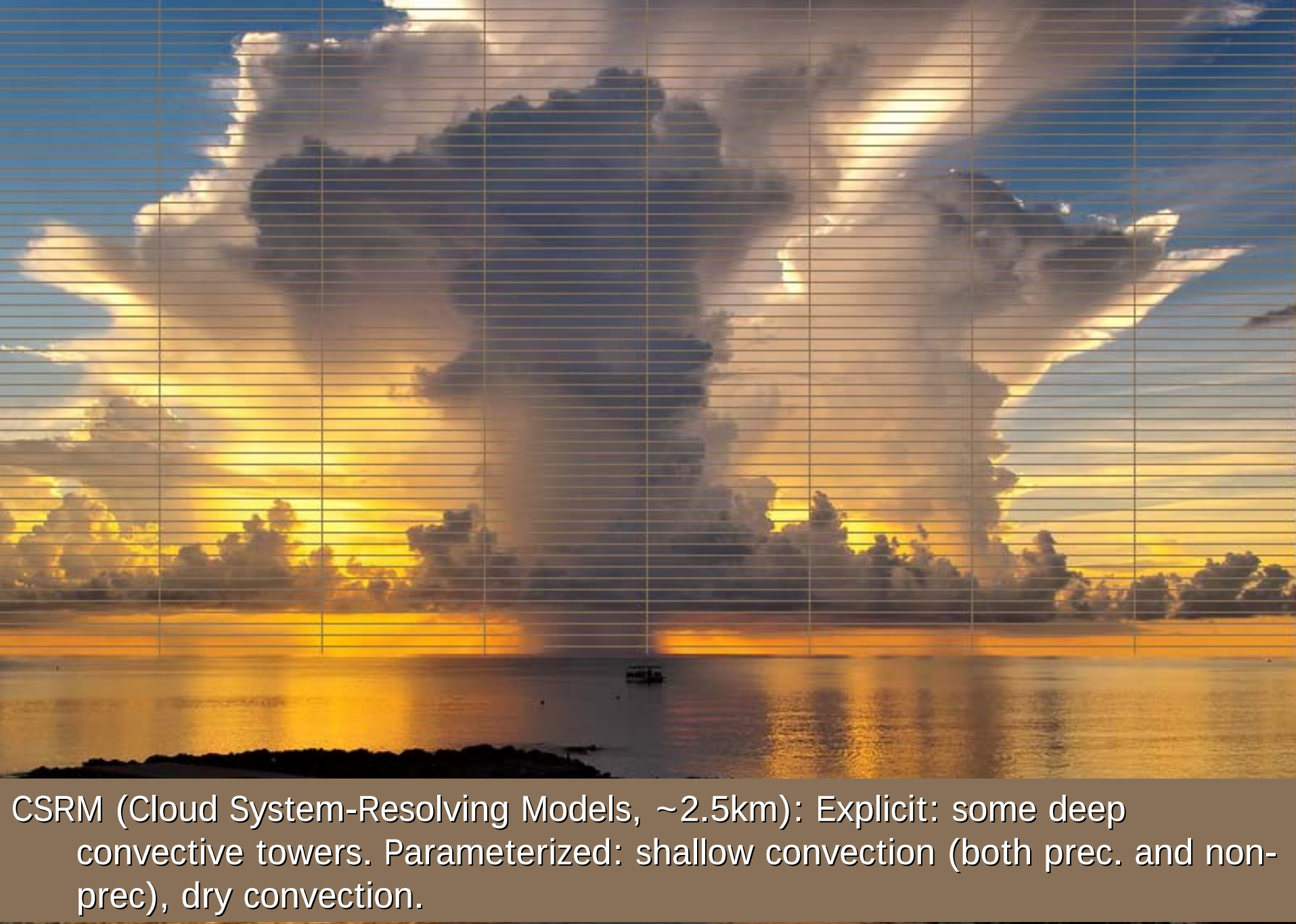
A new equation set for convective parameterization, intermediate between present parameterizations and superparameterizations: 3MT-Fully prognostic.

Jean-Marcel Piriou, Météo-France / CNRM.

NETFAM Workshop, Toulouse, 12-14 March 2007.

