3MT convection: certainties and perspectives.

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Météo-France – CHMI – IRM.

Radostovice Training Course, 2007-03-30.

3MT certainties and perspectives - Summary

- What has been done.
- What we intend to do in the short term (certainties).
- What we hope to do in the long term (some uncertainties).
- What can we expect from 3MT for forecasters?

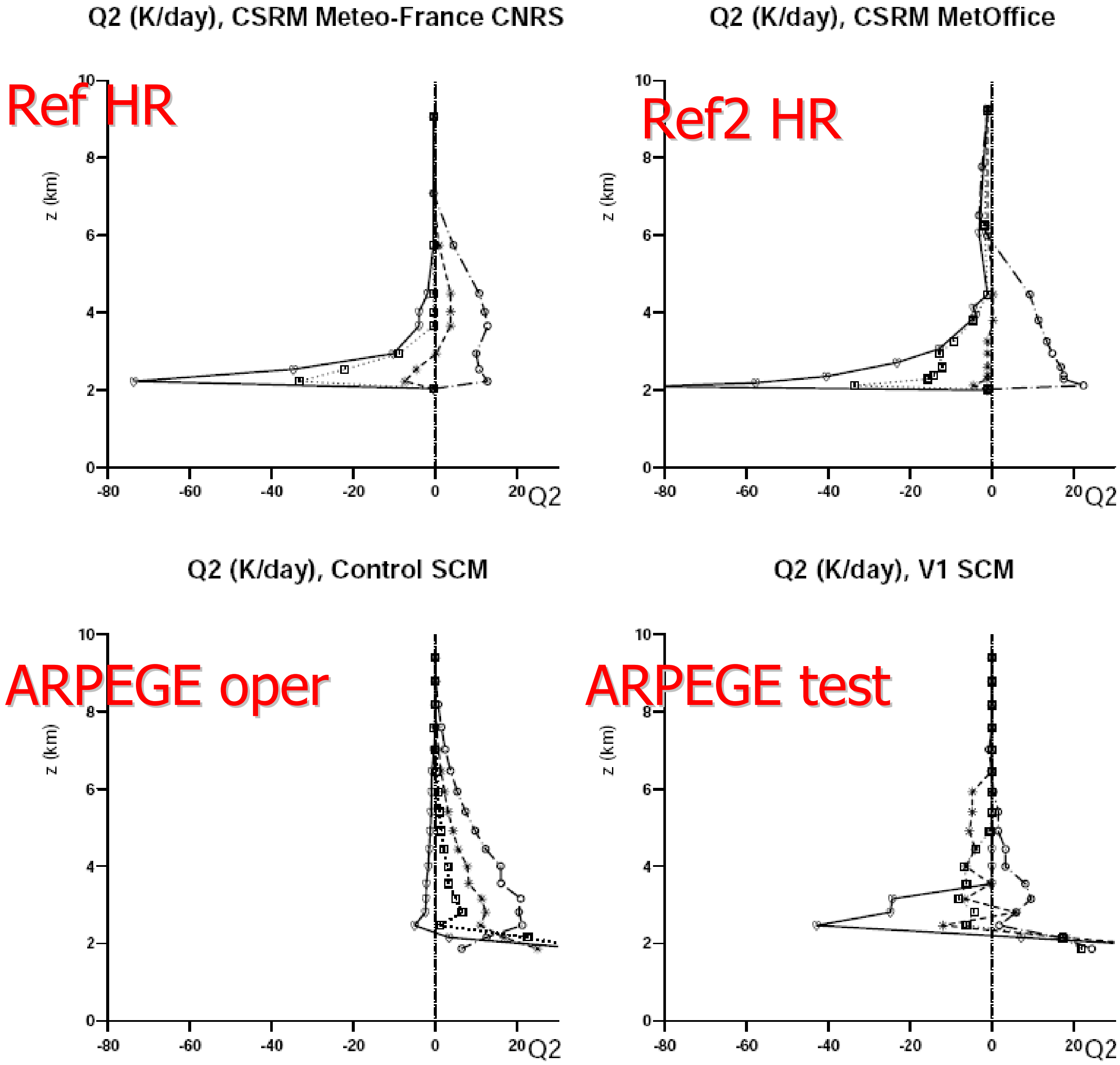
What has been done.

