3MT in ARPEGE and ALADIN

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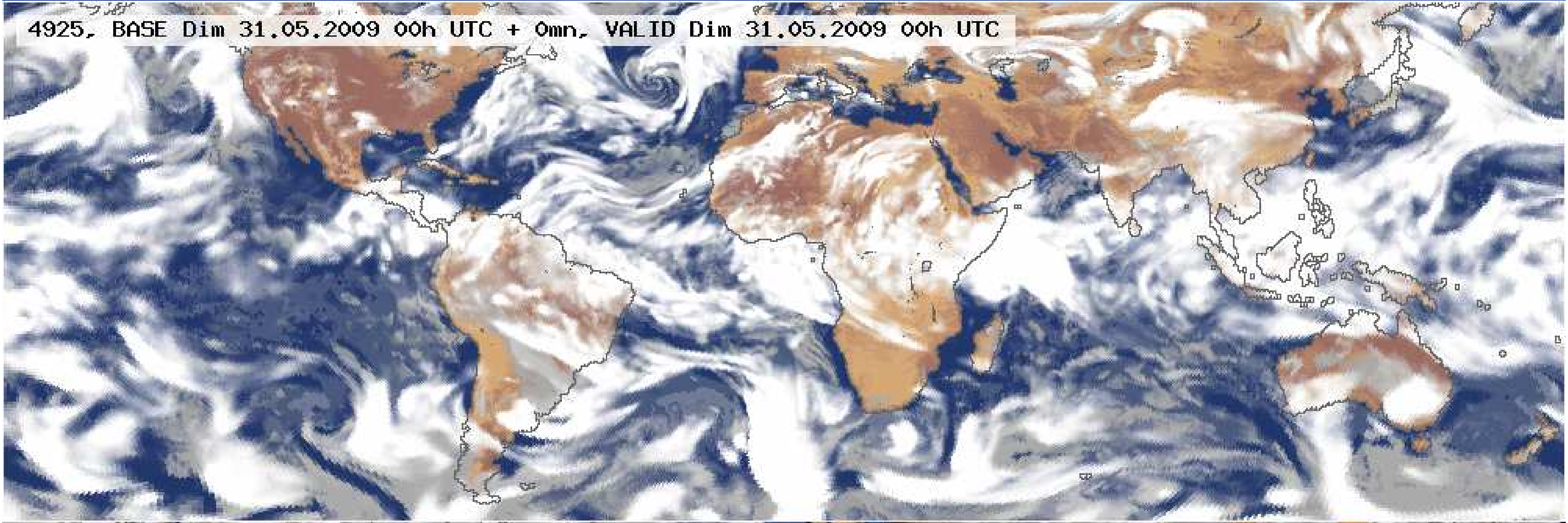
3MT in ARPEGE – ALADIN: Summary

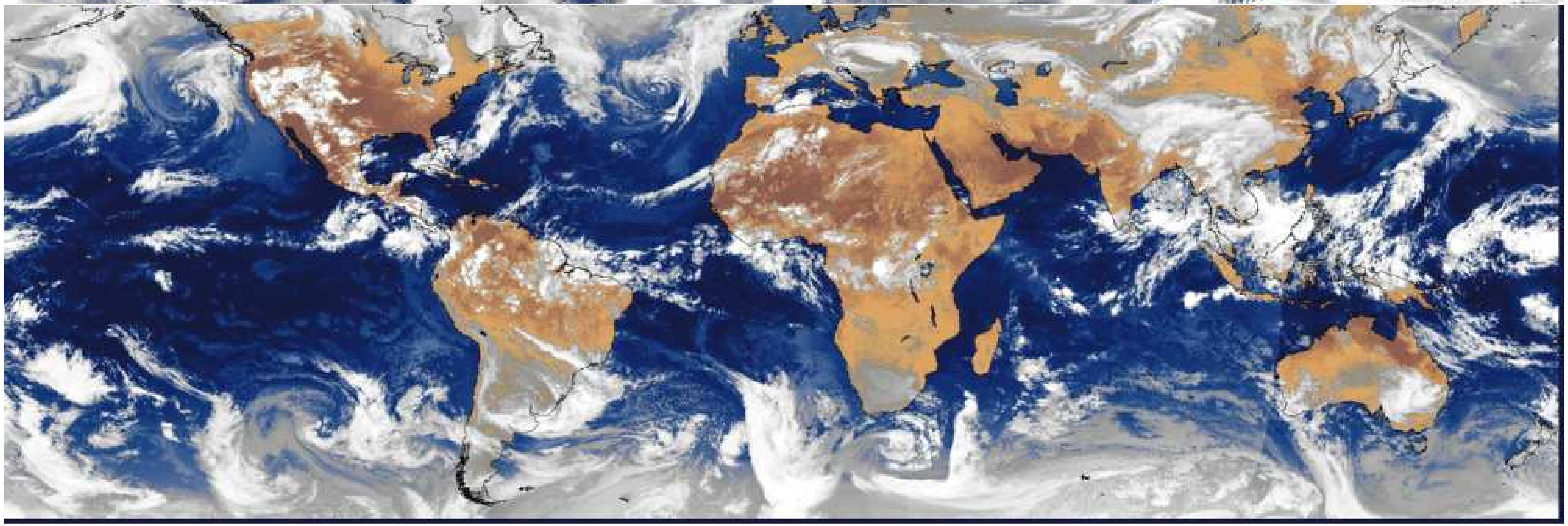
1. Present operational physics.
2. Testing a new subgrid conv. scheme: 3MT in ARPEGE and ALADIN.
3. Towards high resolution models for NWP / Climate: Complexity?
4. High resolution: a perspective FP-MT.

