Subgrid scale convection for ARPEGE and ALADIN: 3MT status.

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Subgrid-scale convection: 3MT - Summary

1. Why 3MT? Motivation.
2. What has been done? Results. (2004 → today).
3. Under progress (short term → 2008).
4. Long term (2009 →).

Why 3MT?
Motivation.

Why 3MT? Current (2004 a nd onwards) 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? « Grey zone » challenge

Yang and Slingo (2001), Guichard et al. (2004), Derbyshire et al. (2004), Mapes (1998).

What has been done.

3MT – What has been done – Overview

Since 2004, collective work ALADIN community:

- A new equation frame for convective parameterization, separating Microphysics and Transport for SGS convection (MT).
- A quite extensive prognostic equation set (area fraction, vertical velocity, water species).
- A cascading approach for intra-time-step microphysics (2MT) Multiscale M T.
- A new common code Modular Multiscale M T (3MT).
- A new prognostic microphysics (toulousian codes, APLMPHYS).

Yanai (1973) equations

(Q1c: convective heating, Q2c: L * convective drying)

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

Transport

Net condensation

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

Stationn. cloud mass budget

Yanai (1973):

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

Detrainment at resolved scale

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: convective heating, Q2c: L * convective drying)

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.

MT – What has been done – Results

ARPEG
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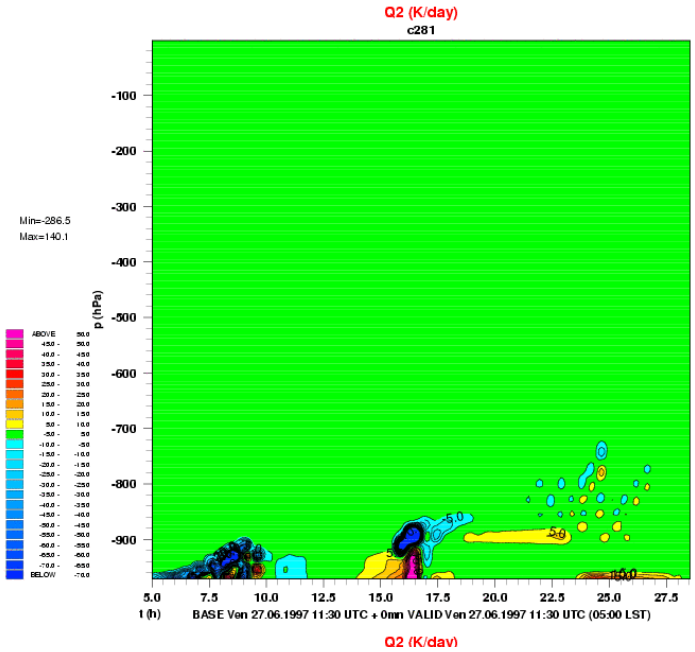
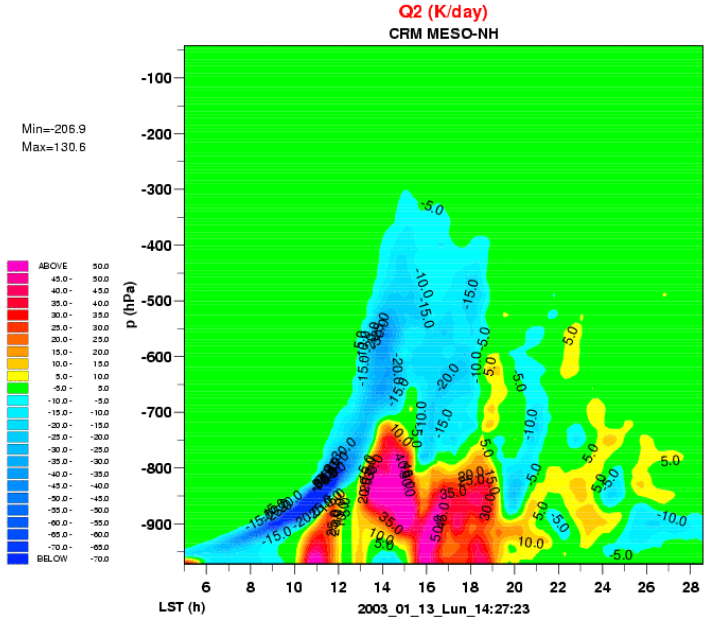
oper