3MT – What has been done – Equations and codes

Since 2004:

- A new equation frame for convective parameterization (MT).
- A quite extensive prognostic equation set (area fraction, vertical velocity, water species).
- A cascading approach for intra-time-step microphysics (2MT).
- A new common code (3MT).
- A new prognostic microphysics (toulousian codes, APLMPHYS).
- A nice result for ALADIN partners.

3MT – What has been done – Results



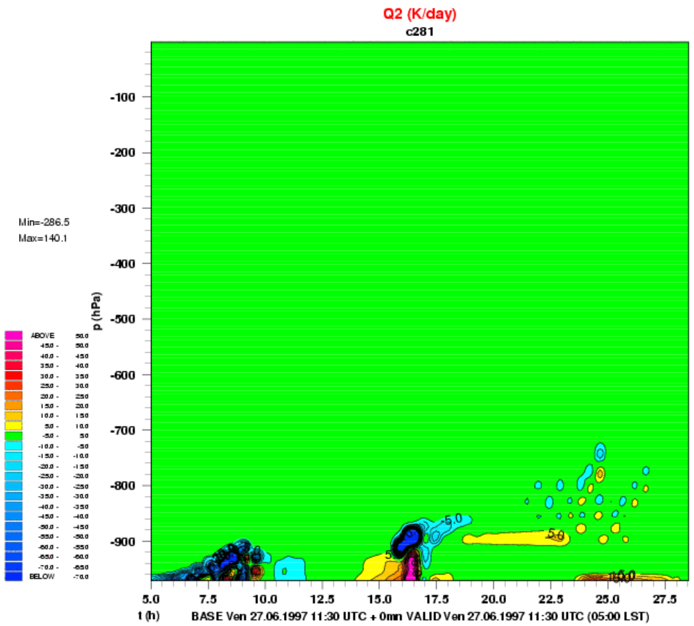
J.-M. Piriou and J.-L. Redelsperger and J.-F. Geleyn and J.-P. Lafore and F. Guichard

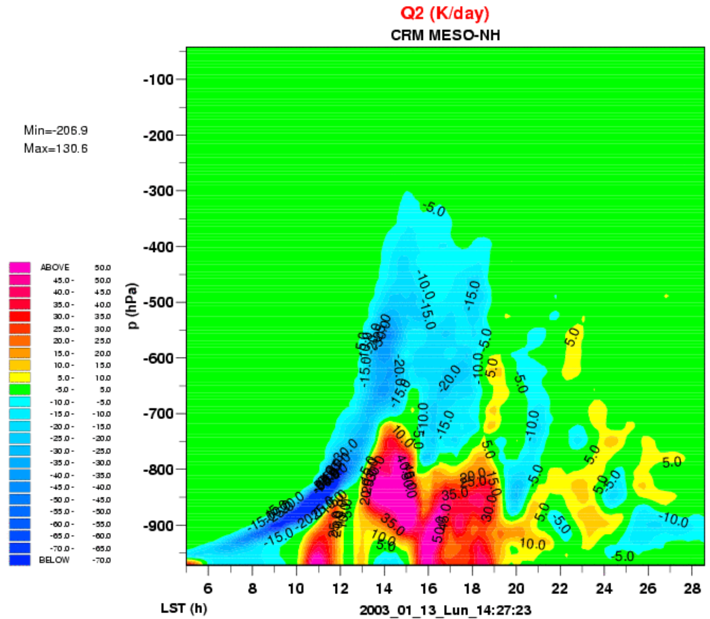
An approach for convective parameterization with memory, in separating microphysics and transport in grid-scale equations

