ALARO physics; development of 3MT

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ALARO-0 works since last EWGLAM

- 3MT (see what follows);
- Radiation: retuning of gaseous transmission functions, including spectral overlap corrections.
- Turbulence: evolution from pseudo-TKE to emulator-TKE, a step towards a full-TKE.
- Preliminary studies on mass variation upon water budget and projection of heat source on temperature AND pressure.

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)

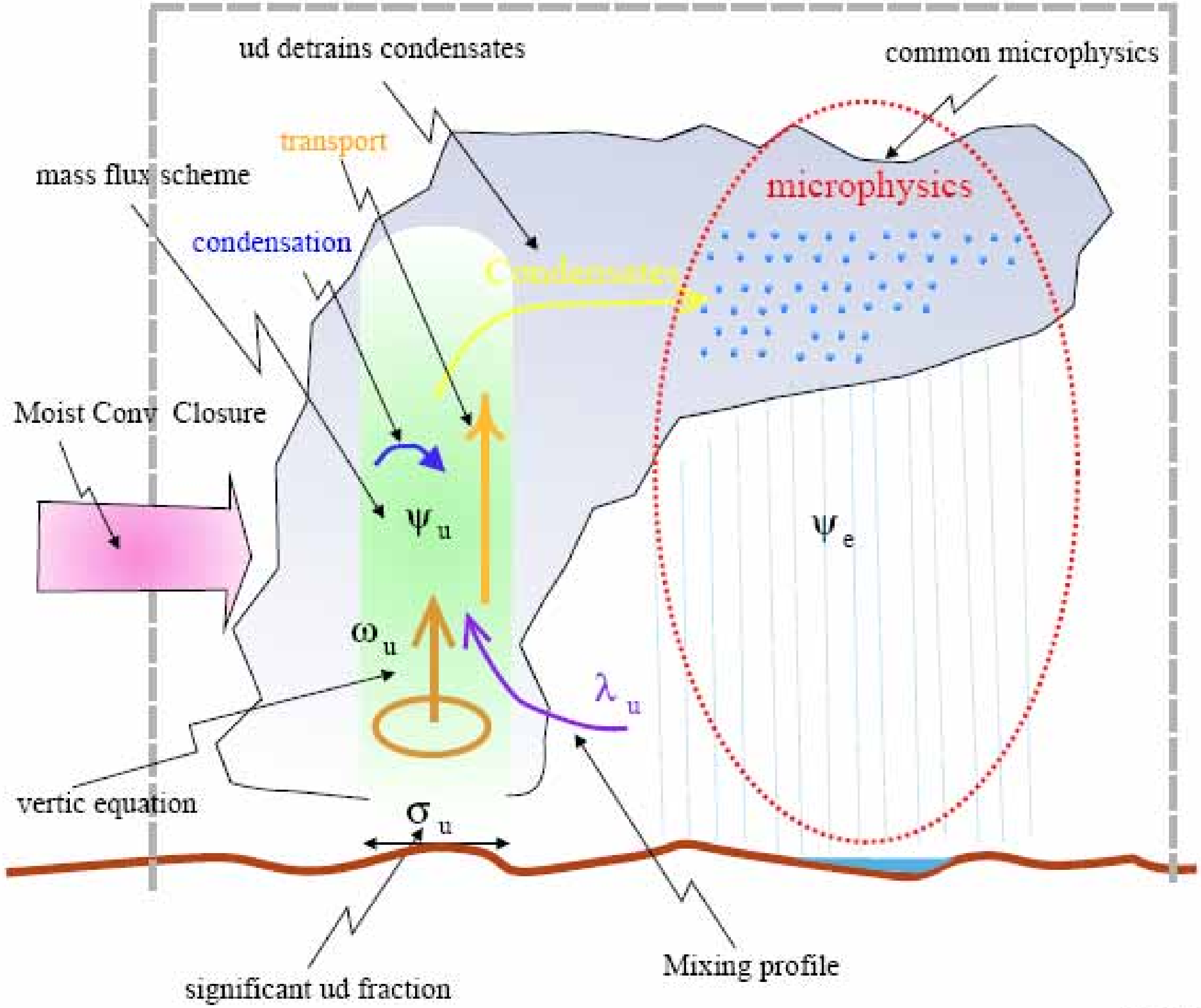
- It is the basic idea behind all what follows.
- Allows to think over two simple facts:
  - Detrainment is conditioned by Entrainment and cloud ascent's characteristics.
  - 'Cloud+precipitation microphysics' surely not instantaneous (fall speed of drops ~ propagation speed of convective structures).
- 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'.

