Laboratoire de Glaciologie et Géophysique de l'Environnement

Université Joseph Fourier GRENOBLE

cnrs advancing the frontiers

LMDz avec la physique du modèle MAR

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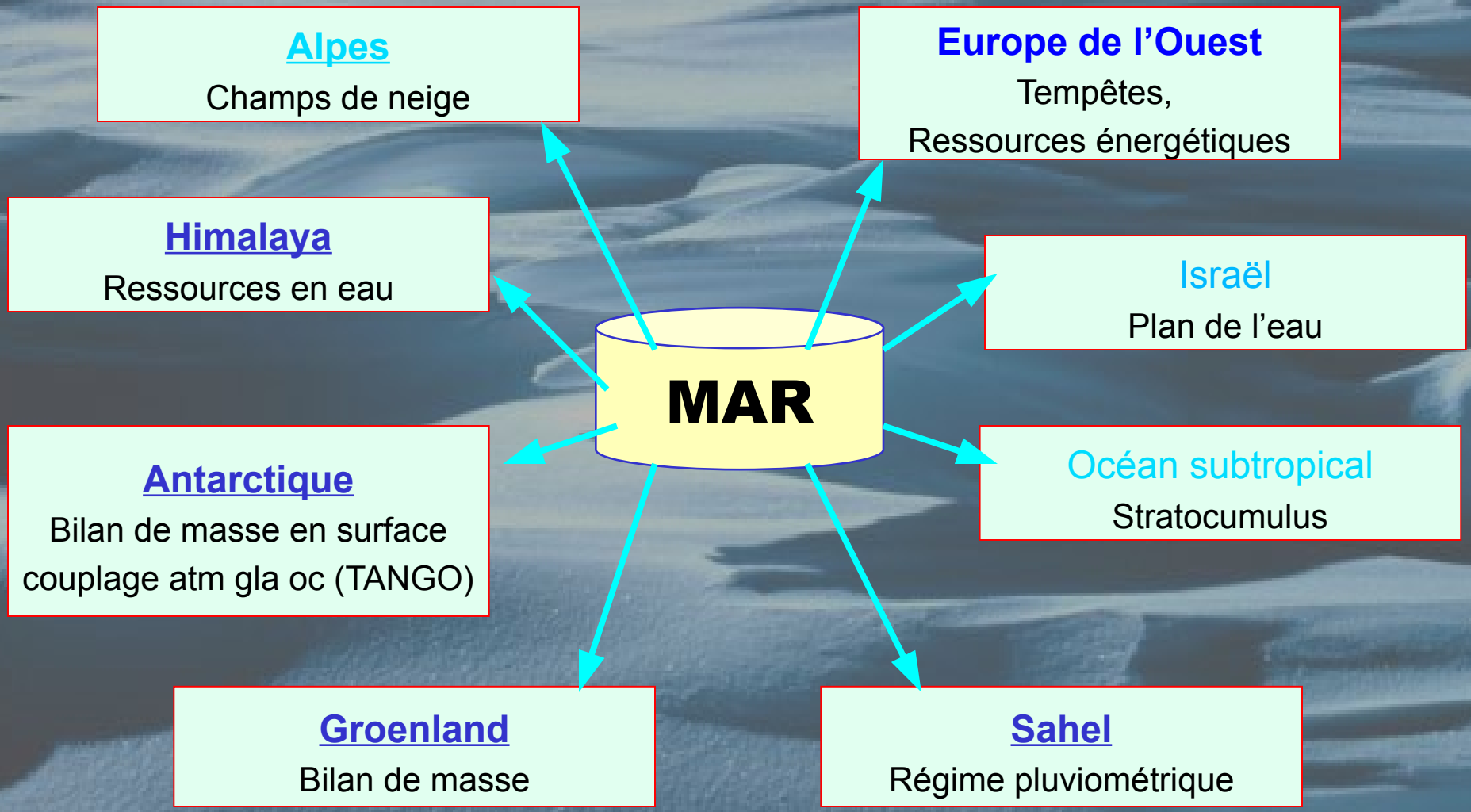
LGGE / Univ. Grenoble / CNRS

Modèle **A**tmosphérique **R**égional = **MAR**

- développé par Hubert Gallée depuis 20 ans
- appliqué à différents cas d'études (cf. biblio annexe)
- modèle de surface développé et testé pour la neige
- microphysique nuageuse (résolution nuages)
- code libre > disponibilité sur plate-forme IPSL via LMDz

MAR - applications



Entrées - Pré-traitement

Initialisation et forçage

- **Sondages (1D)**
  - Vent U,V
  - Température
  - Humidité spécifique
- **MCGA (3D) ➔ imbrication**
  - Vent U,V
  - Température
  - Humidité spécifique

Caractéristiques de surface

- Topographie
- Types de sol
- Végétation, ...

Modèle

MAR (Modèle Atmosphérique Régional)

Dynamique

- Equations primitives
- Hydrostatique
- Coord. verticale : σ
- Modes 1D, 2D et 3D
- $1\ km \leq \Delta x \leq 40\ km$

Paramétrisations

- Rayonnement solaire et IR
- Microphysique nuageuse explicite
- Fermetures turbulentes
- Echanges avec la surface
- Paramétrisation de la convection

Sorties - Post-traitement

- Champs météorologiques 3D
- Statistiques

Comprendre les interactions atmosphère – cryosphère

Processus physiques atmosphériques

- Précipitations (Svalbard, Kergelen, ...) (Charlotte Lang, ULg, Deborah Verfaillie, LGGE)
- Transport éolien (Antarctique) (Hubert Gallée, LGGE Charles Amory, LGGE)
- Fonte (Groenland) (Xavier Fettweis, ULg, Patrick Alexander, UCN)
  (Antarctique de l'Ouest) (Hubert Gallée, LGGE, Tri Data, UCN)
  (Himalaya) (H-W Jacobi, LGGE, Hubert Gallée, LGGE)

Dynamique atmosphérique

- Couplage stratosphère – troposphère (Hubert Gallée, LGGE)
- Changements de circulation atmosphérique et état des surfaces
  - champs de neige (couplage A – C) (Xavier Fettweis, ULg, Heiko Goelzer, VUB)
  - champs de glace de mer (couplage A – G – O) (Nicolas Jourdain, LGGE)

Méthodologie

- Validation de paramétrisations et/ou de configurations dans un LAM (MAR)

Processus	taille domaine	dx	Forçage	Observations
physiques	< Rd	< 10 km	ERA	Terrain,satellite
dynamiques	> Rd	> 10 km	ERA	ERA

- Quantification pour le climat présent
- Downscaling Scénario futur si climat présent OK (condit. nécess. mais PAS suffisante) (Cécile Agosta, Xavier Fettweis, ULg)
- Upscaling (LMDz) (Gilles Delaygue, LGGE)

Comprendre le transport turbulent dans la couche limite

Susanne Preunkert, LGGE

Comprendre les interactions atmosphère – végétation (Afrique des Grands Lacs) (Louis François, ULg)

Processus : Précipitations, Végétation

Méthodologie

- Quantification pour le climat présent
- Scénario futur si climat présent OK (condition nécessaire mais PAS suffisante)

Évaluer les ressources énergétiques (Europe)

