Adjustment, geometry and mass-flux aspects of 3MT

(at least some of them)

J.-F. Geleyn on behalf of many other people

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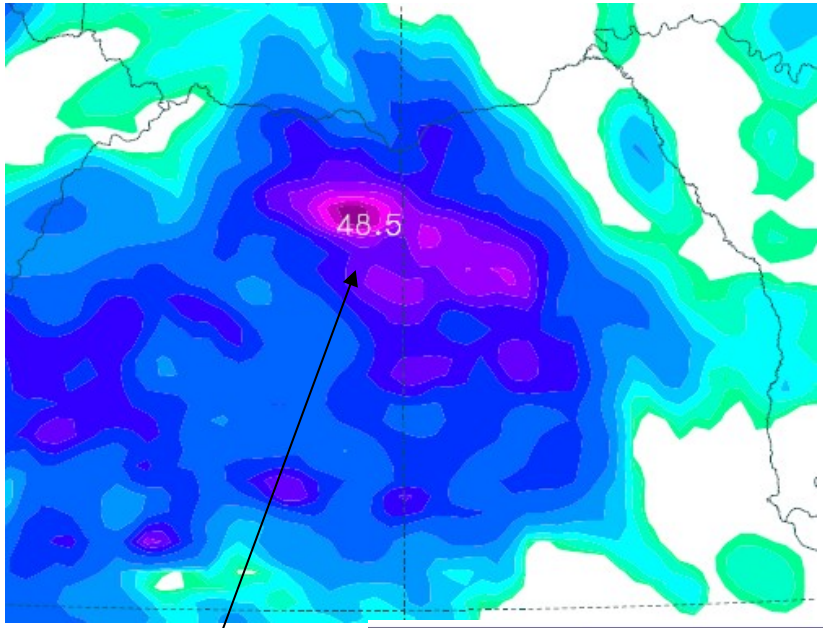
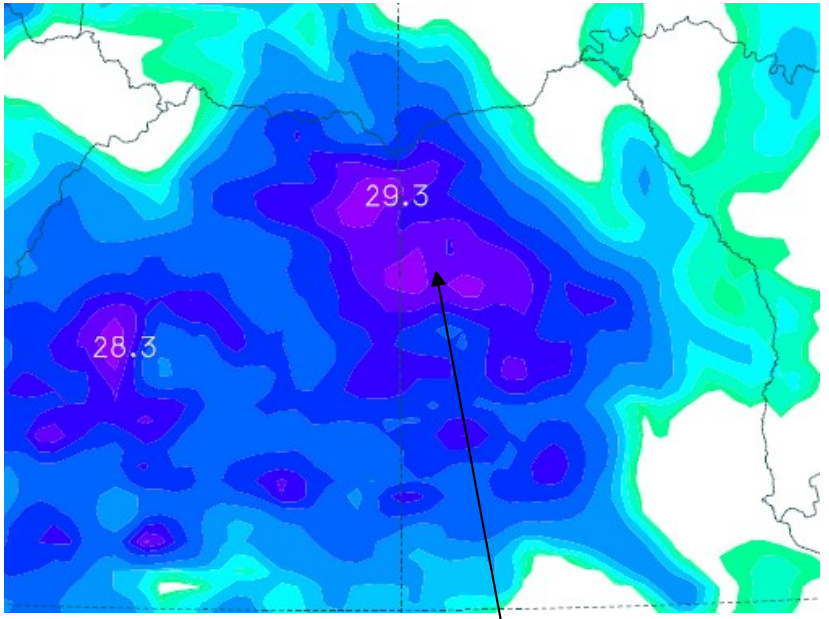
Adjustment and existing convective clouds (1/2)

