3MT and other aspects controlling the convective behaviour in ALARO

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Content of the talk

- 3MT (brief recall + some ideas about the meaning of ‘entrainment’).
- Radiation: retuning of gaseous transmission functions, including spectral overlap corrections.
- Turbulence: evolution from pseudo-TKE to emulator-TKE, a step for compatibility with full-TKE schemes.
- First steps for using a ‘historical’ entrainment rate (memory but no direct prognostic equation).

Why 3MT?

- (i) Attacking the challenge of the horizontal scales (δx ~ 5 km) where precipitating convection is *neither* fully resolved *nor* likely to be correctly parameterised in a 'classical' way.
- (ii) Insisting on *stable* (for longer δt) and *cost-efficient* algorithmic solutions.
- (iii) Having a 'NWP-controlled' progress (*novelty* but quasi *ascending compatibility*).
- (iv) *Modularity-flexibility* as the essential tool to obtain a multi-scale character (being able to swap and/or tune the 'processes description' without touching the structure).
- (v) Using a *prognostic* orientation for reconciliation of ideas about complex microphysics and mass-flux-type parameterisation (neither CRM nor QE).

3MT, the acronym

- A synergy of three ideas/concepts:
  - ***M***odular, because of the ALARO-0 effort made in order to stay compatible with a general phys-dyn interfacing while searching proximity with the AROME concepts;
  - ***M***ulti-scale, because a great deal of the architectural constraint comes from the ‘grey-zone’ oriented work, initiated in 2001 by L. Gerard;
  - ***M***icrophysics & ***T***ransport, to underline the decisive catalysing role played by the central proposal of J.-M. Piriou’s PhD work, made in 2004.

Microphysics AND Transport (M-T)

- It is the basic idea behind 3MT.
- Allows to think over two simple facts:
  - Detrainment is conditioned by Entrainment and cloud ascent's characteristics.
  - 'Cloud+precipitation microphysics' surely not instantaneous (fall speed of drops ~ propagation speed of convective structures).
- Contrary to the 'classical' bulk mass-flux scheme approach, one does not assume a stationary cloud (NEITHER in size NOR in properties).
- Contrary to the 'microphysical plume' approach, microphysics has a rather long lag-time and is not only happening 'within the drafts'.

Time- and space-scale issues

- Basically 3MT is a way to do '***as if***' deep convection was resolved but ***without*** needing to go to scales where this is true.
- This is thanks to:
  - Prognostic and diagnostic 'memory' of convection;
  - A unique micro-physical treatment beyond all sources of condensation.
- But, owing to the peculiar role of entrainment in the M-T concept, this requires to better ***understand*** what one means when 'tuning' an entrainment specification scheme.

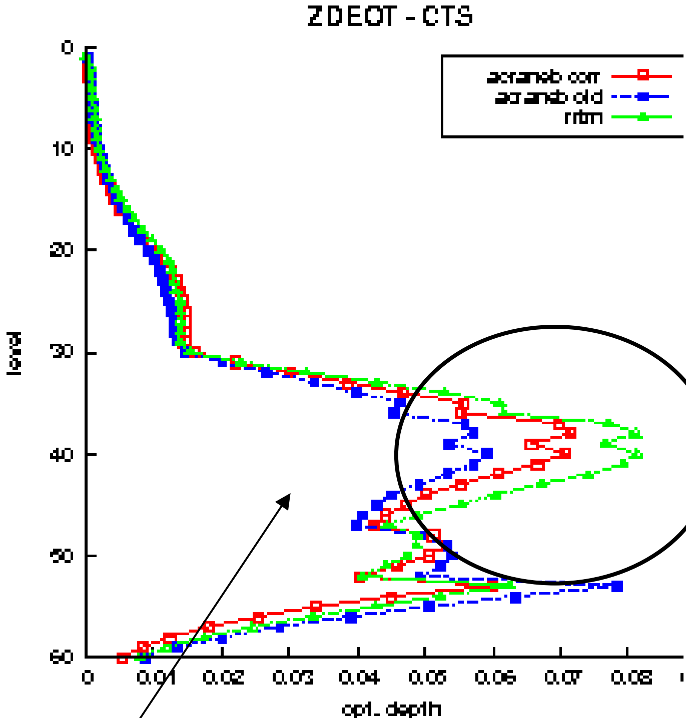
Issues linked with 'entrainment'

