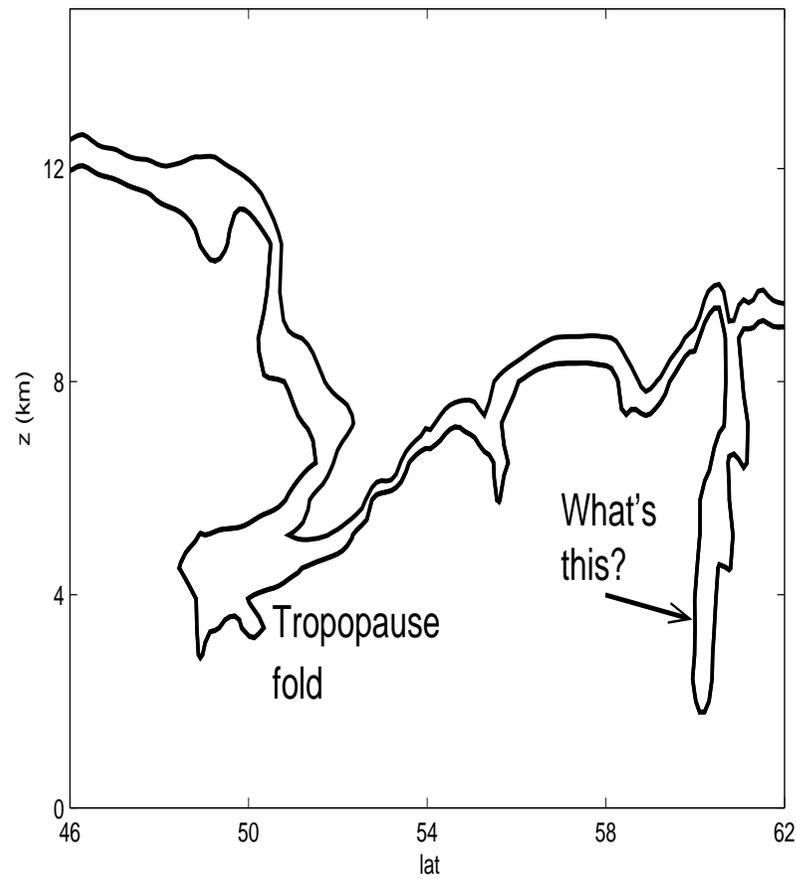
- a single process? (which?)
- a combination of processes?
- a balance between competing processes?



Example at 21Z on 27/07/04



North-south X-section of potential vorticity



Contours of 1 and 2 PVU.



A Lagrangian Budget



- Using potential vorticity for example.
(Easy to do budgets of θ , energy, momentum, moisture...)
- Split-up the full field into component parts:

$$PV(t) = [PV(0)\text{advected from } 0 \text{ to } t]$$

$$+ \int_0^t dt' [PV \text{ generated at } t' \text{ due to convection}$$

and advected from t' to t]

+similarly for other processes

- Each component represents the current location of PV generated at earlier times by a particular model process



Calculations



There are two steps:

