To permit or not to permit convection in the IFS?

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Global Modeling at ECMWF

At the resolutions of the operational applications at ECMWF, deep convection is still mainly parametrised.

But High Res. (9km) already at the edge of the Grey zone of deep convection

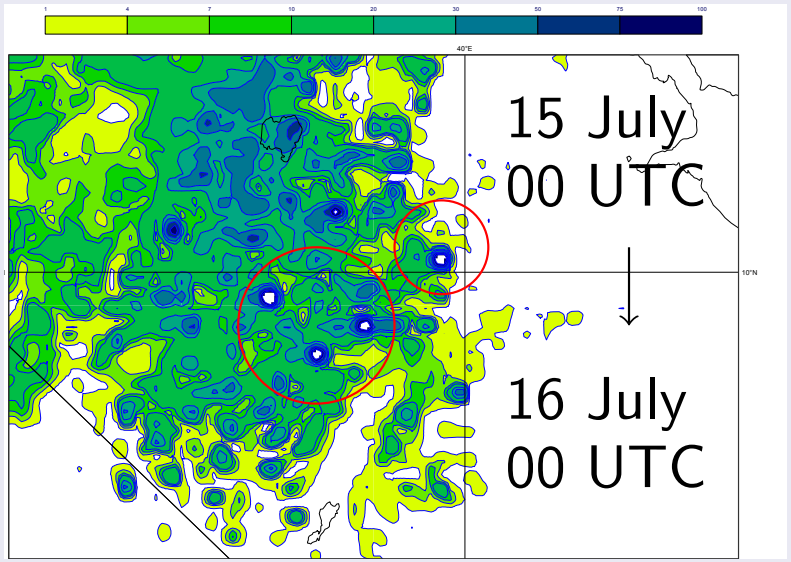
Unrealistic behaviours typical of the grey zone of deep convection already happen.

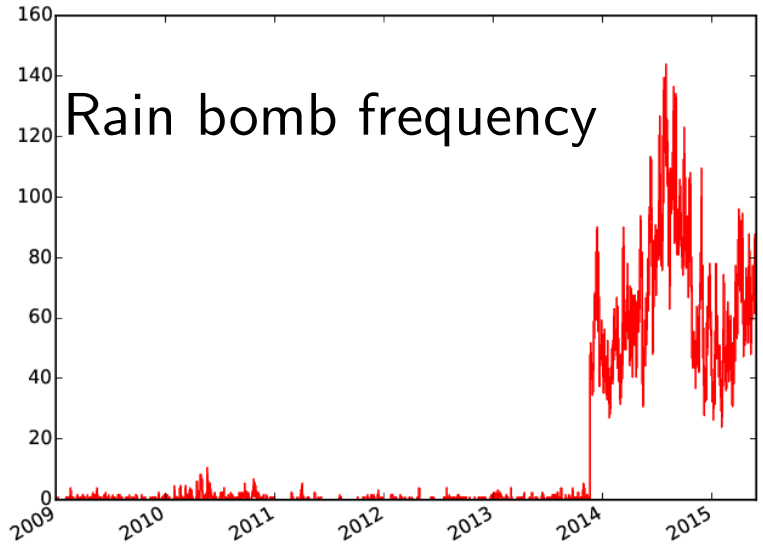
$\Longrightarrow$ next slides

Running the High Res. (9km) with the deep convection off gives very bad "large scale" scores (I've even tried to recompute new analyses to compare with using a "convection-permitting" 4DVAR outer loop...) even if, in some particular cases, the model without deep convection scheme seems to be doing a good job, for the MCSs over the US for example.