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
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

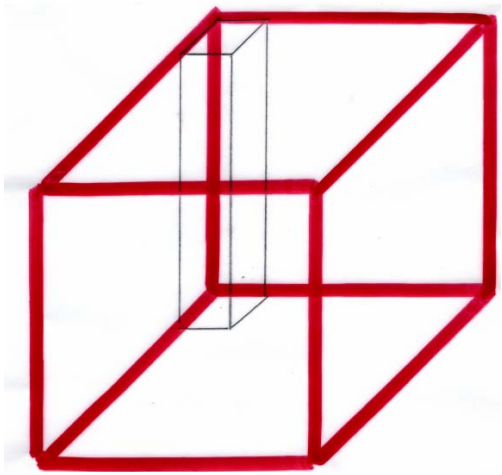
Convection models: computation time, perspectives.

	GCM, LAM	CSRM	LES
Computation time, global prediction	1, 50	10000	10^9
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

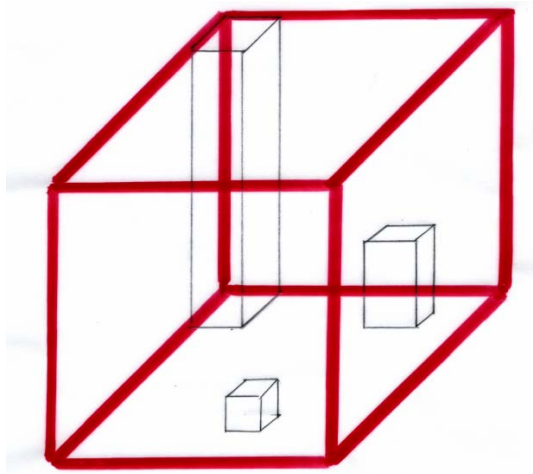
Convection models: computation time, perspectives.

	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

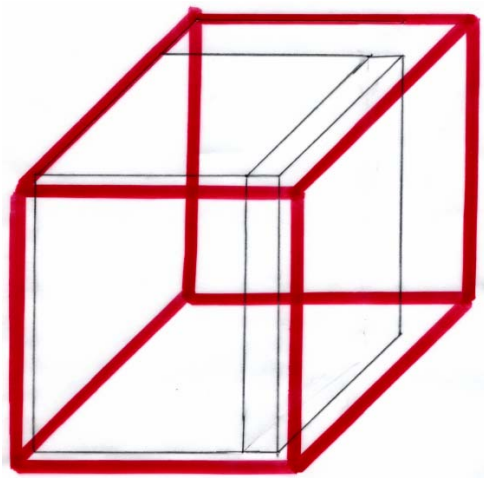
Convective parameterizations



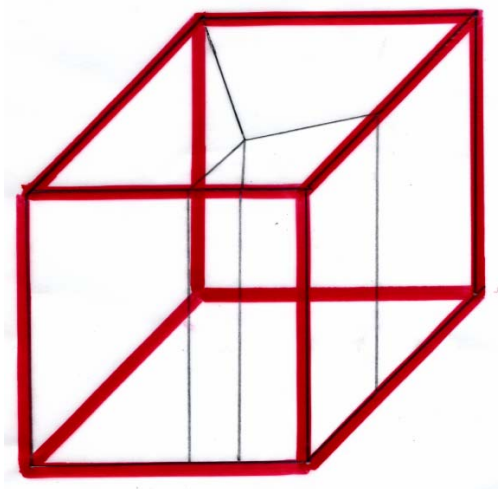
Traditional param.



