ALARO physics; development of 3MT

R. Brožková on behalf of
D. Banciu, B. Catry, J.-F. Geleyn, L. Gerard, J.-M. Piriou, I. Stiperski
L. Amorin, I. Basták, E. Bazile, M. Belluš, P. Bénard, Y. Bouteloup,
F. Bouyssel, J. Cedilnik, M. Derková, D. Drvar, A. Farda,
R. Fournier, G. Hello, M. Janoušek, D. Klaric, T. Kovacic, T. Kráľ,
I. Lelatko, J. Mašek, R. Mládek, N. Pristov, J. Rio, O. Rivière,
P. Smolíková, O. Španiel, P. Termonia, A. Trojáková, M. Tudor,
F. Váňa, Y. Wang, C. Wittmann and several other people testing 'A0'

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)

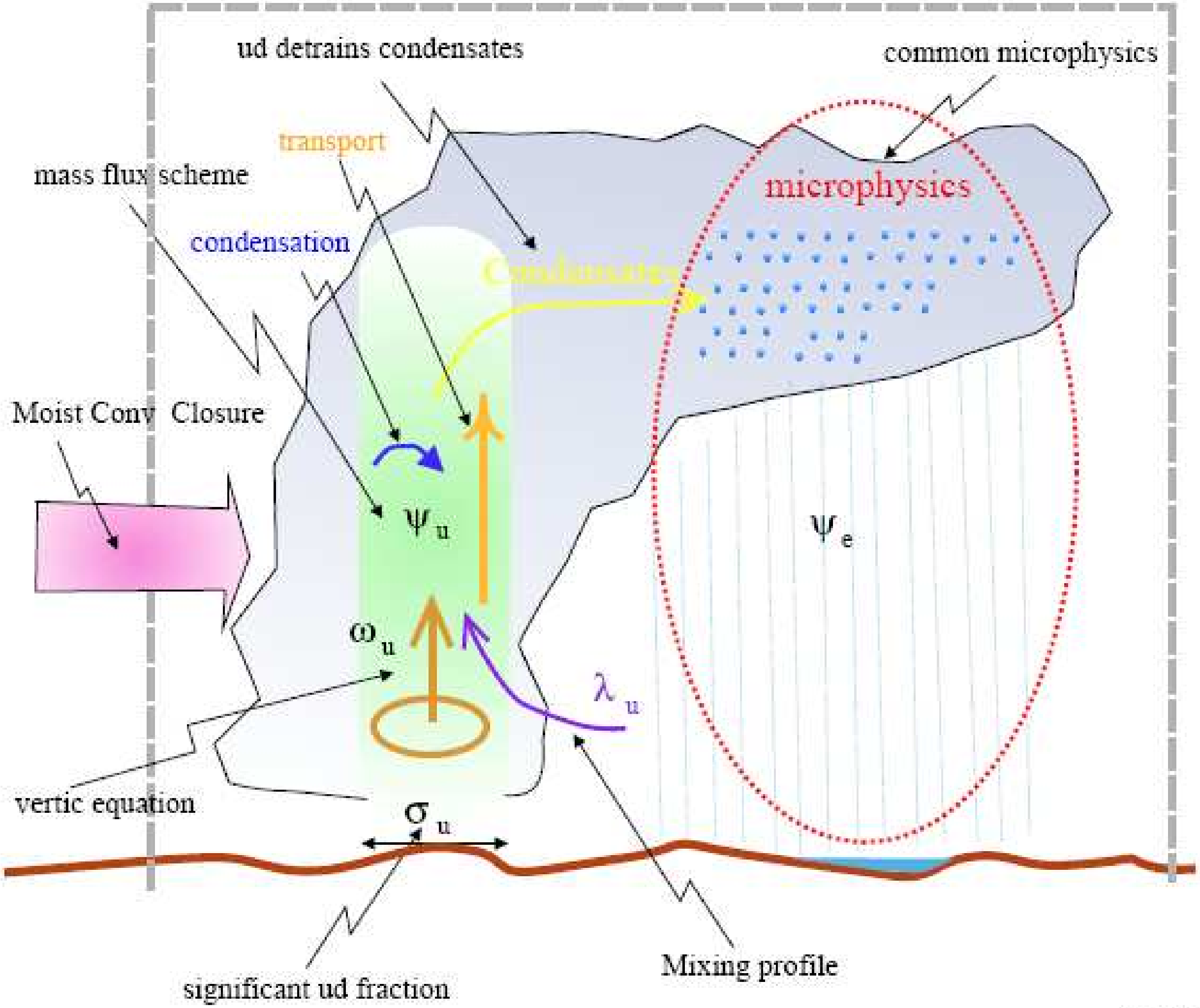
- It is the basic idea behind all what follows.
- Allows to think over two simple facts:
  - Detrainment is conditioned by Entrainment and cloud ascent's characteristics.
  - 'Cloud+precipitation microphysics' surely not instantaneous (fall speed of drops ~ propagation speed of convective structures).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



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.