Éolien Xavier Fettweis, Sébastien Doutreloup, ULg

Solaire Xavier Fettweis, Julien Beaumet, ULg

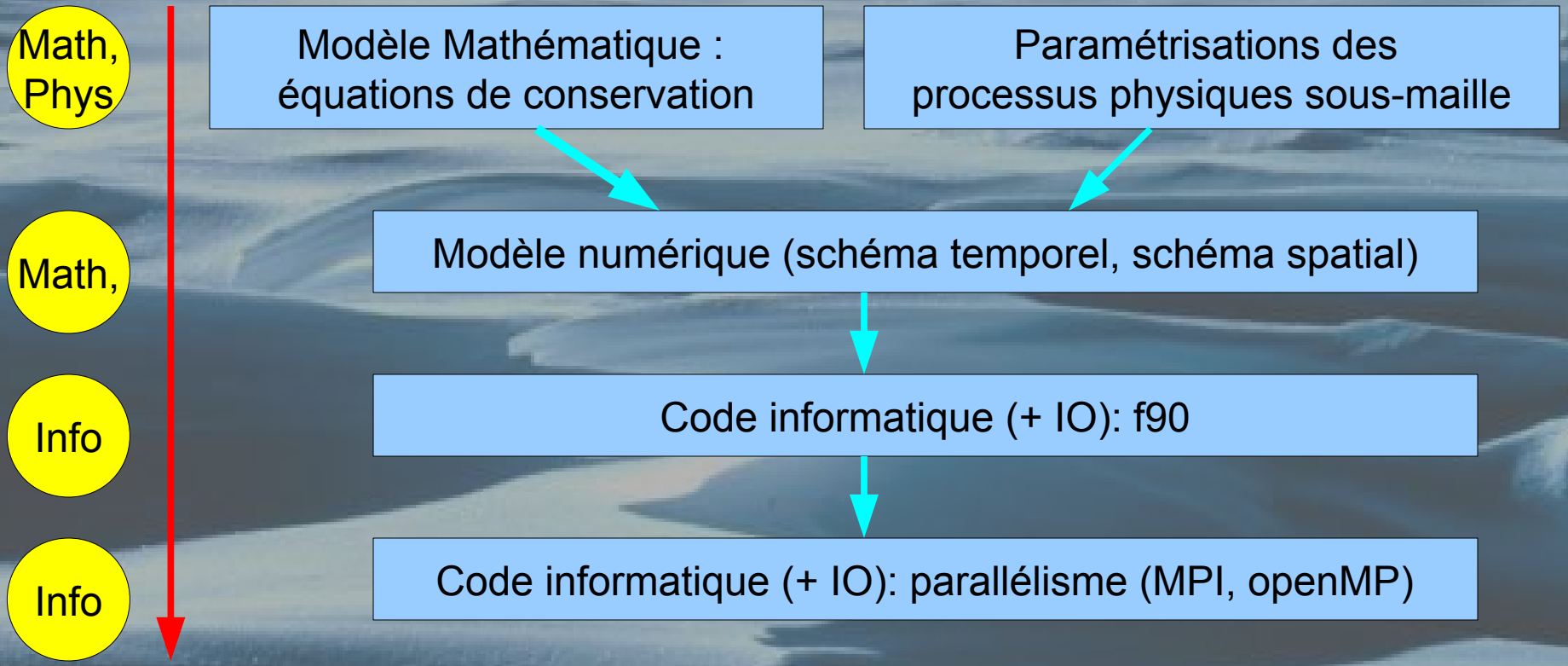
Processus

- Turbulence dans la basse troposphère
- Champs nuageux

Méthodologie

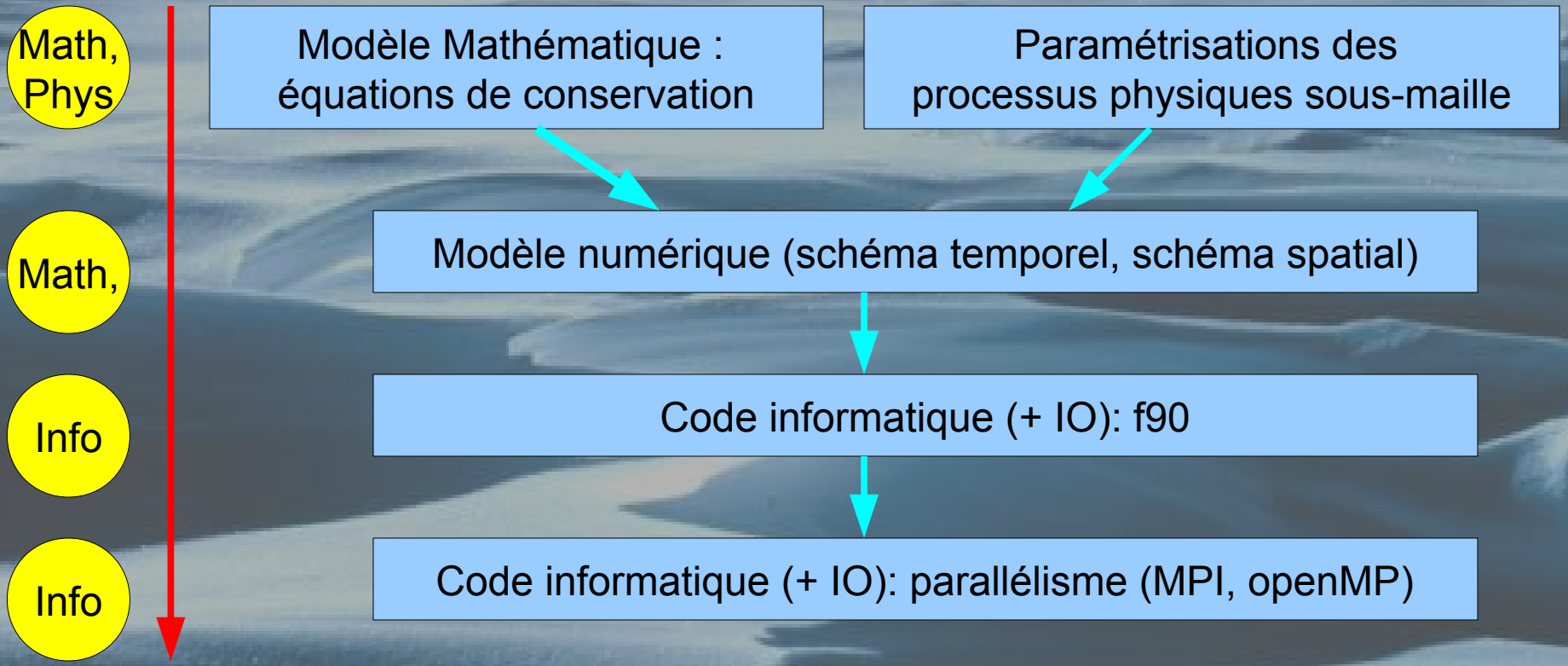
- Validation de configurations dans un LAM (MAR)
- Quantification/validation à l'échelle de quelques jours (prévision du temps)

Développements Techniques



Equations :	Hubert Gallée (LGGE)
Paramétrisations :	Hubert Gallée (LGGE), Xavier Fettweis (ULg), Hans-Werner Jacobi (LGGE)
Code numérique :	Hubert Gallée (LGGE)
F90 + MPI :	Hubert Gallée (LGGE), Aliou Diouf (LGGE)
OpenMP :	Xavier Fettweis (ULg)
IO :	Xavier Fettweis (Ulg), Yann Meurdesoif (LSCE)