Present operational physics in ARPEGE / ALADIN

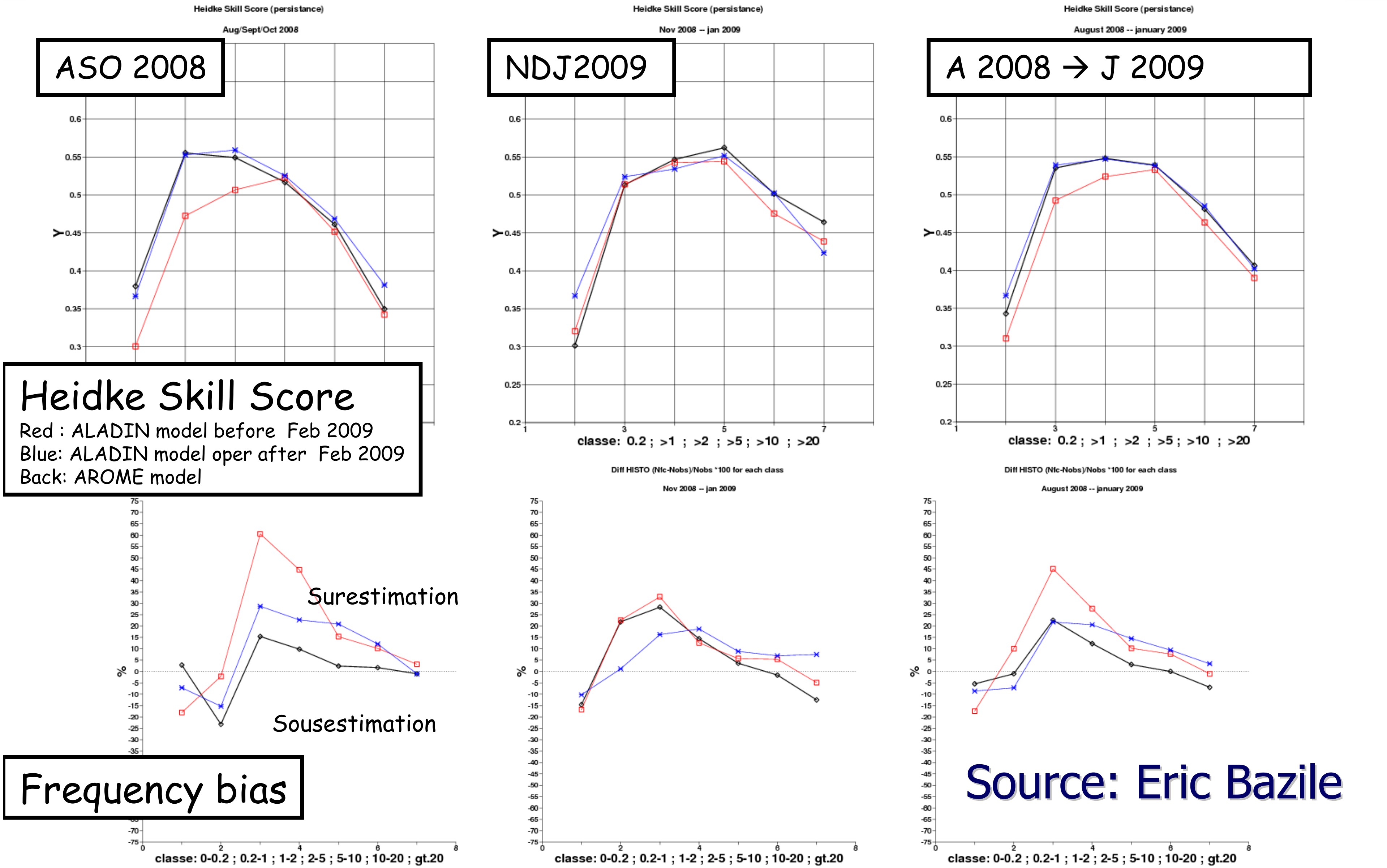
- Dry convection: turbulence scheme Cuxart-Bougeault-Redelsperger (CBR).
- Stratocumulus: turbulence scheme CBR.
- Shallow convection: precipitating and non-precipitating Cu: Kain-Fristch-Bechtold scheme (KFB).
- Deep convection (Cb): Bougeault scheme.

Present operational physics in ARPEGE / ALADIN





Present operational physics in ARPEGE / ALADIN



Source: Eric Bazile

Testing a new scheme: 3MT in ARPEGE - ALADIN

Recent changes: turbulence, microphysics, shallow convection.

Now: deep convection…

3MT: Modular Multiscale Microphysics and Transport.

Piriou et al JAS 2007, Gerard et al MWR 2009.

Motivation: a subgrid and resolved condensation scheme, designed to be run in models from 10km (or more) to 2km, where convection is partly resolved.

Testing a new scheme: 3MT in ARPEGE - ALADIN

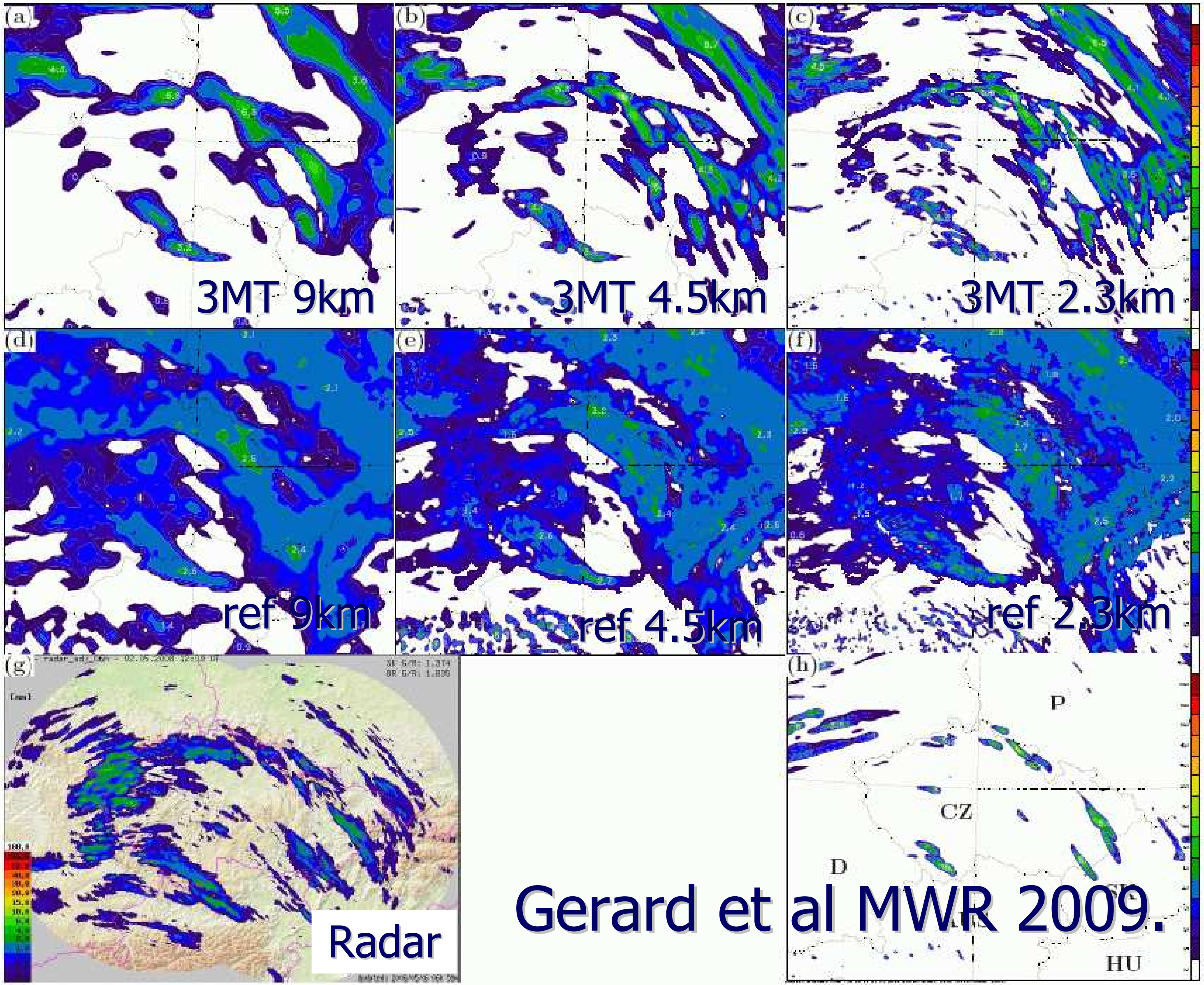
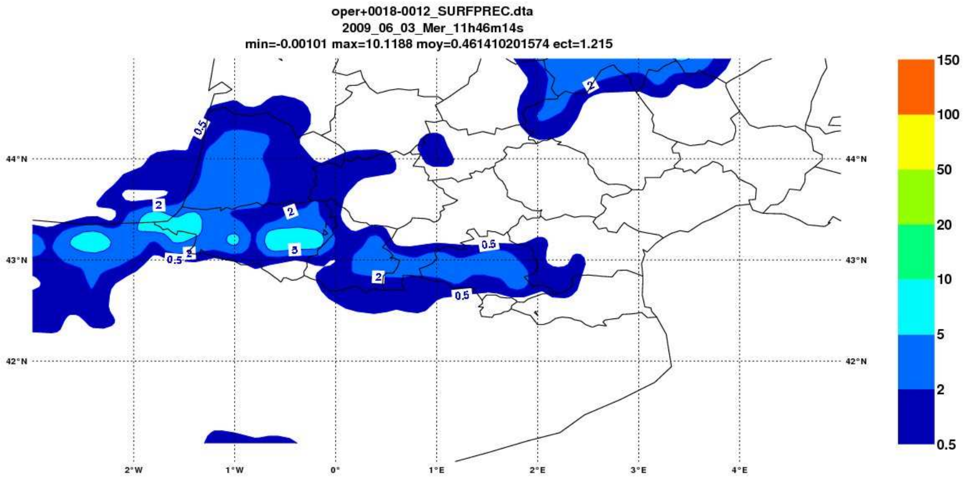


