Regional Cooperation for
Limited Area Modeling in Central Europe

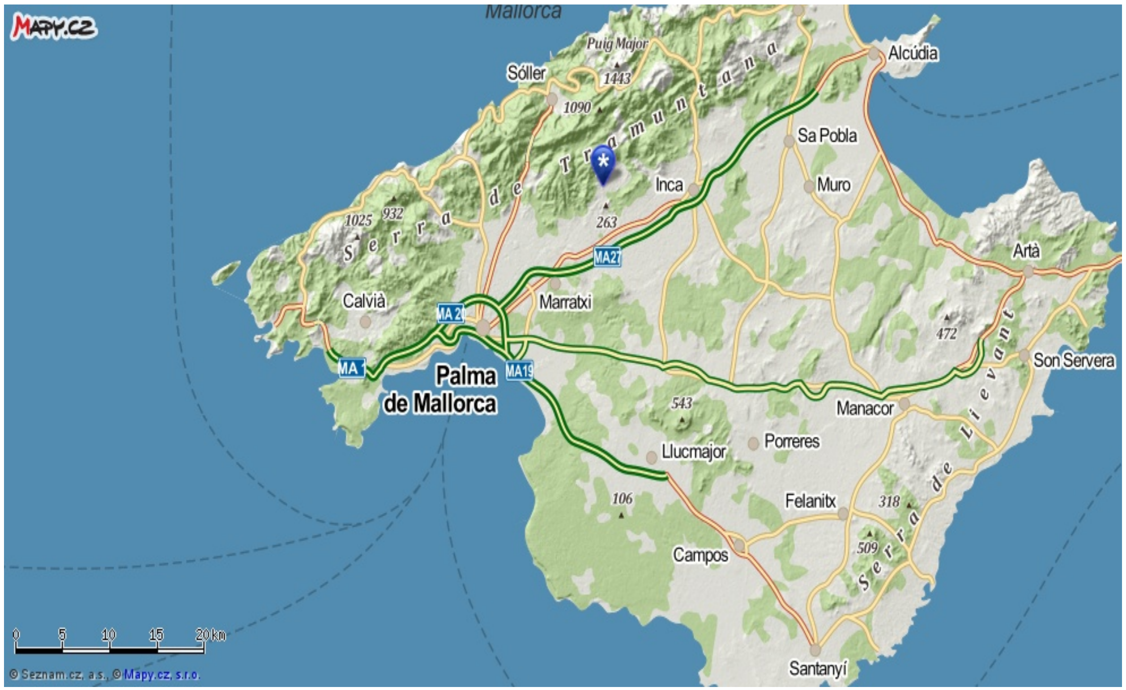
LACE
nwp central europe

ALARO-0 baseline: status and latest results on convective diurnal cycle

ALADIN/HIRLAM Workshop, 15-19 April 2013

DHMZ OMSZ SHMU ZAMG ROMANIA ANM

What is ALARO ?



1) Small town at Mallorca

2) Configuration of the ALADIN NWP System for model physics suited for multi-scale, including prognostic moist deep convection, but not only that.

ALARO-0 short recall

- Enhancement of the model physics:
  - New governing equations for moist physics (barycentric system);
  - Going prognostic; consistency and unification is a goal;
  - Keep modular while having consistent interface to the model dynamics;
  - Tackle the “grey-zone” or “partly resolved” moist deep convection problem;
  - Keep multi-scale (physics works correctly also at coarser resolutions, not exclusively for resolutions around 5 km).
- Nowadays – ALARO applications running at grey zone scales;
- December 2012 – introduction of last improvements in the convection scheme 3MT;
- Declaration of the **ALARO-0 baseline**.

Problem of diurnal cycle

- Known weakness of parameterized moist deep convection:

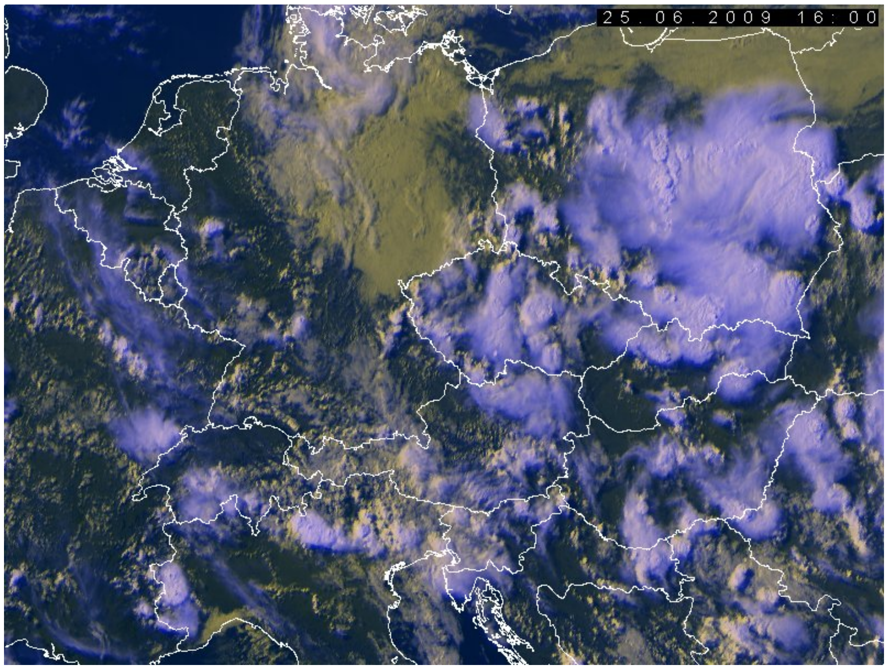
  it starts couple of hours too early.

- This is true also for a prognostic scheme like 3MT in its “standard” version (prognostic velocities and area fractions).
- A study: can we improve the diurnal cycle phase and intensity of convection by introducing more “memory” and “flexibility”?

