3MT convection: core concepts.

Jean-Marcel Piriou, Luc Gerard, Jean-François Geleyn,
Météo-France, IRM, CHMI.

Radostovice Training Course, 2007-03-29.

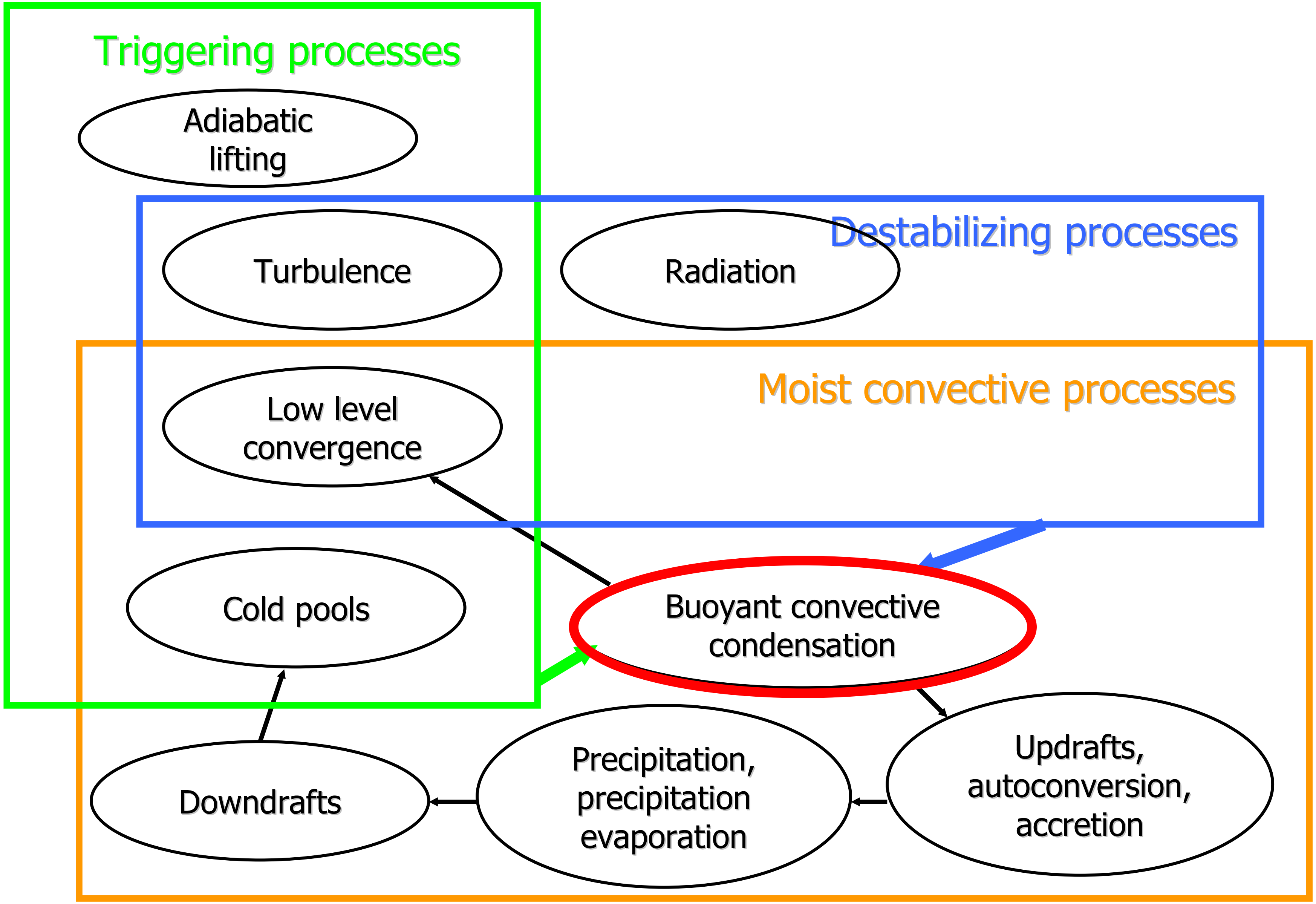
Summarizing problems

1. Phase-lead of the predicted diurnal cycle of convection (and thus too short transitions from shallow to deep).

2. Underestimated sensitivity of convection to mid-tropospheric humidity.

3. Causality problems (even more true at high resolution ~5 km): what is non-convective? What part of the resolved circulation is « already » convective? How to define the forcer and the forced processes?