Développements Techniques



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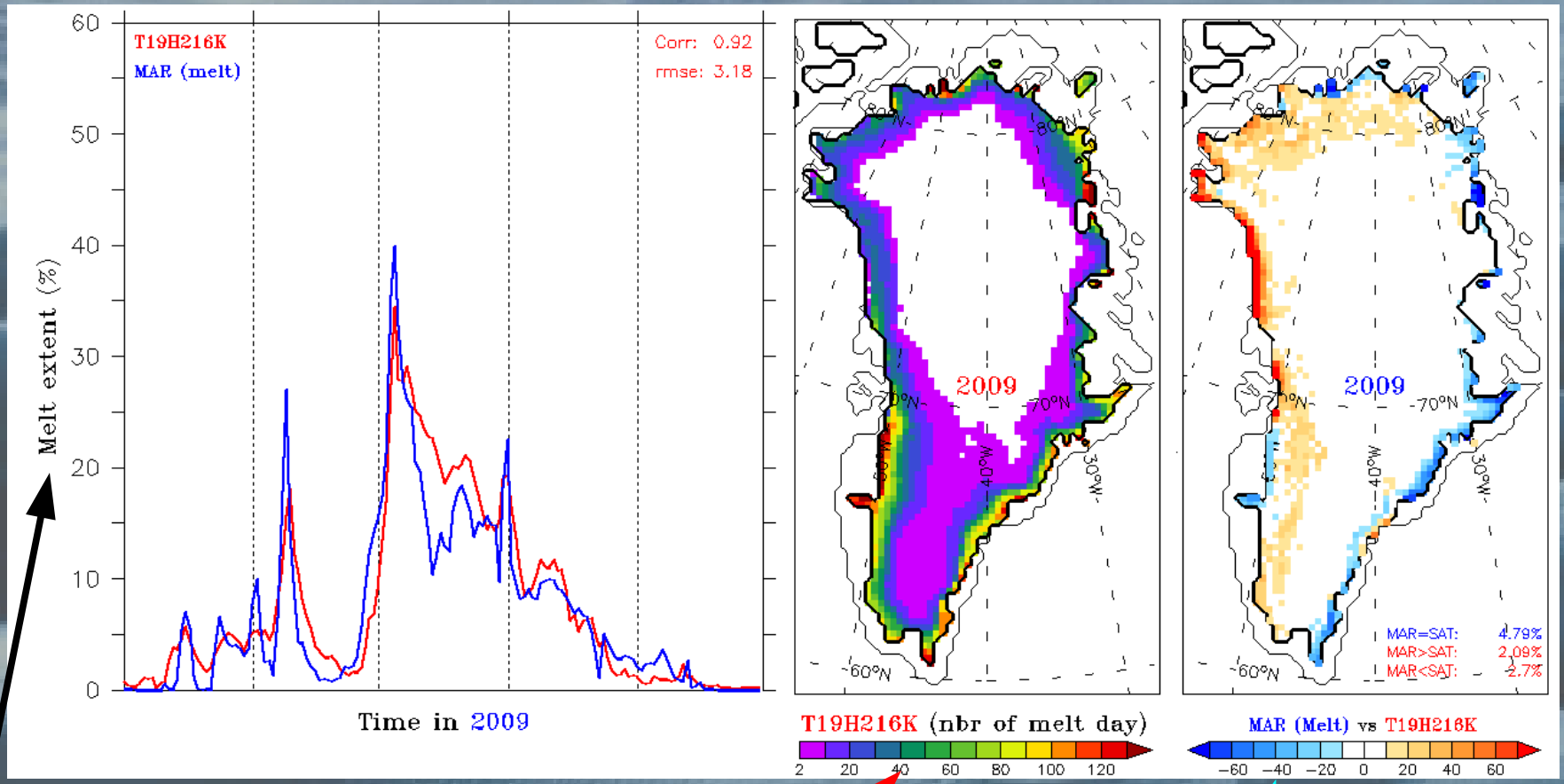
MAR versus microwave-derived melt extent during summer 2009