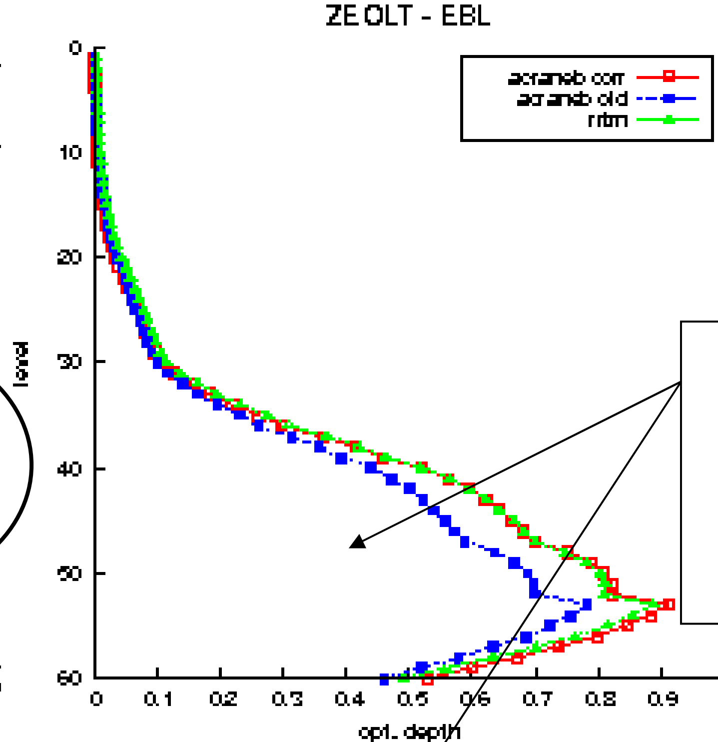
- There are two (often confused) possible definitions of 'entrainment':
  - The contribution to the increase of the mass-flux;
  - The rate of influencing the thermodynamic properties of the ascent.
- In case lateral detrainment and lateral entrainment increase simutaneously, the second effect is enhanced, not the first one.
- In the framework of 3MT, it is quite important to distinguish the two, because one is not specifying detrainment.
- Going from diagnostic to prognostic calculation of the mass-flux (ACCVIMP => ACCVUD), one had to strongly increase the entrainment rates (***second definition in both cases***) in order to get the same averaged mass-fluxes (validated via Q1 and Q2), despite having exactly the same computation of the ascent. ***Other tried tunings had no similar impact.***
- This went fortunately in the right direction, when comparing with 'observations' or 'LES-implied' numerical results.

Radiative forcing (1/3)

- Right from the start of the ALARO-0 development, the need was documented for better gaseous transmission functions, even when taking into account the progress that would result from transforming ‘ACRABNEB’ for making it “NER-compatible”.
- This has only been concretised recently, even if first steps were taken already in 2004.
- When effective, the change should improve (inter alii) a cold temperature bias detected in HIRLAM verifications.
- Positive impact in winter hence, but it will not remain without influence on convective activity in summer …

Radiative forcing (2/3)