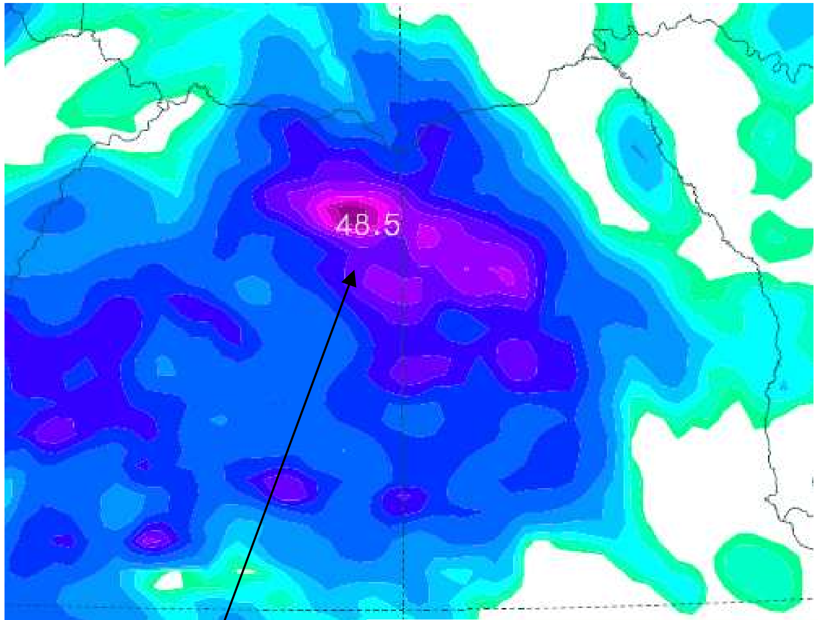
Time- and space-specific aspects

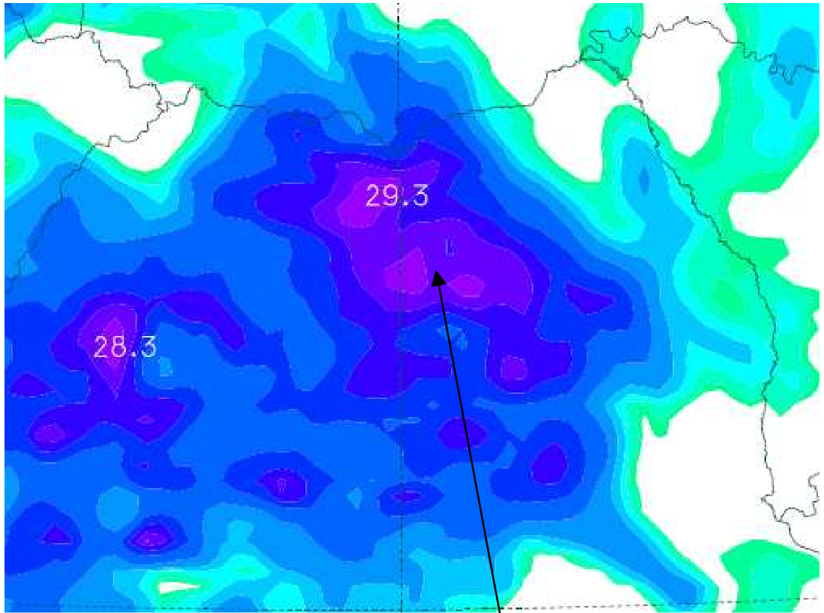
- Basically 3MT is a way to do ‘***as if***’ deep convection was resolved but ***without*** needing to go to scales where this is true.
- This is thanks to:
  - Prognostic and diagnostic ‘memory’ of convection;
  - A unique micro-physical treatment beyond all sources of condensation.
- Some examples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