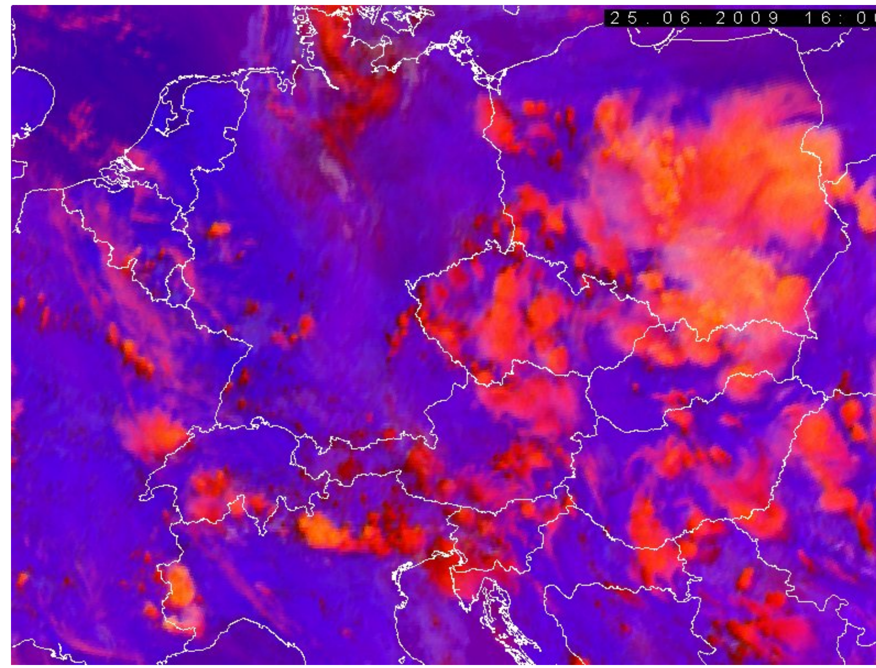
Set-up of the study

- Period June-July 2009 in Central Europe with very strong convective activity every day;
- Well pronounced daily cycle of convection observed from 24 June to 4 July => period of 11 days;
- Hourly precipitation amounts were extracted from the merged observations from radars and gauges over territory of Czech Republic and surroundings.

Illustration of the situation (25 June 2009)

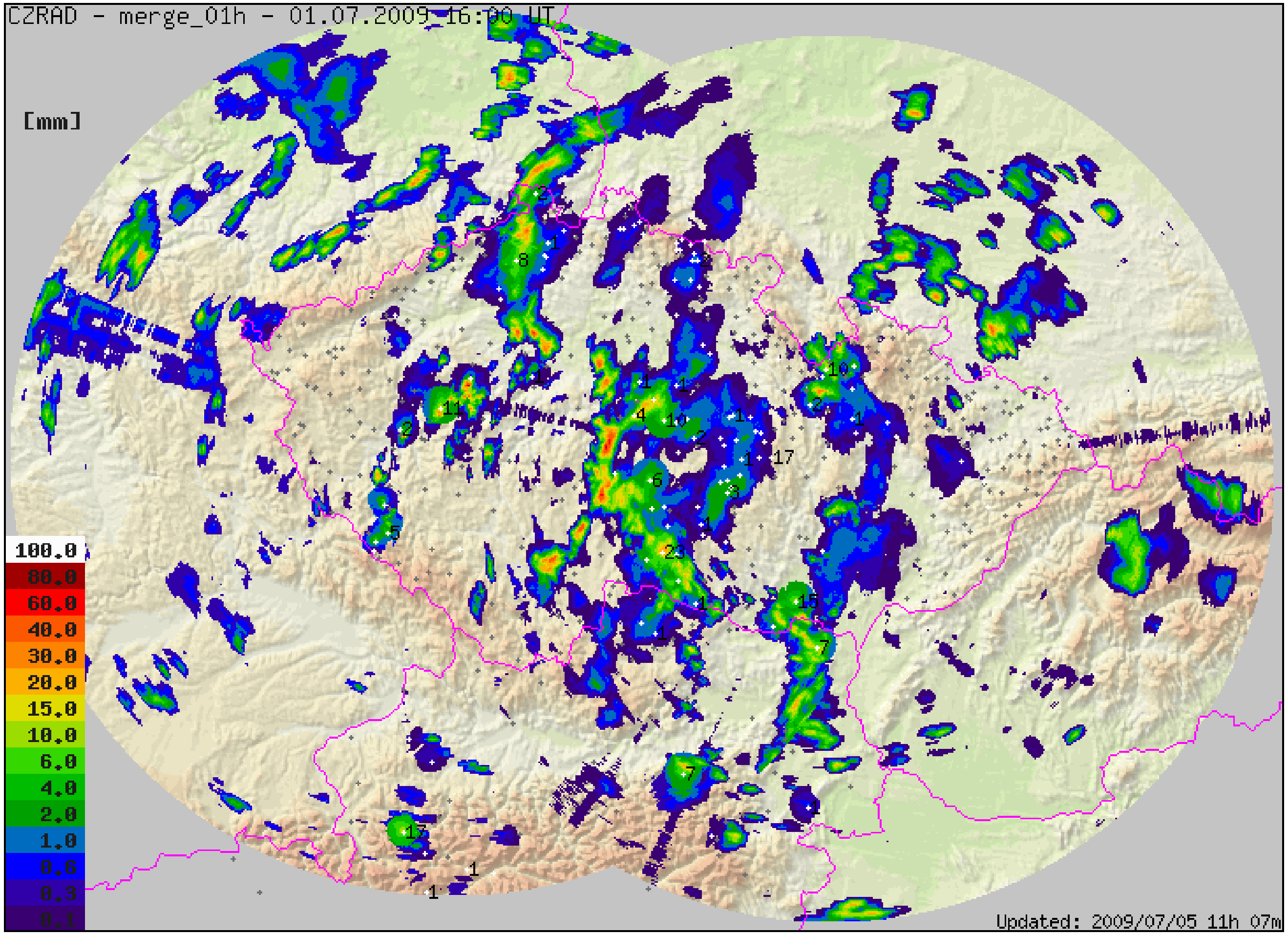


Visible-Infrared



"Storm" – to show high climbing clouds; yellowish color indicates important amount of ice.