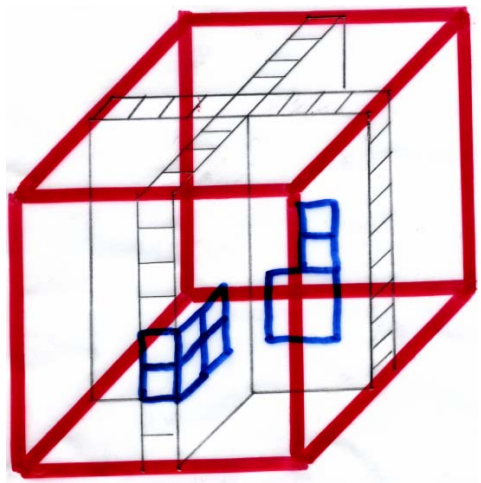
Arakawa Schubert 1974



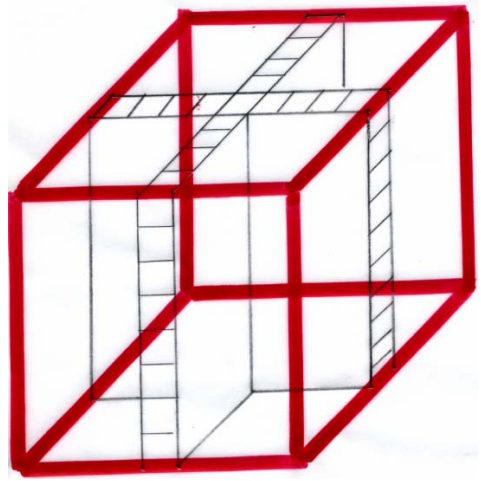
3MT



3MT-FP



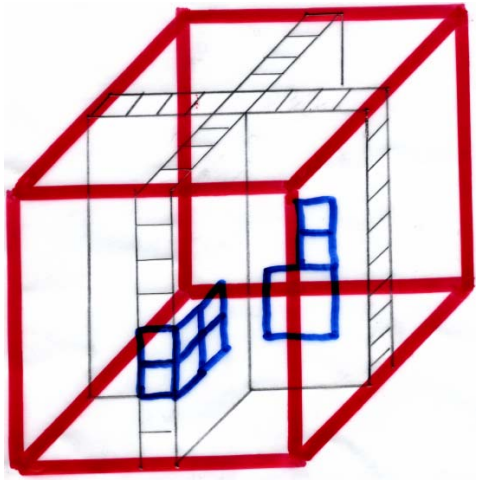
CSRM-SCA J.-I. Yano



Superparameterization

Laprise, Bechtold, Grabowski, Randall, Khairoutdinov

CSRM-SCA: a compressed CSRM

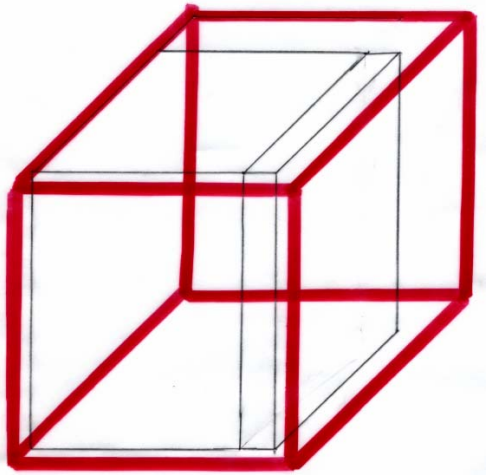


CSRM-SCA J.-I. Yano

Work done by Jun-Ichi Yano (Météo-France and CNRS),

- Application of the segmentally-constant approximation (SCA) onto the full CSRM system.
- Parameterization to decide creating new cells, fusing close cells ➔ adaptative grid.
- If all cells active, CSRM-SCA becomes a standard CSRM model.