Adjustment and existing convective clouds

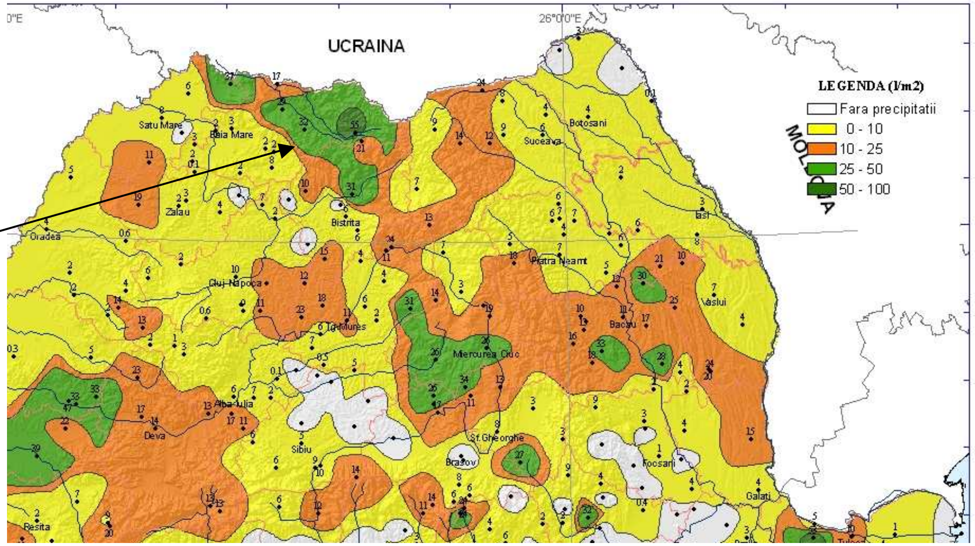
- When sub-grid scale convection is fully prognostic (case of 3MT), associated condensates are not all converted to falling species within the same time-step.
- If nothing is done, adjustment process at the beginning of the next time-step will treat them as mean box values and they will evaporate in 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

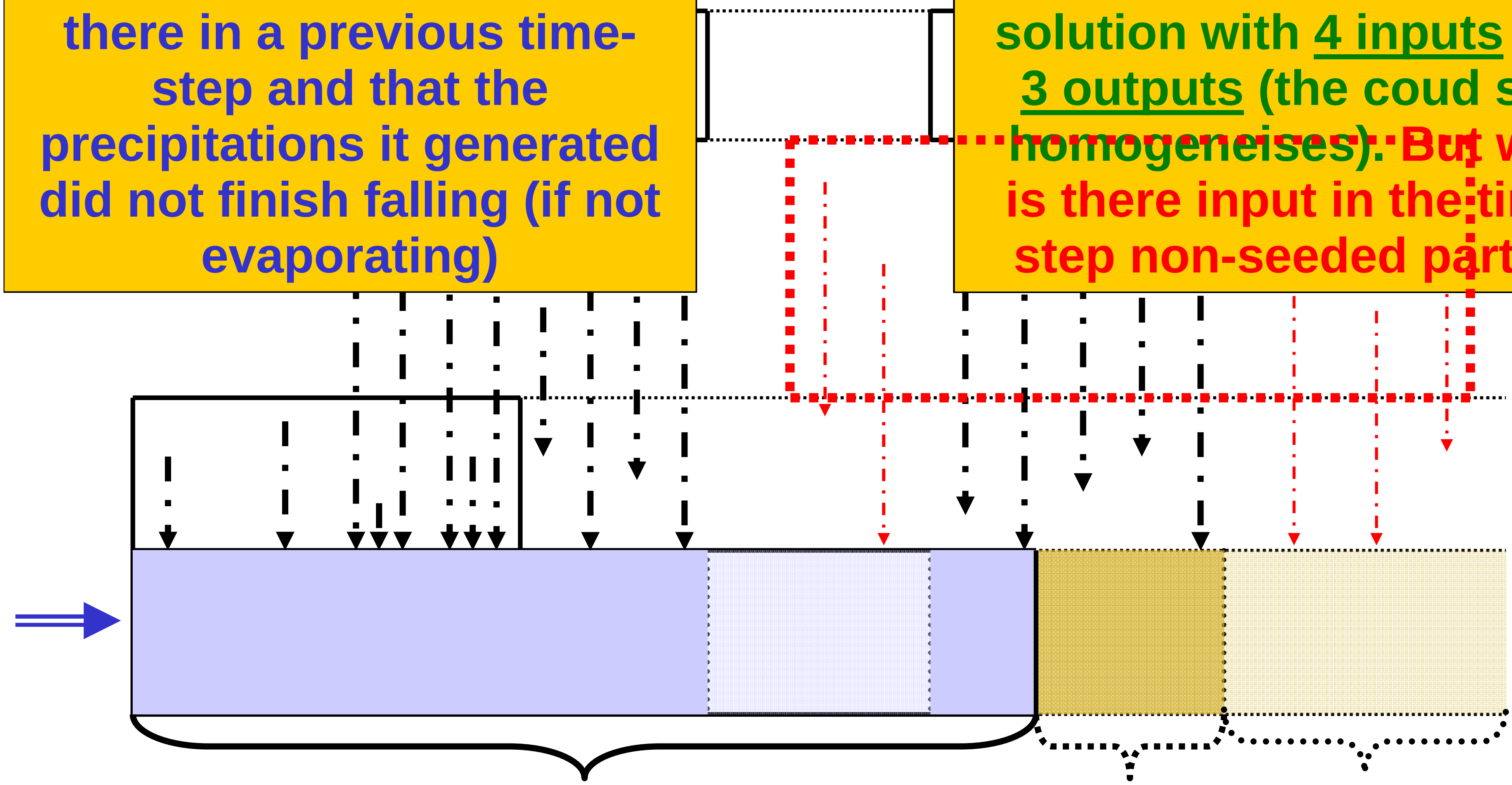
- Microphysics:
  - Processes of collection, evaporation and melting/freezing of falling precipitations depend on:
    - Cloudy or clear-sky environment locally and above;
    - Whether considered parcel is seeded or not.
  - Why: because sub-grid convective clouds cannot be represented by mean grid 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 <u>4 inputs</u> and <u>3 outputs</u> (the coud still homogeneises). But why is there input in the time-step non-seeded parts ?