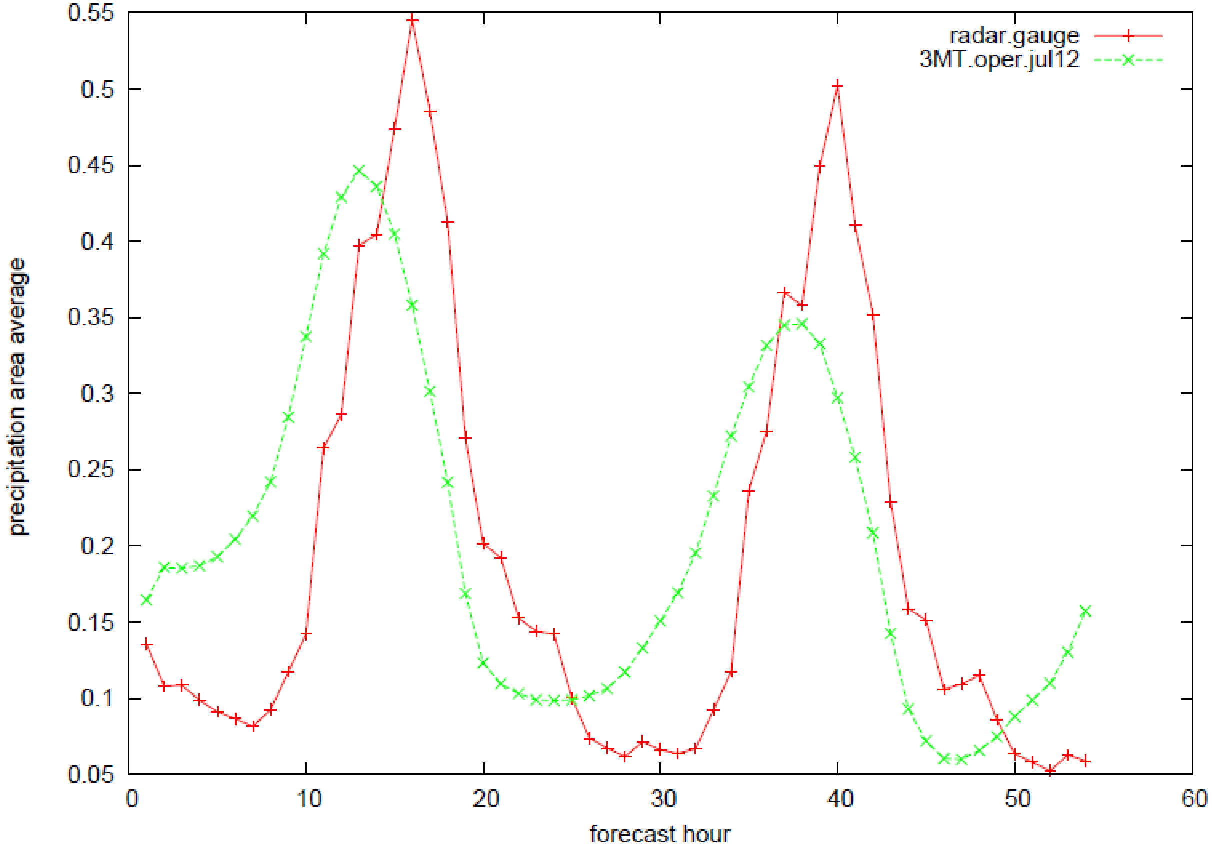
Precipitation observations -area



Demonstration of the problem (1)

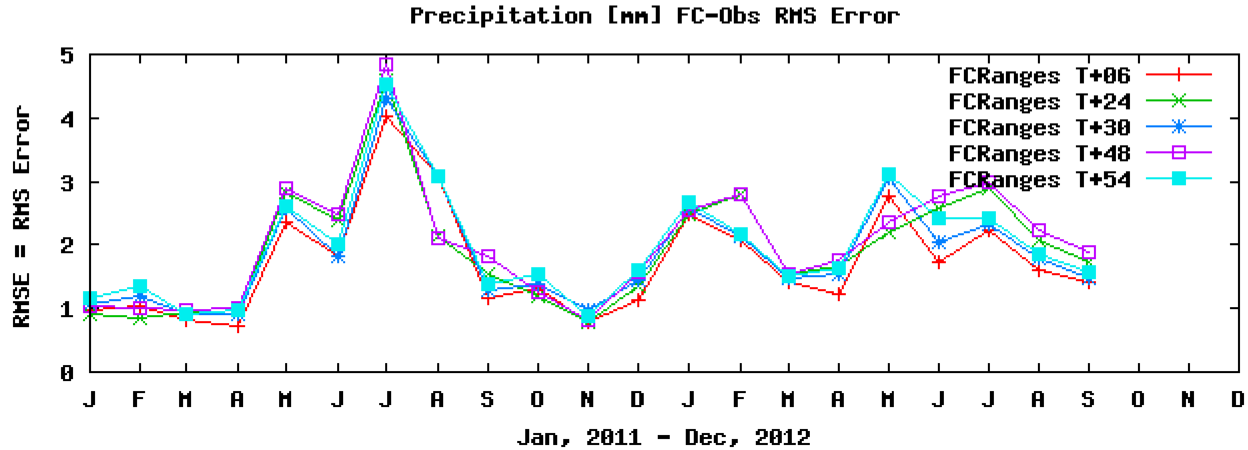
11 realizations' average of mean hourly precipitation over the area

- Model starts rain ear
- Early decay as well;
- Too much precipitati
in the morning;
- Lack of precipitation
in the late afternoon
and in the evening.

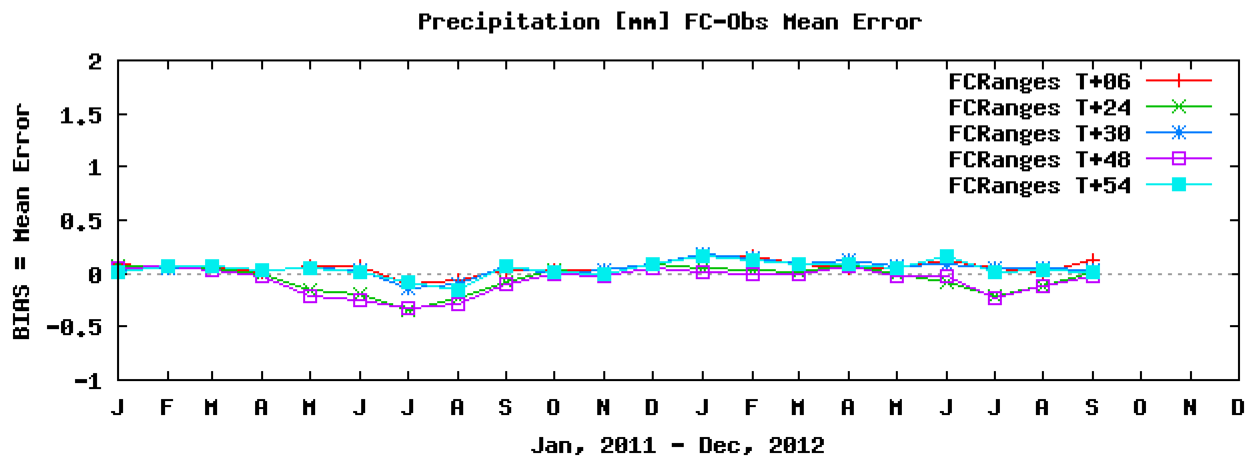


Demonstration of the problem (2)

Verification scores – monthly mean over Central Europe last two years



- Negative bias in summer for the forecast range 24h (rainfall sum between 18h and 24h UTC; analysis: 0h UTC.
- Confirmation of the diurnal cycle problem.