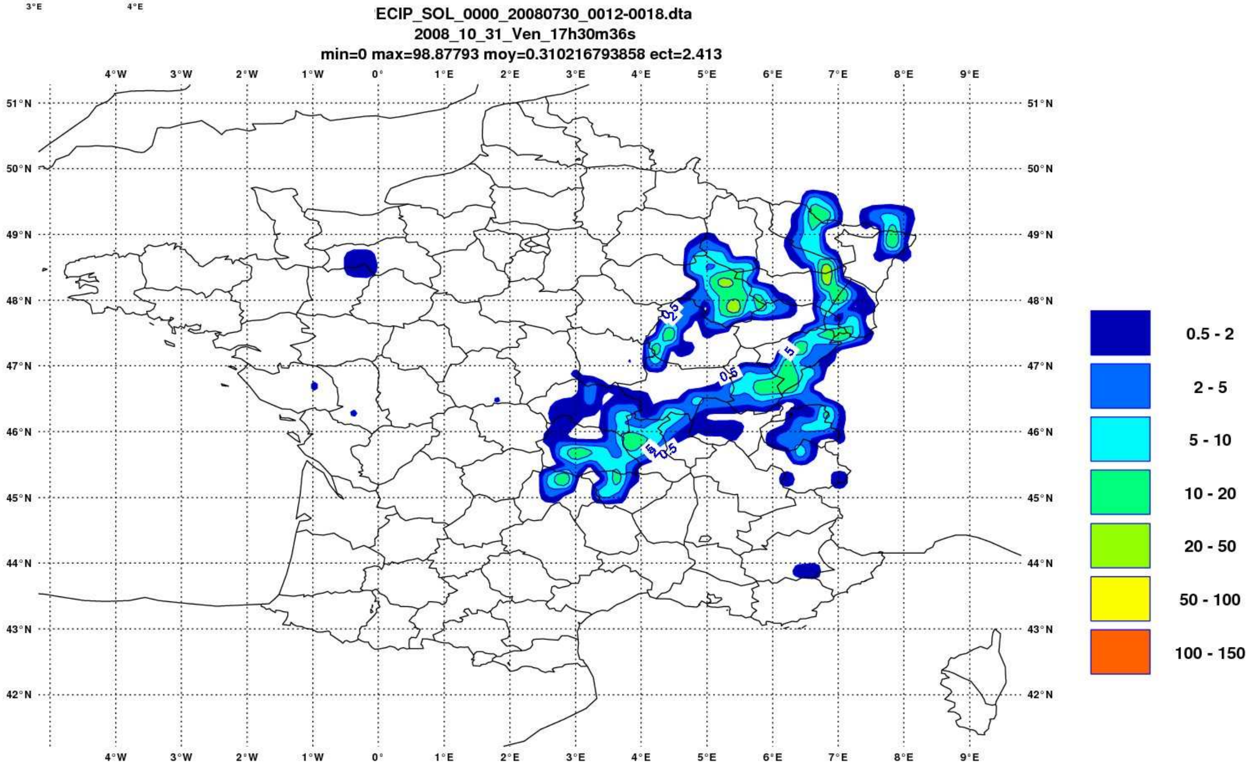
Fig. 11. Accumulated precipitation over Central Europe on 2 May 2008 between 0600 and 1200 UTC. Scaled radar composite image (g). Forecasts from initial conditions of 0000 UTC at resolution 9km (a,d) and 4.5km (b,e) (hydrostatic) and at 2.3km non-hydrostatic (c,f,h). 3MT (a,b,c), 'diagnostic' (d,e,f) and 'no convection scheme' (h).