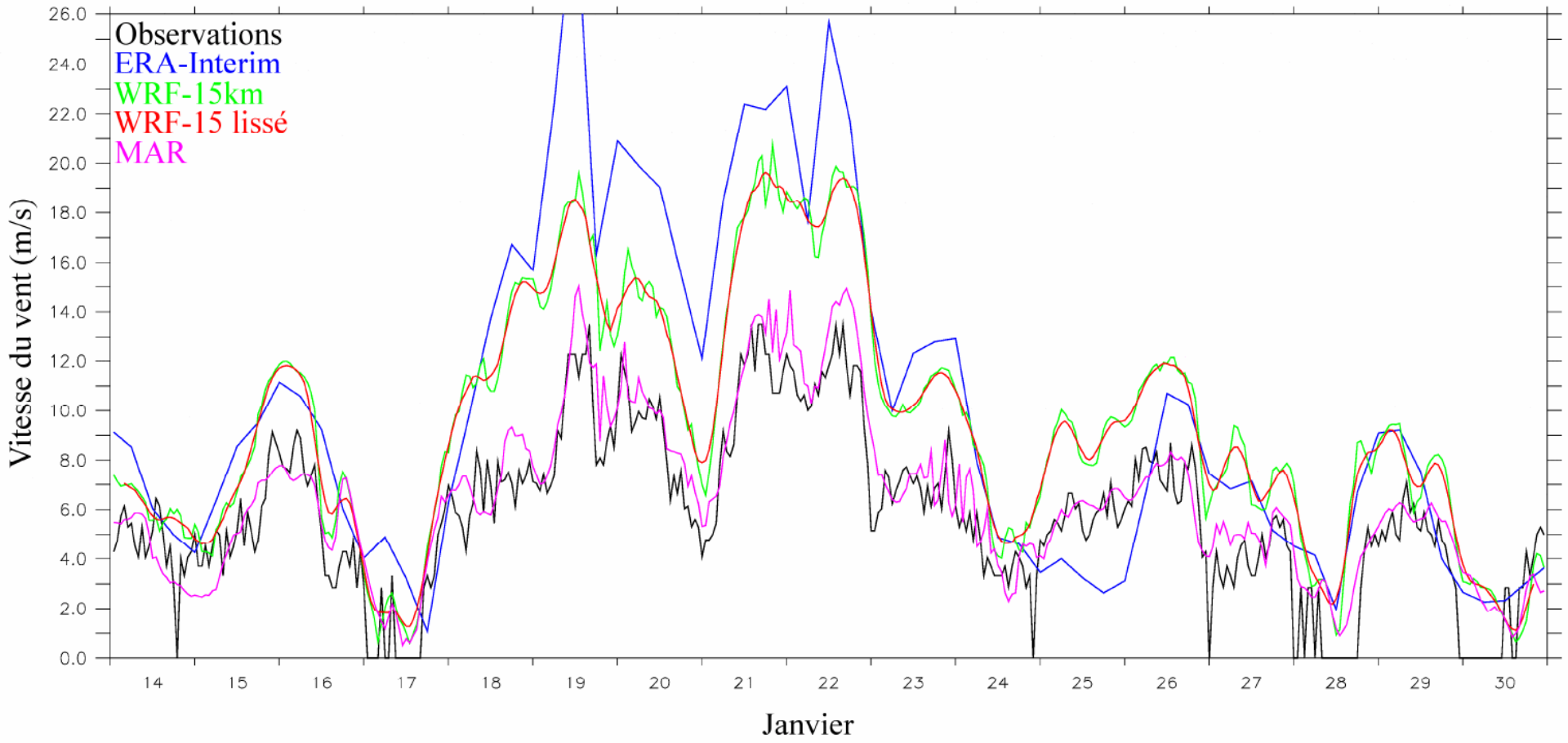
Percentage of the ice sheet surface

Number of melt day derived from T19H

Difference with MAR

TAILLE Domaine < R_d

Comparaison MAR – WRF sur la Belgique



TAILLE Domaine < R_d

Couplage de la physique de MAR à la dynamique de LMDz

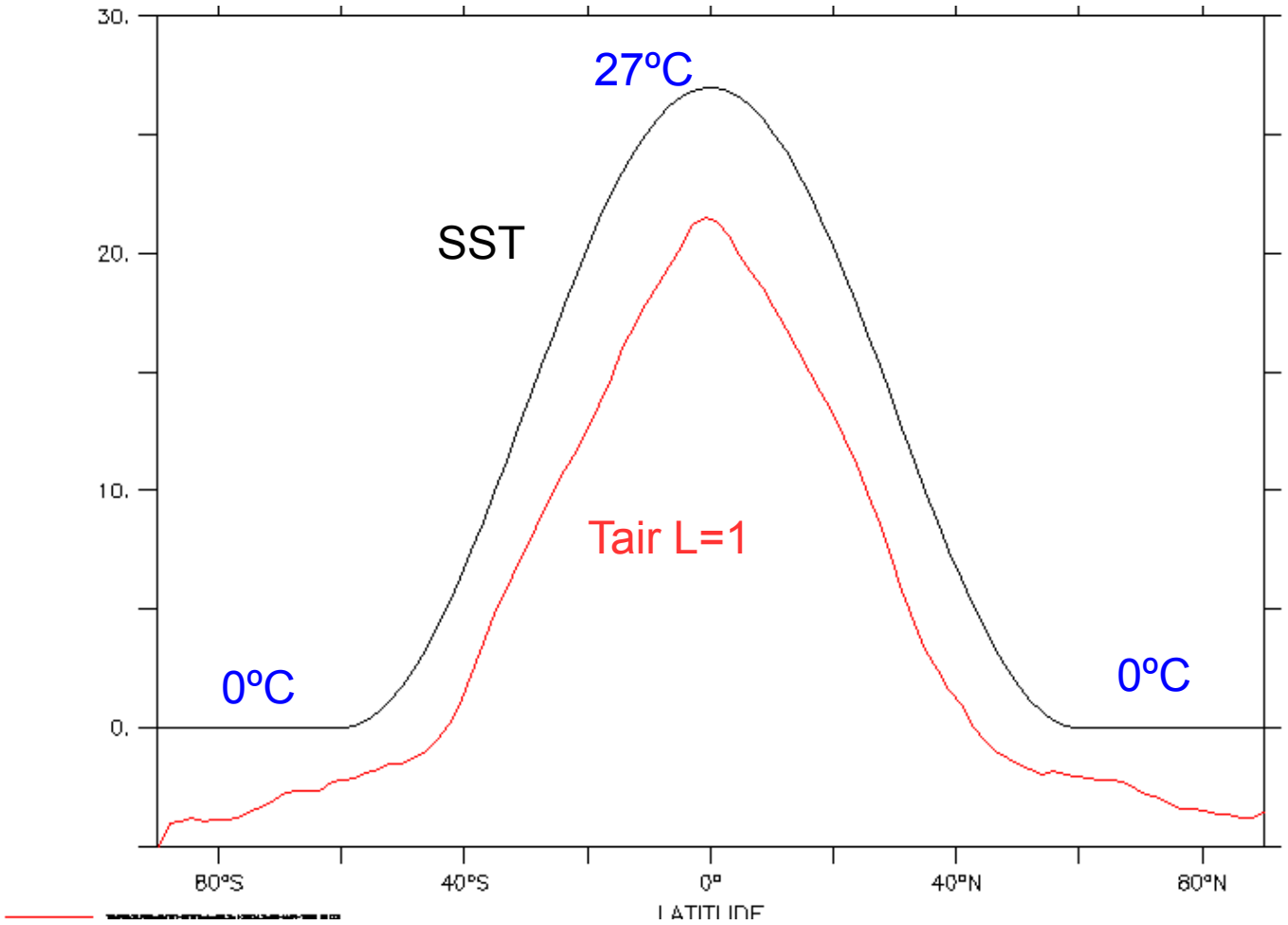
- réalisé par Martin Ménégoz (*contrat terminé*), Hubert Gallée & Gilles Delaygue (LGGE), Frédéric Hourdin & Laurent Fairhead (LMD)
- physique de MAR ré-écrite : 3D -> 2D colonnes
- interface physique de MAR ré-écrite : `call physiq()`
- `makefile` ré-écrit : option de compilation '`-p mar`'
- à ce jour : tests en aquaplanète; analyses en cours
- microphysique nuageuse de MAR = *cloud resolving model* (1 km < dx < 40 km) > problème à attendre sur nuages ?

Autre développement : parallélisation de MAR en MPI presque terminée (H. Gallée)

Autre travail réalisé par M. Ménégoz : branchement de SISVAT (modèle de neige de MAR) à LMDz (suite travail de H.Punge)

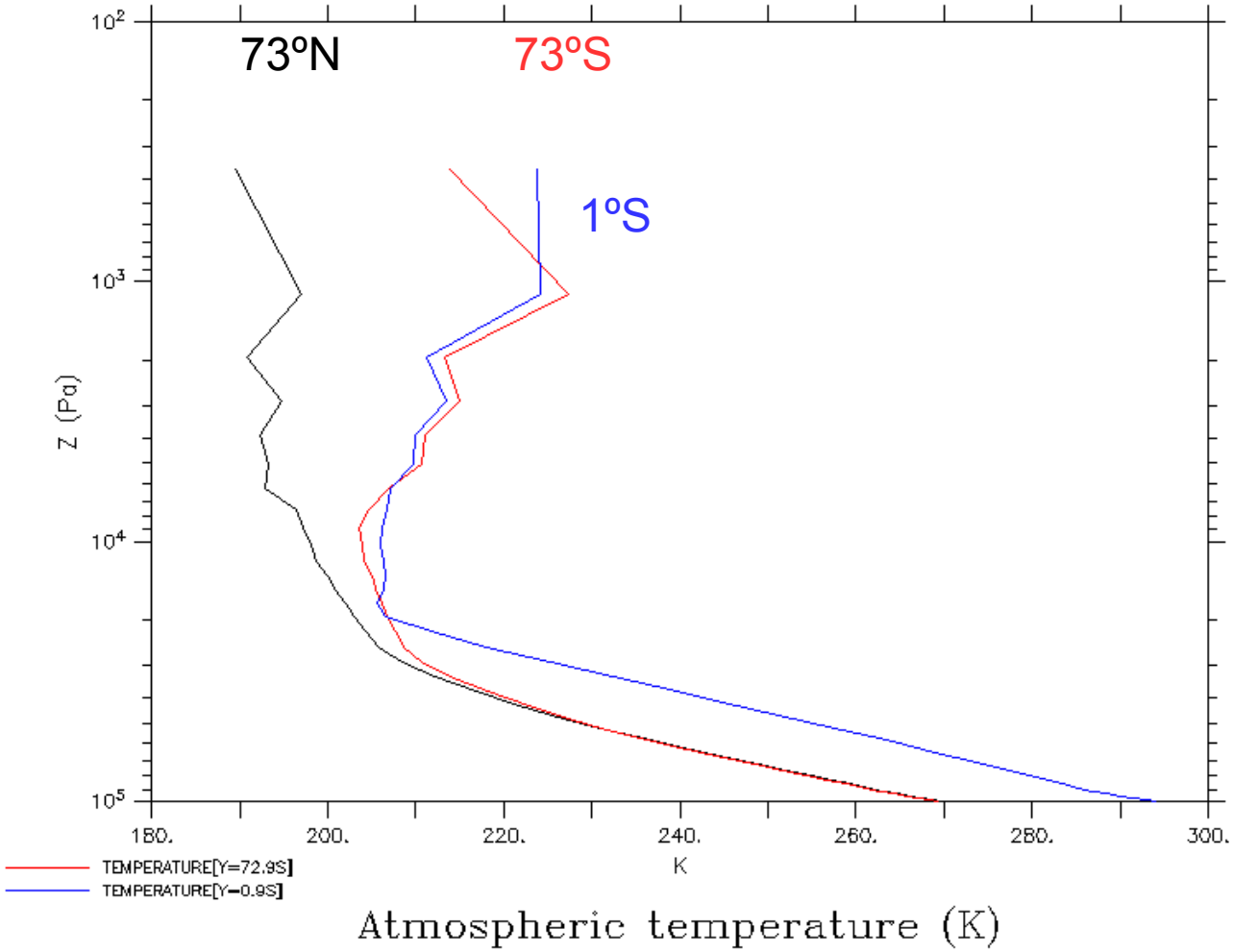
Tests en aquaplanète : 144 × 96 × 39, dt (dyn+phys) = 2mn, sauf convection (20mn) et radiatif (40mn)

sorties instantanées (1 janv > fin mars)