Proposal (1)

- In the scheme, entrainment rate also depends on buoyancy (*Ib*):

$$Ent = f(\lambda_x, \lambda_n, \phi - \phi_b) \qquad \lambda_n = \frac{1}{1/E_n + \alpha I_b} \qquad \lambda_x = \frac{1}{1/E_x + \alpha I_b}$$

$$I_b = \int_{\phi_s}^{\phi} (h_{nea} - \bar{h}) d\phi$$

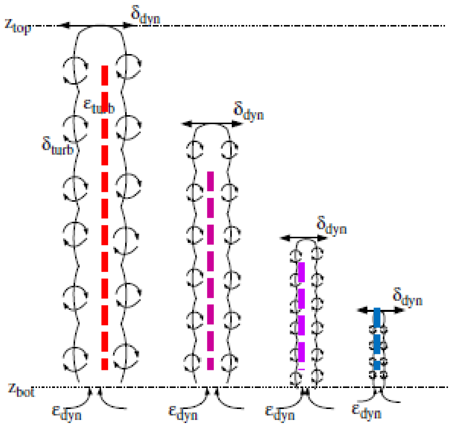
En, *Ex* and *α* are tuning parameters.

- Parameter *α* is proposed to depend on relative humidity of environment (idea of P. Bechtold applied to our case) - closer to saturation => lower entrainment:

$$\alpha^* = \alpha \frac{\int_{\phi_s}^{\phi} \overline{R_h} (h_{nea} - \bar{h}) d\phi}{I_b}$$

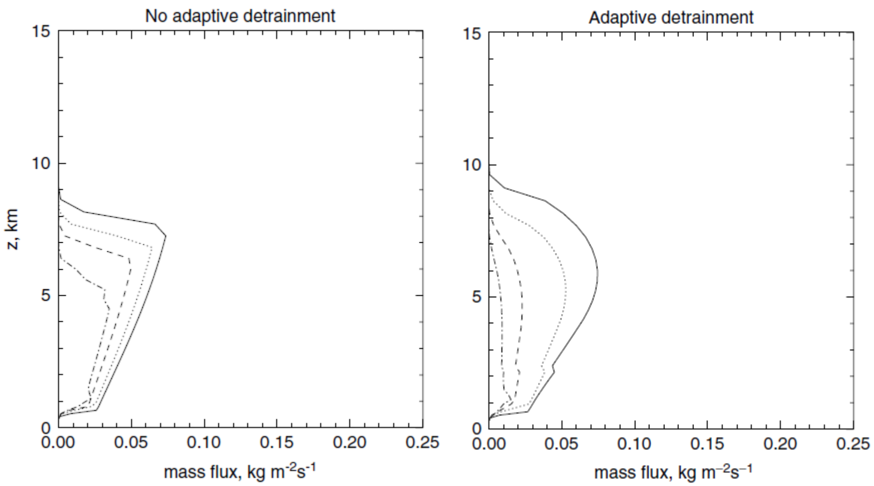
Proposal (2)

- Less entraining clouds get higher and are warmer; in the scheme, the equivalent cloud profile is computed by "reducing" layers' thickness to go up and relaxing moist static energy to non-entraining case via warmer conditions.



$$\Delta\phi' = \Delta\phi/\{1 + \nu\chi max(0, h_{nea} - h_u)\}$$

- Tuning parameter ν determines height and shape of profiles, similarly to illustration taken from Derbyshire et al., 2011.
- Left picture: as if $\nu=0$;
- Right: as if tuned value of ν.



Proposal (2)’

- In the proposal, tuning parameter ν is made dependent on previous precipitation activity – evaporation:

$$\nu = z\alpha/(z+\alpha) \qquad\qquad z = \frac{z^{t-\Delta t} + (\kappa E + \nu_{min})\,\Delta t/\tau}{1+\Delta t/\tau}$$

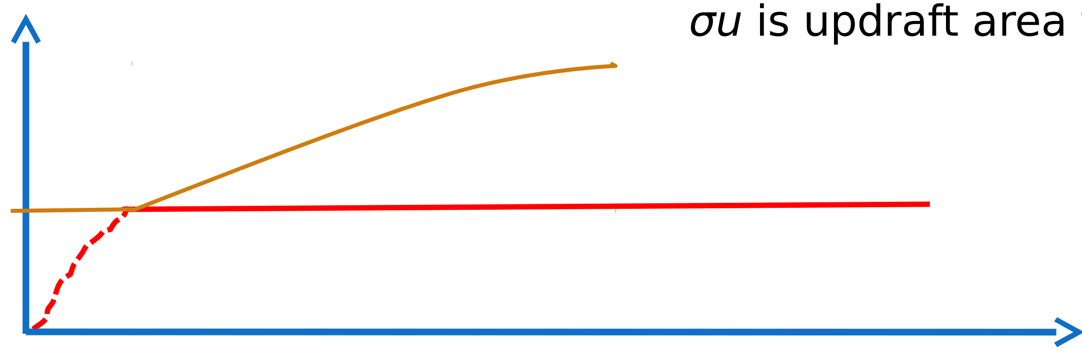
- Parameters z and α have the same physical dimension – inverse of geopotential.
- With κ and τ being tuning parameters, E is evaporation.
- More rain => more evaporation => higher clouds => convection activity is maintained longer.
- This proposal results from various attempts to cope with the entrainment dilemma (Mapes and Neale, 2011); the combination with α avoids too big values of ν.