Testing a new scheme: 3MT in ARPEGE - ALADIN

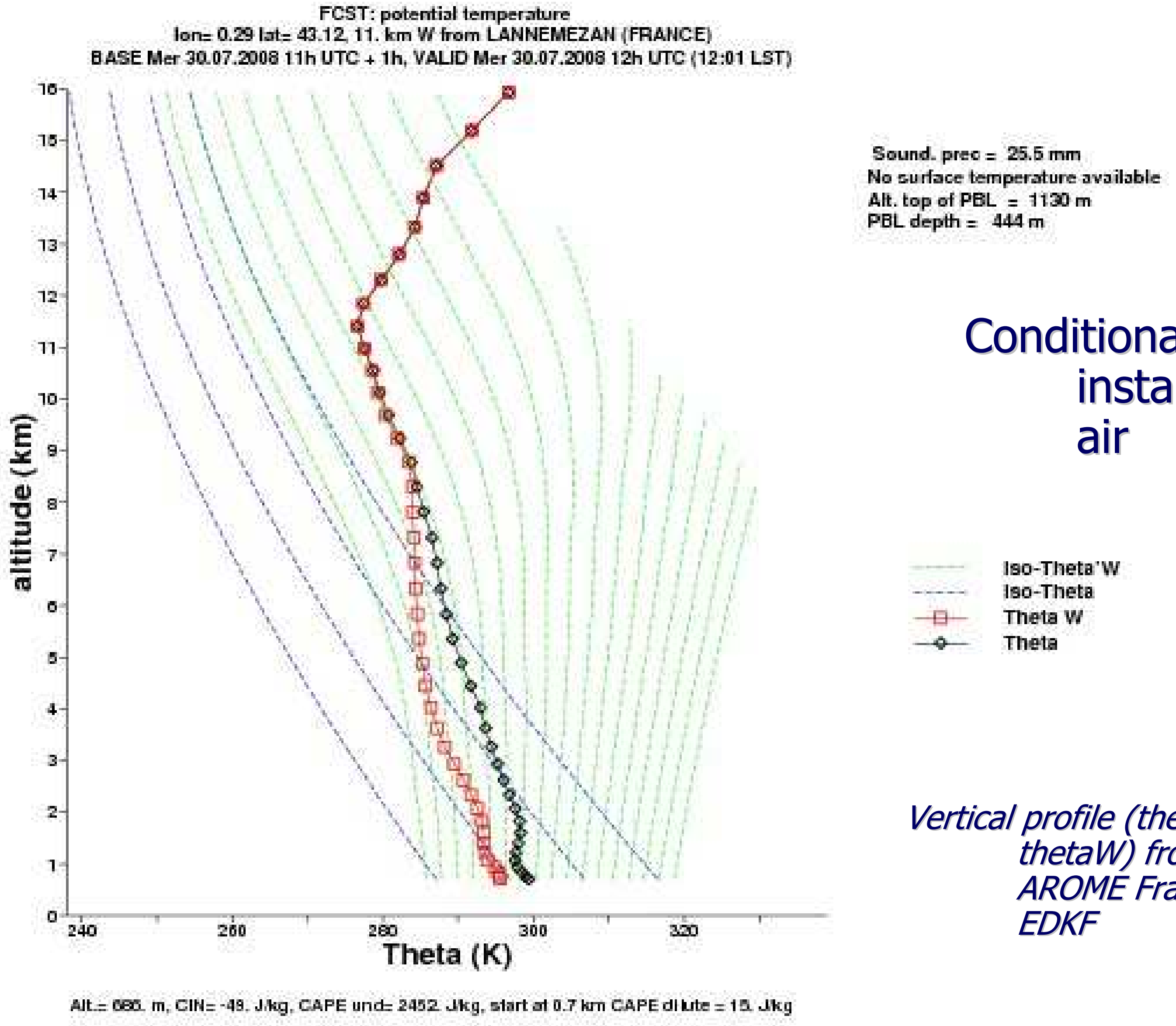


ARPEGE oper: precipitation P18h-P12h (mm)

ANTILOPE, precipitation analysis between 12h et 18h (mm)



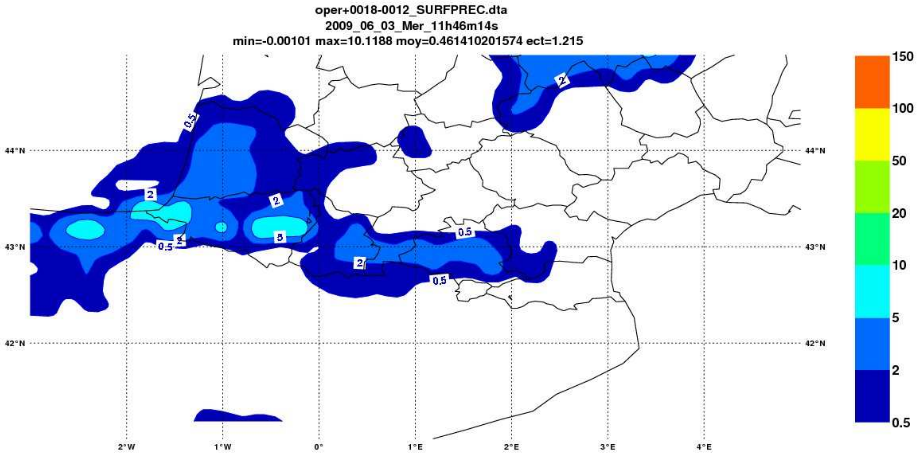
Testing a new scheme: 3MT in ARPEGE - ALADIN



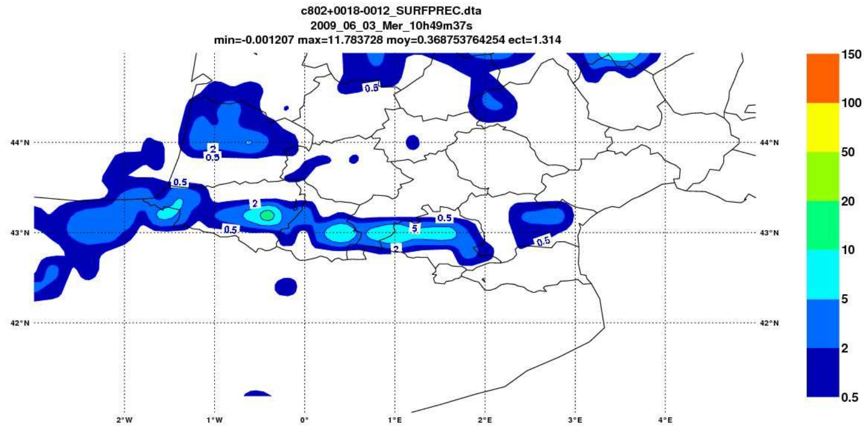
Conditional instability, dry air

Vertical profile (theta, thetaW) from AROME France EDKF

Testing a new scheme: 3MT in ARPEGE - ALADIN

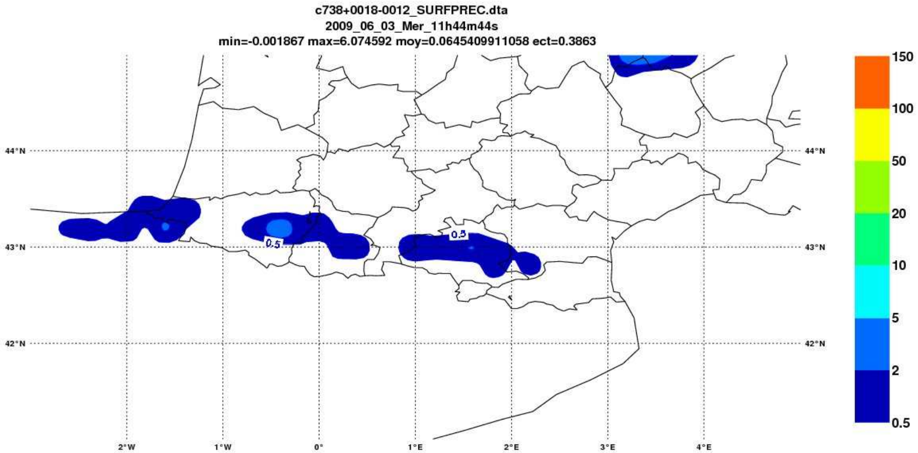


ARPEGE oper au 30.7.2008.