3MT: main features



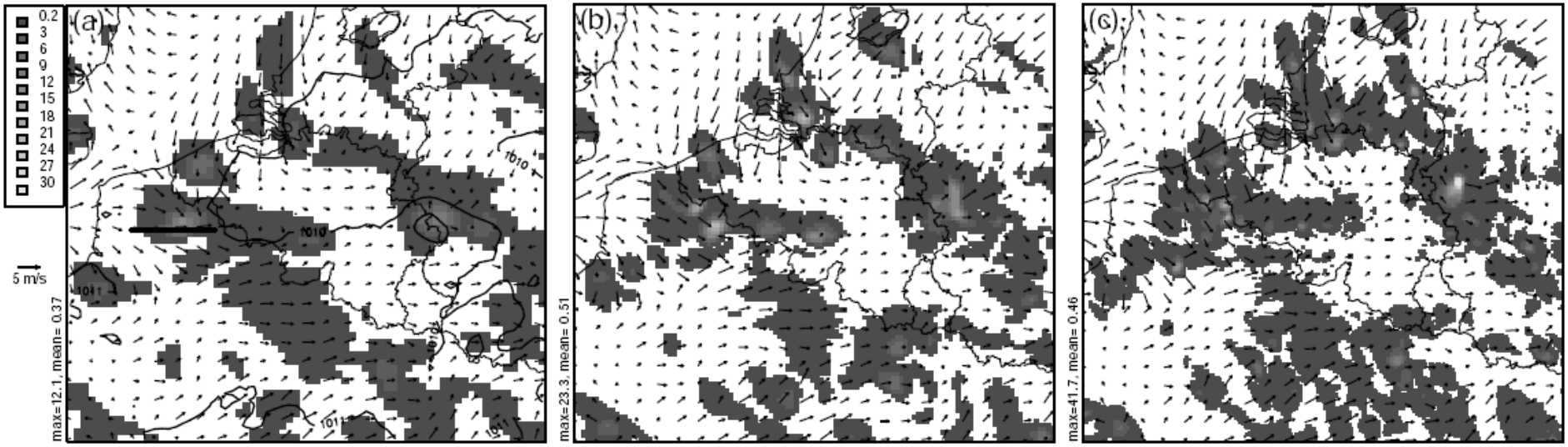
3MT

Initiated in 2003, Separating Microphysics from Transport terms (MT), in grid-scale equations

- central role to microphysics, improve causal link between processes: condensation, autoconversion, precipitation evaporation ➔ entrainment rates, ... Prognostic microphysics, updraft/downdraft area fraction, vertical velocity,
- share microphysics between param. and CSRM,
- relax cloud mass budget stationnarity assumption,
- microphysics cascading inside time-step (no double counting between resolved and subgrid-scale).

3MT: results

3MT: Modular Multiscale Microphysics and Transport.

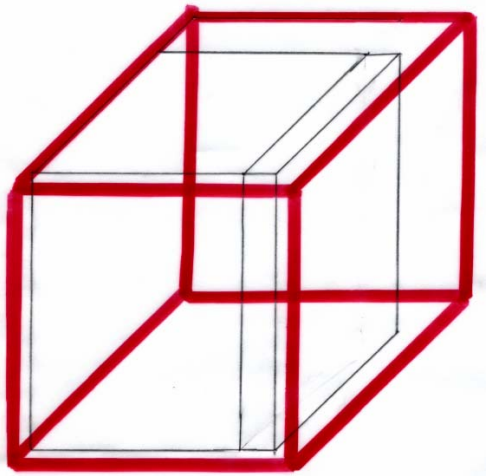


7 km 4 km 2 km

10/09/2005 Case Study. 1-hour Precipitation (mm). Source Gerard (QJRMS 2007).

Under progress: endeavour entering operations for NWP in 2008, in LAM and GCM, Meteo-France and ALADIN partners.

3MT



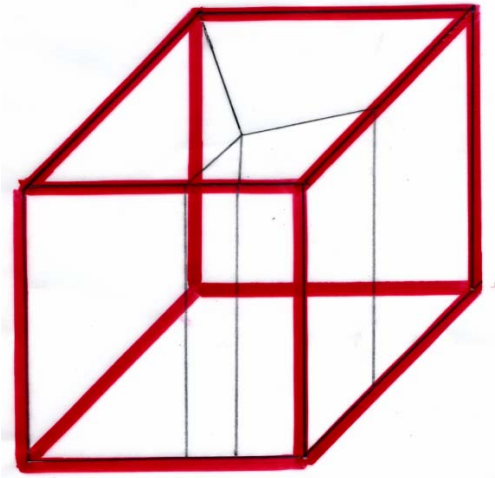
3MT

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 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)

Next step 3MT-FP (Fully Prognostic)



3MT-FP

Main objectives:

- as many prognostic variables as in the host model (no closure on massflux),
- endeavour using convective equations closer to those of CSRMs (where possible),
- ➔ increase numerical complexity, decrease conceptual complexity,
- multi-modal approach (like AS74),
- parameterization only for E, D, momentum,
- HOPE: better than traditional parameterizations, cheaper than superparameterizations!

3MT-FP: equation set, mode #i

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

$$
\begin{cases}
\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{cases}
$$

microphysique

transport horiz. transport vert.

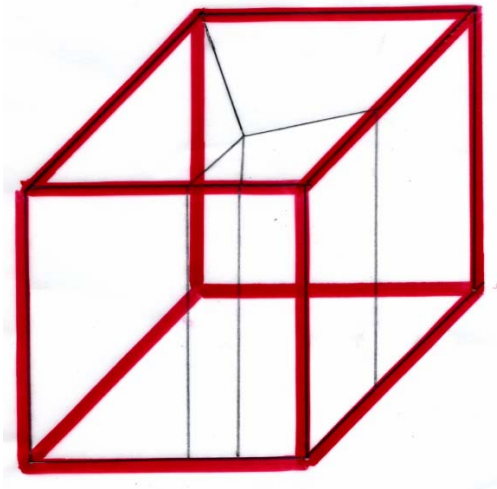
sources/puits de vent horiz. et vert.