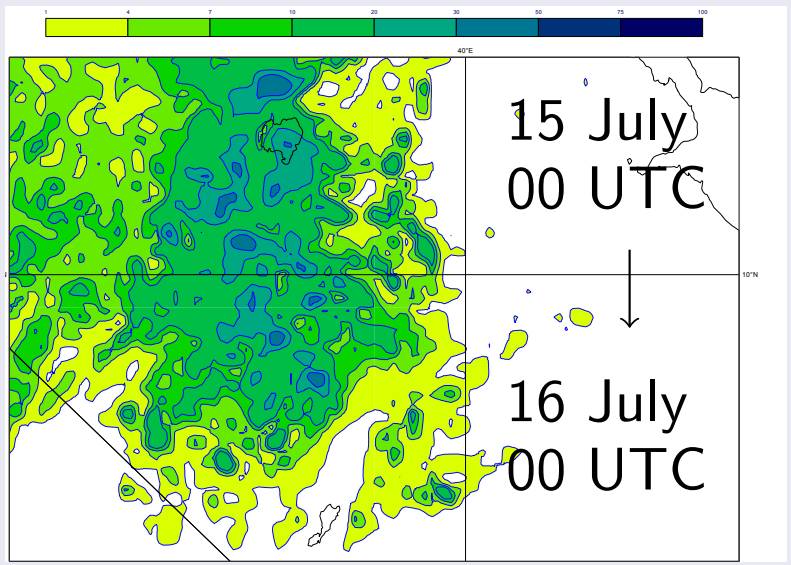
Rain bombs: East Africa, July 2015

Precipitation in 24h, TL1279





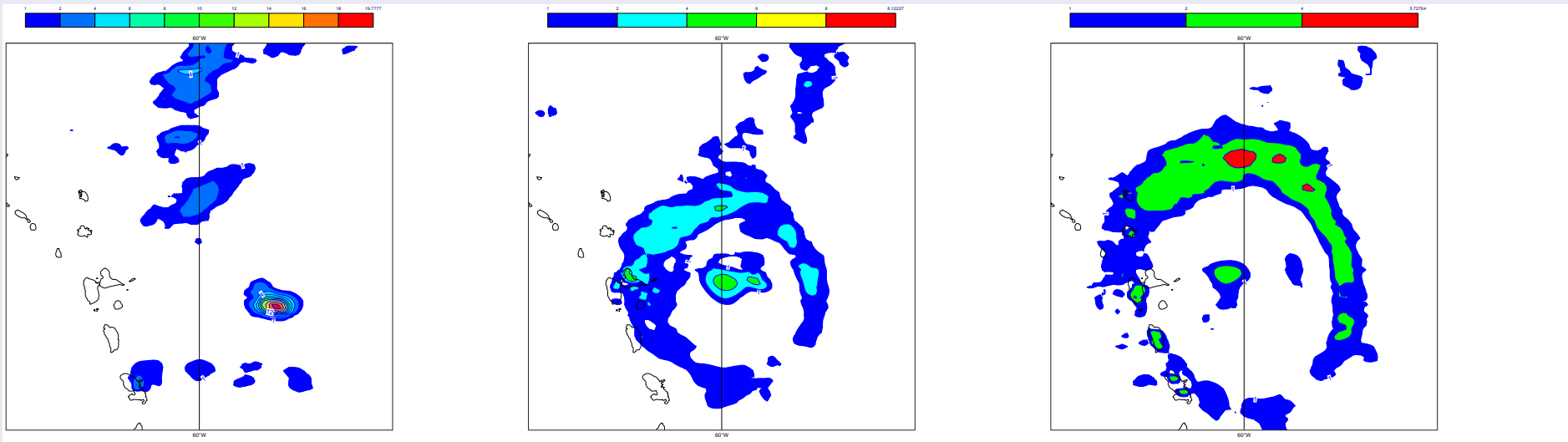
precipitation in 24h, TC1279



Rain Bomb started when a modification was introduced in the convection scheme to improve the daily cycle of convection. They're gone with the cubic grid.

Density currents and convection initiation

High Res (TCo1279), 03/08/2016, Caribbean



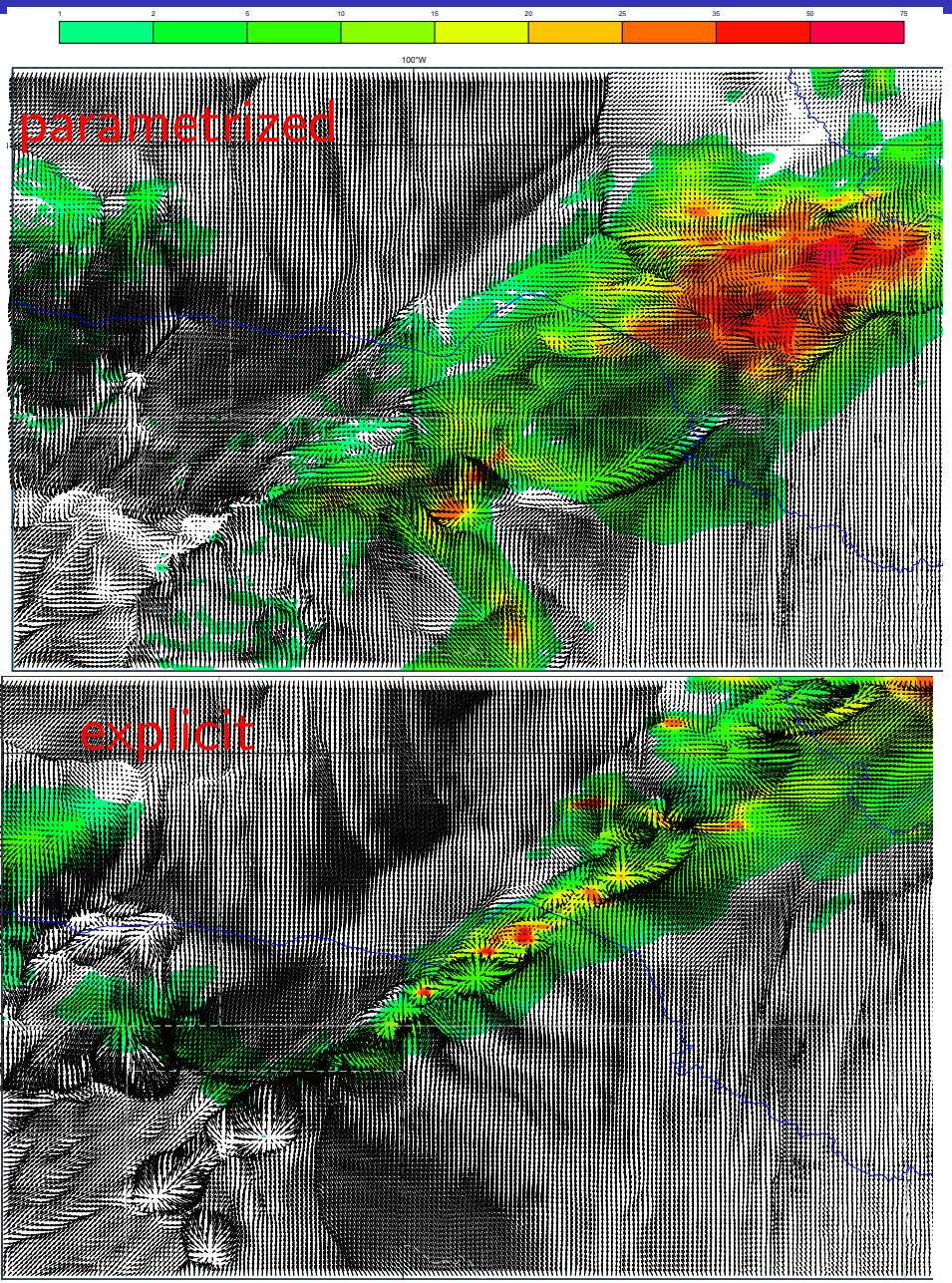
600 km

Seen in nature, but probably not with this scale....