Proposal (3)

- Closure, formulated in terms of moisture convergence, can have a modulation of a CAPE type (Luc Gerard).
- Arriving moisture may be either all consumed in condensation (CVGQ closure only), or it is partly consumed, partly it loads moist static energy reservoir for a later “use” (mixed type of closure).

$$CVGQ' = CVGQ * MIN\left(1, \mu\, \sigma_u(CVGQ')\right)$$

σu is updraft area fraction



Tuning parameters

- Entrainment parameters [all in s2m-2]:

  $\alpha = 4.5E\text{-}05$; $En = 5.E\text{-}06$; $Ex = 1.6E\text{-}04$;

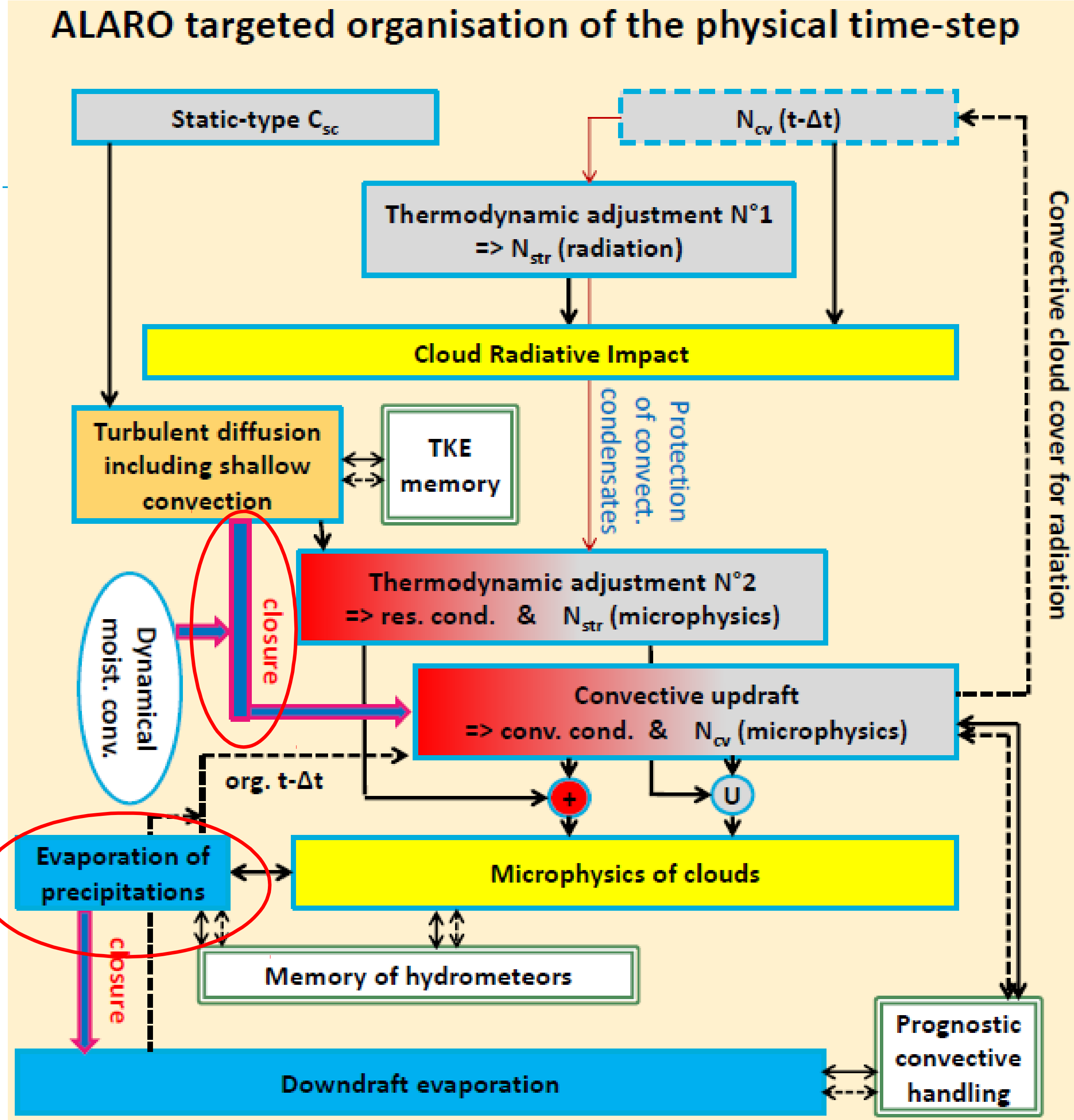
- Evaporation “memory” time-scale:

  $\tau = 1/\Omega$;

- Minimum parameter $\nu = 0$;
- Tuning parameter $\kappa = 0.18$ [s3kg-1];
- Closure tuning parameter $\mu = 15$.