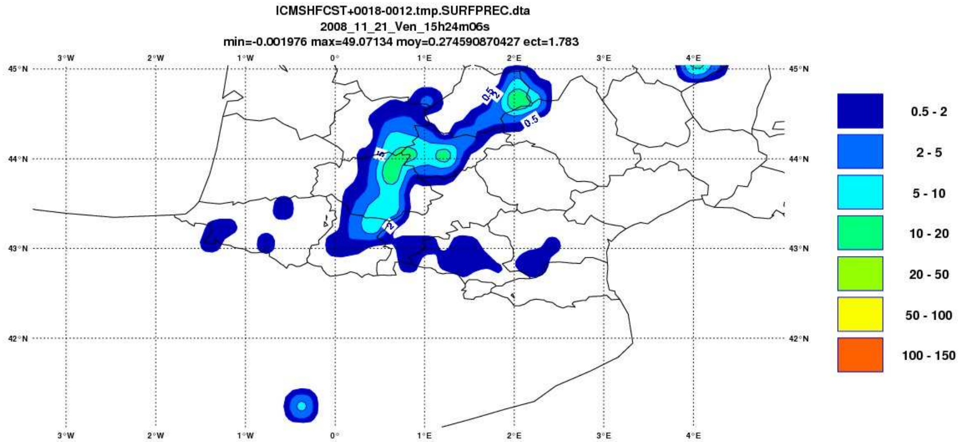


ARPEGE oper au 5.6.2009.

ARPEGE 3MT



AROME 2.5 km EDKF



Testing a new scheme: 3MT in ARPEGE - ALADIN

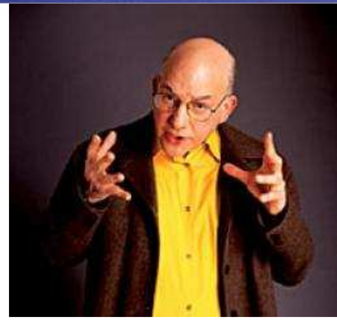
3MT perspectives:

- Test in operational context, associated with CBR prognostic TKE turbulence scheme.
- Extend 3MT to shallow convection.
- Use a prognostic variable to deal with density currents → better diurnal cycle and onset of convection.

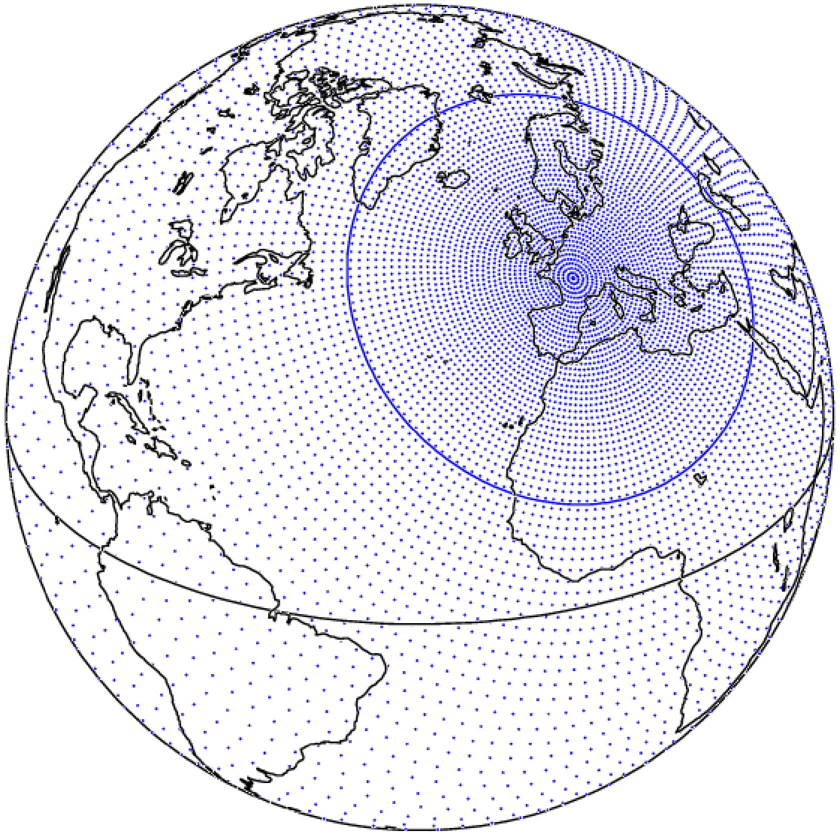
Towards high resolution modelling:

Increase or decrease complexity?

Dimension, complexity



Gregory Chaitin, December 2003: Complexity of a physical process: size (in bits) of the smallest source code which simulates the process. Navier-Stokes + radiation + microphysics + parameterizations ➔ thousands of FORTRAN source lines.



Dimension of a problem: number of points in space and time, where the above complexity needs t be computed. Predictions 5 days range, dt 15mn, 50km horizontal, 41 levels: ~10^10 spatio-temporal points.

Prediction cost: product (dimension * complexity).

Dimension, complexity

Paradox: in numerical prediction

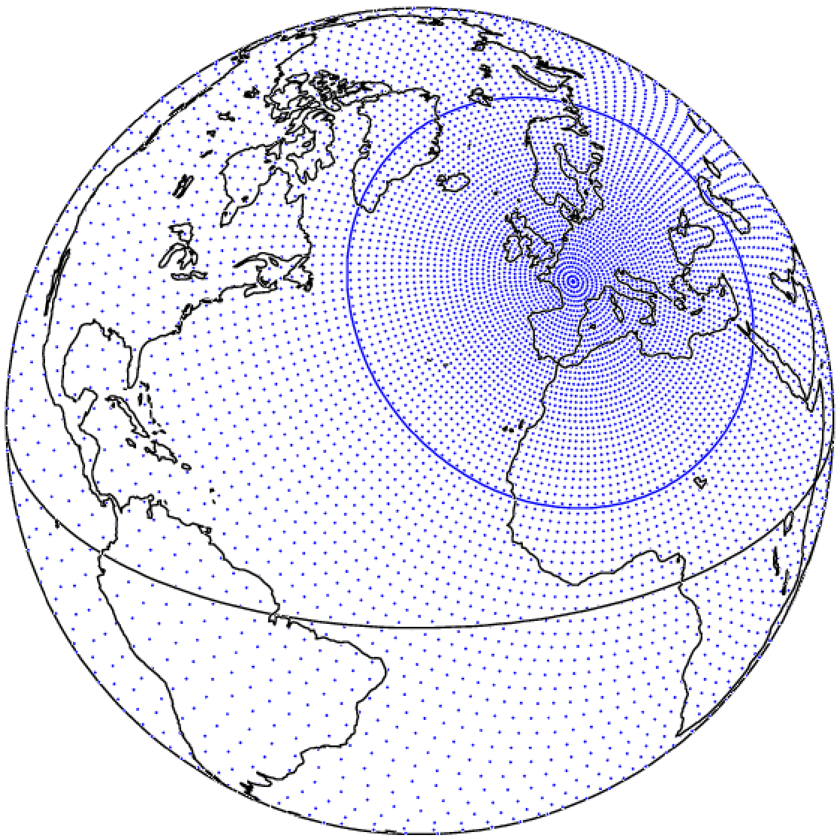
Reduce cost ➔ Reduce dimension ➔
Increase of complexity

Reversely,

More computation power ➔ Increase of dimension ➔ decrease or increase complexity.

Increase complexity: take into account a new process (e.g. in microphysics).

Decrease complexity: suppress an approximative concept in parameterization, being closer to primitive equations (ex: suppress the convective parametrization, as going from CSRM to LES).