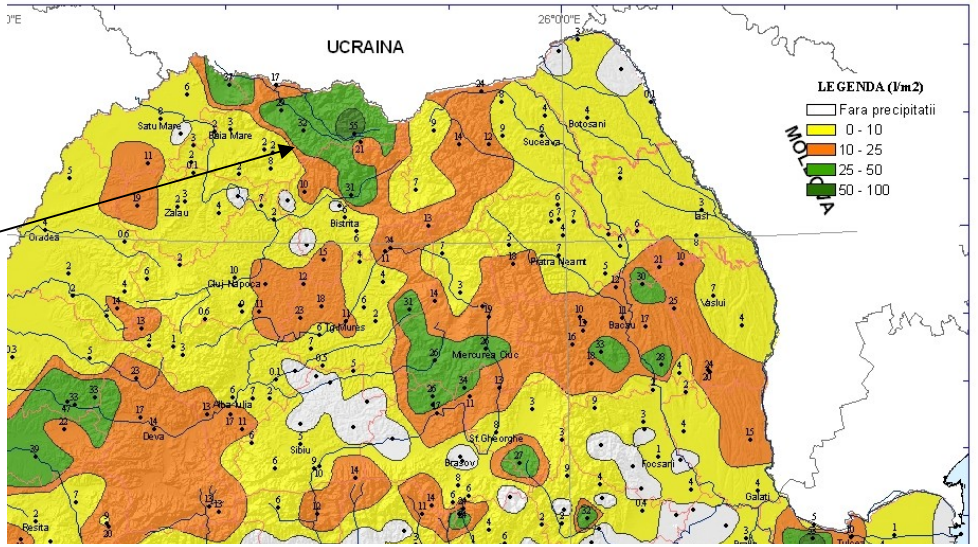
- When sub-grid scale convection is fully prognostic (case of 3MT), associated condensates are not all converted to falling species within the same time-step.
- If nothing is done, adjustment process at the beginning of the next time-step will treat them as mean box values and they will evaporate in 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 (2/2)





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 (1/4)

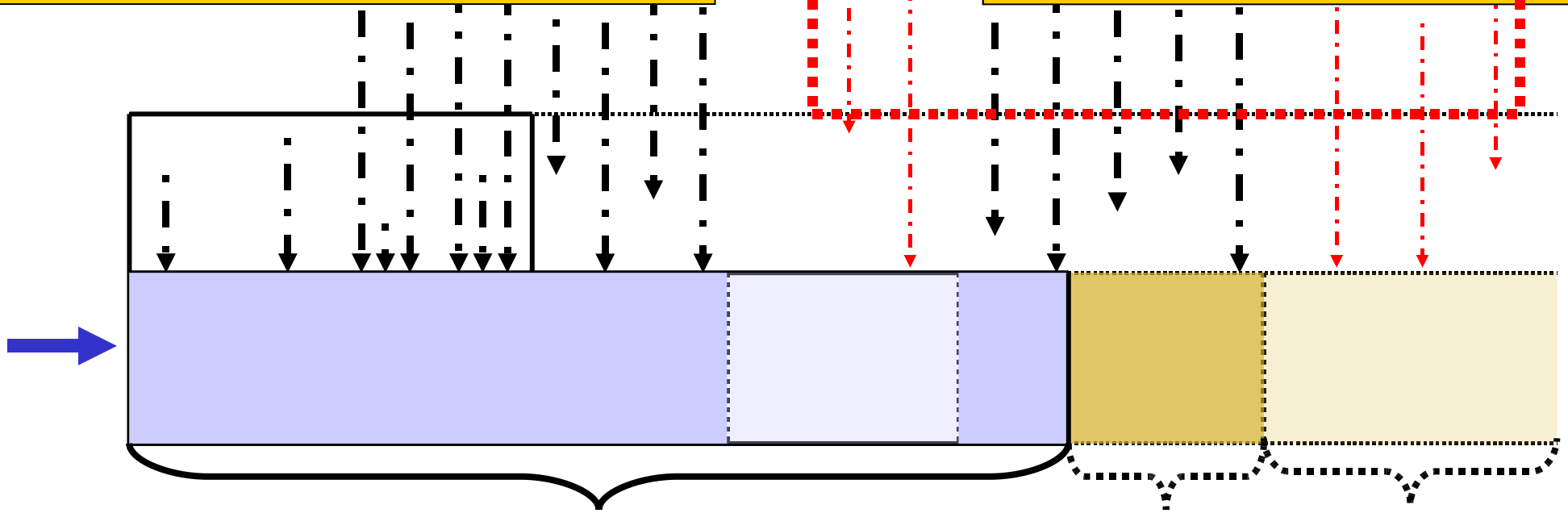
- Microphysics:
  - Processes of collection, evaporation and melting/freezing of falling precipitations depend on:
    - Cloudy or clear-sky environment locally and above;
    - Whether considered parcel is seeded or not.
  - Why: because sub-grid convective clouds cannot be represented by mean grid 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 (3/4)