J. Atmos. Sci. 2007, accepted

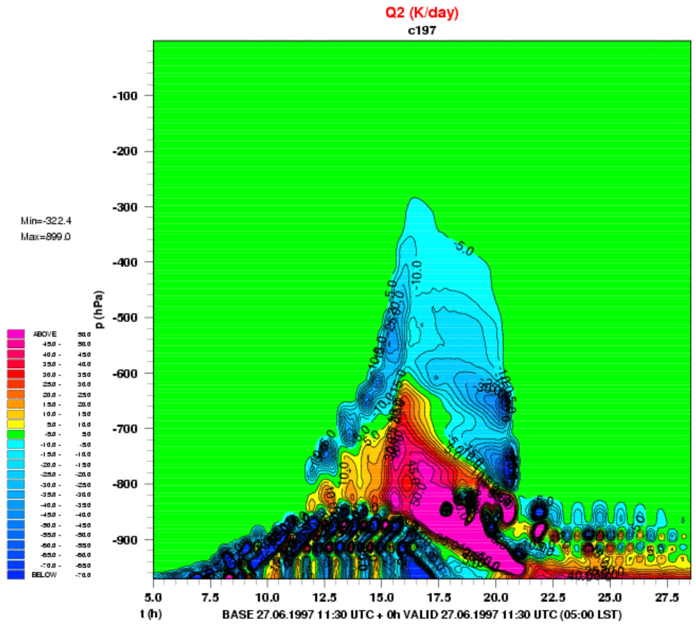
3MT – What has been done – Results

ARPEGE
oper





CRM
MNH



ARPEGE
V1 + entr.
historique

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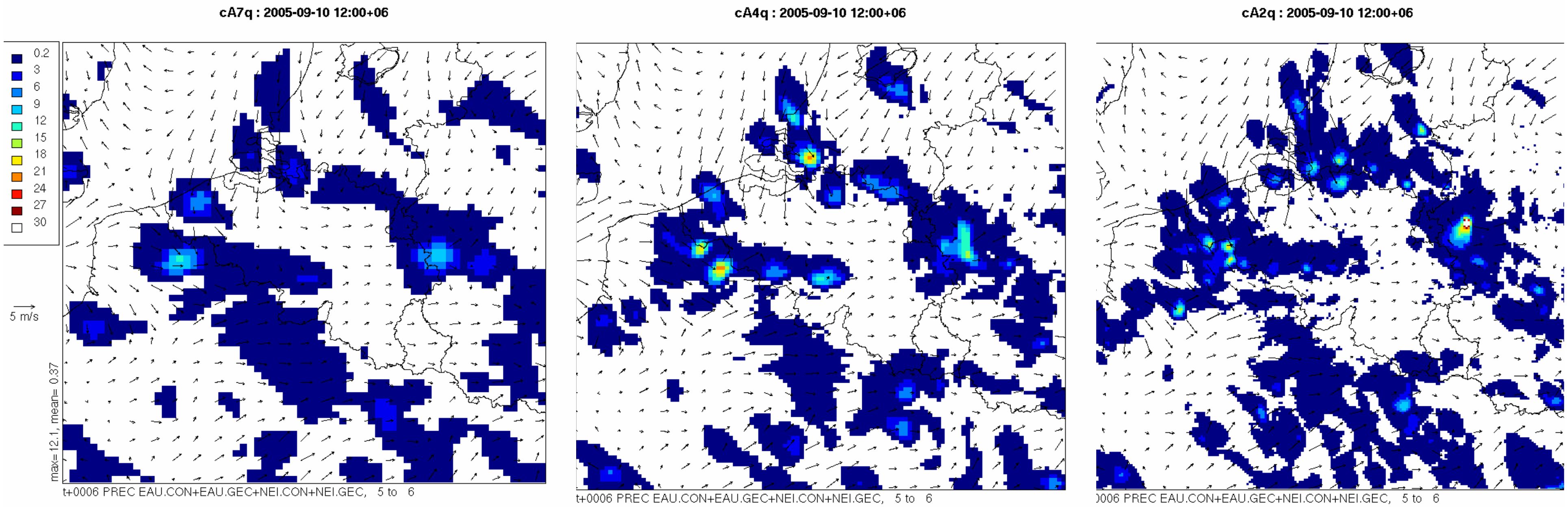
3MT – What has been done – Results

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.
- Modular code developed in Prague-Bruxelles ➔ 3MT (Modular Multiscale Microphysics and Transport) ➔ ALARO-0, oper. ARPEGE ALADIN 2008.

3MT – 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-Geleyn equations.
- Communication: Documentation.
- Communication: This workshop.
- Communication and politics: better understanding between partners.

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

3MT – Short term

- Extract bugs from this new code!…
- 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-Geleyn equations.