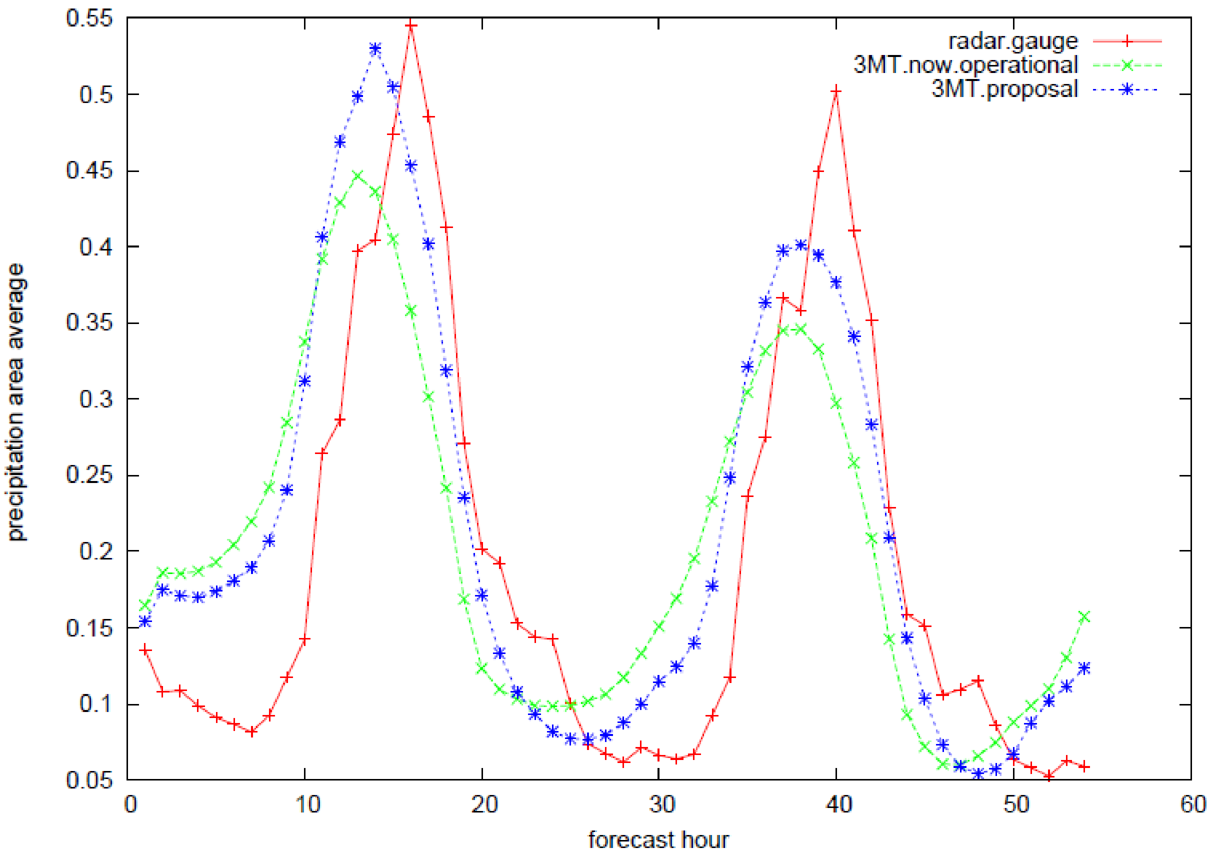
Organization of the physics' time-step

3 cloud covers;
2 types of condensation;
2 types of evaporation;
1 radiation comp.;
1 microphysics comp.;
Implicit moisture PDF in adjustment;
Flexible closure.

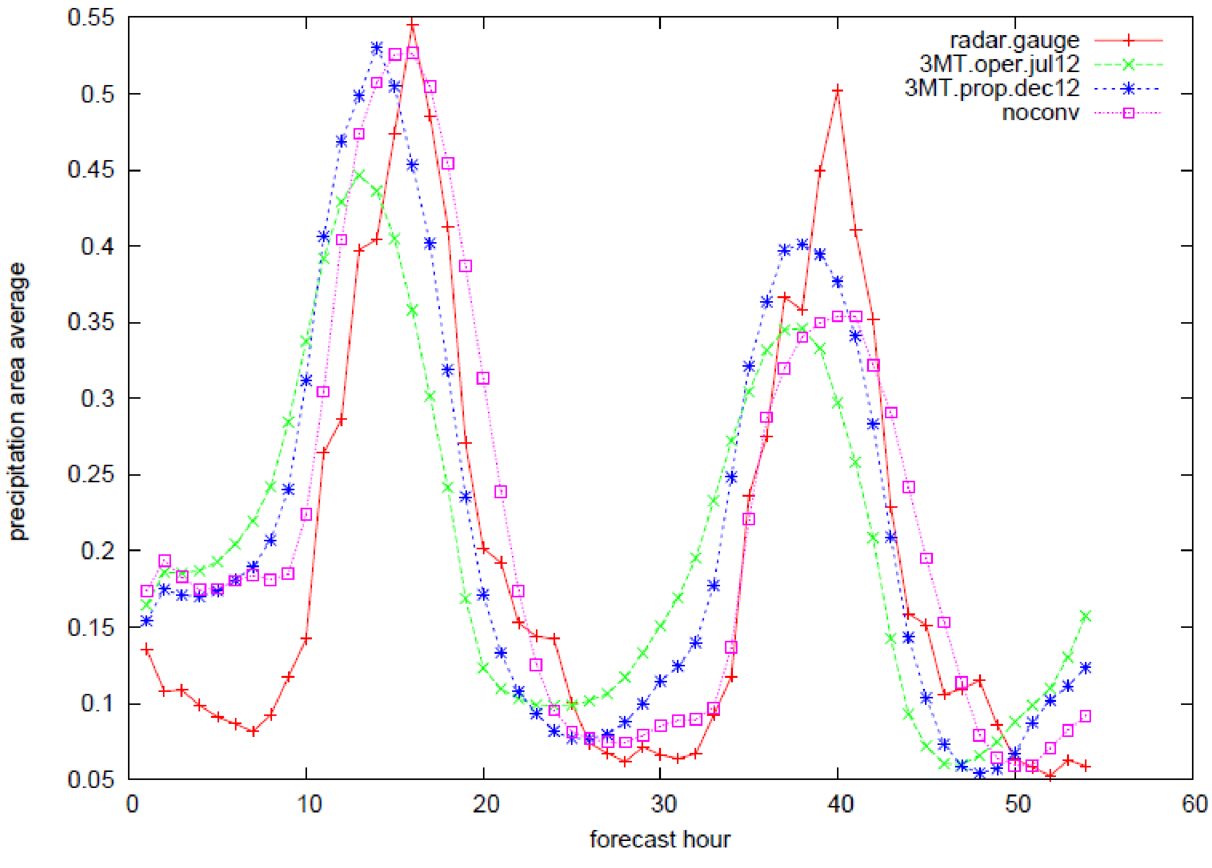


Impact on diurnal cycle

11 realizations' average of mean hourly precipitation over the area



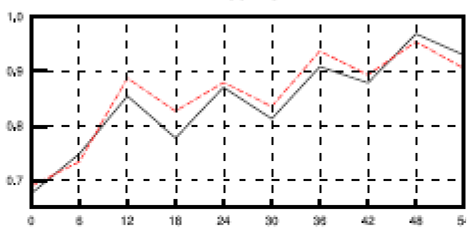
Moist deep parameterization activated or not (1)



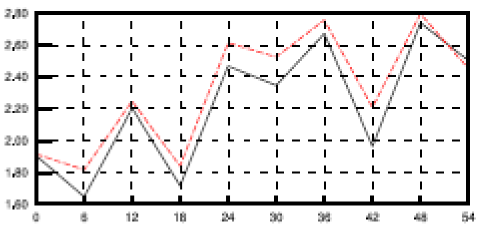
Average of 11 realisations. Even at 4.7km, runs without moist deep convection have good timing of the diurnal cycle, but …

Moist deep parameterization activated or not (2)