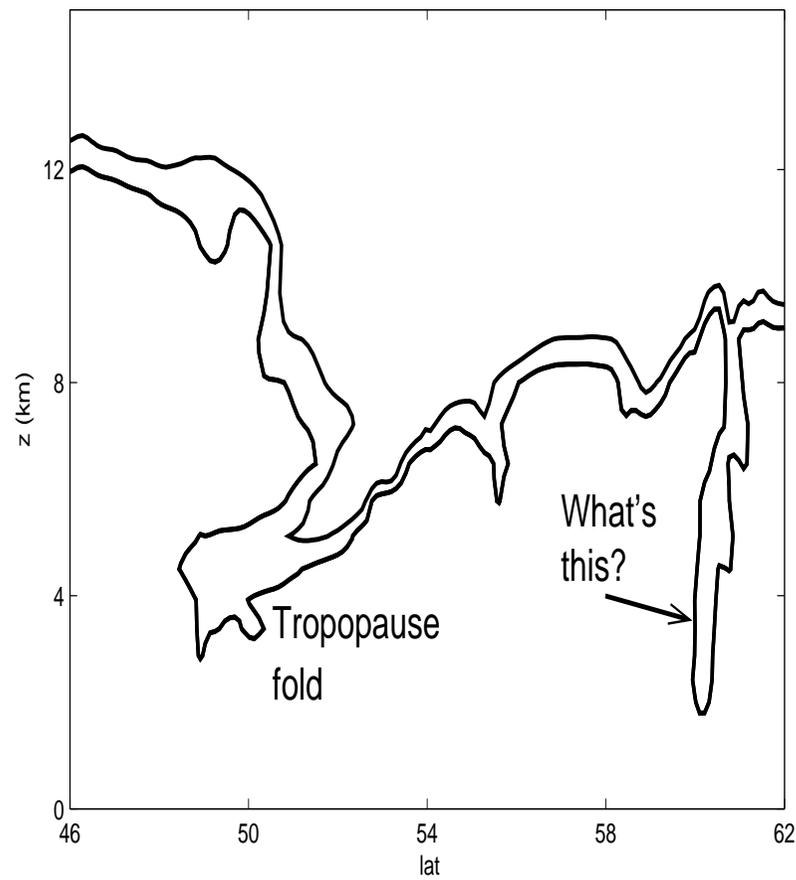
1. At each timestep, determine generation of PV due to each process
2. Add this to the diagnostic field and advect each field
 - Can advect each component as a tracer field or as a prognostic model variable