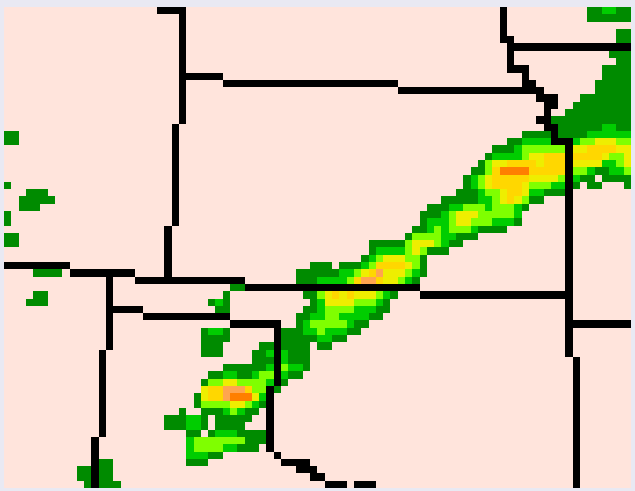
VORTEX2: TL3999 (5 km) simulations

6h accumulated precipitation and wind

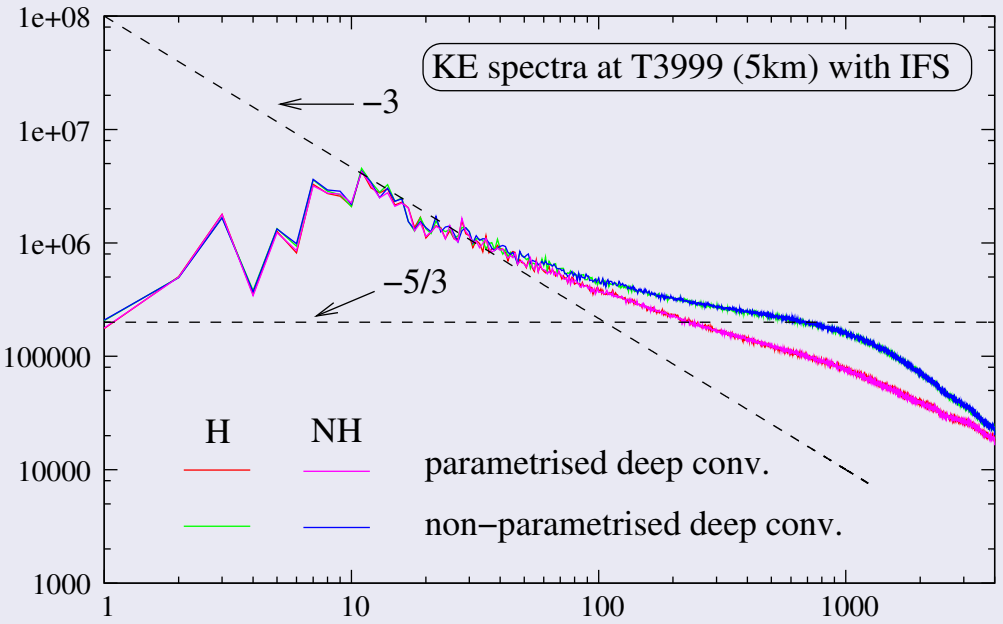
$\Rightarrow$



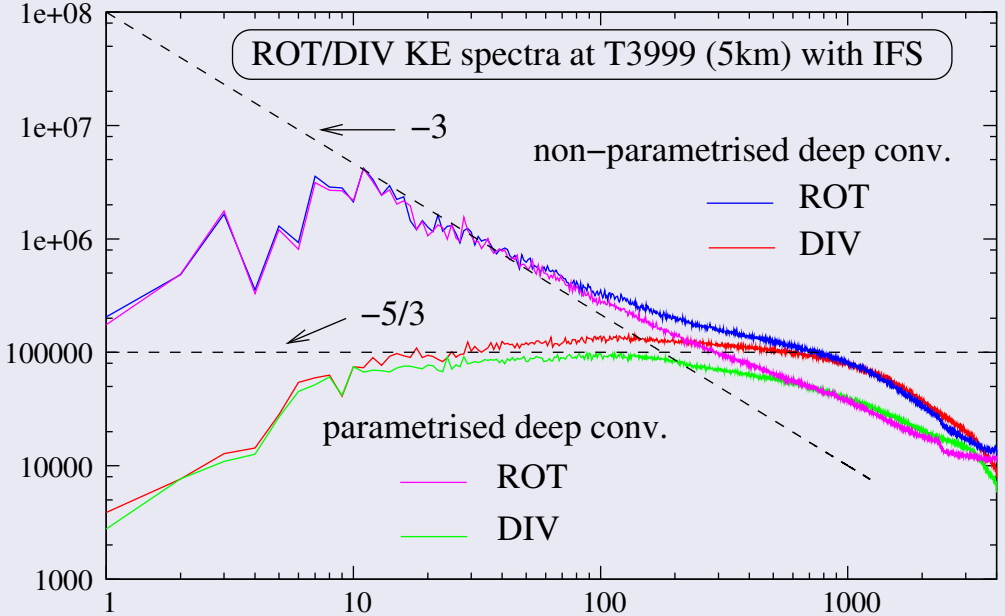
Squall line during VORTEX2 May 2009



H and NH-IFS in the grey zone of convection

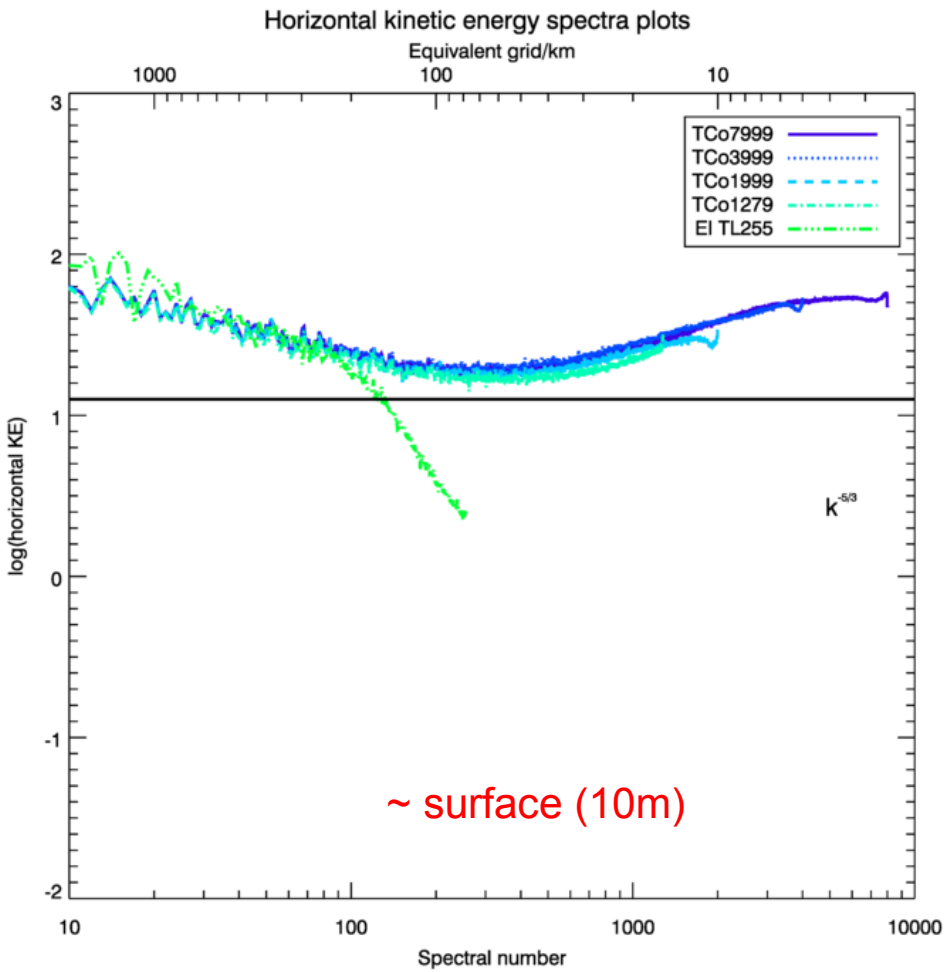