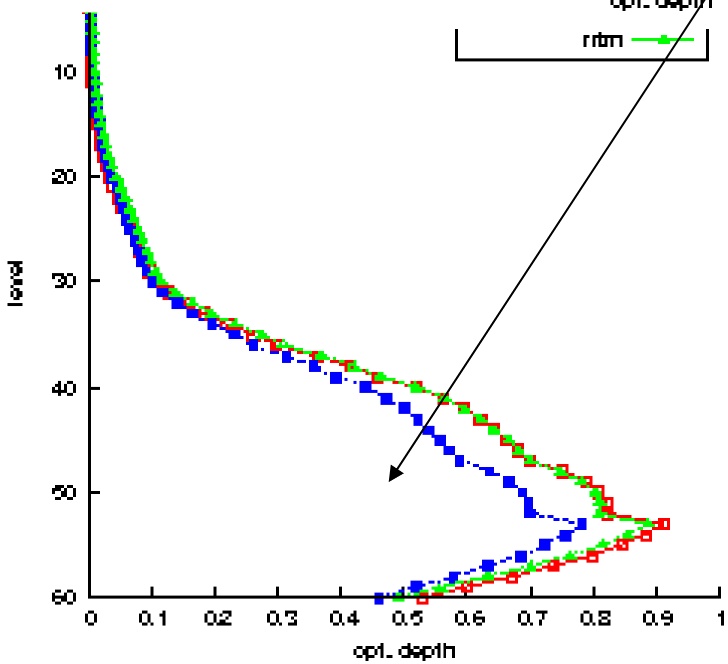


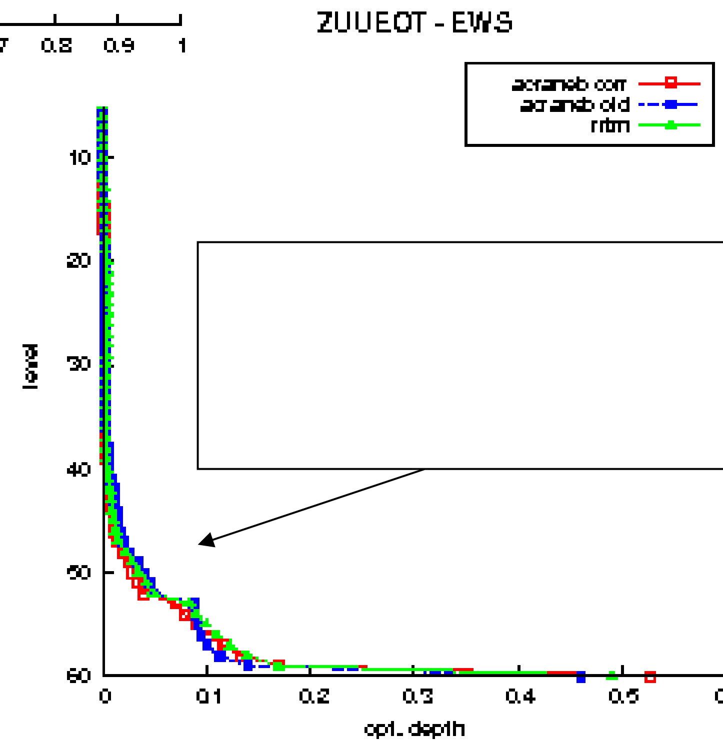


RRTM (reference)