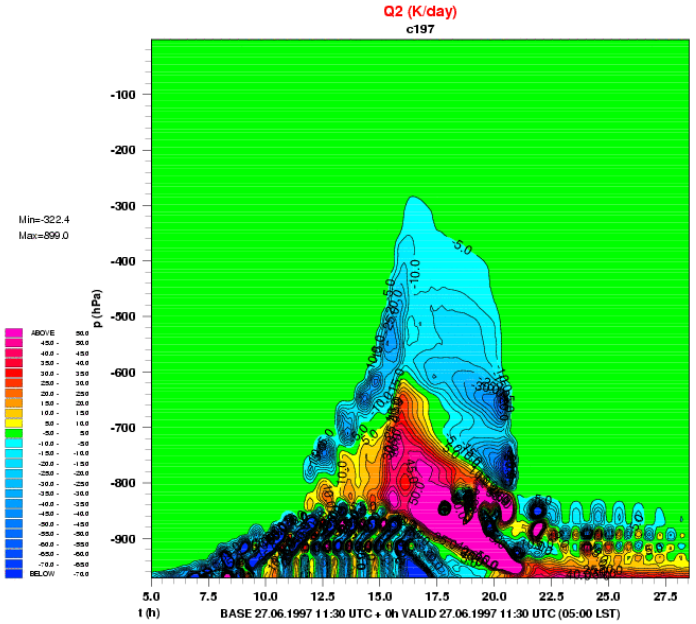
CRM
MNH

Convective drying simulated by 3 models

Source: 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

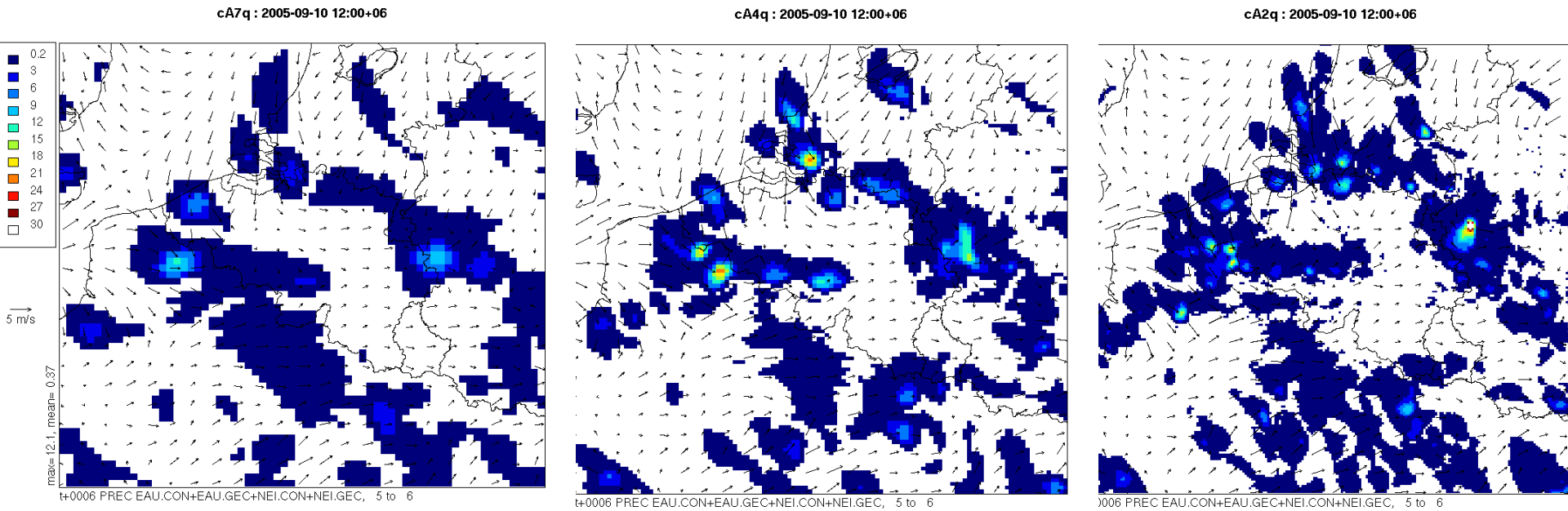
J. Atmos. Sci. 2007, accepted



ARPEGE
MT, prog.
entr

2MT – What has been done – Results

2MT: Multiscale Microphysics and Transport.



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.

2MT – What has been done – Publications

J.-M. Piriou (2005), PhD thesis, « MT equations, causality, sensitivity to humidity, diurnal cycle of convection ».

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

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.

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

3MT – What has been done – Results

- A modular code was developped (3MT), compatible with the Catry et al. 2007 equations.

What we intend to do in the short term (certainties).

3MT – Short term

- Validate and tune ➔ 1D tests, 3D tests, from strong events to stratiform drizzle, false alarms…
- Objective: 3MT in operations in ARPEGE and ALADIN in 2008.
- Validation and development should be done based on a common 3MT code version ➔ synergy. This implies future 3MT code phasings.
- Interface 3MT with DDH, and DDH with Catry et al. 2007 equations.