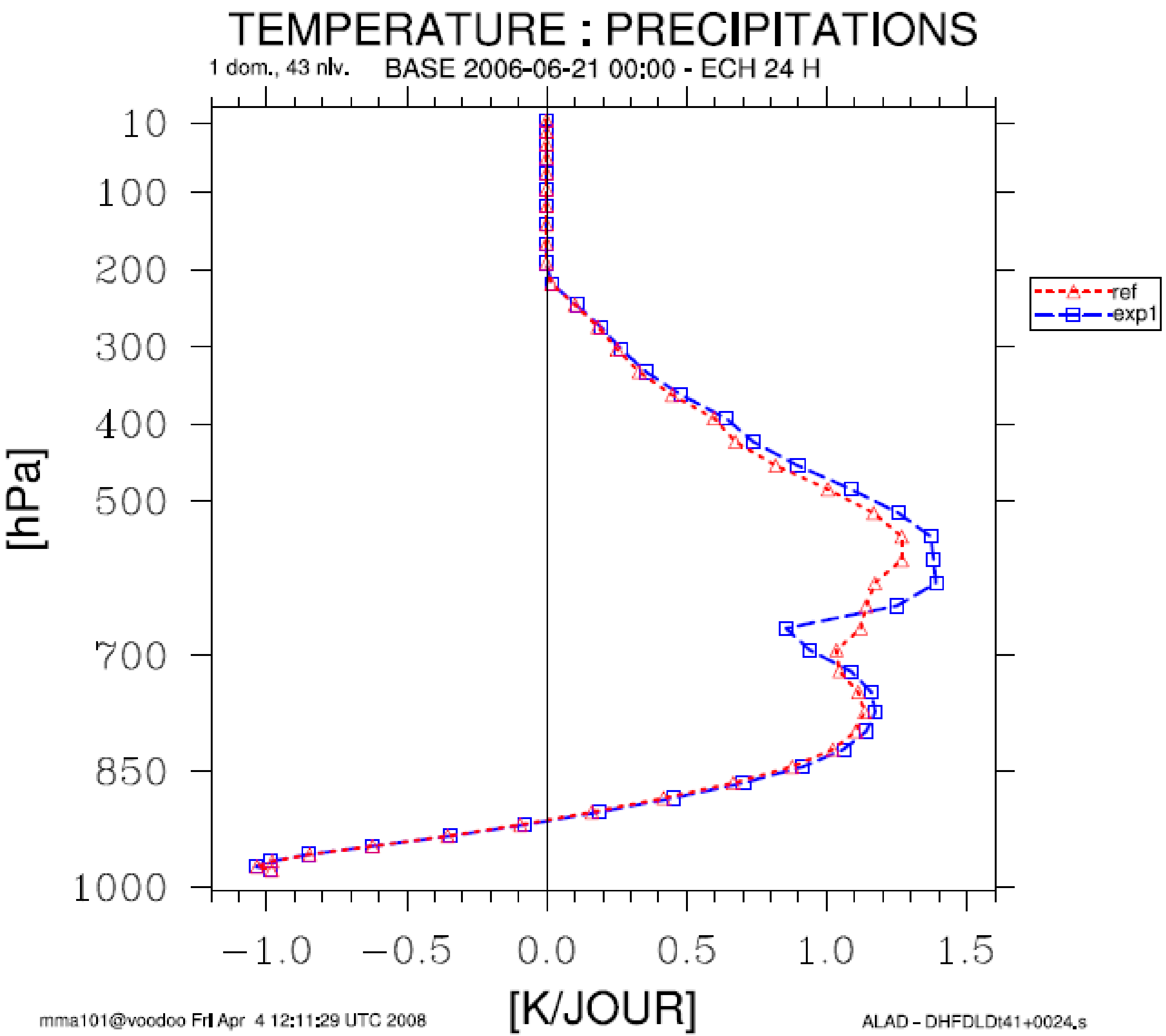


Random overlap of parts separated by clear air, maximum overlap of adjacent parts (schematic view)