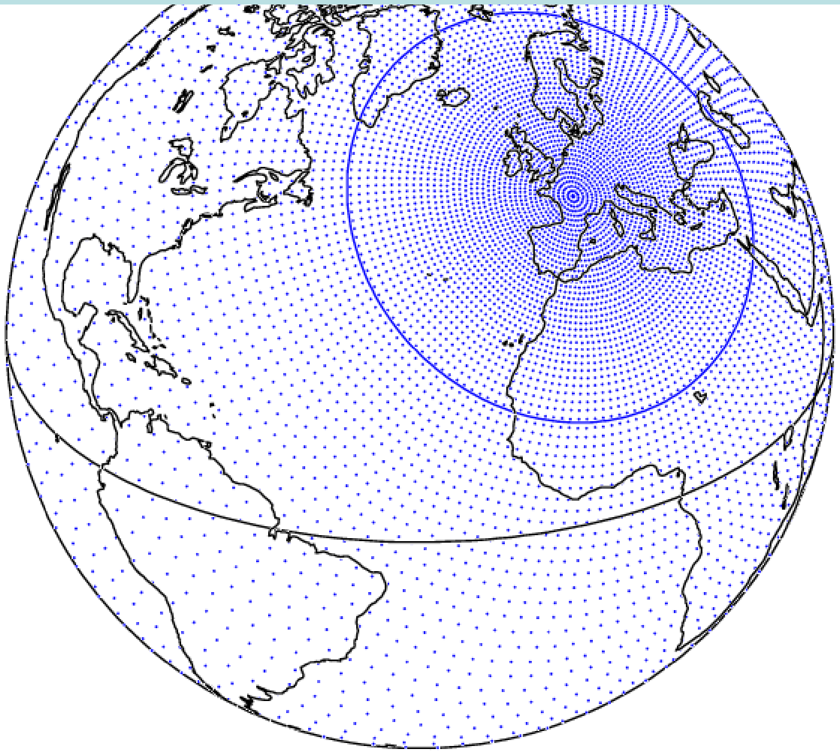
Dimension, complexity

Complexity in numerical prediction has two sources:

Numerical complexity: number of prognostic variables (and equations)

Conceptual complexity: number of equations, based on an approximate physical concept (statistical). Ex: single ascent in convection, mixing length in turbulence, plane-parallel clouds in radiation, etc

Numerical complexity easier to deal with than conceptual complexity.



Numerical complexity: source of variability and realism , source of positive feedbacks (instabilities, noise), additional variables need to be initialized.

Conceptual complexity: if some concepts are approximative, what about interactions between several such approximative concepts (+ and - feedbacks) ➔ difficult to handle and tune.

An alternative to statistical approaches: multimodal FP-MT

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

transport horiz. — transport vert.

microphysique

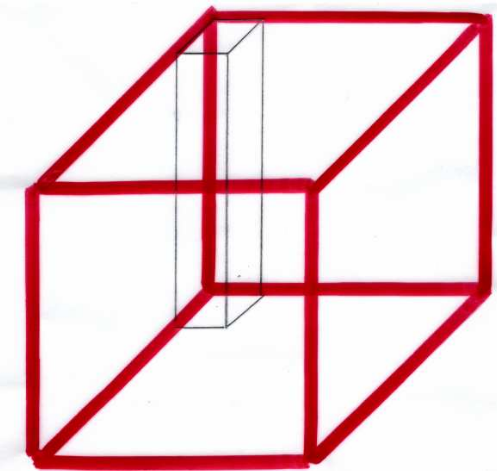
$$
\left\{
\begin{array}{lcl}
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \overline{\rho}^i \sigma_i}{\partial t}\right)_{cp} & = & \sum_{j\neq i}(E_{ij} - D_{ij}) - \frac{1}{\overline{\rho}^i}\frac{\partial}{\partial z}\overline{\rho}^i \sigma_i \overline{w}^i \\
\frac{1}{\overline{\rho}^i}\left(\frac{\partial \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)
$$

sources/puits de vent horiz. et vert.

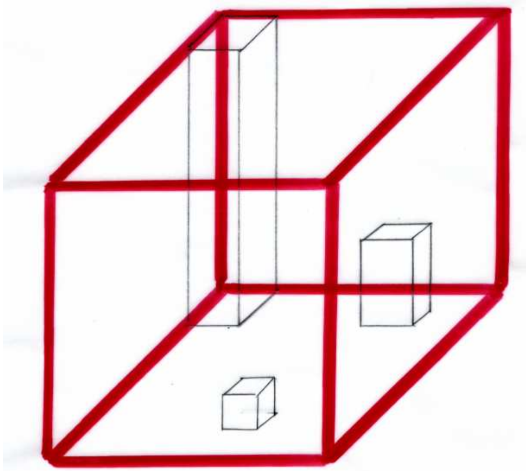
N subgrid-scale modes, i=1,n. (ex: updraft, downdraft, density current, etc). For each mode: a set of prognostic equations for mass (sigma), water vapour, condensates, heat, horizontal and vertical wind. In red: microphysics: condensation, evaporation, autoconversion, collection, etc.

Description. Closer to primitive equations ➔ bridge with superparamétrisations.

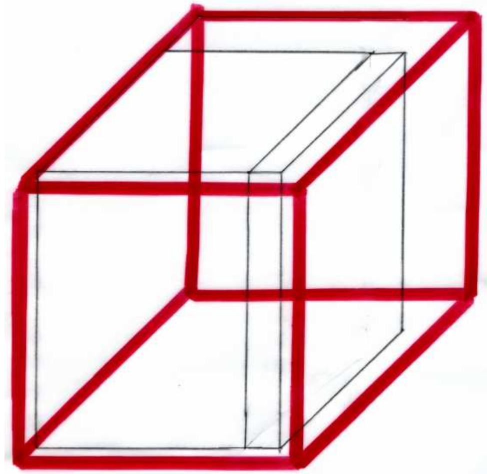
An alternative to statistical approaches: multimodal FP-MT



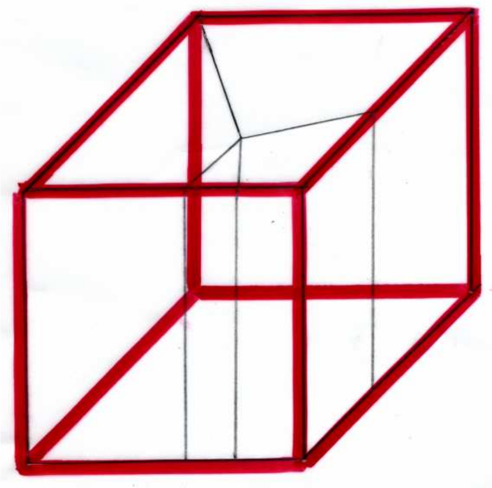
Classical param.