 - Error in the method can be estimated by reconstructing the full field



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North-south X-section of potential vorticity

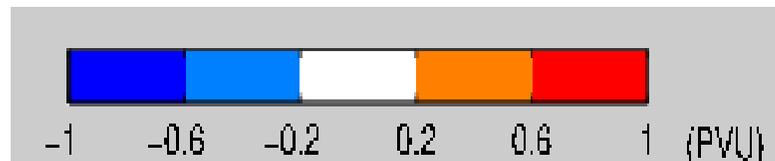
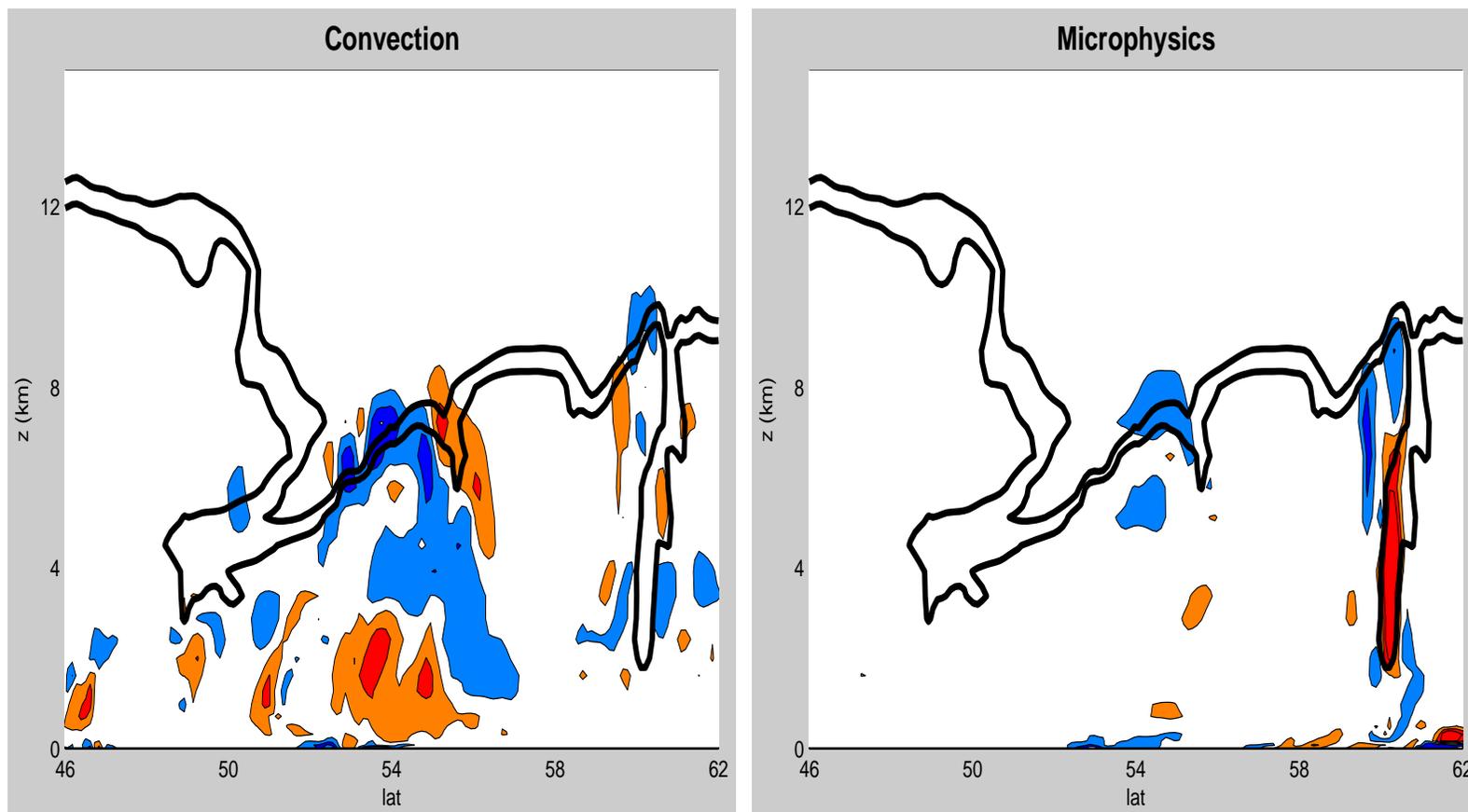