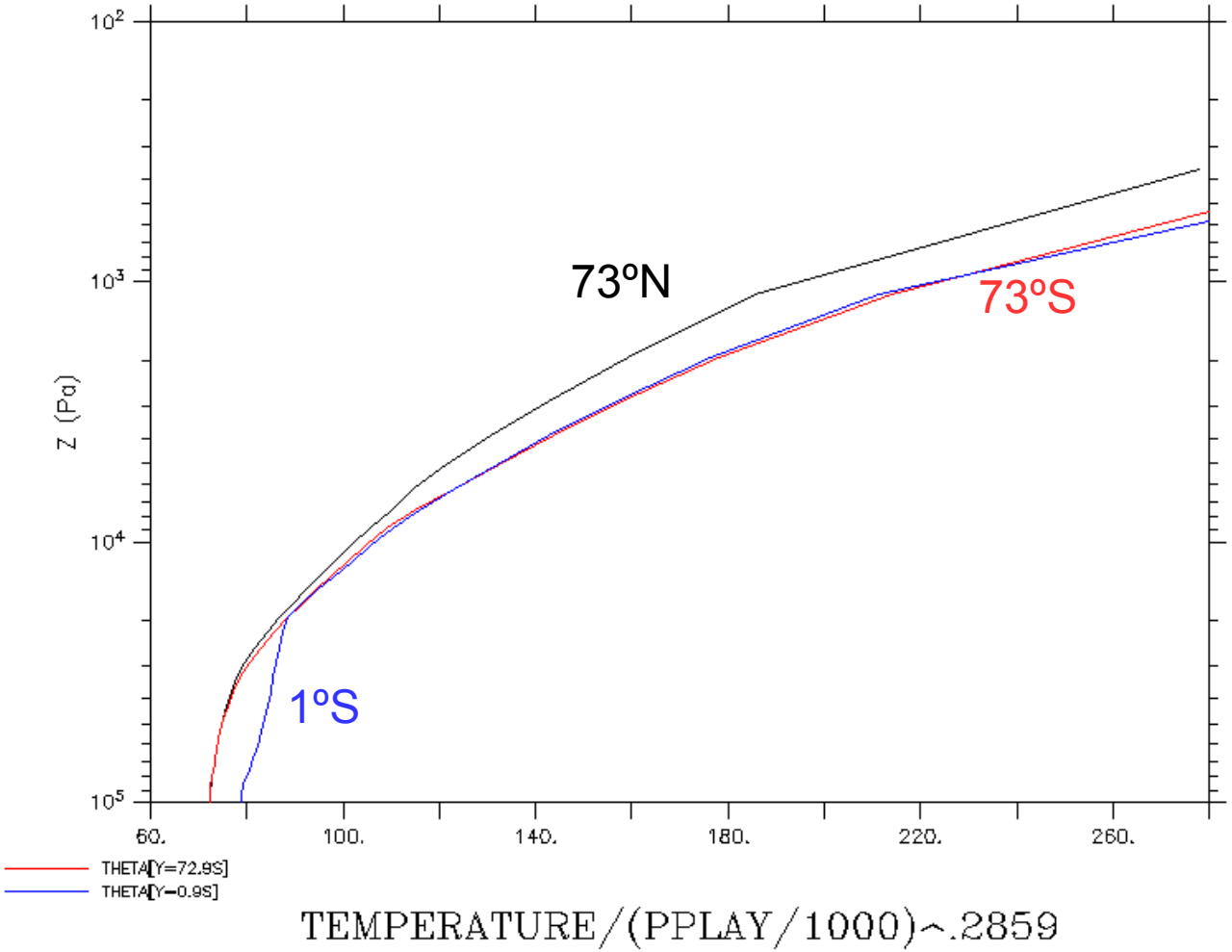
Profils Tair (été austral)

480K @5Pa



Profils Tpot (été austral)

1100K @5Pa



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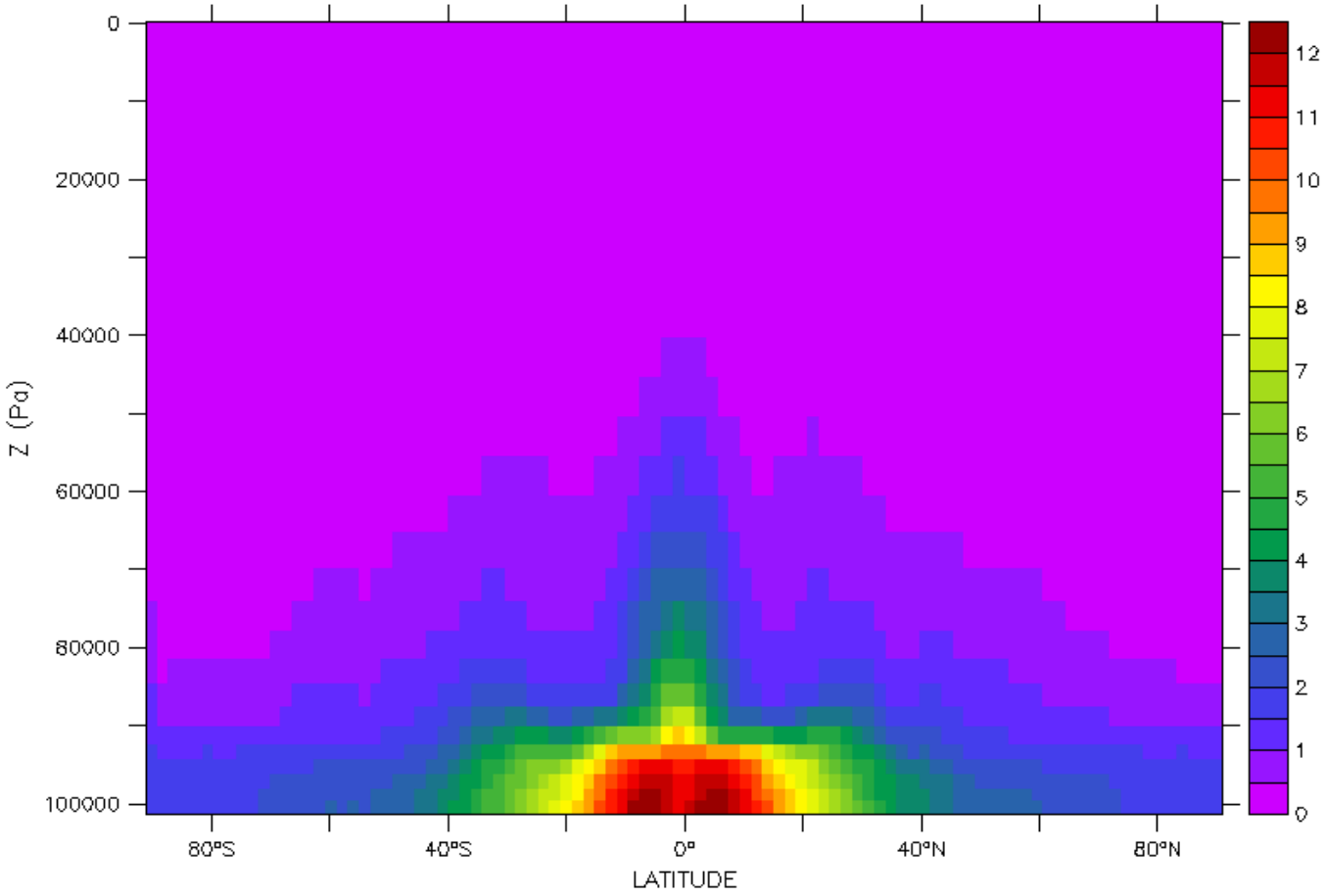
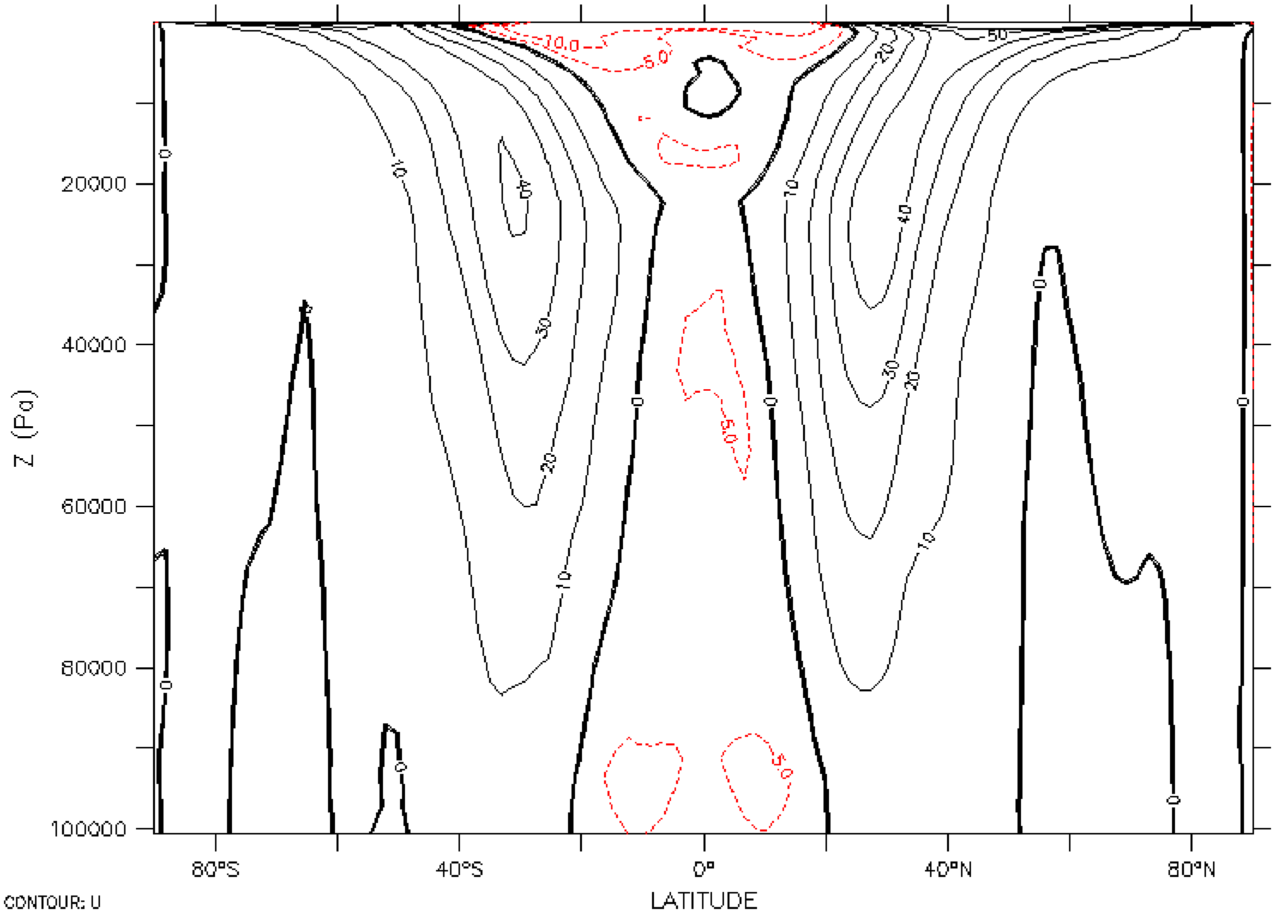
Humidité spécifique (g/kg)