Why 3MT?

- (i) Attacking, within a long-term perspective, the challenge of the horizontal scales ($\delta x \sim 5$ 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

Main Choices



L. Gerard, 29 March 2007

The nice sides …

- NWP orientation: bulk mass-flux but fully prognostic handling of the mass-flux AND of the 2D closure.
- With M-T and a prognostic equation for the mass-flux, no need to parameterise anymore detrainment for deep convection.
- Facility to work on ‘modularity for flexibility’.
- One single microphysical-type computation, except for the condensation/re-evaporation, the latter being obtained from the sum of a ‘resolved’ contribution and of a ‘convective’ one => with a good closure, model-controlled self-extinction of convection at high resolution.
- Lot of freedom for a complex fully prognostic micro-physics => more ‘memory’ of past convective events.
- The ‘cold-pool’ effect’s parameterisation comes rather naturally in this framework (ongoing work).

But …

- The handling of the ‘cascade’ (neither sequential nor parallel treatment of individual contributions) is not always easy:
  - Avoiding ‘double-counting’ for closure assumptions is not trivial;
  - The sedimentation aspect of the downdraft impact must be treated heuristically;
  - In order not to iterate expensive computations, one must choose well which information to pass (or not) to the next time-step (and how to use it).
- Not enough effort was devoted to the closure formulation, especially in view of its ‘multi-scale’ impact.
- For a ‘deep’ framework, a vertically constant area fraction for drafts is OK; but this does not hold anymore in the ‘shallow’ case.
- Trying to go at last towards a unique description of cloudiness will be a hard task.