Contours of 1 and 2 PVU.



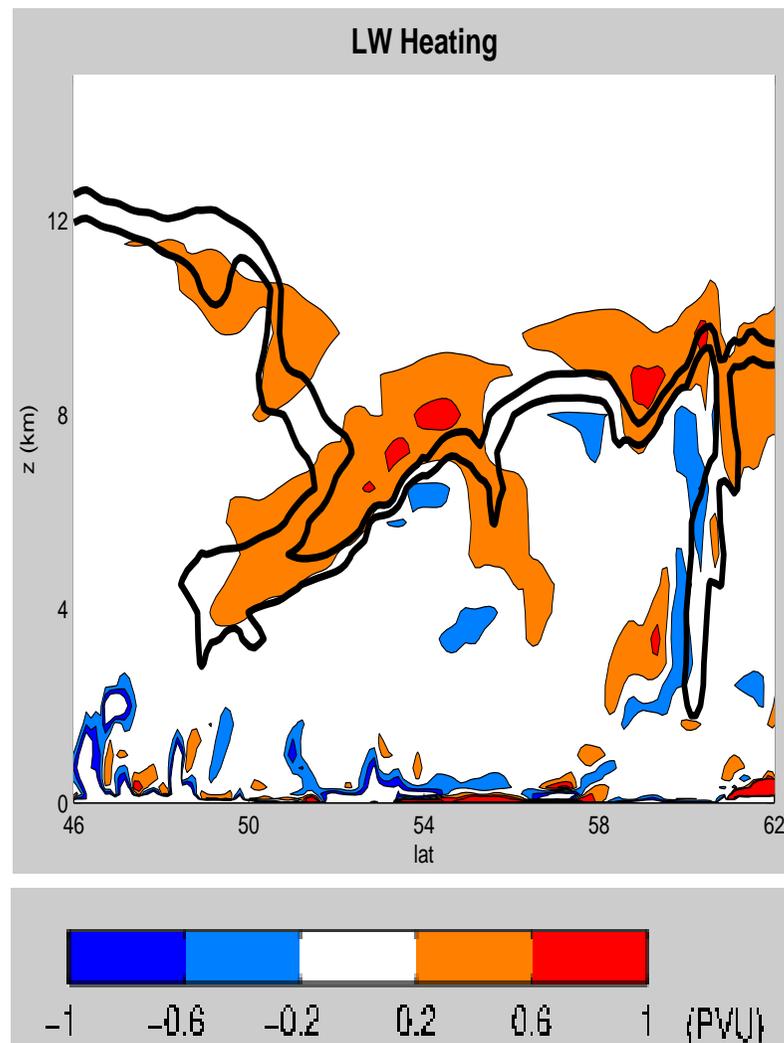
Convective and Large-Scale Cloud

PV at T+21 due to action of convection and large-scale cloud



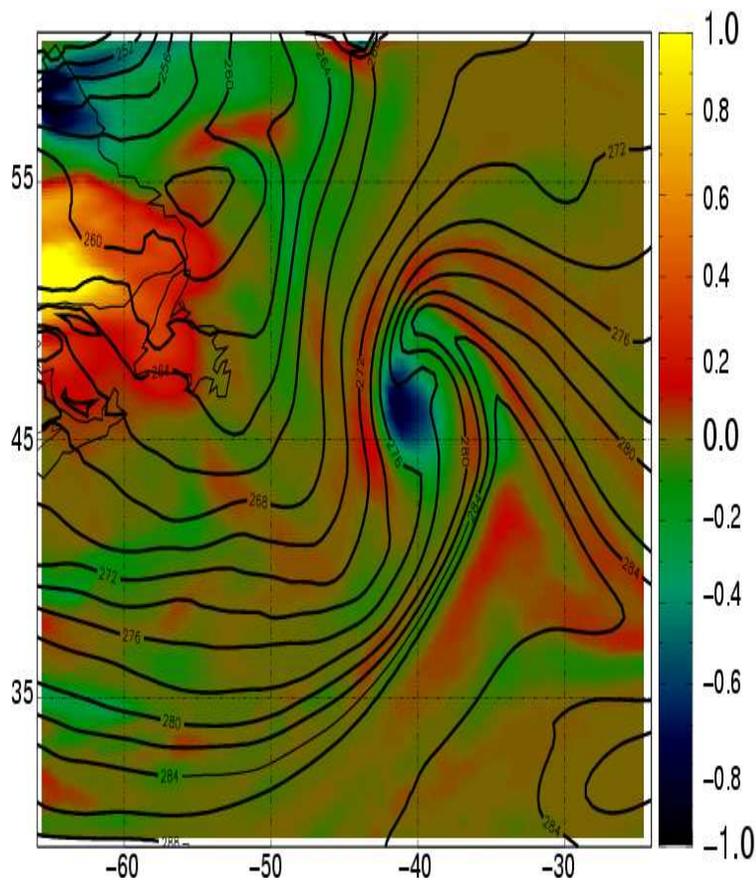
LW Cooling at Cloud Top

PV at T+21 due to longwave radiation

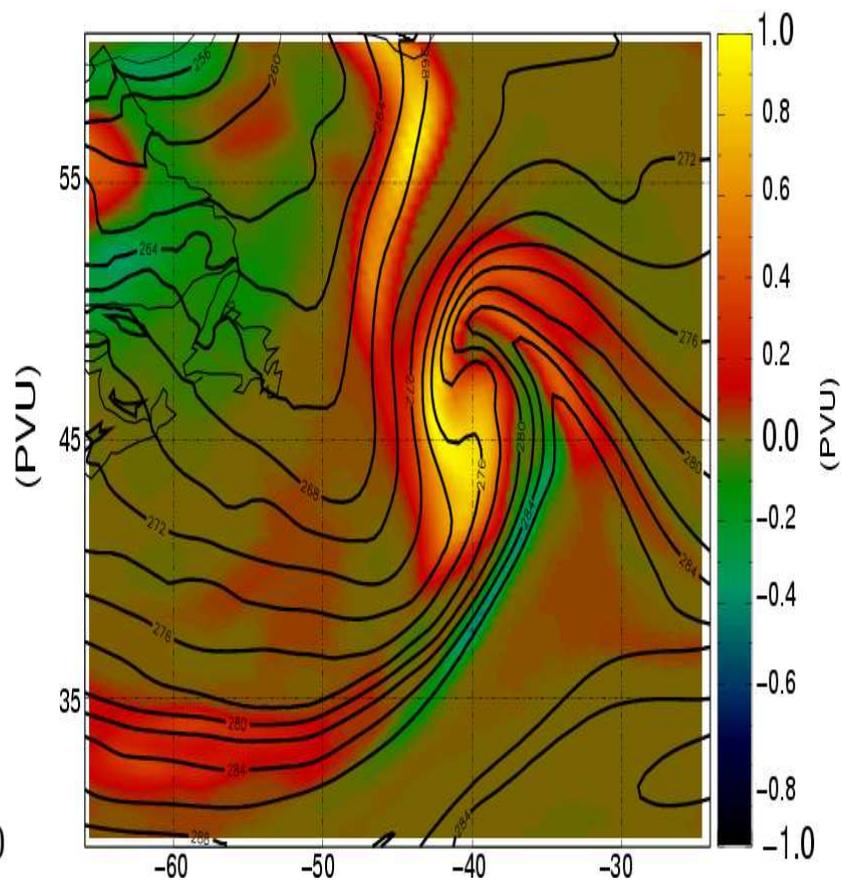


Effects of boundary-layer friction

Frictional PV generation at T+24 in FASTEX IOP15



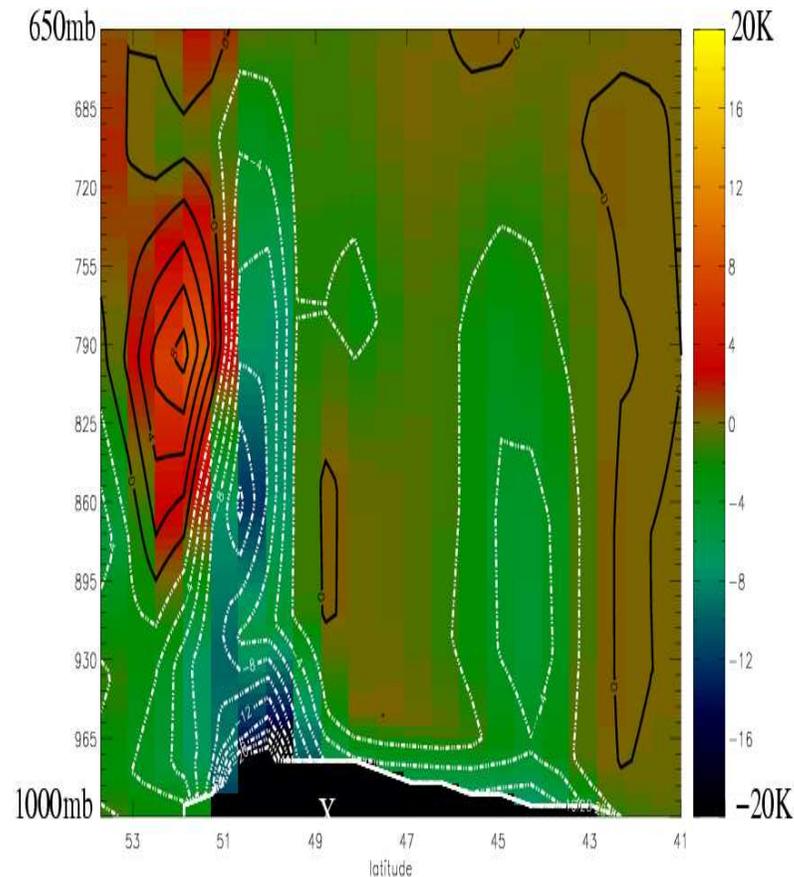
Barotropic term on 900mb.



Baroclinic term on 850mb.

Example of a θ budget

X-section at T+24 across low centre of FASTEX IOP15



Production of large-scale rain above the warm front, some of which evaporates on its way to the surface.

Conclusions



- A Lagrangian budget provides a way to disentangle and compare the effects of model components
- Tells you which physical processes are important
 - which may be valuable knowledge scientifically
 - but also tells you the bits of the model for which your decisions matter
 - and the bits you can safely treat as a black box



So what do I do next?



If you want to use these diagnostics...

- Contact me to get the extra code!
- r.s.plant@rdg.ac.uk



What am I offering?

Well-tested code available for different versions and different budgets...

- Old dynamics (v4.5)
- New dynamics (v5.3 and v5.5)
- Advection as a tracer or as for the model θ field
- Budgets of PV, θ and θ^2
- Happy to advise on constructing other budgets