3MT – Short term (continued)

- **Extend 3MT toward dry and shallow convection:**
  - Introduce adiabatic ascent mode –as in Piriou et al. (2007)-, change vertical wind equation.
  - 3MT dry and shallow ➔ unified treatment of all convective types, better transitions between cloud types.
  - 1D tests: BOMEX, EUROCS diurnal cycle of shallow cumulus. 3D tests.
  - Work in the short term, results in the medium term?!

What we hope to do in the long term (some uncertainties).

3MT – Long term

- Long term: 2009 and onwards.
- As long as 3MT works for dry, shallow and deep convection in ARPEGE and ALADIN ➔ tests in AROME, for precipitating SGS clouds (Cu & Sc).
- FP-3MT: Fully-Prognostic version of 3MT, intermediate between convective parameterizations and so called « superparameterizations ».

3MT – Conclusion, perspectives

3MT: new concept and code frame, some results 1D and 3D, articles published.

In the short term (2008) forecasters may expect from 3MT:

- Better consistency between resolved and subgrid-scale precipitation (no grid point storms).
- Better timing of severe convective events.
- Usage in « grey zone », i.e. at any wished and intermediate resolution between 10 and 2 km.

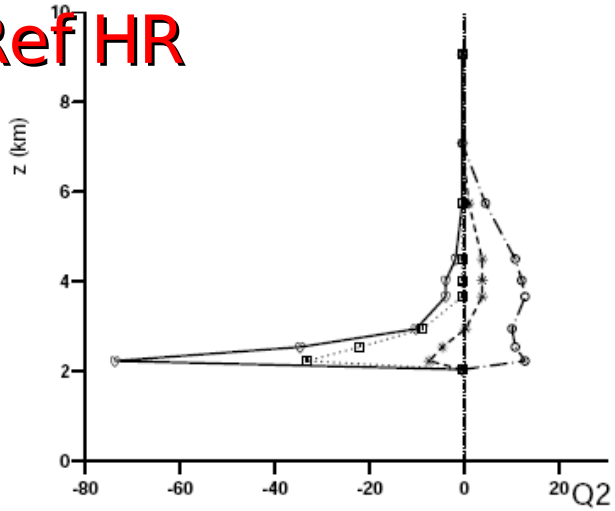
3MT: got results, a collective work, still a long

Fin

MT – What has been done – Results

Q2 (K/day), CSRM Meteo-France CNRS

Ref HR



Q2 (K/day), CSRM MetOffice

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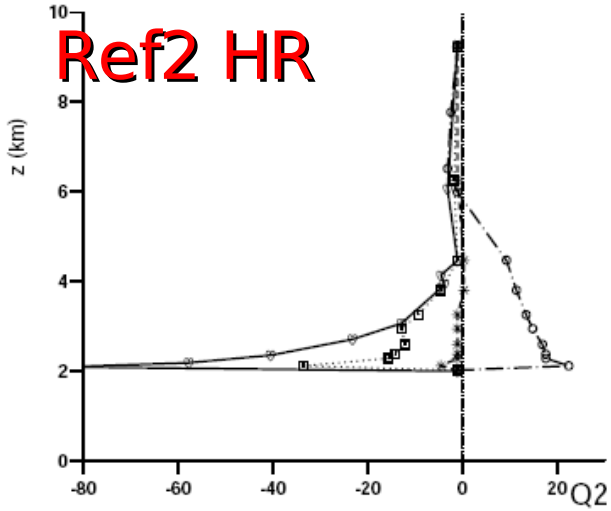
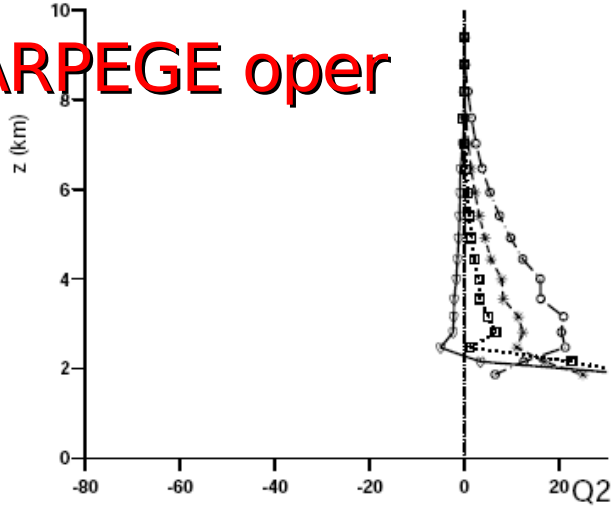