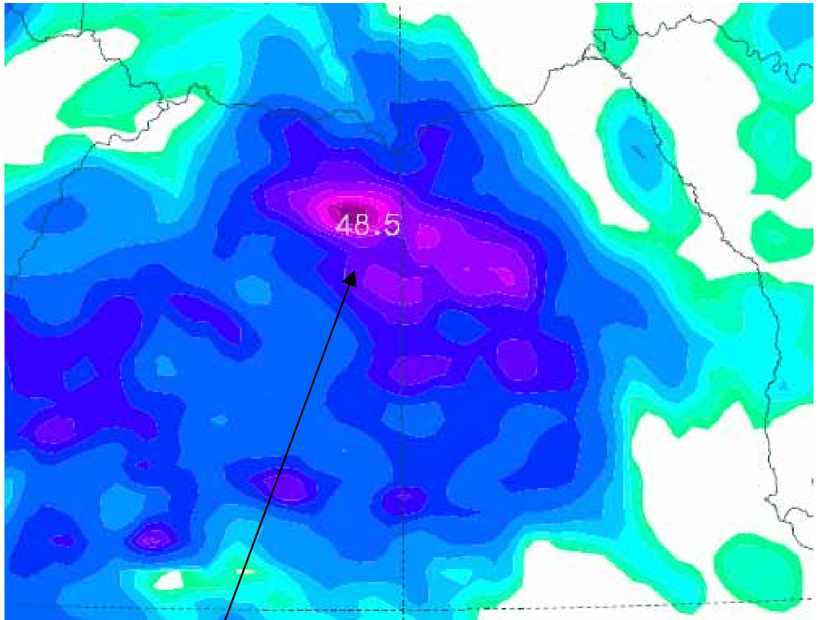
Time- and space-specific aspects

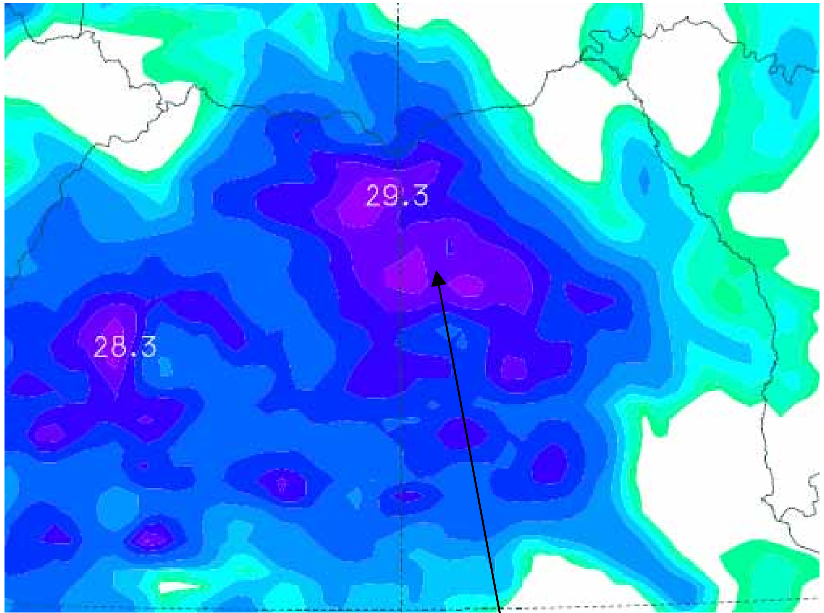
- Basically 3MT is a way to do ‘***as if***’ deep convection was resolved but ***without*** needing to go to scales where this is true.
- This is thanks to:
  - Prognostic and diagnostic ‘memory’ of convection;
  - A unique micro-physical treatment beyond all sources of condensation.
- Some examples of either case and of their interaction follow.

Adjustment and existing convective clouds

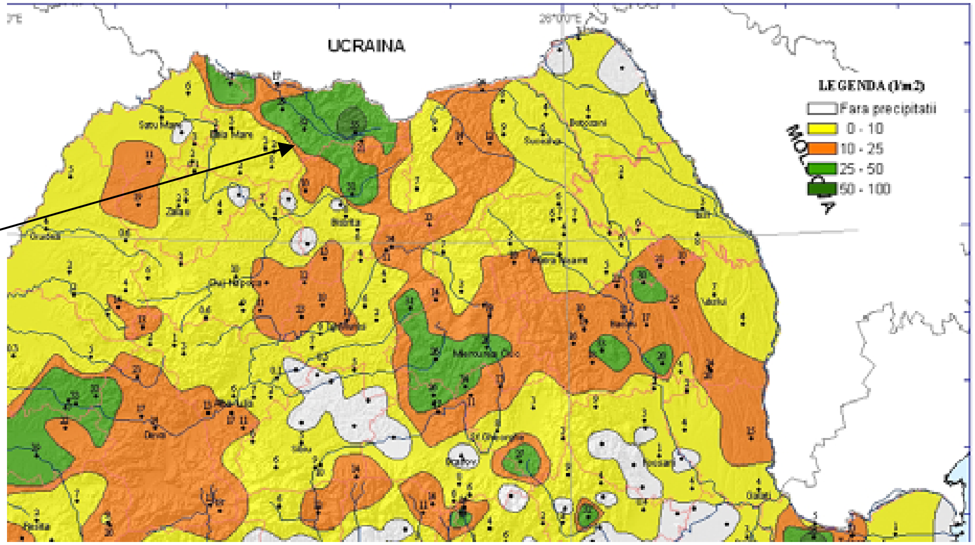
- When sub-grid scale convection is fully prognostic (case of 3MT), associated condensates are not all converted to falling species within the same time-step.
- If nothing is done, adjustment process at the beginning of the next time-step will treat them as mean box values and they will evaporate in surrounding dry air. This has a feed-back on the convective activity.
- Cure: to introduce an option into the adjustment computation taking into account the existing convective cloudiness.
- At the moment it is done in case of Xu-Randall type of adjustment but this option should be introduced to other options/schemes.