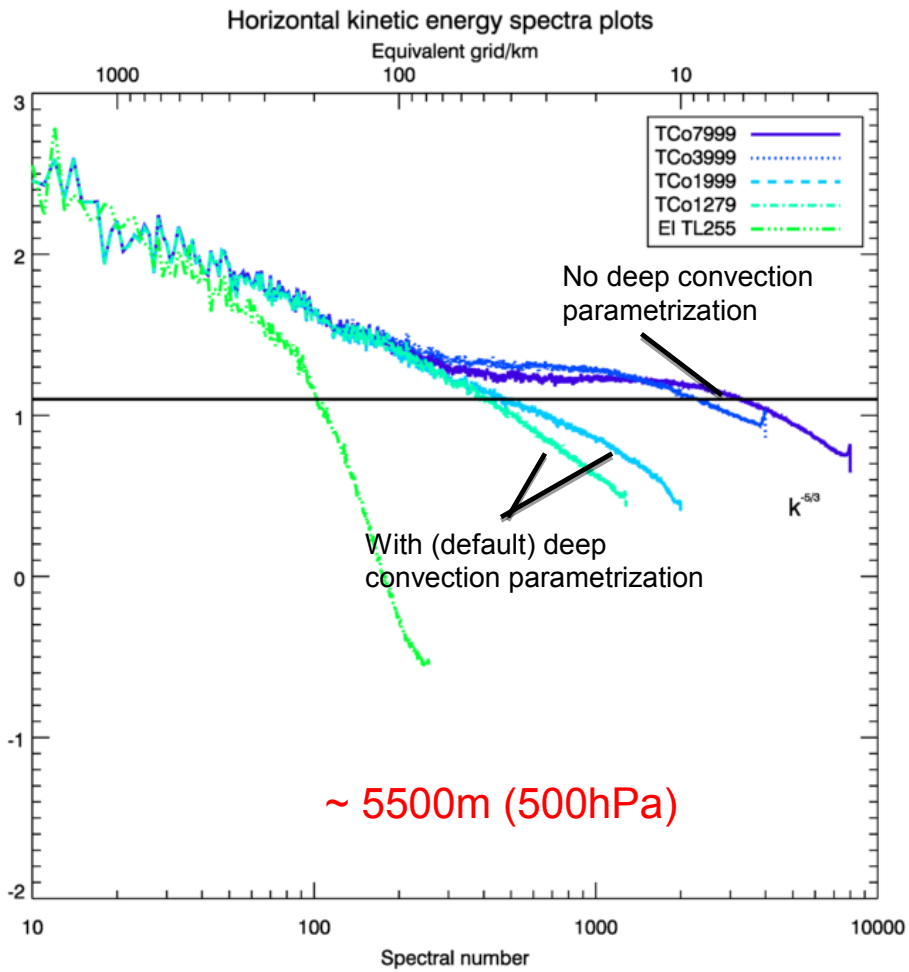
Simulations at T3999
($\Delta x \simeq 5$ km)



KE spectra in the (hydrostatic) 1km resolution run

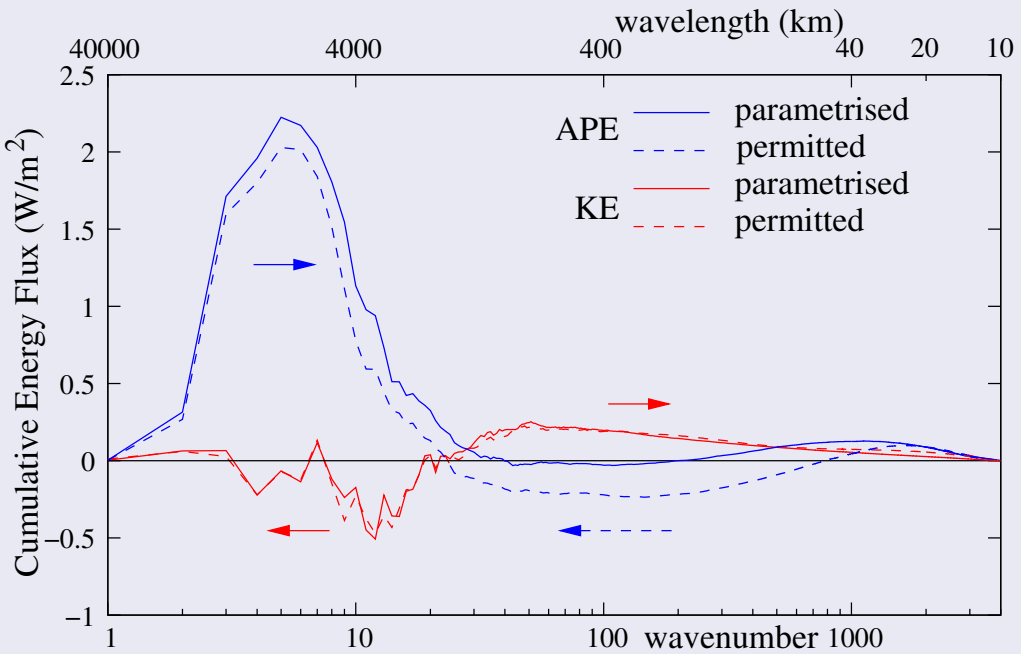
Global Kinetic Energy (scaled by n^5/3) in 1.3km global simulations TCo7999 L62





Implication for model error growth?