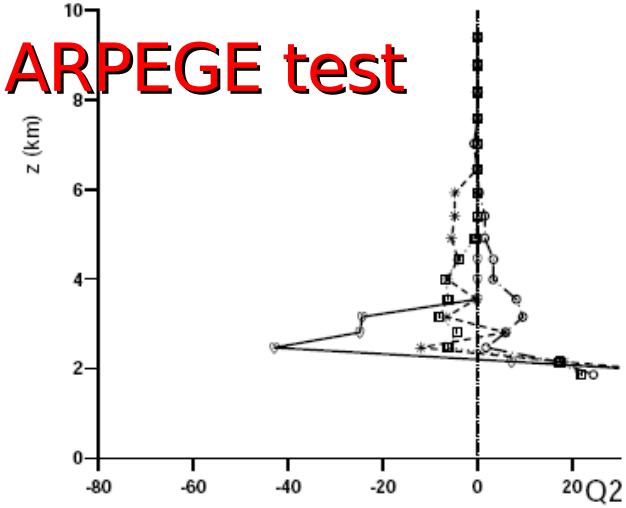
Q2 (K/day), Control SCM

ARPEGE oper



Q2 (K/day), V1 SCM

ARPEGE test



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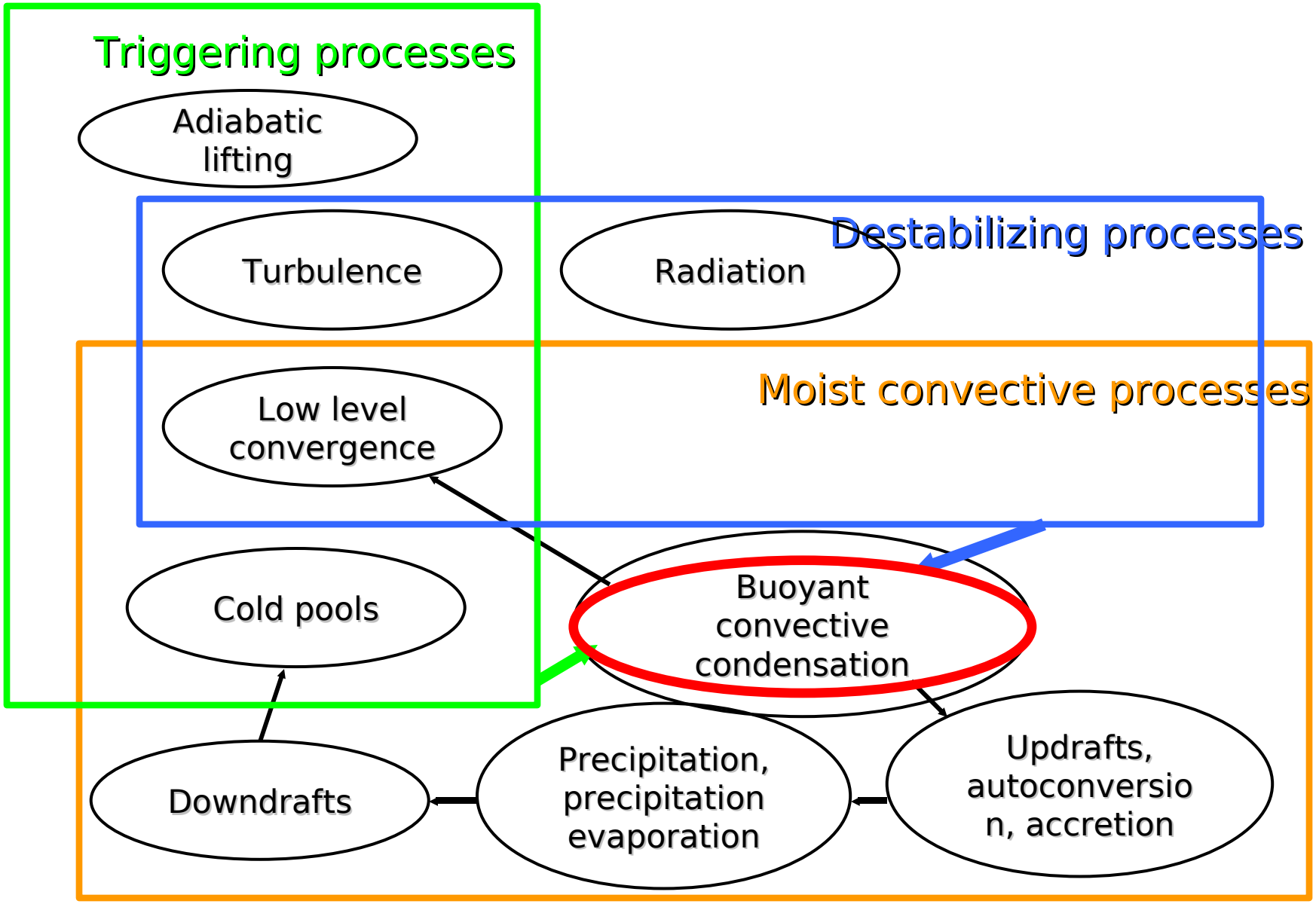
Causality; PhD work (2005)



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

Microphysics and Transport (MT) equations