3MT – Short term (continued)

- Extend 3MT code 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.
  - Jean-Marcel Piriou, Luc Gerard, and others.
  - 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

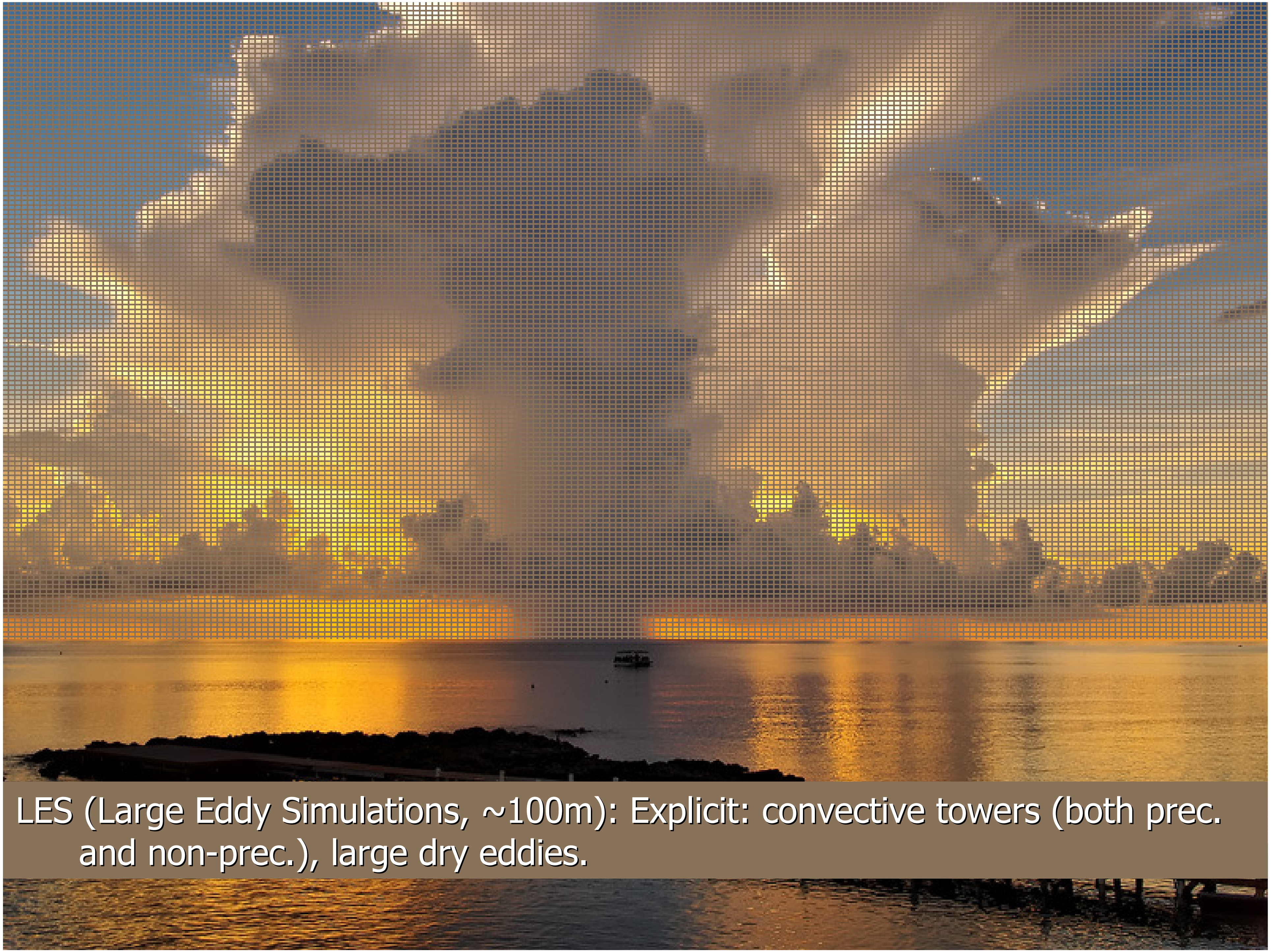
- Long term: 2009 and onwards.
- Extend 3MT to stratocumulus.
  - Feasible, thanks to the area fractions reaching 1.
  - Switch stratocumulus from the turbulence paradigm to the mass-flux paradigm (feasible, but really new!).
- As long as 3MT works for dry, shallow and deep convection in ARPEGE and ALADIN ➔ tests in AROME.

Some convection models…

GCM (Global Circulation Models, ~50km) or LAM (Limited Area Models, ~5km):

Parameterized: deep convection, shallow convection (both prec. and non-prec.), dry convection (thermals).

CSRM (Cloud System-Resolving Models, ~2.5km): Explicit: some deep convective towers. Parameterized: shallow convection (both prec. and non-prec), dry convection.



LES (Large Eddy Simulations, ~100m): Explicit: convective towers (both prec. and non-prec.), large dry eddies.