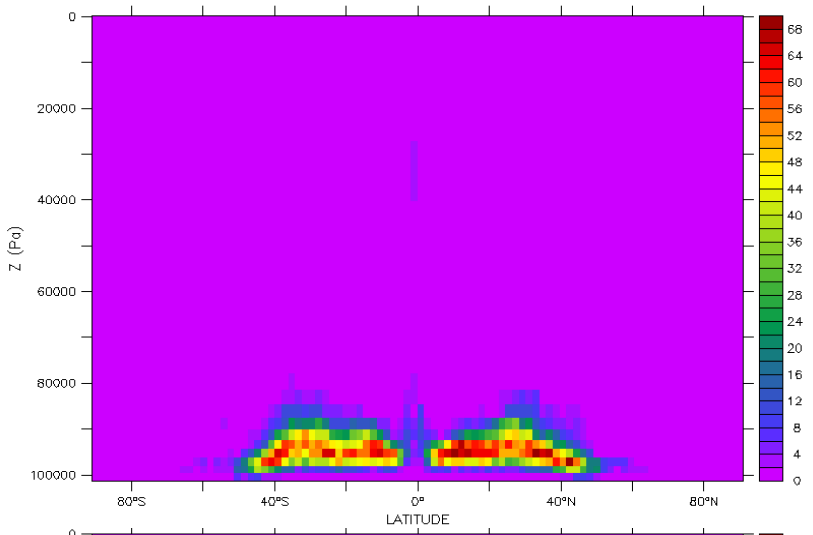
Eastward Zonal Wind (m/s)

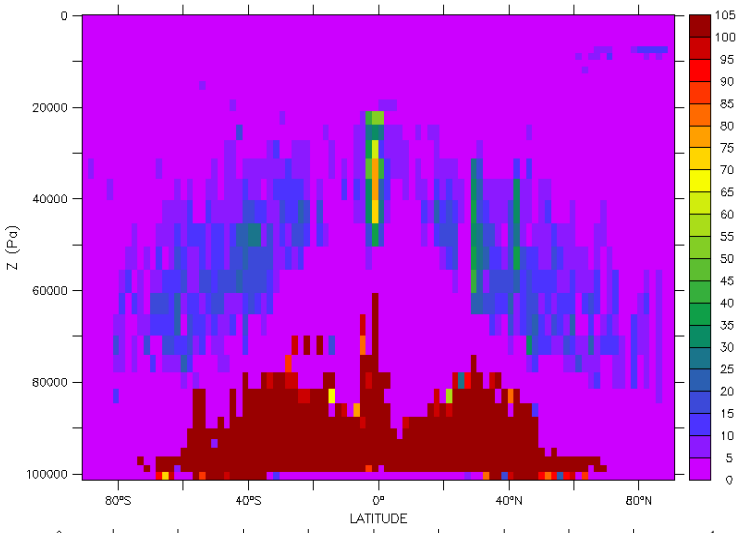
Fraction nuageuse (% / boite) :