Adjustment and existing convective clouds





3MT std



24h precipitation sum
Courtesy of INMH

3MT but
existing convective condensates are treated as resolved in the new time-step: squall line structure is smoothed out.

Geometry of clouds and rain

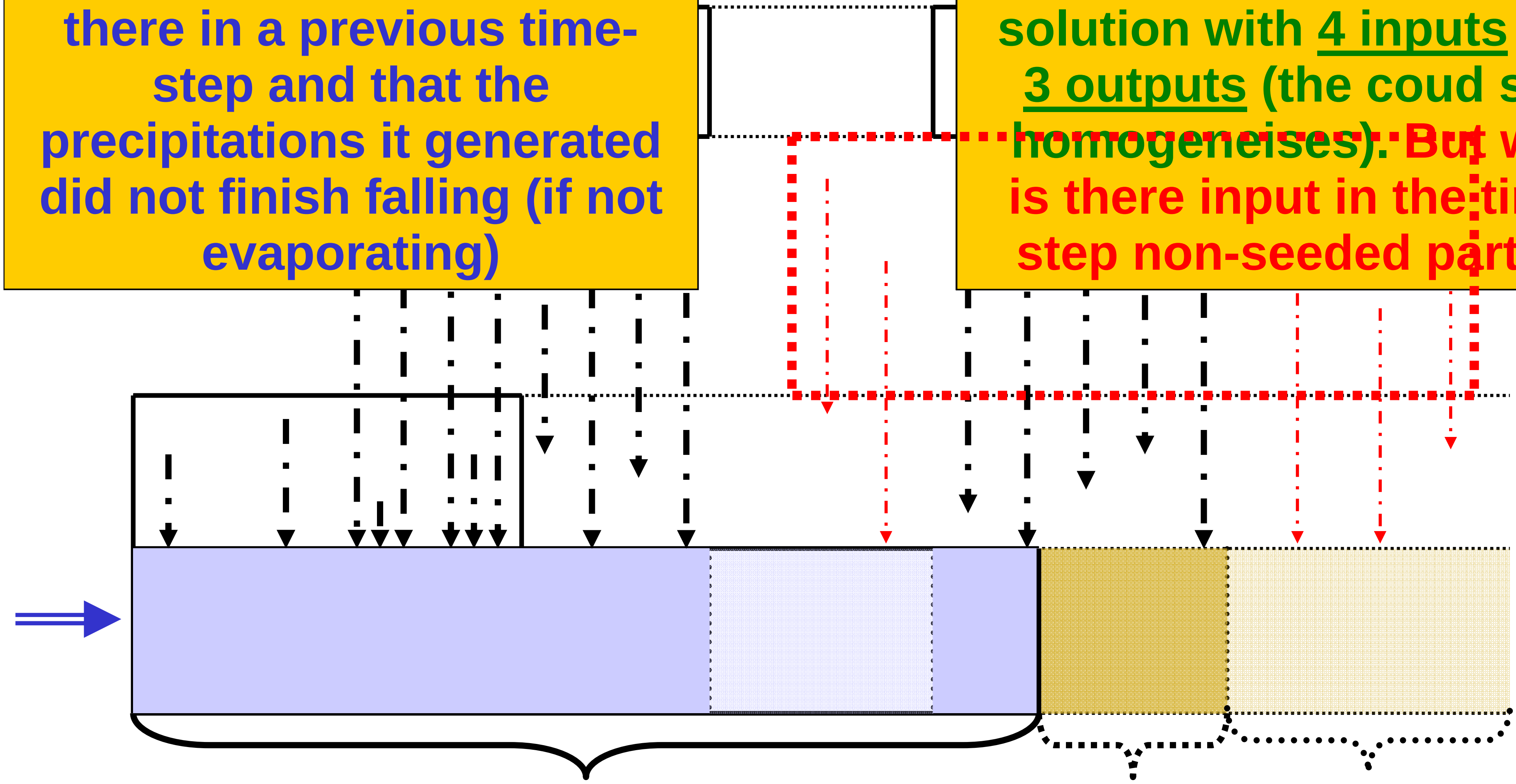
- Microphysics:
  - Processes of collection, evaporation and melting/freezing of falling precipitations depend on:
    - Cloudy or clear-sky environment locally and above;
    - Whether considered parcel is seeded or not.
  - Why: because sub-grid convective clouds cannot be represented by mean grid values
  - How: the ‘process’ routine are called for geometrical categories, as needed.