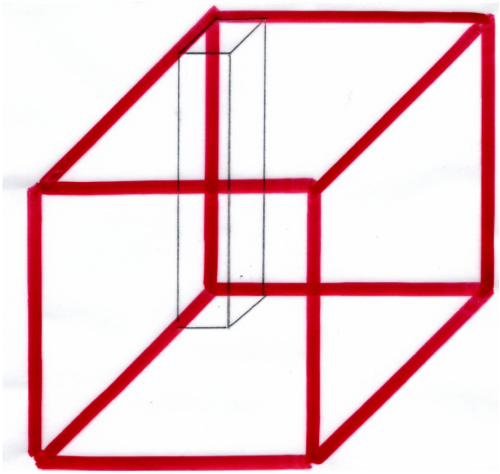
Convection models: computation time, perspectives.

	GCM, LAM	CSRM	LES
Computation time, global prediction	1, 50	10000	10^9
In operations, global	Now, 2016	2027	2052
In operations, limited area (say, France)	Now	2009	2033
Deep conv. *Cu congestus, Cb*	Parameterized	Explicit	Explicit
Shallow conv. (both prec. and non-prec.) *Cu, Sc*	Parameterized	Parameterized	Explicit
Dry conv. *Thermals*	Parameterized	Parameterized	Explicit

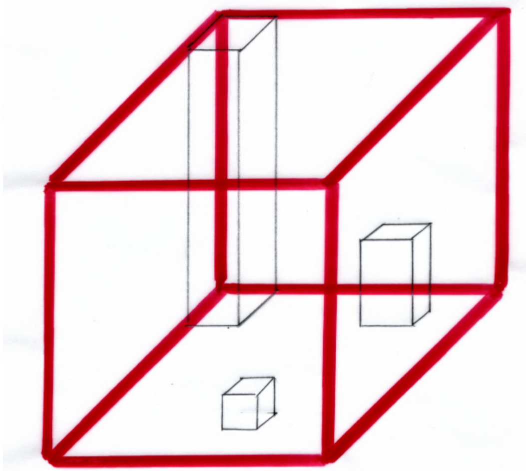
3MT – Long term – Preparing the 2010-2020 period

- LAM: parameterized precipitating convection. Strong sensitivity to initial conditions. Can afford ensemble runs.
- CSRM: resolved precipitating convective circulations. Strong sensitivity to initial conditions. Few runs.
- Kerry Emanuel (Farnham, 2005): «The present situation of the international meteorological community is: LAMs try to predict the unresolvable, CSRMs try to resolve the unpredictable.»
- For both ALADIN and AROME, need to improve the SGS physics with quite « cheap » physics, in order to access to ensemble runs.

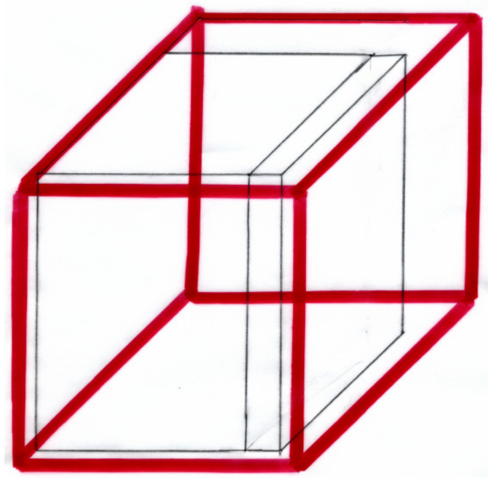
Convective parameterizations



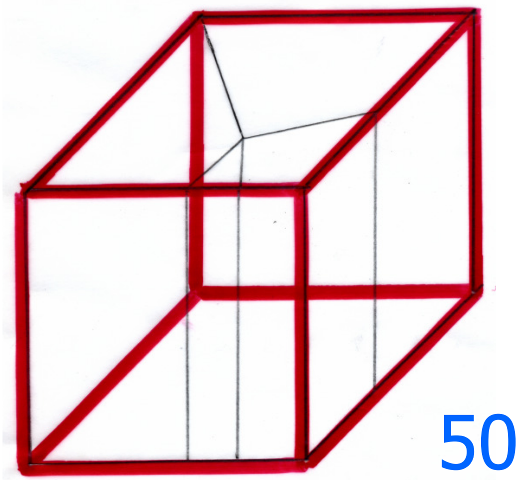
1 Traditional param.