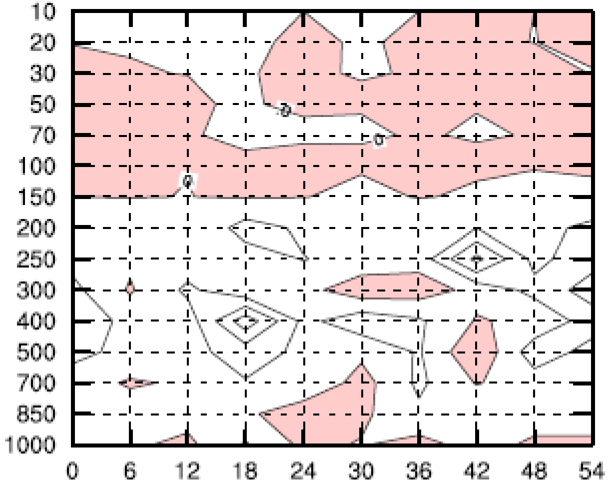
Model scores over 15 days; “no convection” is red dash



T-700 hPa STDE



W-700 hPa STDE

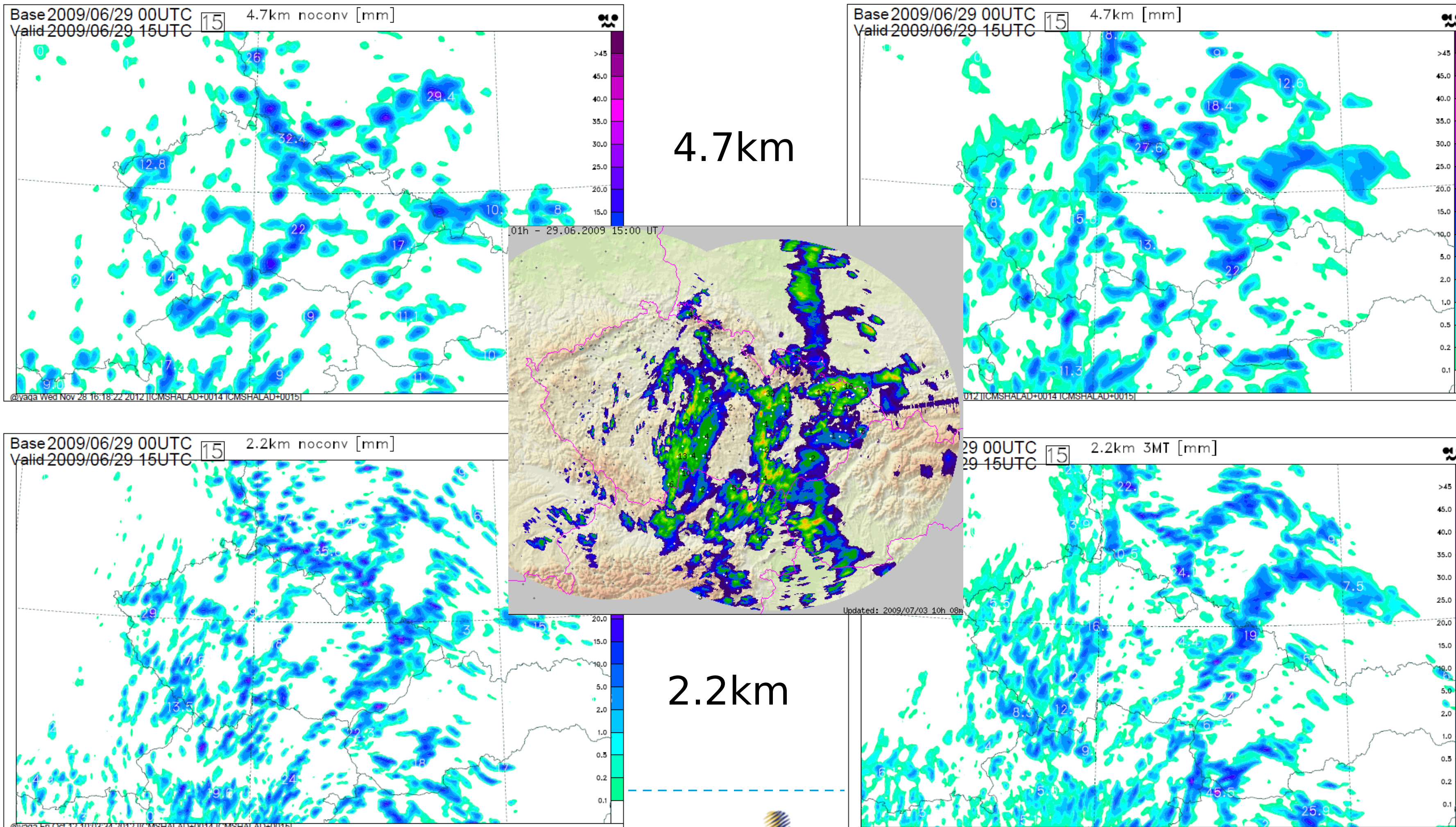


RH STDE average profile:
White area indicate worse score for the “non-convection” case.

It is visible for evening hours of culminating convection.

Moist deep parameterization activated or not (3)