Geometry of clouds and rain => how to find an algorithm to describe this kind of facts?

Geometry of clouds and rain

Because there was a cloud there in a previous time-step and that the precipitations it generated did not finish falling (if not evaporating)

This is now the correct solution with 4 inputs and 3 outputs (the coud still homogeneises). But why is there input in the time-step non-seeded parts ?

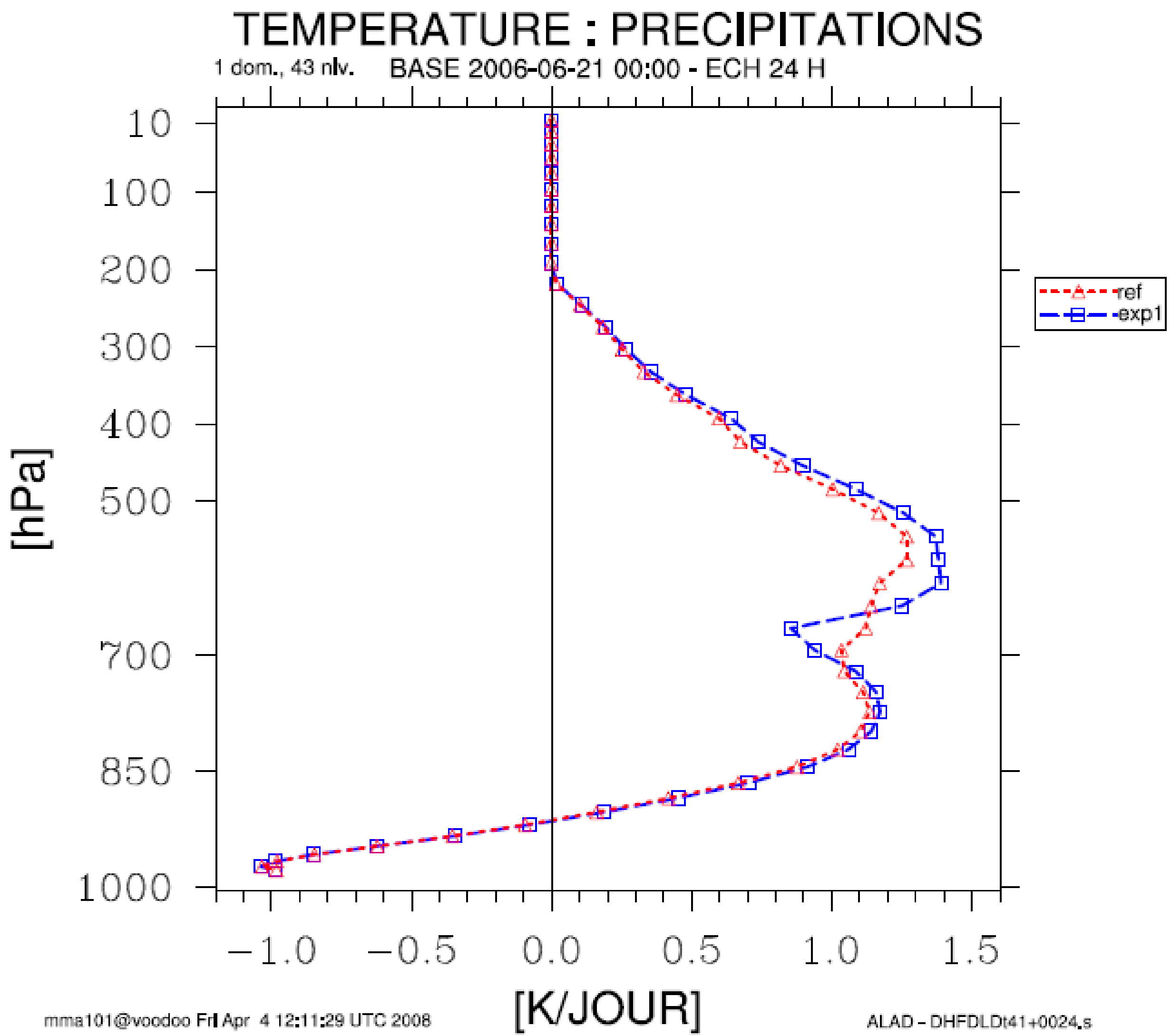


Random overlap of parts separated by clear air, maximum overlap of adjacent parts (schematic view)

Addressing a weakness of the original M-T proposal

- Even in convective drafts, condensation-evaporation can be viewed as being controlled by '**local**' feed-backs.
- This originally led to the idea (Piriou et al., 2007) to 'feed' microphysics, <u>for the convective part</u>, just by the product of the mass-flux by the moist adiabatic local vertical gradient of q_v.
- But melting-freezing of falling precipitation of sub-grid scale origin relies on computations cumulative in the vertical, i.e. '**non-local**'.
- If nothing is done, using the original formulation leads to an artificial 'double detrainment' like effect (weak convective ascents cannot pass the 0°C 'barrier' in the M-T computations).