Energy Cascades



Non-linear energy transfers across scales (Malardel and Wedi, 2016)

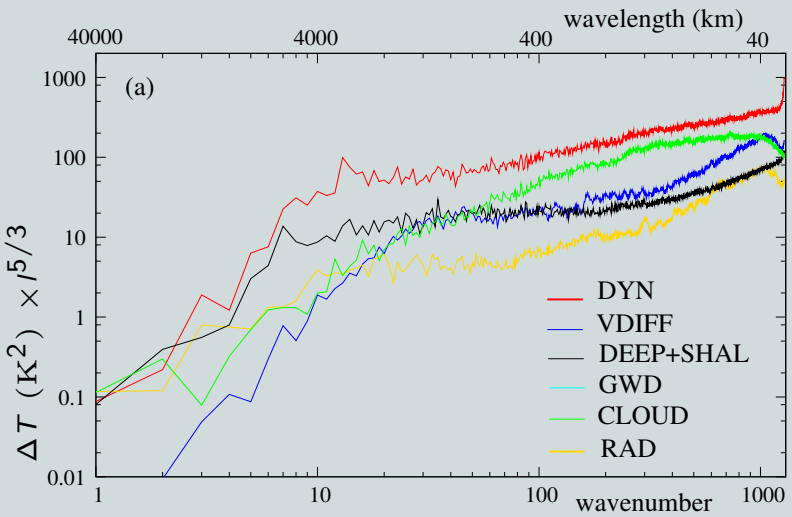
For medium range forecast, dilemma as resolutions increases:

- explicit representation of convection, but with a risk of upscale error propagation,
- control de convection (and the interaction with the larger scales) in a parametrisation but accept the limitation of the parametrisation

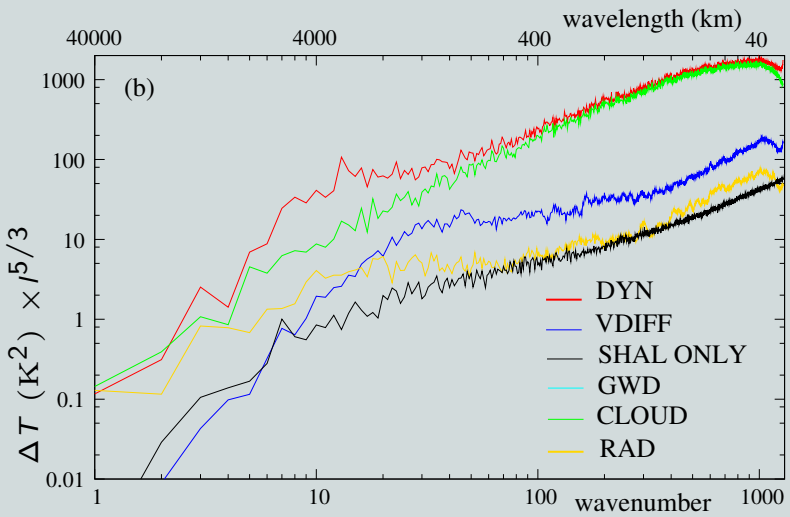
Diagnostic of spectral variance of model tendencies

Physics tendencies: T at 700 hPa

Deep conv. scheme

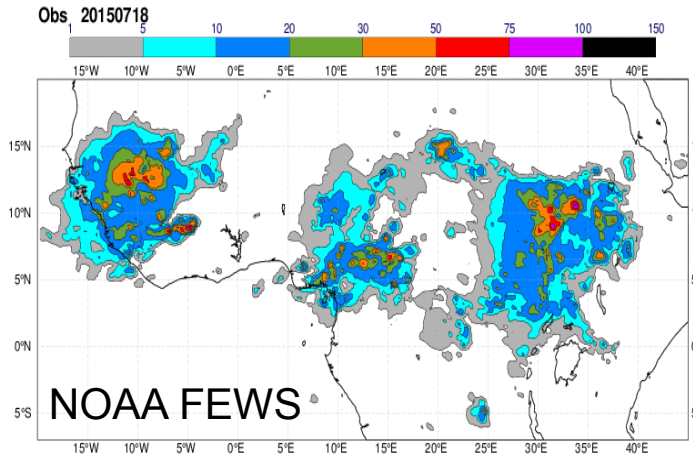


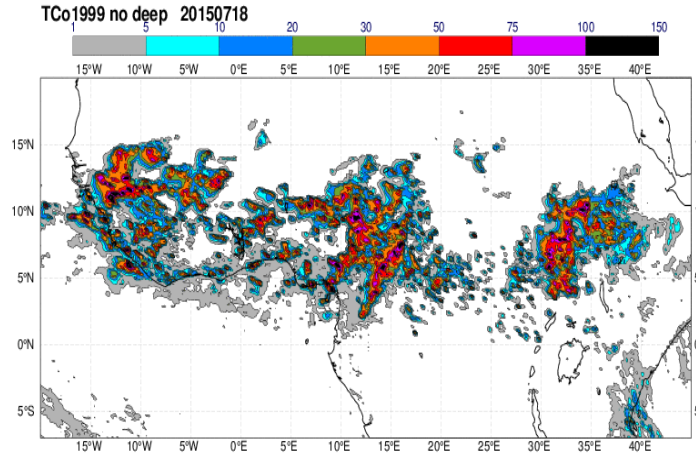
Explicit conv.