(2)

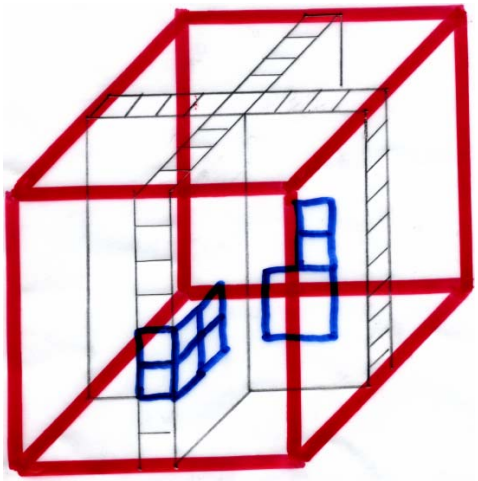
n subgrid-scale modes, i=1,n. For each mode: equation set above. Mass (sigma), water vapour, cloudy condensates, prec. condensates, heat, horizontal and vertical wind. Red: microphysics: condensation, evaporation, autoconversion, collection, sensible exchanges between precipitation and surr. air, etc.

Description. 3MT-FP closer to primitive equations, still a param. ➔ collaboration, link to superparamétrisations, comp. time.

More about 3MT-FP (Fully Prognostic) and compressed CSRM...



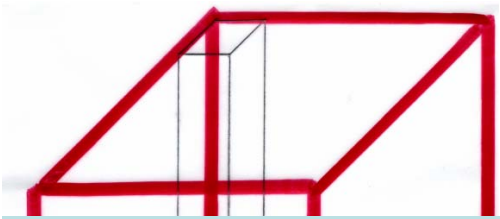
3MT-FP

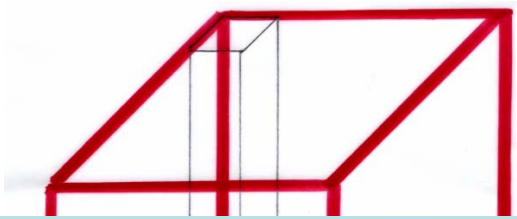


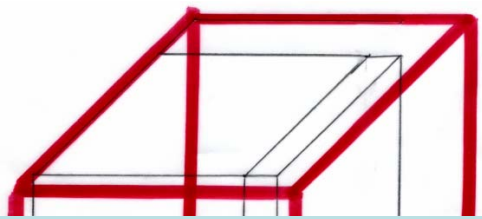
CSRM-SCA J.-I. Yano

J.-I. Yano and J.-M. Piriou, « Deduction into the massflux convective parameterization from a full Cloud-Resolving Model (CRM) system under a segmentally-constant approximation (SCA) », To be submitted in a few days!

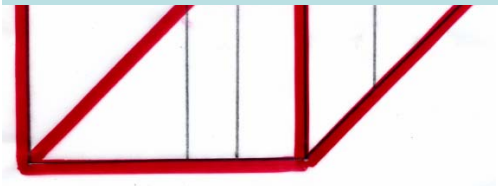
Conclusions, perspectives



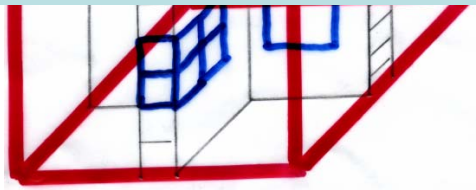




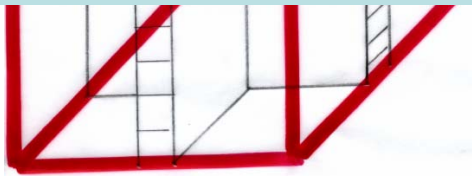
- 3MT: a 3-year collective work, runs in 3D, pre-operational (2007 in ALADIN Prague, 2008 in ARPEGE ALADIN in Toulouse).
- A consistent hierarchy of equation systems, for convective parameterization, between traditional parameterization and superparameterization. 3MT-FP and CRM-SCA-compressed still need to be tested!



3MT-FP



CSRM-SCA J.-I. Yano



Superparameterization

Fin