Causality; PhD work (2005)



From Yanai (1973) equations to the MT equation set.

Yanai (1973) equations

(Q1c: réchauffement convectif, Q2c: assèchement convectif fois L)

$$\begin{cases} Q_{1c} = L\,c_N - \dfrac{\partial}{\partial p}\overline{\omega' s'} \\ Q_{2c} = L\,c_N + L\,\dfrac{\partial}{\partial p}\overline{\omega' q'} \end{cases}$$

Transport

Condensation nette

$$\begin{cases} \dfrac{\partial \sigma}{\partial t} = 0 = -D + E - \dfrac{\partial \omega^*}{\partial p} & \text{(masse)} \\ \dfrac{\partial \sigma s}{\partial t} = 0 = -D s_D + E\overline{s} - \dfrac{\partial \omega^* s}{\partial p} + L\,c & \text{(chaleur)} \\ \dfrac{\partial \sigma q}{\partial t} = 0 = -D q_D + E\overline{q} - \dfrac{\partial \omega^* q}{\partial p} - c & \text{(vapeur d'eau)} \\ \dfrac{\partial \sigma l}{\partial t} = 0 = -D l_D - \dfrac{\partial \omega^* l}{\partial p} + c - r & \text{(eau liquide)} \end{cases}$$

Bilan nuageux stationnarisé

Yanai (1973):

$$\begin{cases} Q_{1c} = \omega^* \dfrac{\partial \overline{s}}{\partial p} + D\,(s_D - \overline{s} - L\,l_D) \\ Q_{2c} = -L\,\omega^* \dfrac{\partial \overline{q}}{\partial p} - L\,D\,(q_D - \overline{q} + l_D) \end{cases}$$

Détraînement à échelle résolue

Pseudo-subsidence

GATE (1974), Arakawa-Schubert (1974), Bougeault (1985), Tiedtke (1989), Fritsch-Chappell (1980), Kain-Fritsch (1990), KF-Bechtold (2001), …

Microphysics and Transport (MT) equations

(Q1c: réchauffement convectif, Q2c: assèchement convectif fois L)

In the MT approach:

No need any more to parameterize mean detrainment at resolved scale.

Quality of the scheme moved to that of its microphysics.

Relax cloud stationnarity assumption.

M & T couplés:

$$Q_{2c} = -L\,\omega^*\,(\hat{C}_{CF} + \hat{C}_{CNF} - \hat{E}_{CN}) - L\,E_{CP} + L\,\frac{\partial}{\partial p}\omega^*(q - \overline{q})$$

Microphysics and Transport (MT) equations

CVP

CVNP

CV sèche

Continuité de la microphys.

Microphys.

Vit. vert., ferm.

MT-CCF:

$$
\begin{cases}
Q_{1c} = -L\,\omega^*\,(\hat{C}_{CF} + \hat{C}_{CNF} - \hat{E}_{CN}) - L\,E_{CP} - P - \dfrac{\partial}{\partial p}\omega^*(s - \overline{s}) \\
Q_{2c} = -L\,\omega^*\,(\hat{C}_{CF} + \hat{C}_{CNF} - \hat{E}_{CN}) - L\,E_{CP} + L\,\dfrac{\partial}{\partial p}\omega^*(q - \overline{q})
\end{cases}
$$

Air humide, CVP
Yanai (1973)
Bougeault (1985)