moyenne zonale

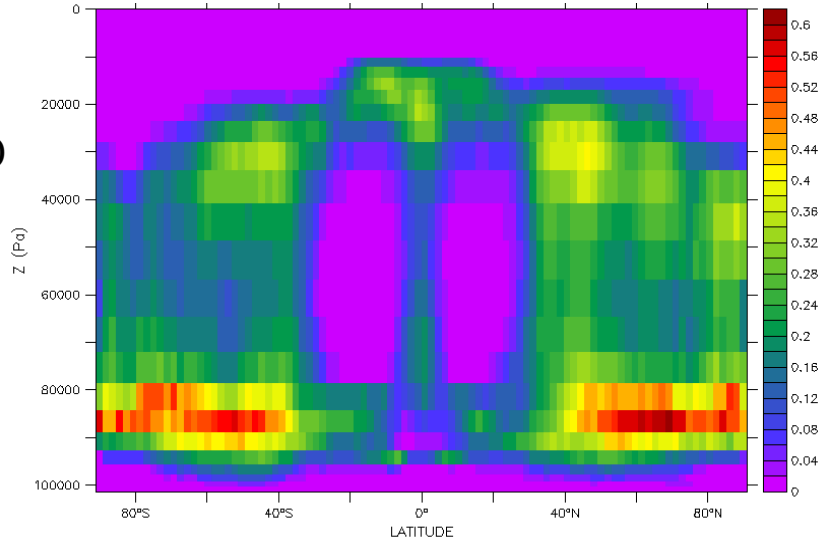
maximum

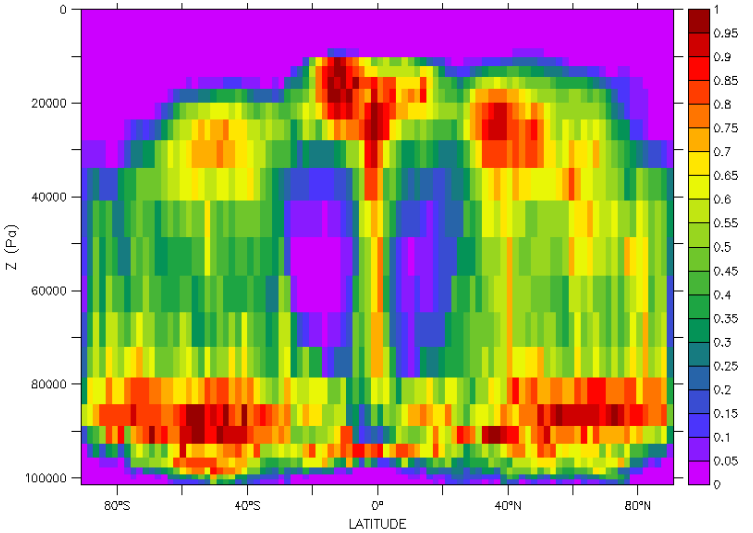
phyMAR

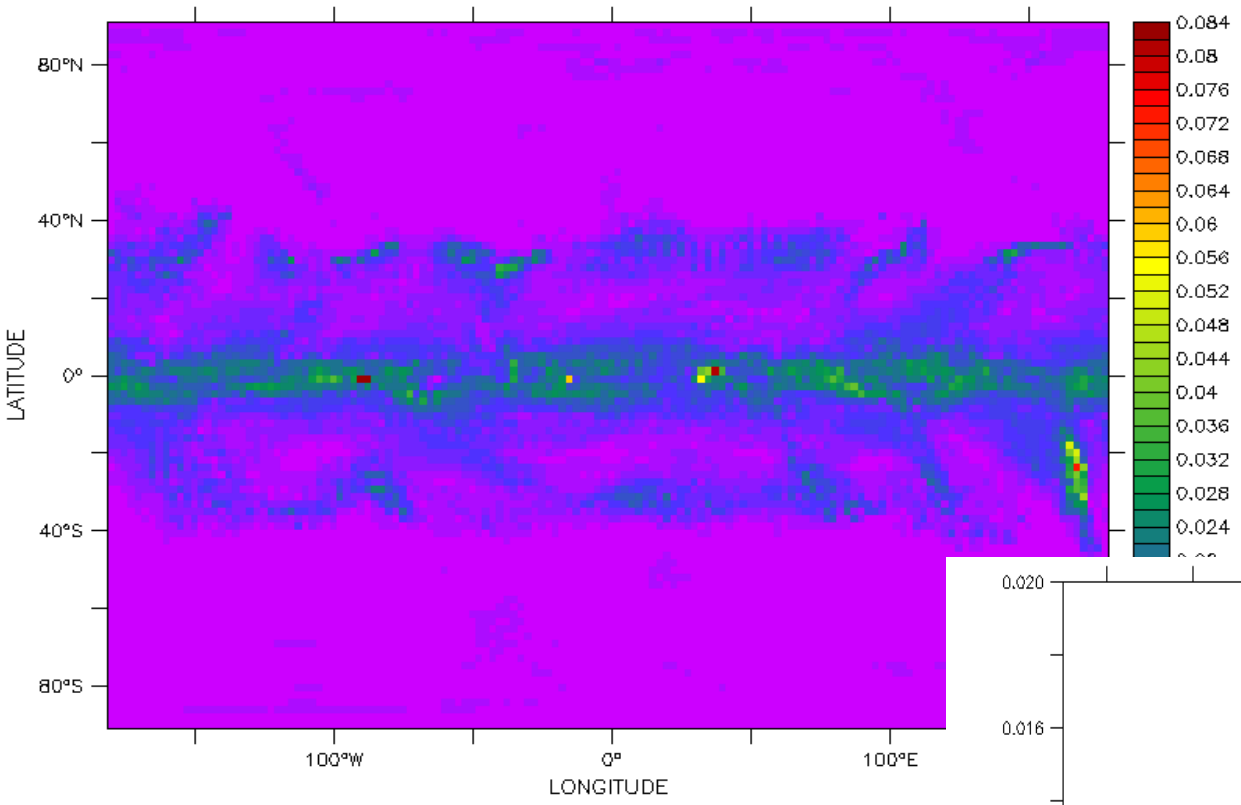




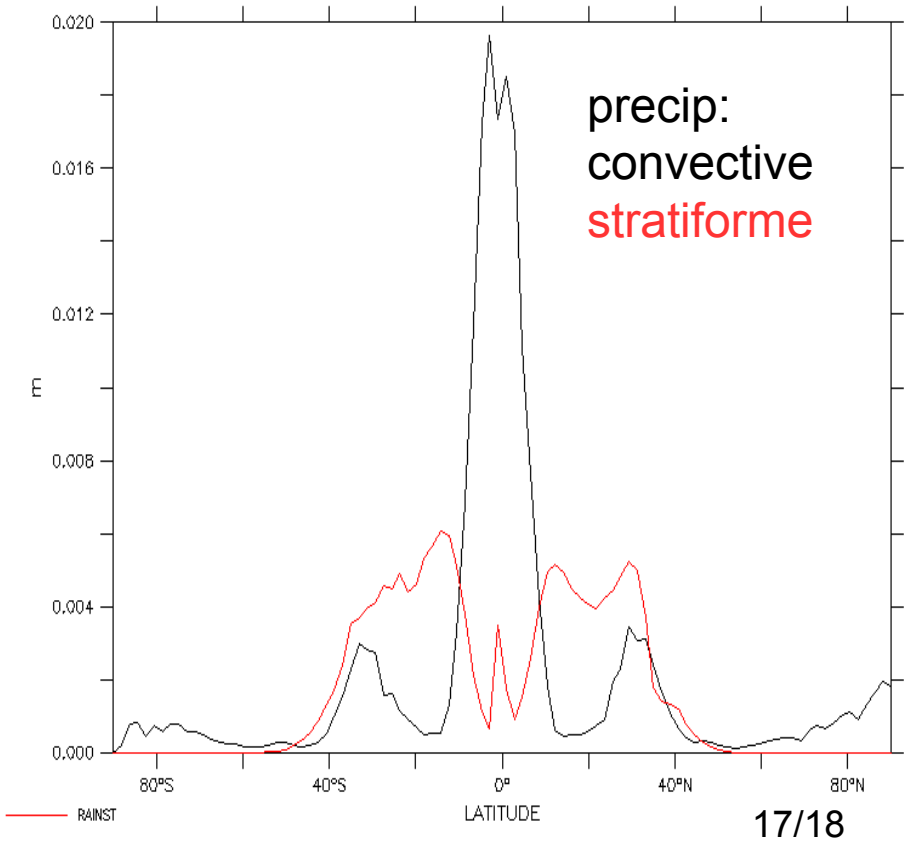
phyLMD







rainfall convectif + stratiform (m



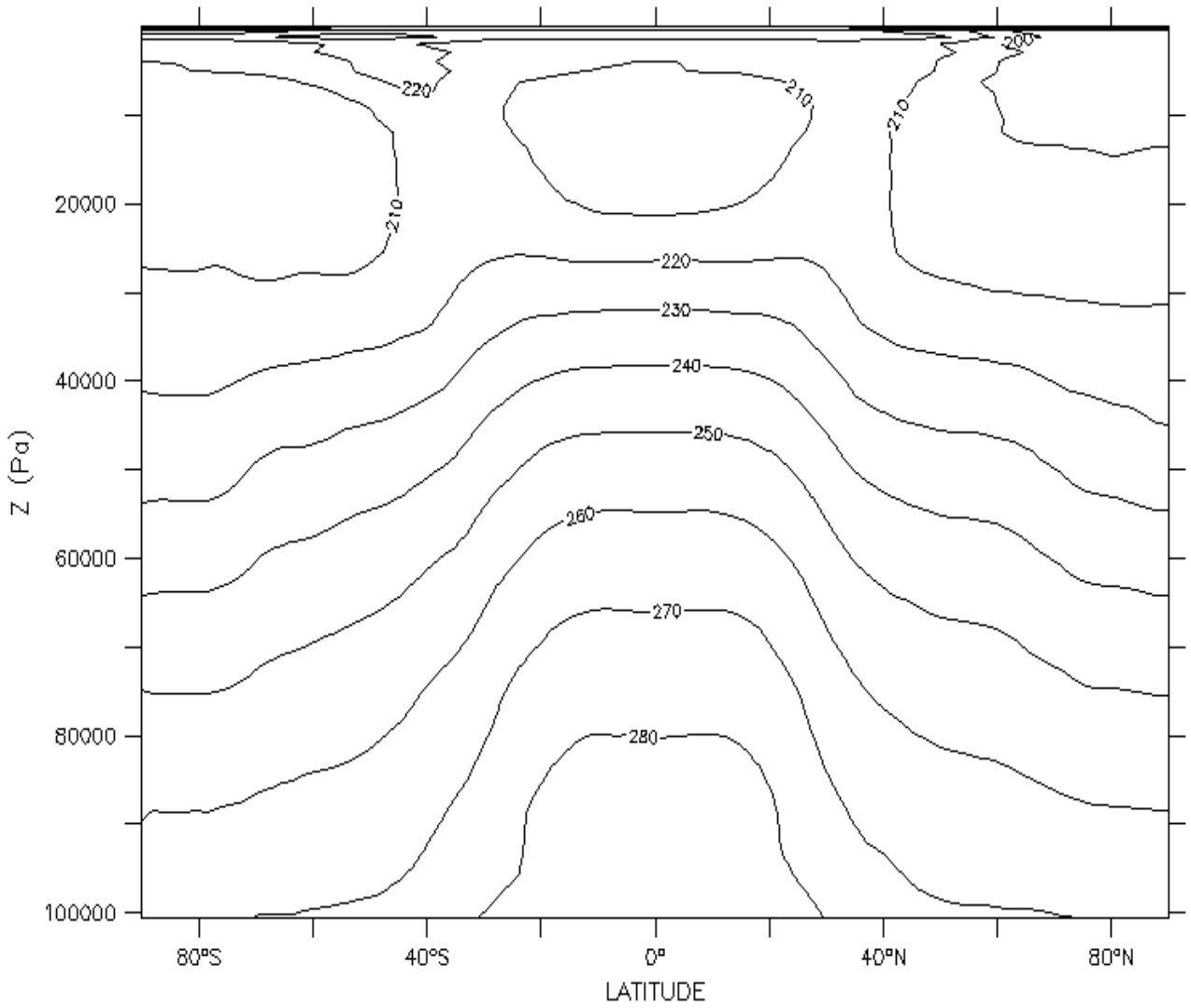
Précipitations

Couplage de la physique de MAR à la dynamique de LMDz
– conclusions –

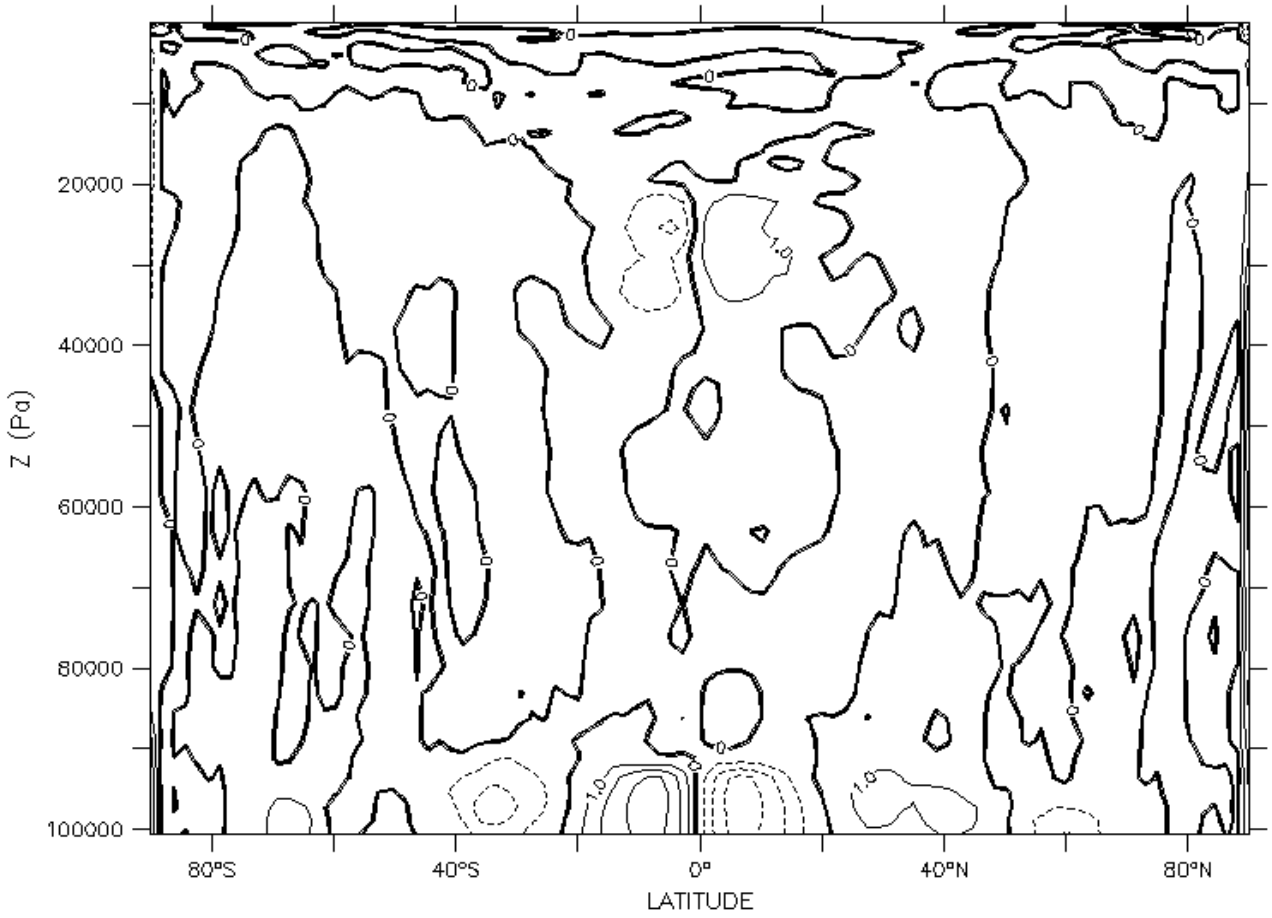
- à ce jour branchement de ‘phyMAR’ à LMDz fonctionne (en aquaplanète...)
- problème de convection profonde : extension verticale + intensité très limitées