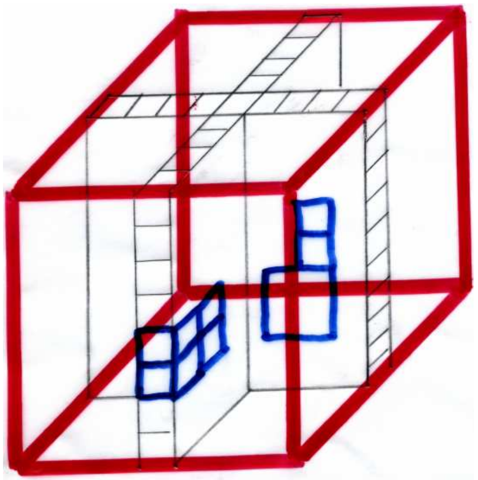
Arakawa Schubert 1974



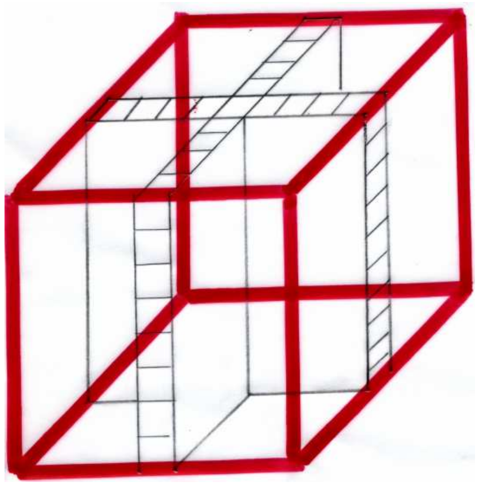
3MT



FP-MT



CSRM-SCA J.-I. Yano



Superparamétrisation

Conclusions / perspectives

- 3MT in precipitating convection mode, in test in ARPEGE / ALADIN, associated to prog. TKE scheme and KFB shallow convection scheme.

- Perspectives: exend to shallow convection, develop prognostic entrainment.

- Towards high resolution modelling: numerical complexity easier than conceptual complexity.

- Fully-Prognostic MT: a multimodal alternative to statistical schemes?