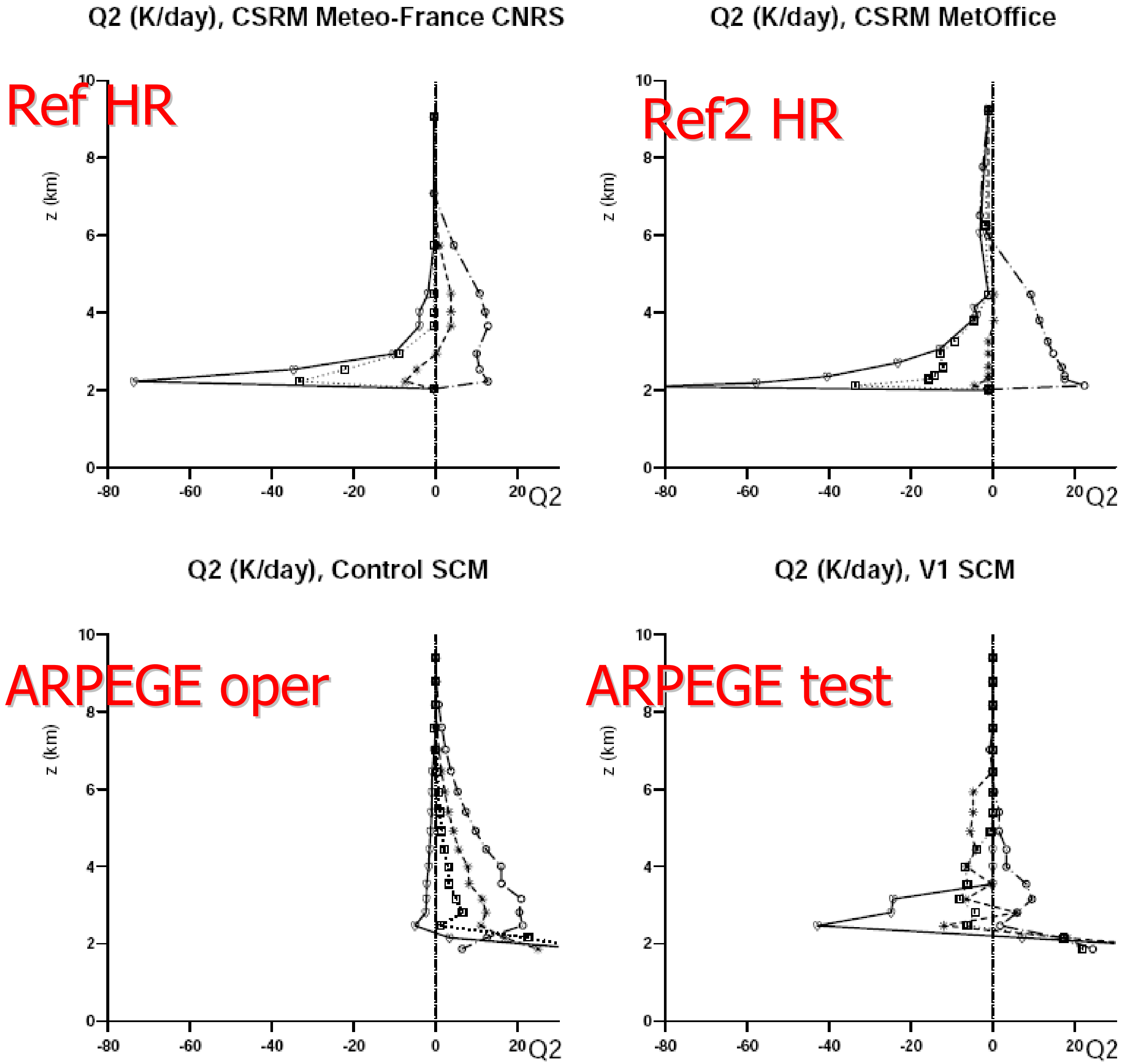
Simpl. de la microphys.

Complexif. de la microphys.

Synergie méthodologique

CRM, LES

MT results: sensitivity to mid-tropospheric humidity



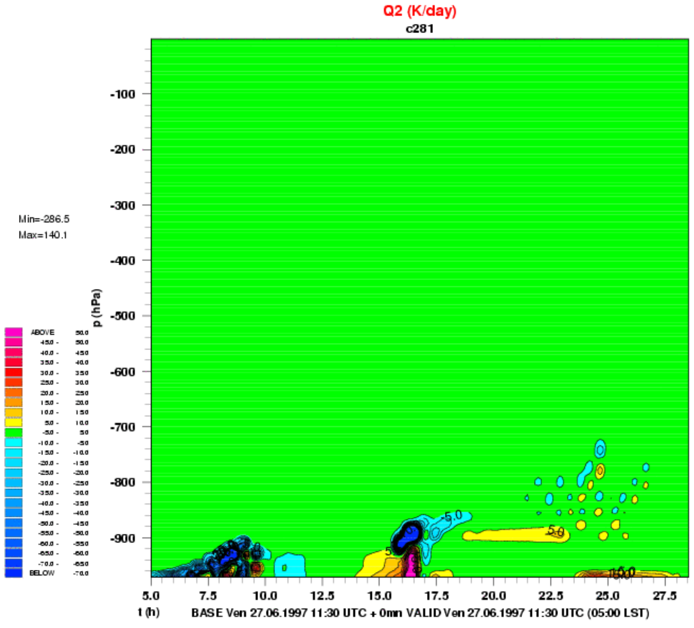
J.-M. Piriou and J.-L. Redelsperger and J.-F. Geleyn and J.-P. Lafore and F. Guichard