Old ACRANEB

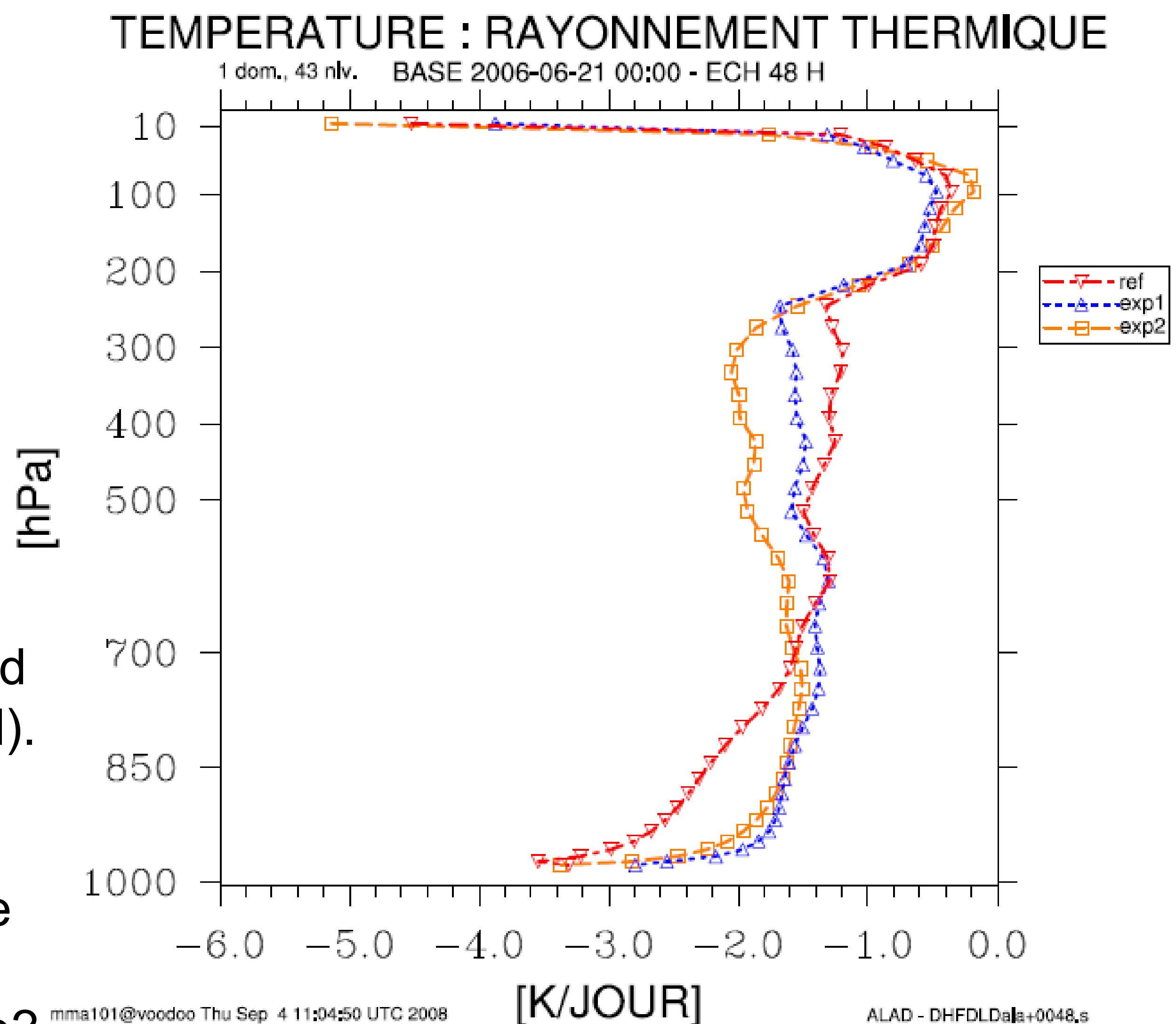
New ACRANEB





Radiative forcing (3/3)

DDH output:
Reference: current acraneb
Exp 1: new acraneb
Exp 2: RRTM (reference)