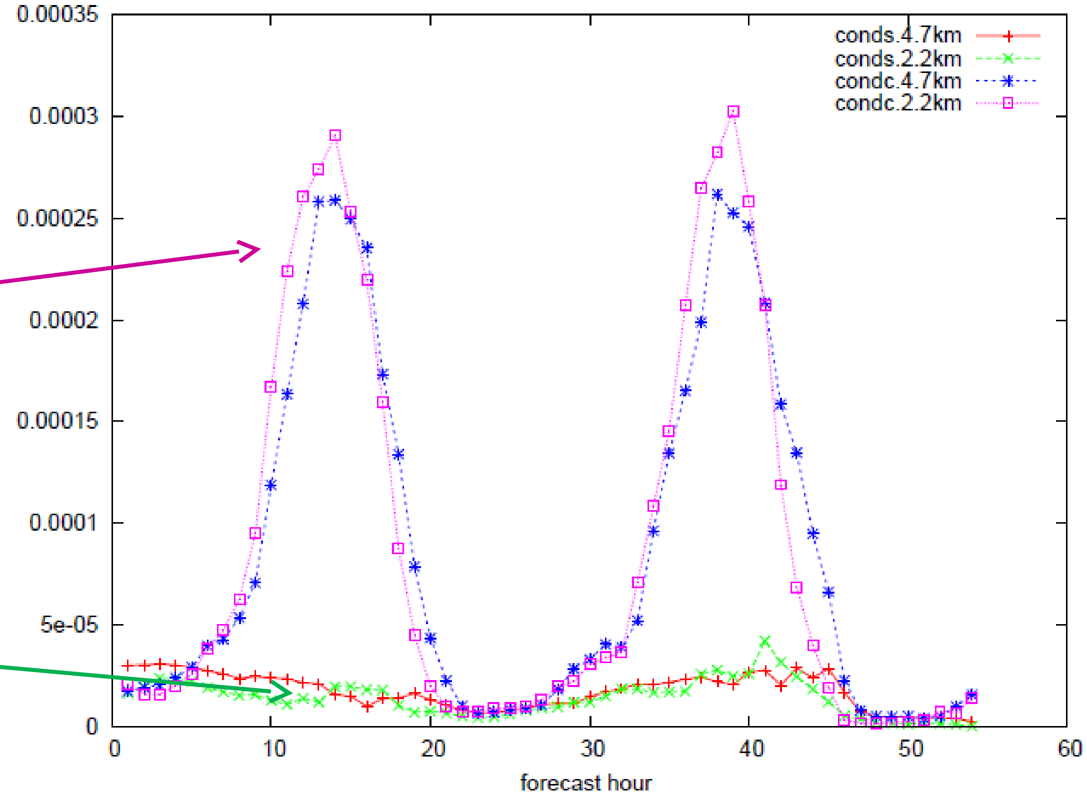
No convection | Convection



Diurnal cycle of condensation

convective

resolved



Vertically integrated condensation : “convective” and “resolved” parts. Even at 2.2km the convection scheme is still quite active – we do not know yet whether our changes of the closure would improve convergence to “all resolved” solution at higher resolutions.

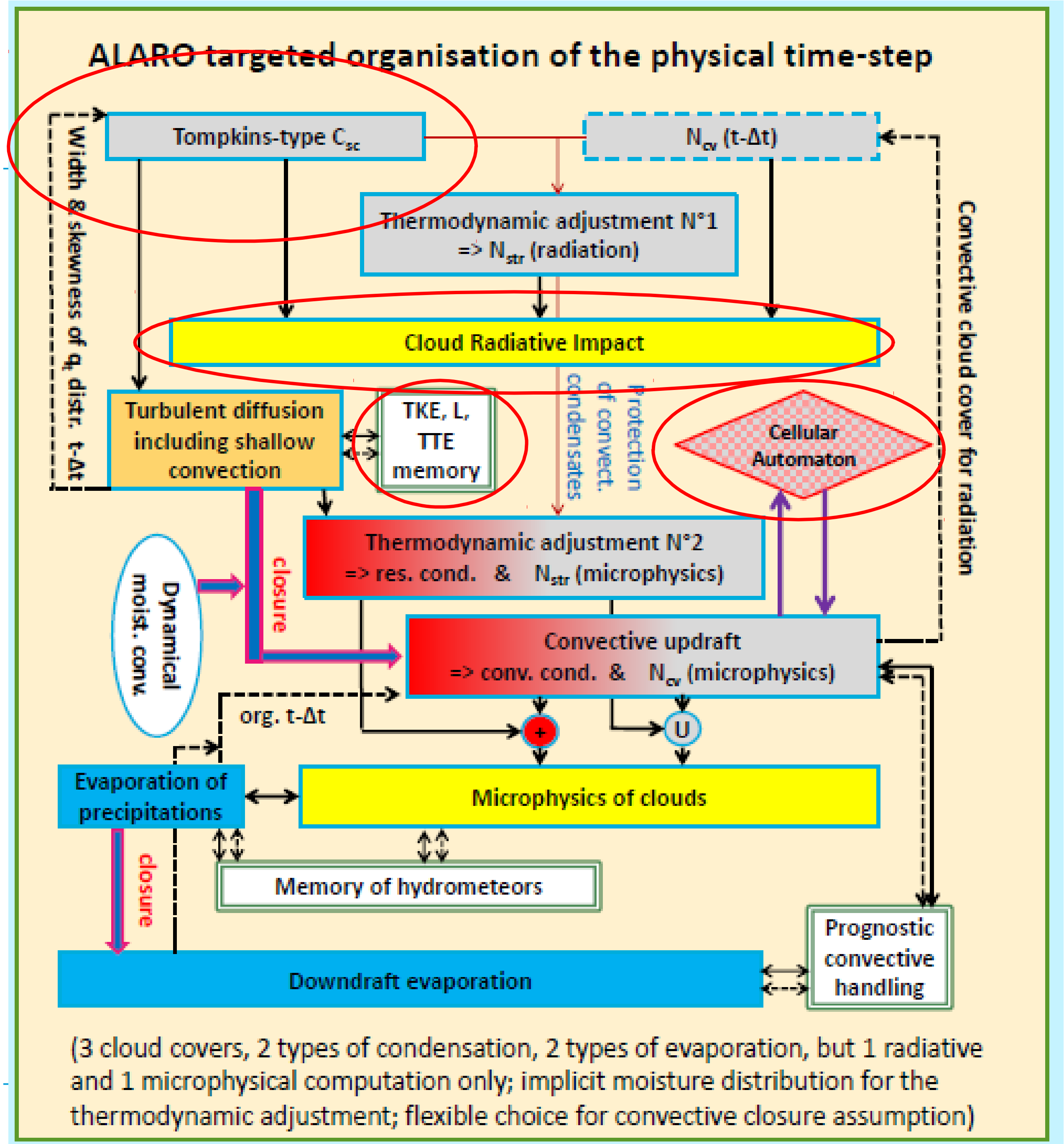
Outlook – current/future developments

- Tompkin's type shallow convection cloudiness;

Prognostic mixing length nd prognostic Total urbulent Energy;

- Cellular automaton.

Radiation scheme with ntermittency.



Conclusions

- To obey 3 constraints for intense moist deep convection:
  - Multi-scale performance;
  - Not to have grey-zone syndromes;
  - Represent well the diurnal cycle;

  is a difficult task and requires compromises.
- At high resolution, without the moist deep convection parameterization, we get a correct diurnal cycle, but not necessarily good structures and scores.
- In the 3MT scheme, total condensation is of the same amplitude like in the case without a convective parameterization. 3MT has the advantage of better precipitation organization, but the weakness is the still too early onset, despite recent progress via memory of adaptive detrainment and mixed closure.
- Ongoing work, in parallel and in interaction with other improvements of the physics time-step, see Neva's talk.