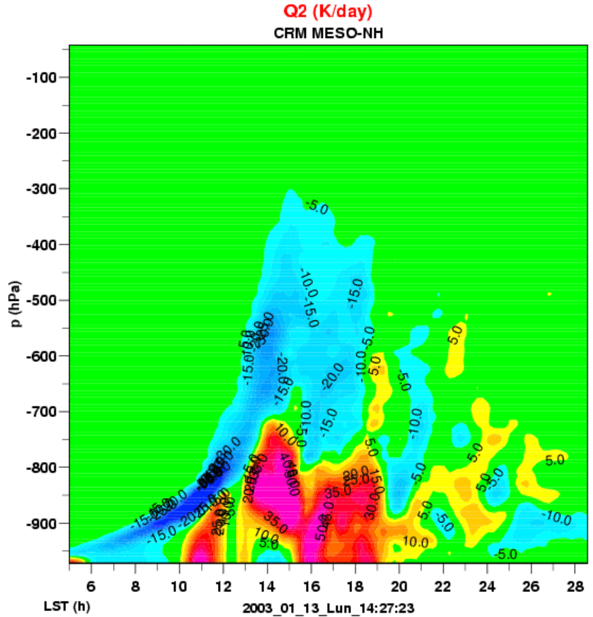
An approach for convective parameterization with memory, in separating microphysics and transport in grid-scale equations

J. Atmos. Sci. 2007, accepted

MT results: diurnal cycle of deep convection

ARPEGE
oper





CRM
MNH

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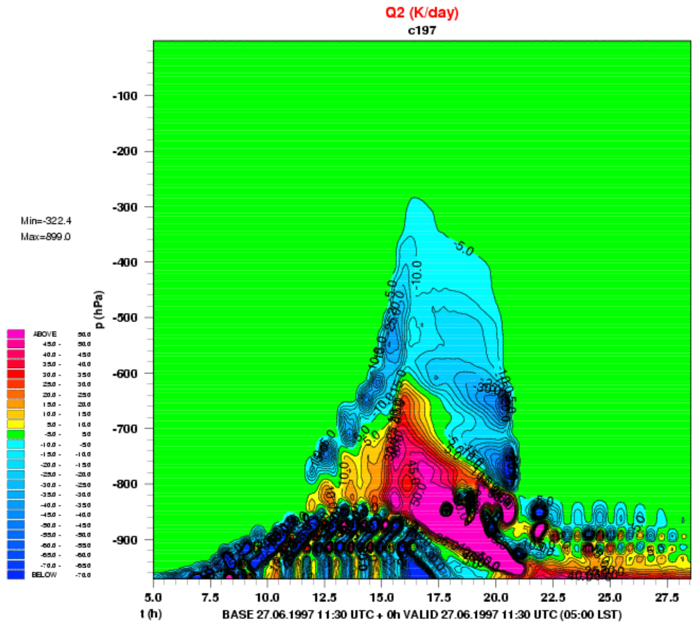

ARPEGE
V1 + entr.
historique

MT approach for convective param. Piriou (2005) 1/3

- **Summarizing results:**
  - Results similar to control schemes in wet situations (GATE, TOGA-COARE).
  - Better in drier and more difficult situations: sensitivity to humidity (EUROCS SH), diurnal cycle of deep convection over land (EUROCS DCL).
  - All above results got with a single version of code, and same tuning parameters → more general.