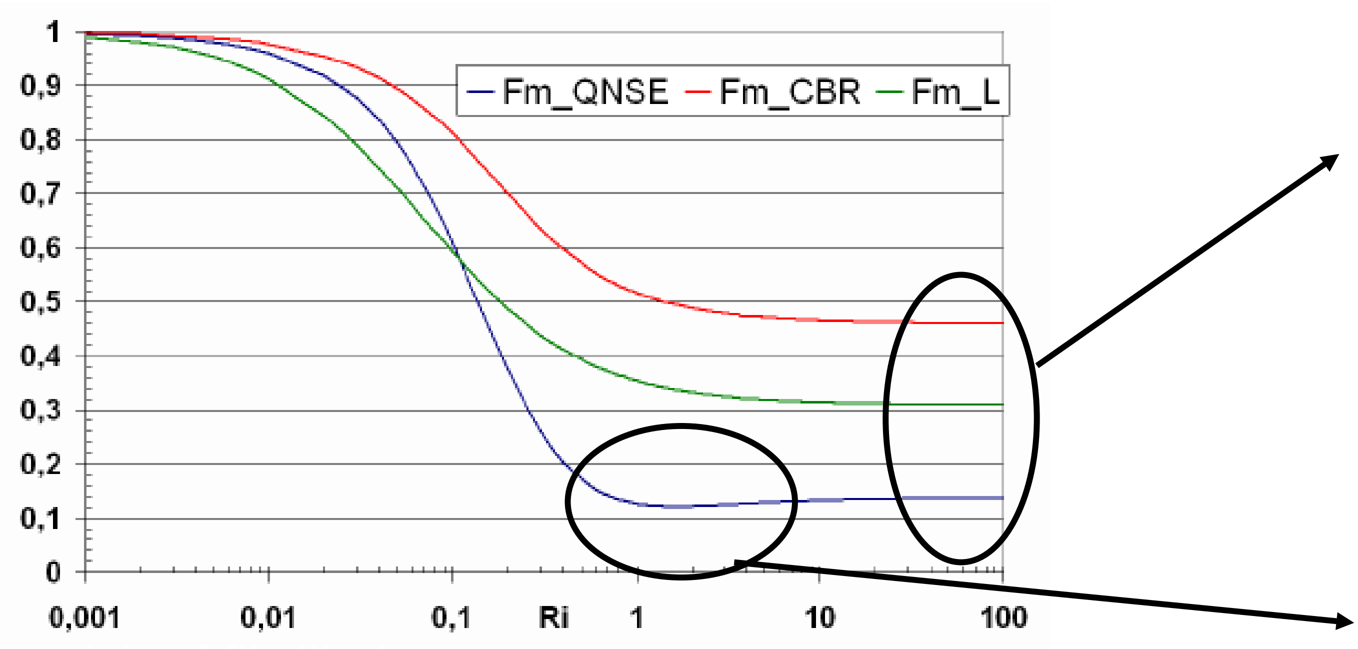


The fit with RRTM is far better (and the remaining difference structural). The impact of warmer PBL and colder upper troposphere is an unwelcome increase of convective activity => need for more entrainment => but in which scope?

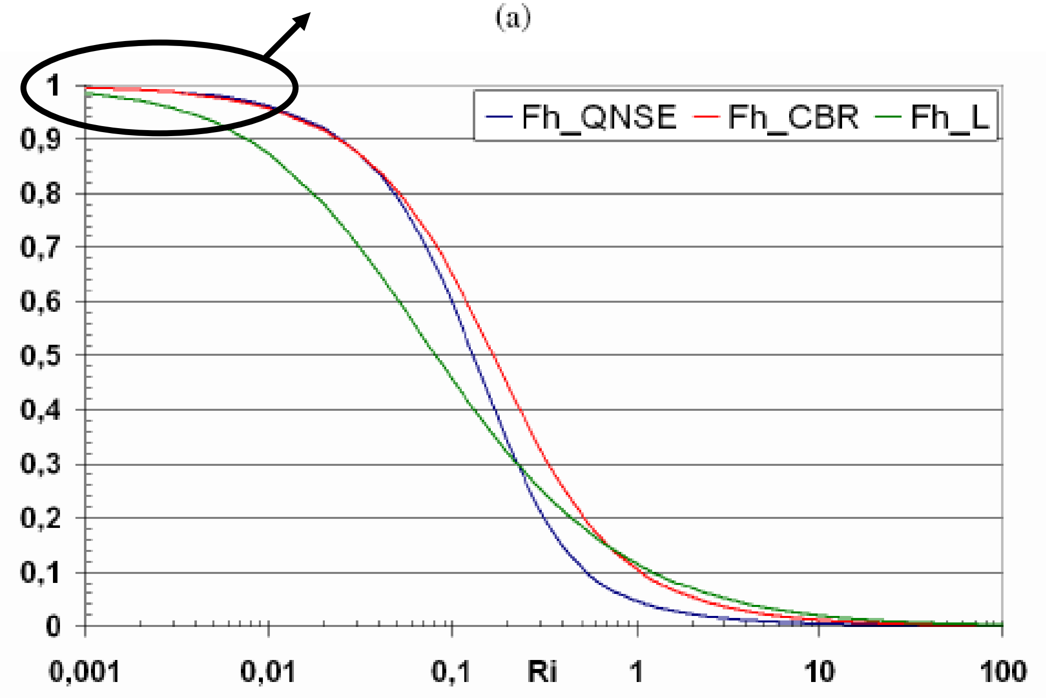
Turbulent vertical exchange (1/3)