Fin

3MT in ARPEGE – ALADIN: Summary

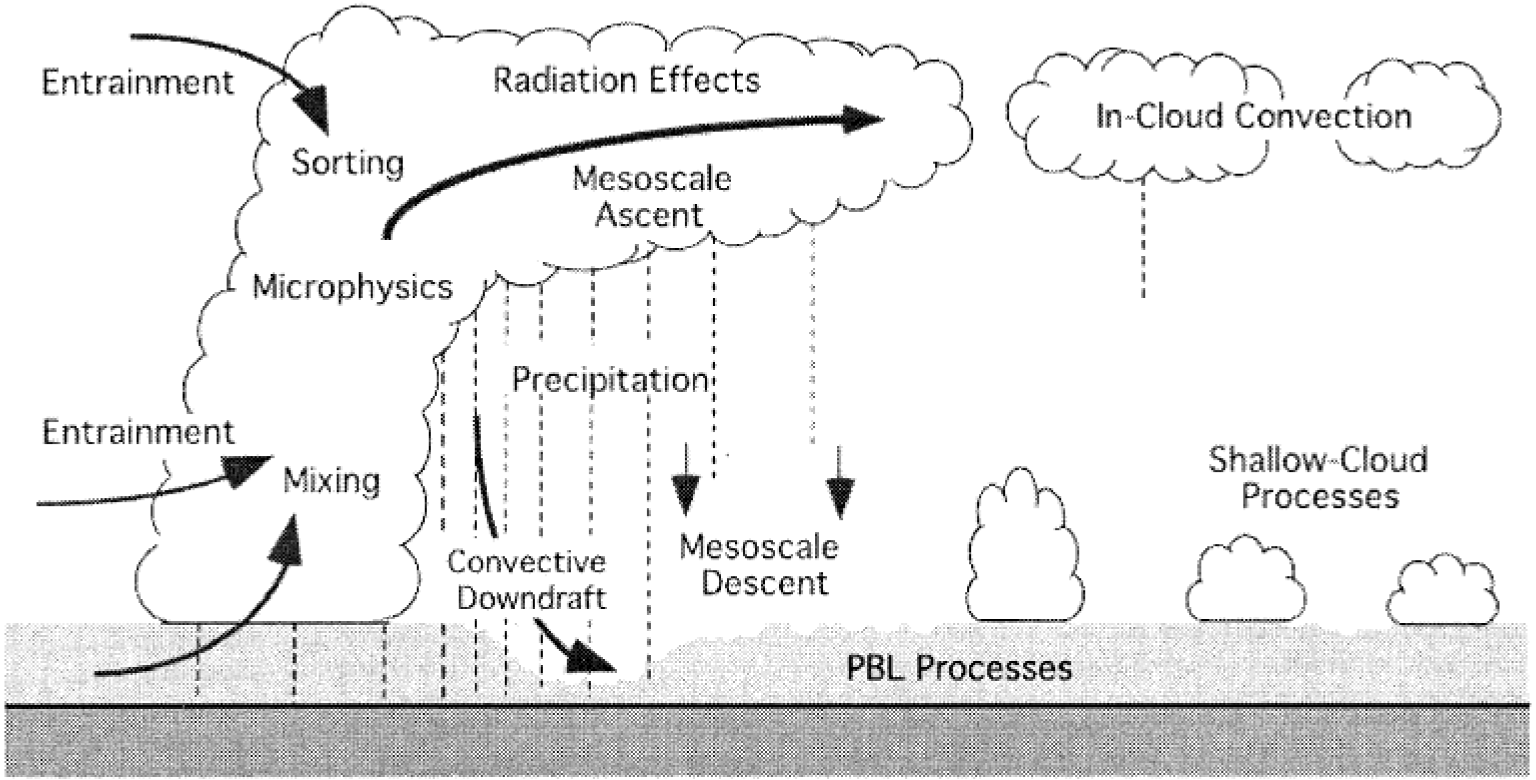


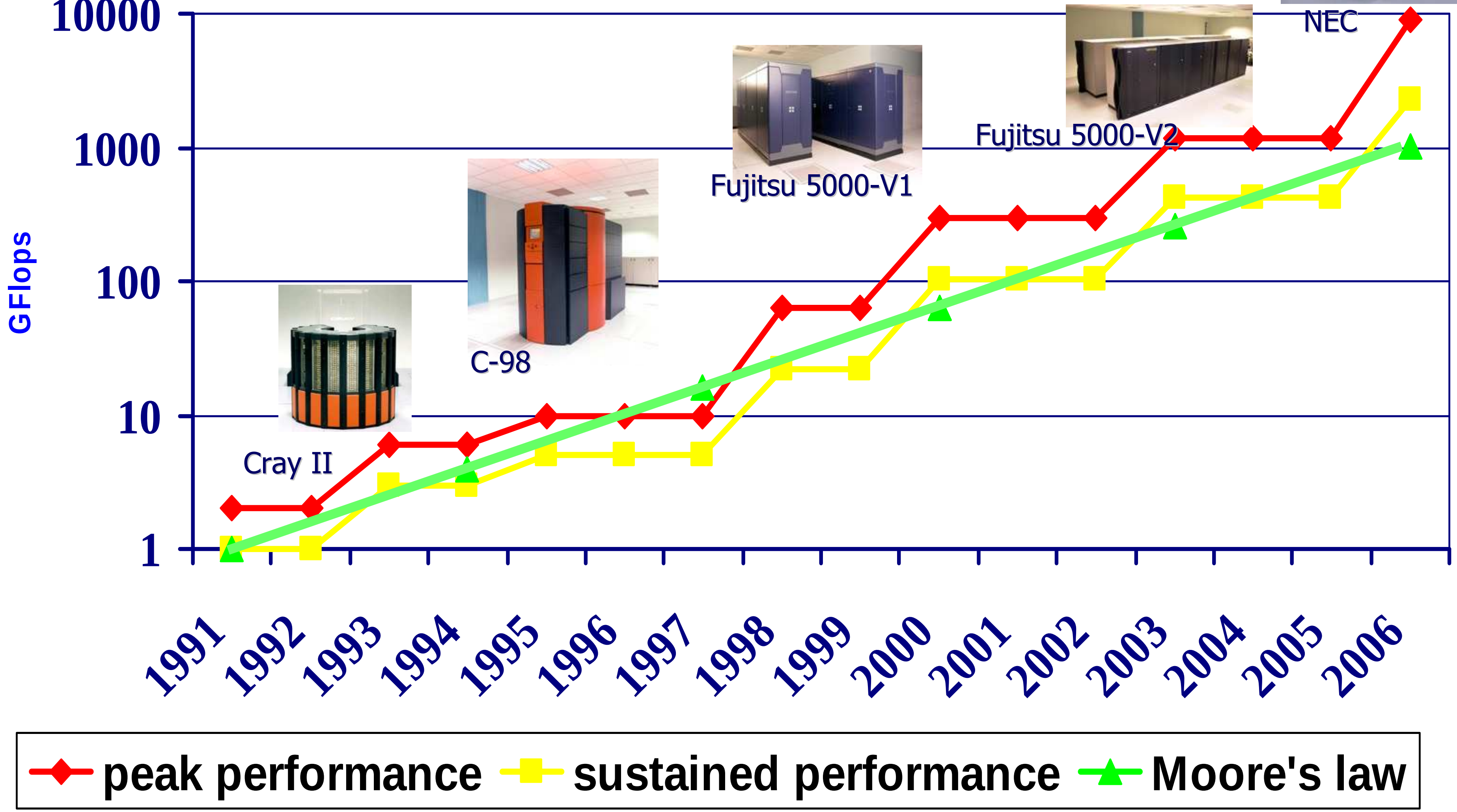
Schéma source Arakawa (JC 2004).

Complexité conceptuelle: entraînement, tri de flottabilité, précipitation, évaporation, courants descendants, soulèvement.

Interaction avec le rayonnement, effets de masque, recouvrements aléatoires/maximaux, etc.

Or, équations primitives.

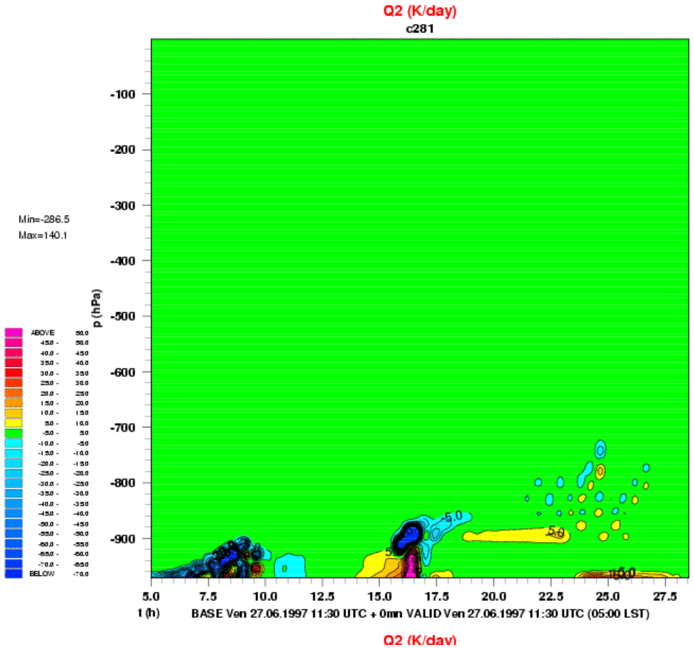
3MT in ARPEGE – ALADIN: Summary

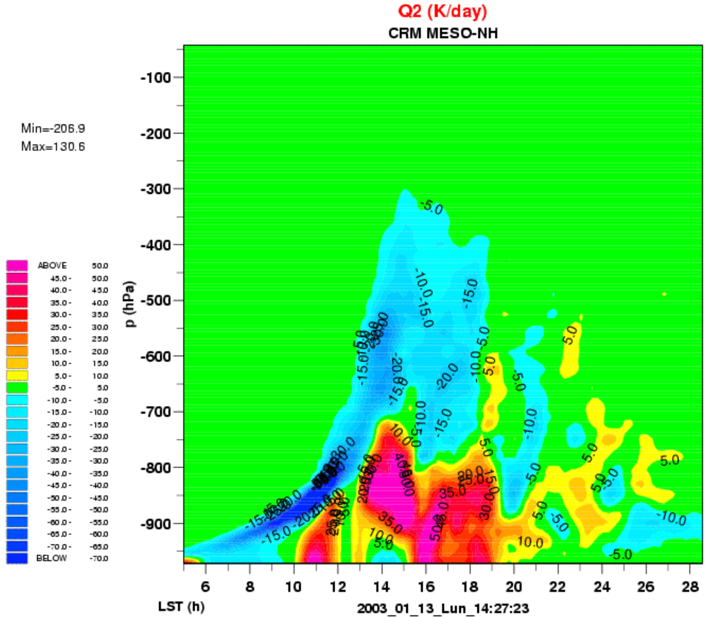


Graphique source Météo-France/DSI, NEC

MT – What has been done – Results

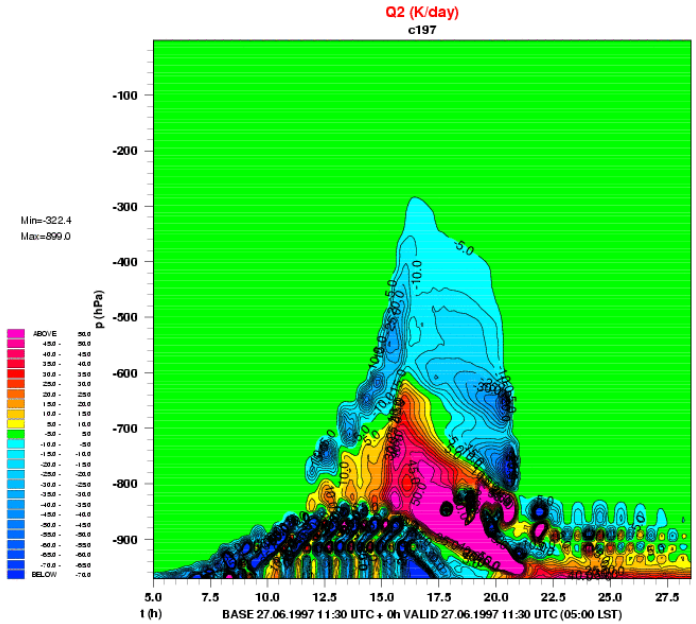
ARPEGE
oper





CRM
MNH

Convective drying simulated by 3 models



ARPEGE
MT, prog. entr

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