- Cure = iterative computation
  - Estimates of the melting/freezing latent heats are obtained with the help of 'minimum' microphysical computations having as input the first guess of convective condensation rates;
  - Change of the said convective condensation rates in order to balance the obtained 'corrections' (melting => cooling => more condensation & vice-versa for freezing);
  - Convergence is fast (one iteration is enough).

Mitigation of the double-detrainment-like behaviour



Blue curve: ‘double detrainment syndrome’ **Red curve: iterative latent heats effect (cure)**

Operational applications

- At most LACE countries ALARO-0 including 3MT becomes progressively operational.
- Benefits also exist for resolutions inside and at the upper limit of the grey zone.
- Belgian colleagues will soon take advantage of this 3MT «goodie».
- Tests at many scales are ongoing, mostly with encouraging results.

	ALARO-0-minus-3MT	Full ALARO-0
Cz	30/1/07	4/6/08
At	13/9/07	(LAEF) + soon
Sk	19/2/08	19/8/08
Hr	25/2/08	
Si	X	16/6/08
Be (5km)	X	soon

3MT's sampling of the 'grey-zone'

Diagnostic convection representation incompatible with 'grey-zone' scales

Δx=9.0 km (2x) | Δx=4.5 km (2x) | Δx=2.3 km (3x)