- The so-called p-TKE development ('p' for pseudo) was undertaken for several reasons:
  - Gaining experience with space and time memory of TKE;
  - Having maximum ascending compatibility with the well-tuned operational Louis-type scheme;
  - Computing shallow convection still by Ri*(Ri,d(q_{sat}-q)/dz) and keeping the same anti-fibrillation scheme, while writing d(TKE)/dt=…
- The method designed in 2001 by Redelsperger et al. for connecting M/O-type surface fluxes and CBR-type PBL fluxes was used (extended along the vertical) to fulfill these three constraints.
- It was decided in 2007 to modify p-TKE into something 'emulating' the full behaviour of a CBR-type TKE scheme, when shallow convection & anti-fibrillation are 'switched off' => e-TKE concept.
- Extending the 'e-TKE' idea in 2008 to QNSE (a new turbulent theory relying on spectral anisotropic analysis rather than on Reynolds decomposition) brought in a new view on the p-TKE vs. e-TKE issue.

Turbulent vertical exchange (2/3)



(a)

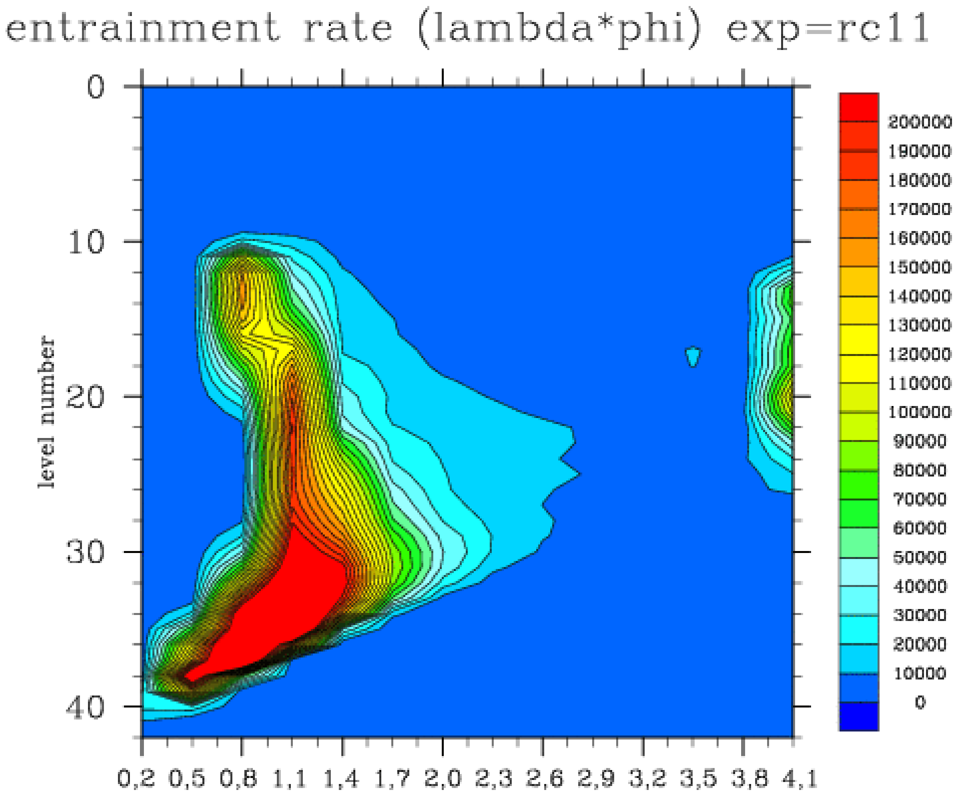


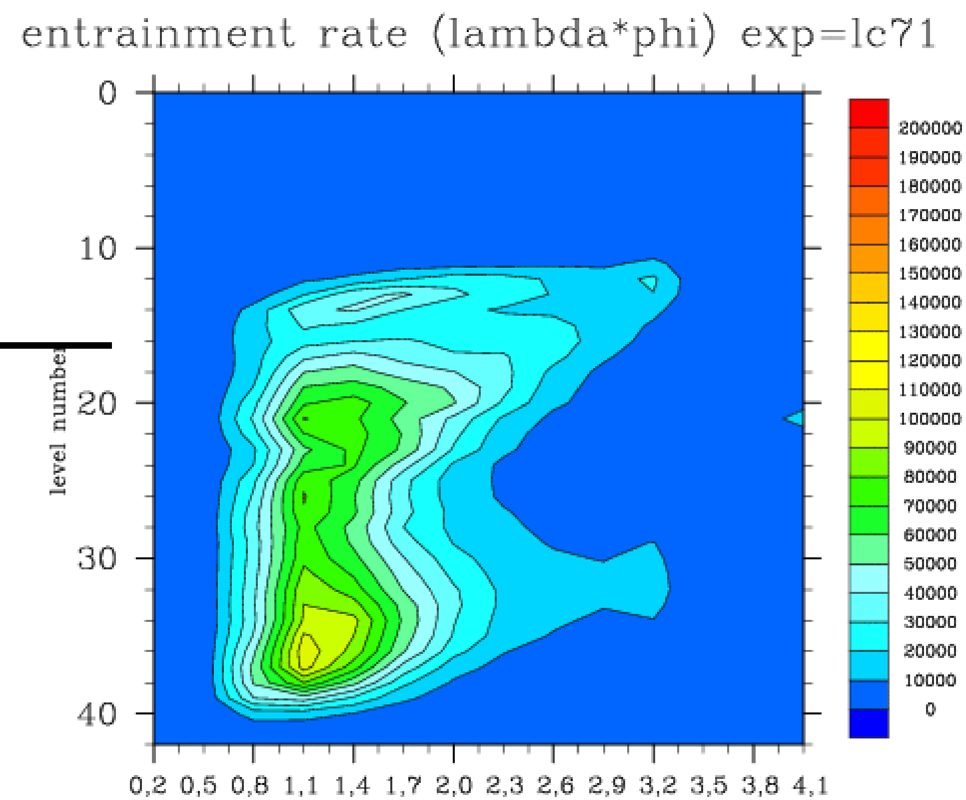
(b)

Turbulent vertical exchange (3/3)

- When rewriting the full-TKE schemes (CRB & QNSE) in a Newtonian relaxation framework (i.e. what is done in e-TKE when one forgets p-TKE for a moment), one sees that:
  - There is one degree of freedom more in QNSE than in CBR (a Ri-dependency in the shear induced creation of TKE); **hence the big differences seen in F_m**;