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, for the convective part, 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℃ '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)

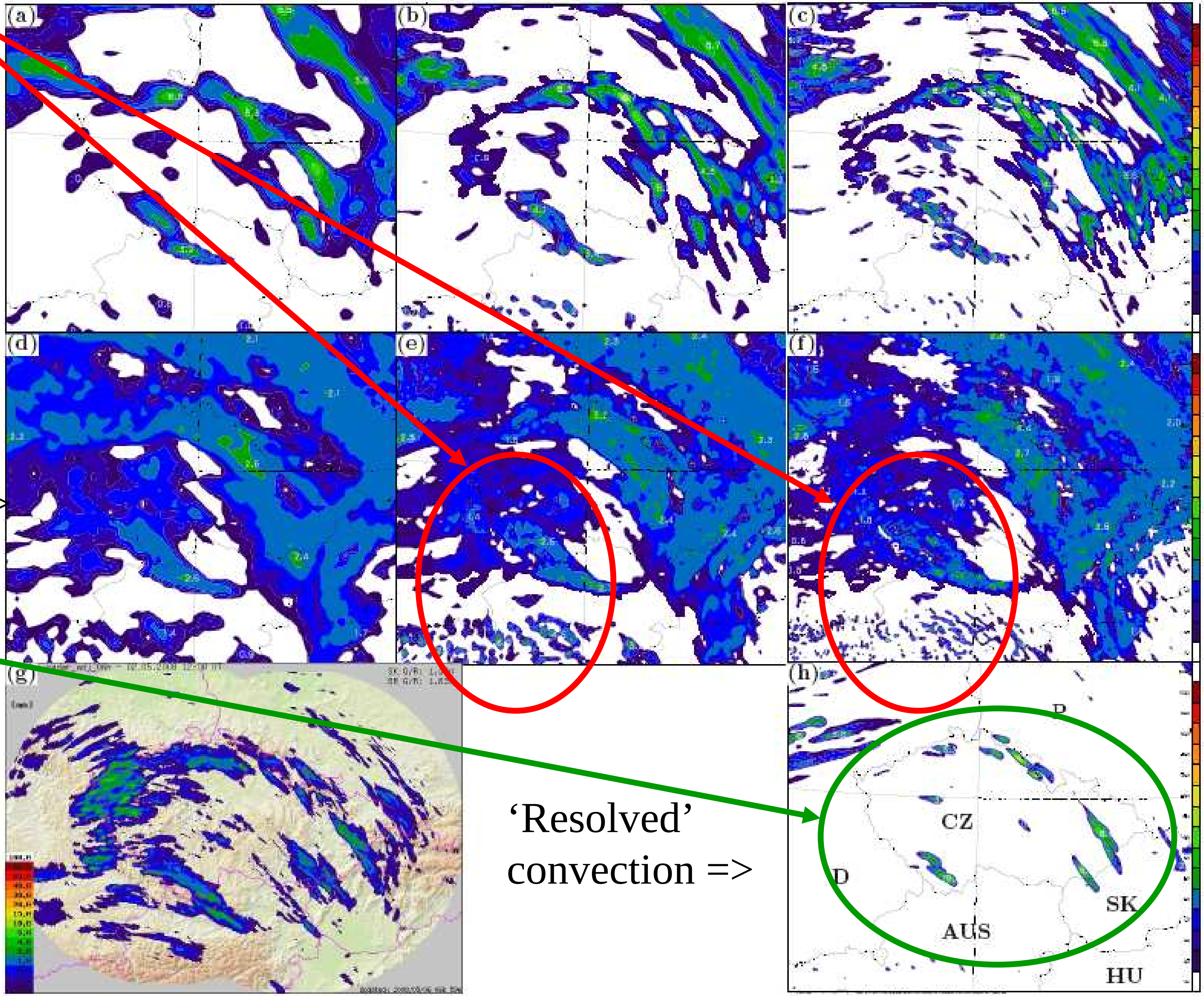
A0 with 3MT =>

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).