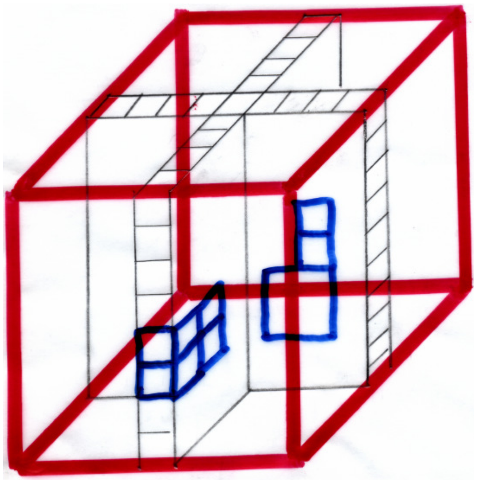
1.3 Arakawa Schubert 1974



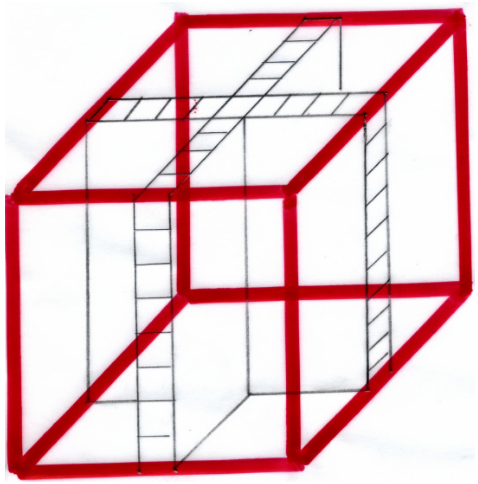
1.3 3MT



6 3MT-FP



50 CSRM-SCA J.-I. Yano



500 Superparameterization

Laprise, Bechtold, Grabowski, Randall, Khairoutdinov

3MT – Long term – Fully Prognostic version

3MT-FP (Fully Prognostic): n interactive prognostic modes.

transport horiz. — transport vert. — microphysique — sources/puits de vent horiz. et vert.

$$
\left\{
\begin{array}{lcl}
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i}{\partial t}\right)_{cp} & = & \sum_{j\neq i}(E_{ij}-D_{ij}) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{q_v}^i}{\partial t}\right)_{cp} & = & -\overline{C}^i + \overline{E_C}^i + \overline{E_P}^i + \sum_{j\neq i}(E_{ij}\overline{q_v}^j - D_{ij}\overline{q_v}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i\overline{q_v}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{q_l}^i}{\partial t}\right)_{cp} & = & \overline{C}^i - \overline{E_C}^i - \overline{A}^i + \sum_{j\neq i}(E_{ij}\overline{q_l}^j - D_{ij}\overline{q_l}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i\overline{q_l}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{q_r}^i}{\partial t}\right)_{cp} & = & \overline{A}^i - \overline{E_P}^i + \sum_{j\neq i}(E_{ij}\overline{q_r}^j - D_{ij}\overline{q_r}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w_s}^i\overline{q_r}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{s}^i}{\partial t}\right)_{cp} & = & \overline{LC}^i - \overline{LE_C}^i - \overline{LE_P}^i + \overline{H}^i + \sum_{j\neq i}(E_{ij}\overline{s}^j - D_{ij}\overline{s}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i\overline{s}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{u}^i}{\partial t}\right)_{cp} & = & \overline{S_u}^i + \sum_{j\neq i}(E_{ij}\overline{u}^j - D_{ij}\overline{u}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i\overline{u}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i \overline{w}^i}{\partial t}\right)_{cp} & = & \overline{S_w}^i + \sum_{j\neq i}(E_{ij}\overline{w}^j - D_{ij}\overline{w}^i) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i\sigma_i\overline{w}^i\overline{w}^i
\end{array}
\right. \quad (2)
$$

n subgrid-scale modes, i=1,n. mass (sigma), water species, heat, horizontal and vertical wind. In red: microphysics: condensation, evaporation, autoconversion, collection, sens. heat prec., etc.

n modes: updraft, downdraft, density current, environment. No resolved variable any more. Fully interacting modes: n*(n-1)/2 . Parameterize E, D and wind sources.

Cold pools and prognostic entrainment, advection systems across grid-points.

Conclusion:
3MT for forecasters?

3MT Certainties and perspectives - Conclusion

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, a long path to go!

Fin