  - This dependency corresponds to an implicit relationship between the K-coefficient for momentum, the Richardson flux number and the relaxation time scale;
  - This relationship is fulfilled by CBR (consistent disappearance of the additional degree of freedom), but not by the current implementation of p-TKE (too 'automatically' copy-pasted on CBR equations, when it was developed).
- Hence:
  - **Either** one searches 'new' Louis-type functions allowing a consistent use of p-TKE (but with less ascending compatibility with respect to the diagnostic scheme);
  - The new F_m function is then likely to show some non monotonous behaviour for big Ri values, **see previous diagram**;
  - **Or** one goes 100% towards an independent e-TKE (with the unavoidable task of the 'ideal' choice for mixing lengths). **This is the likely solution**, OK for shallow convection with some rewriting, but what about anti-fibrillation … ? Open issue!

First trials with ‘historic entrainment’





Conclusions

- Surely more work on (at least) the entrainment prescription in 3MT for ALARO-0, once more realistic radiative and turbulent forcing terms are used.
- Whether the associated retuning should take place with ‘static’ or ‘historic’ prescription of the entrainment rate remains an open issue.
- In any case, one should very probably get higher effective entrainment rates, pursuing the convergence with observed values, already started when moving from diagnostic to prognostic mass-flux calculations, thanks to the ‘M-T catalyser’.