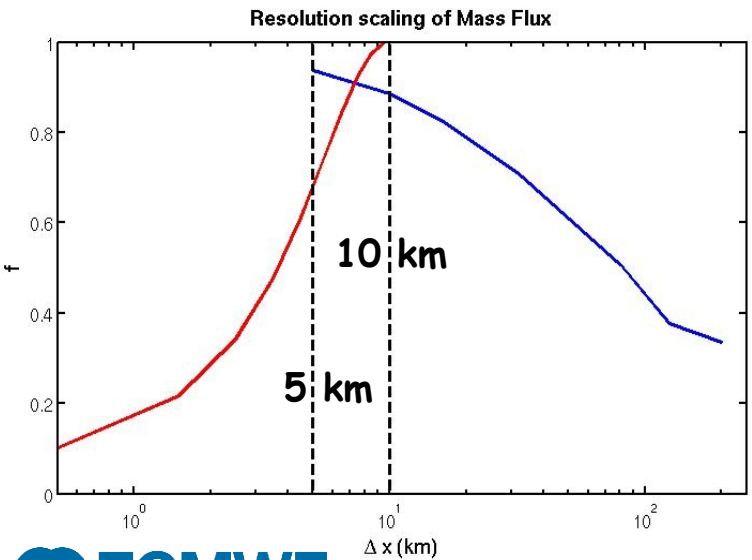
Scale aware convection scheme

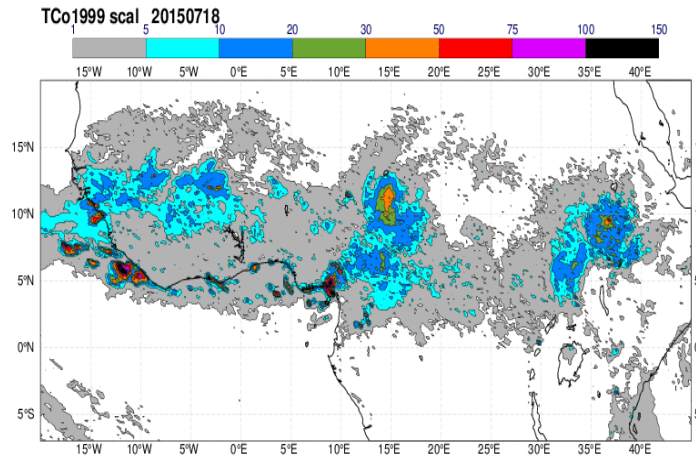
Rescaling of Mass Flux scheme in the grey zone (P. Bechtold)