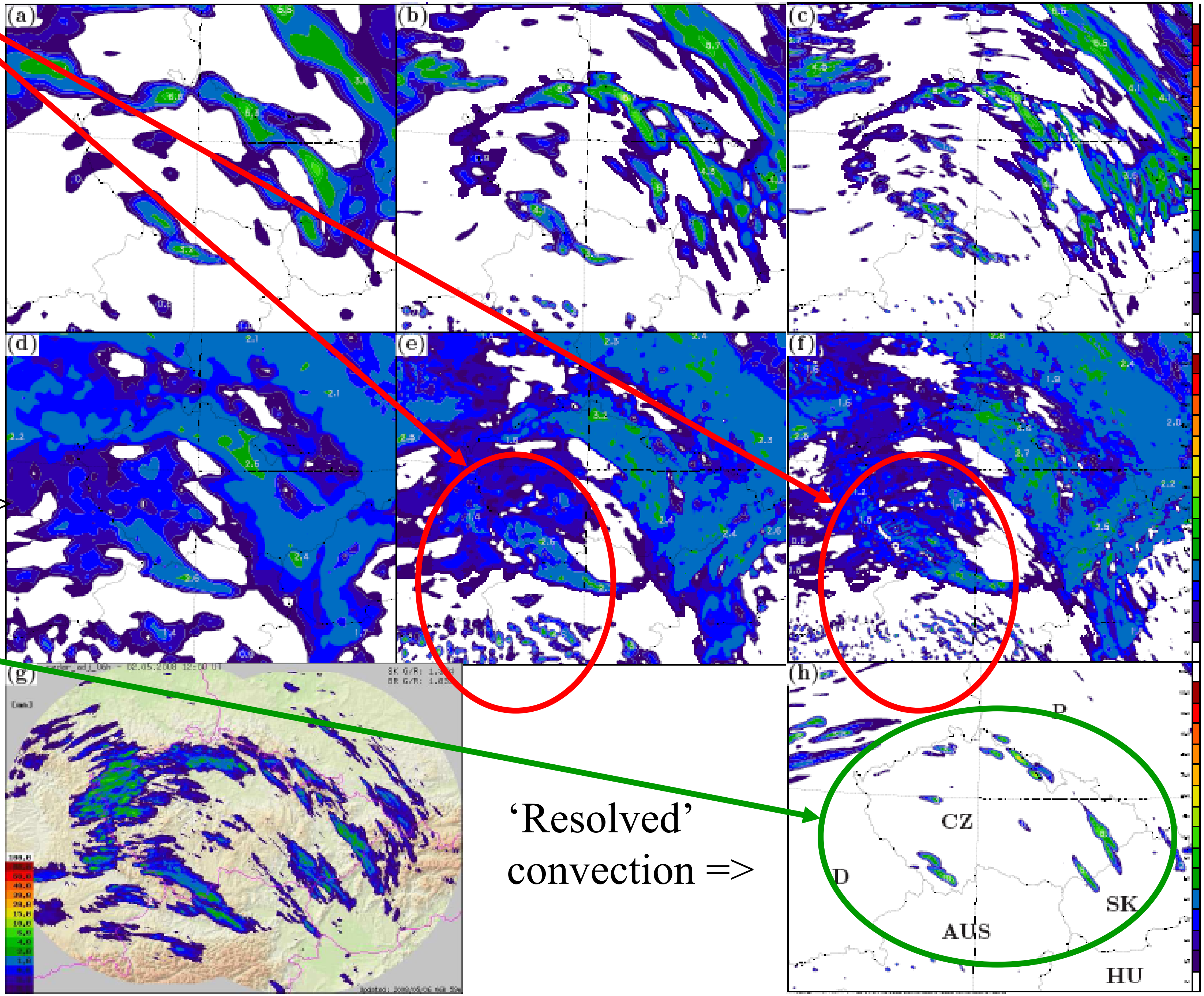
A0 with 3MT =>

A0 without 3MT =>

At least here and then, convection parameterisation is necessary at 2.3 km scale

Observed precipitations =>

'Resolved' convection =>



Conclusions

- 3MT cannot be viewed as a convective scheme only.
- Prognostic character and joint treatment of both resolved and sub-grid scale moist processes require cross time-stepping solutions.
- 3MT was originally targeted for the grey zone but its range of validity in terms of scales is much wider.
- Given the novelty of 3MT, the remaining of the ALARO-0 design is currently rather guided by the idea of ascending compatibility.
- Modularity in 3MT and around it opens the possibility of diversified representation of basic processes => joint efforts (starting already within HARMONIE).