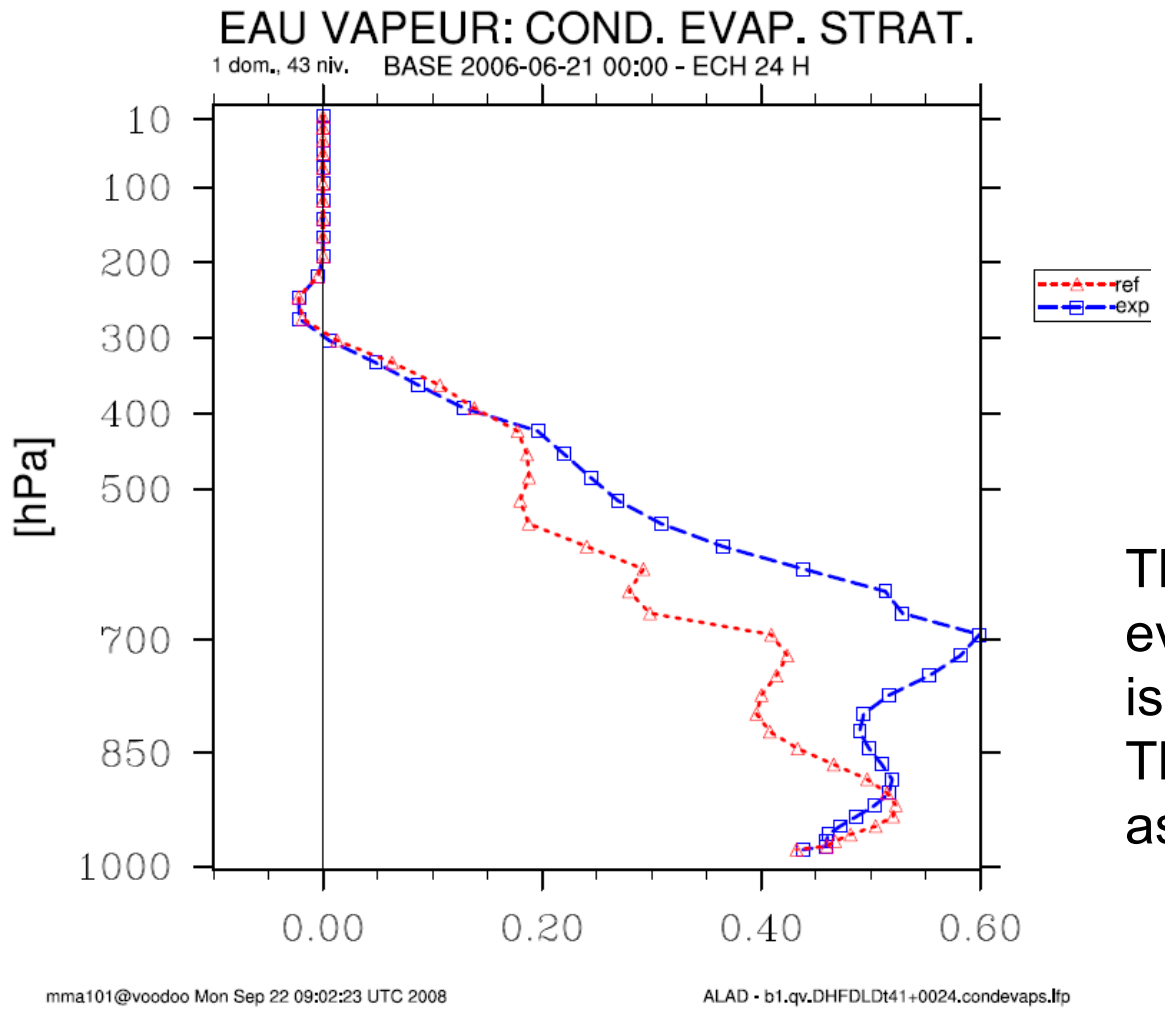
Because there was a cloud there in a previous time-step and that the precipitations it generated did not finish falling (if not evaporating)

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)

Geometry of clouds and rain (4/4)



Two options are currently coded:

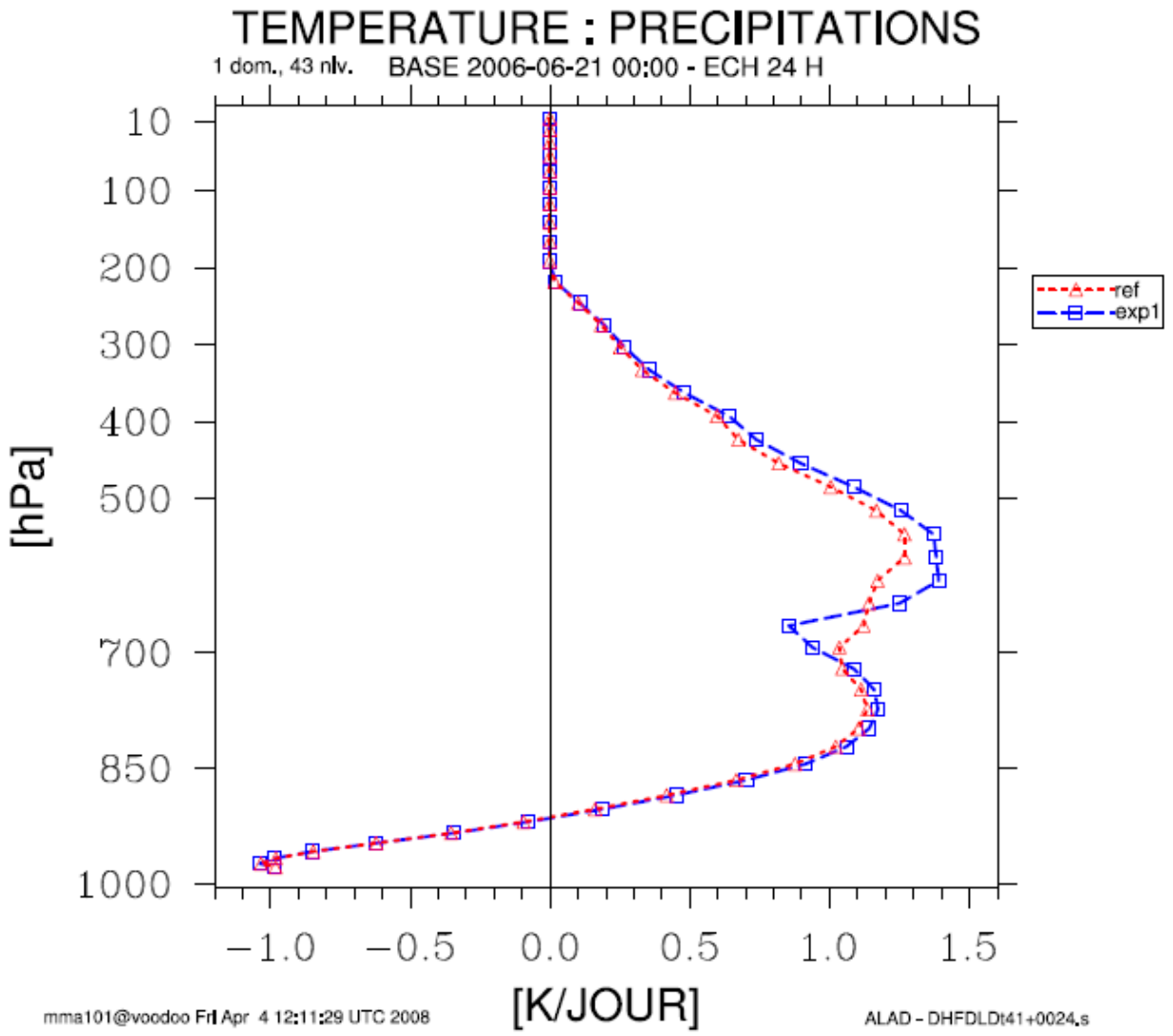
- Maximum overlap of clouds (more realistic) – reference;
-Random overlap of clouds – exp 1

The impact (here shown for evaporation of falling species) is not negligible.
The problem cannot be treated as linear.

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°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)**

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.
- The ‘memory’ aspect of 3MT will be further enhanced if the RK solution for the ‘resolved adjustment’ works well (ongoing work with SMHI).
- Given the novelty of 3MT, the remaining of the ALARO-0 design is ***currently (see previous talk)*** 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, planned elsewhere).