5km simulation without mass-flux parameterization

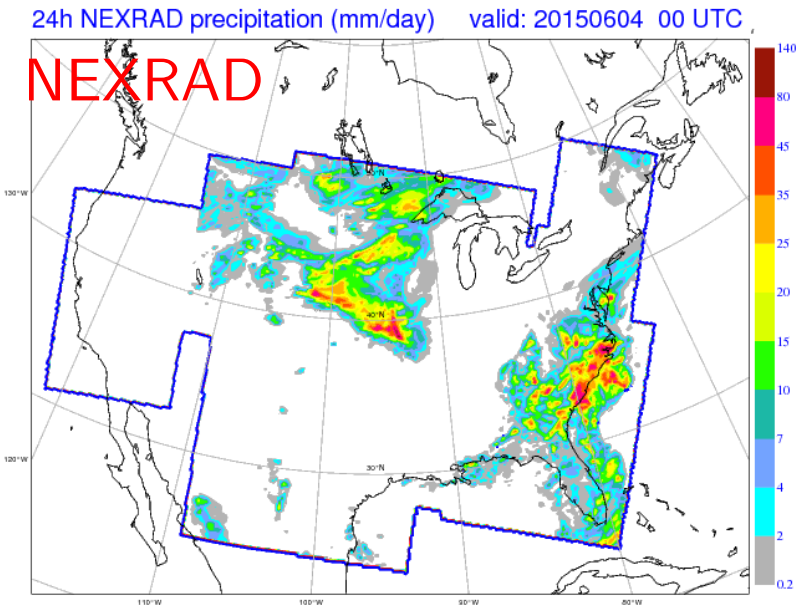


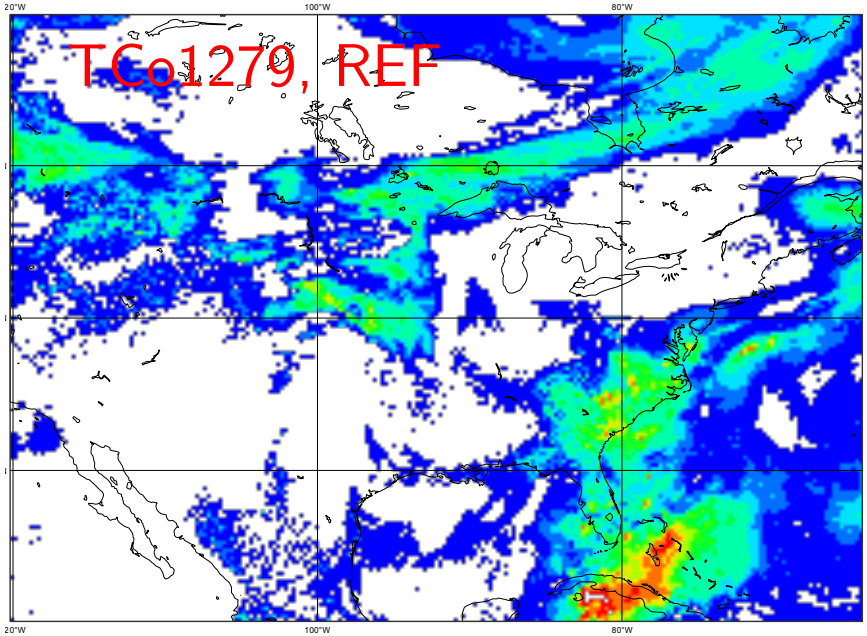


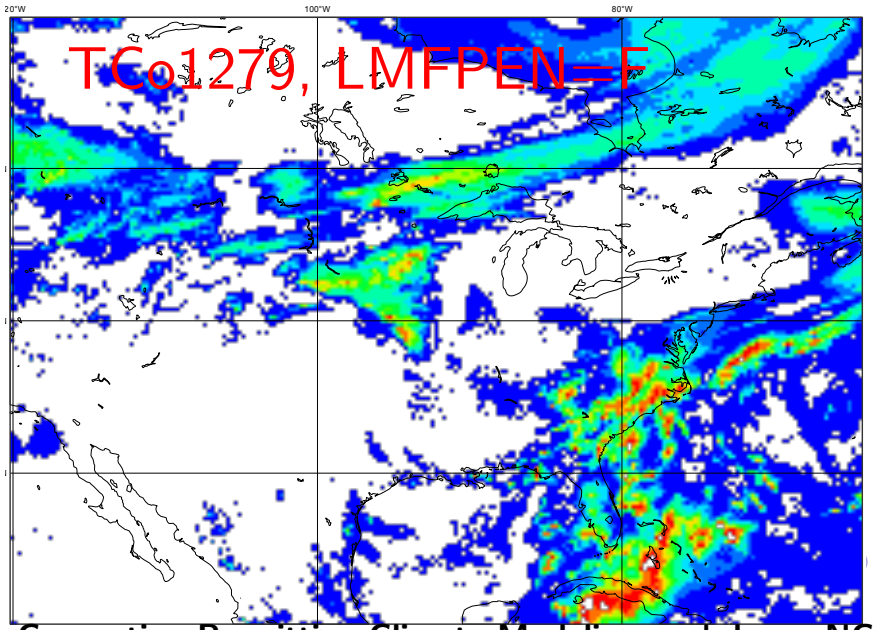
5km simulation with rescaled mass-flux parameterization

Grey zone of convection: MCs over U.S.

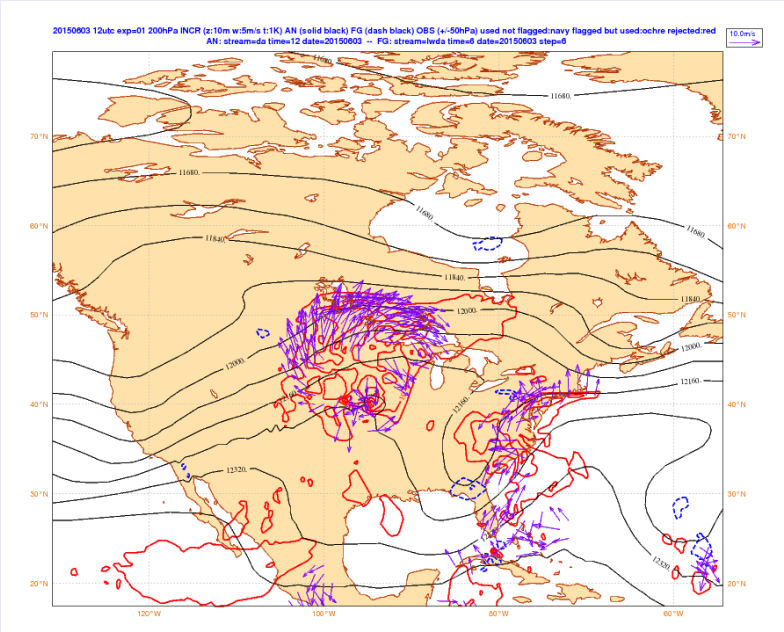
Error in the representation of the MCSs over the US seem to be one of the main causes for poor forecasts over Europe (Rodwell et al, 2013).



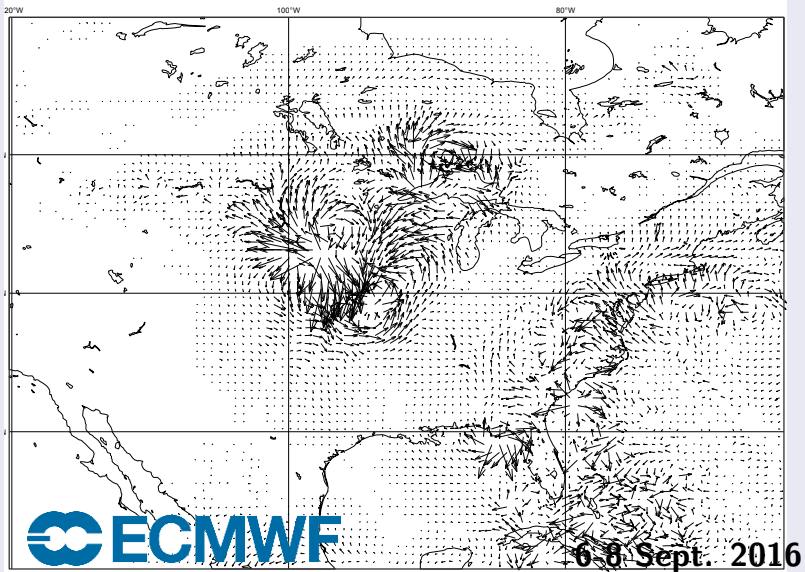




MCs case : 3 June 2015, 00UTC, wind at 200hPa



IFS increment at 3 June 2015, 00UTC +12



200hPa Wind difference between TCo1279 with LMFPEN=F and TCo1279 REF

Mass flux approach for the grey zone of convection

Net mass advection inside the physics (HYMACS, Kuell, Gassmann and Bott, 2007)

Look also at `http://www2.mmm.ucar.edu/wrf/users/workshops/WS2012/ppts/lecture2.pdf` gives the motivations behind "Grell-3D"

$$\frac{\partial(\rho\psi)}{\partial t}\Big)_{conv} = -\frac{\partial(M_u(\psi_u - \overline{\psi})}{\partial z} = -[\frac{\partial(M_u\psi_u)}{\partial z} + \frac{\partial(-M_u\overline{\psi})}{\partial z}]$$