MT approach for convective param. Piriou (2005) 2/3

- **Clean separation between microphysics and transport.** The parameterization exercise is partly moved from detrainment to microphysics.
- Relax the cloud stationnary assumption.
- Buoyant condensation at the heart of the parameterization system.
- Can deal with dry, non-precipitating convection and precipitating convection.
- Can share microphysics with a CSRM or LES.

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MT approach for convective param. Piriou (2005) 3/3

- **Some limitations in this first prototype:**
  - Still crude microphysics (diagnostic).
  - Constant and « small » updraft fraction.
  - Question of dependency to mesh size not addressed.

➔ Welcome to Gerard and Geleyn collaboration!

2MT: Multiscale Microphysics and Transport

L. Gerard and J.-F. Geleyn:

- Pronostic microphysics (cloud condensates, precipitations).
- Prognostic area fraction (updraft / downdraft).
- Prognostic vertical velocity.
- Microphysical cascade inside time-step.

L. Gerard and J.-F. Geleyn, « Evolution of a subgrid deep convection parameterization in a limited area model with increasing resolution », (QJRMS 2005)

L. Gerard, « An integrated package for subgrid convection, clouds and precipitation compatible with the meso-gamma scales » (QJRMS 2007, accepted)

2MT: Multiscale Microphysics and Transport

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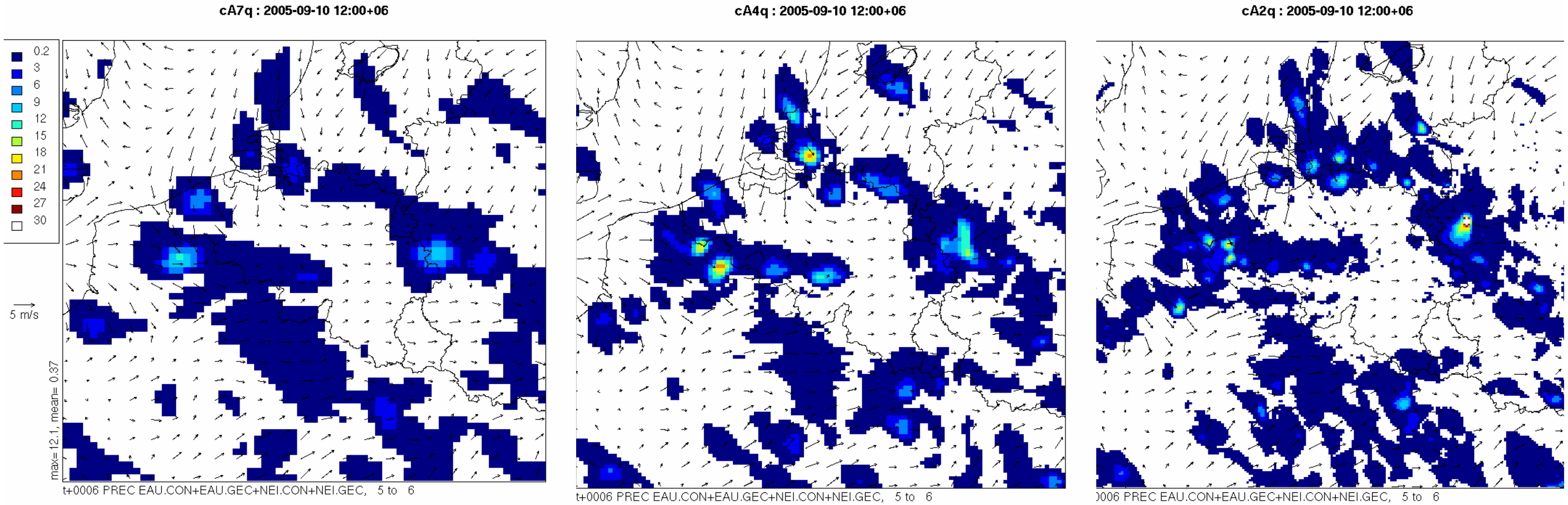

7 km 4 km 2 km

Cas du 10/09/2005. Cumul de précipitation en 1h (mm). Source Gerard (QJRMS 2007).

- MT + additional prognostic variables + cascading microphysics ➔ relevant for « grey zone » ➔ 2MT.
- Modular code developed in Prague-Bruxelles ➔ 3MT (Modular Multiscale Microphysics and Transport) ➔ ALARO-0, oper. ARPEGE ALADIN 2008.

Fin