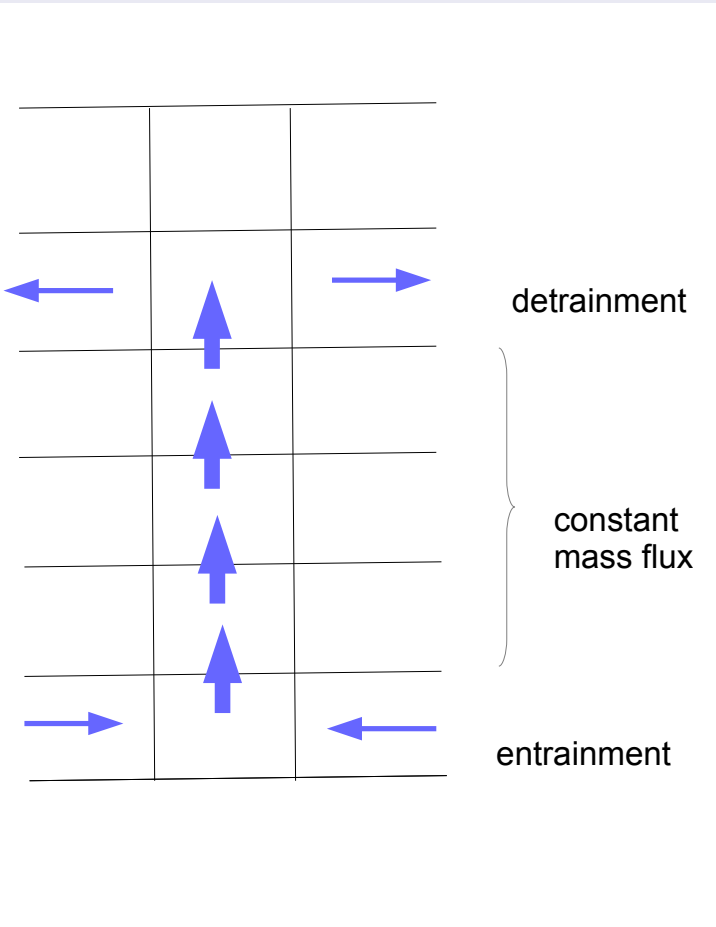
$$\Downarrow$$

$$\frac{\partial(\rho\psi)}{\partial t}\Big)_{conv} = -\frac{\partial(M_u\psi_u)}{\partial z}$$

- The compensating subsidence is not parametrised by the convection scheme $\Rightarrow$ the dynamics is expected to close the budget of ψ.
- The physics is coupled to the continuity equation.

How does the dynamics react to a parametrised net mass transport?

Academic simulation of a tracer transport by a single column updraft

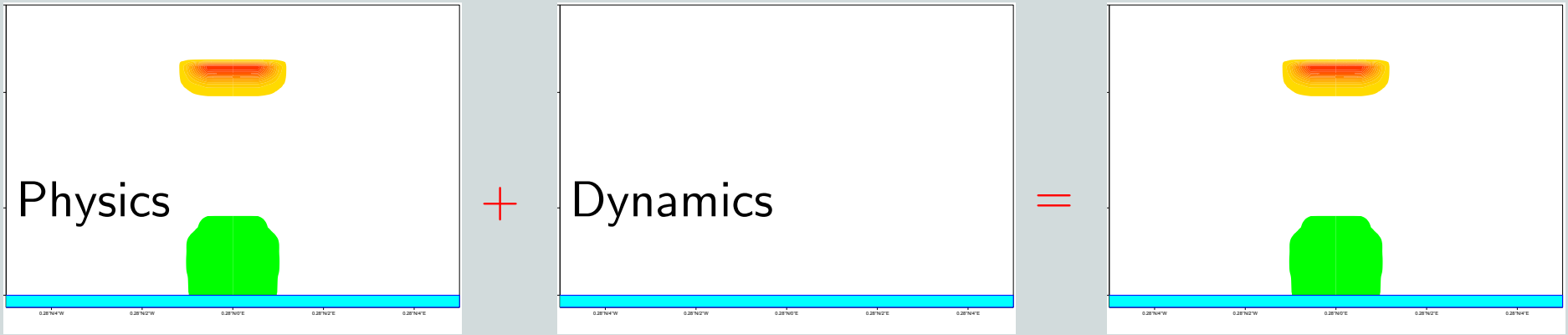


- subgrid mixing of a passive tracer (not part of the total mass, not part of the buoyancy, unlike moisture)
- passive tracer with same initial profile as moisture
- no wind, temperature and moisture from Klemp and Wilhelmsom,78
- only the concentration of traceur + total mass in the new scheme are transported by the mass flux (temperature and moisture of parcels adjust instantaneously to the environment, not energetically correct, but only for illustration purpose)

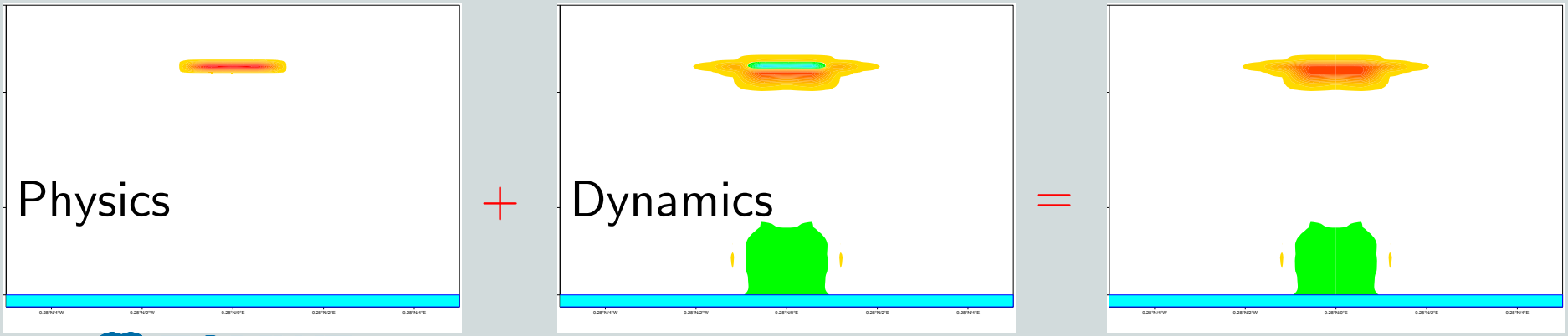
How does the dynamics react to a parametrised net mass transport?

6h. accumulated tendencies for a passive tracer

Current mass flux scheme



New mass flux scheme



Summary

- at 9 km resolution, IFS is at the edge of the grey zone of deep convection
- getting ready for an ensemble at 5 km around 2025
  - hydrostatic is not a problem
  - work on scale aware representations of convection (strict monitoring of impact on model climate and model errors), PBL representation, coupling with the surface, representation of GW.