  strato-cumulus trop proches de l’équateur; basse troposphère trop froide ?

  conversion SCu > cumulus à forcer ?
- tests de sensibilité en cours (paramétrisations microphysique nuages; résolution)
- développement pour simulation réaliste avec continents

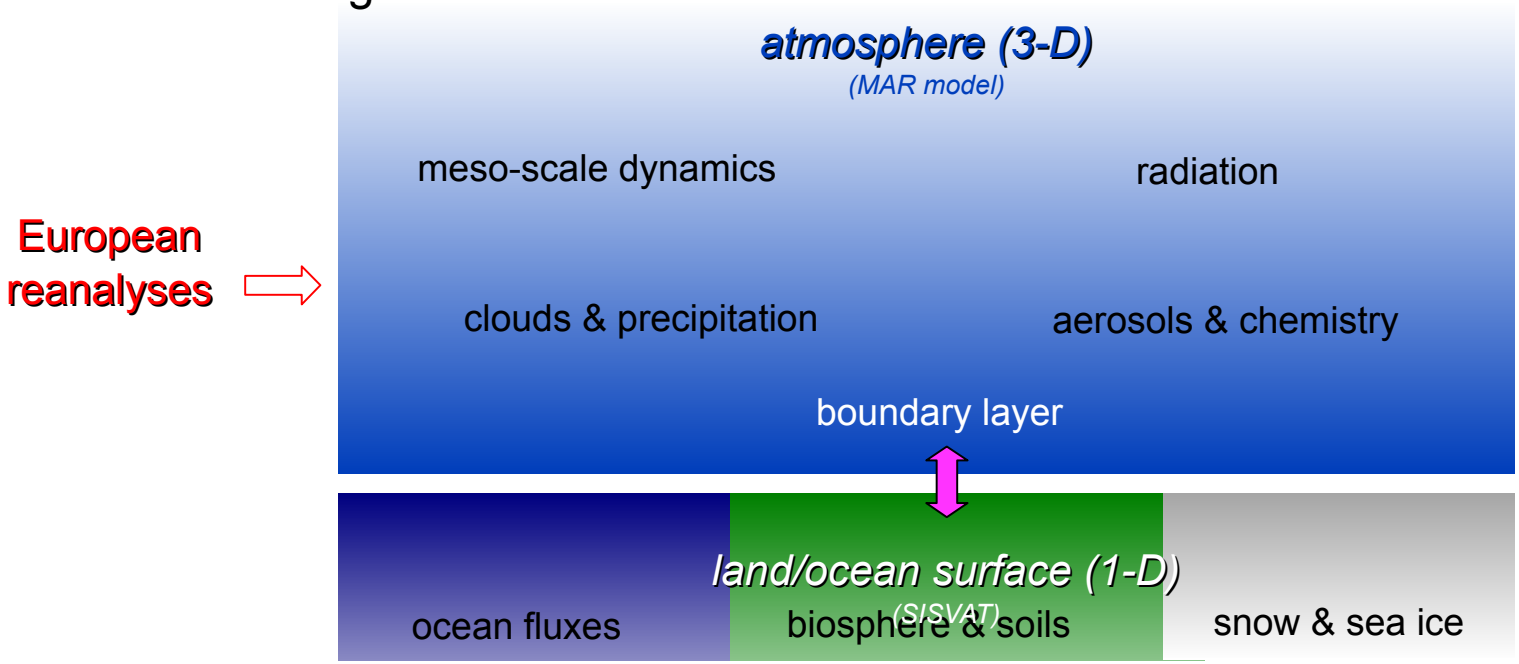


Atmospheric temperature (K)



Northward Meridional Wind (m/s)

Le modèle régional MAR



- Schéma de **surface** SISVAT (*Soil - Ice - Snow - Vegetation - Atmosphere - Transfer model*) :
  n couches de sol + 1 couche de végétation + *n* couches de neige
  équations pronostiques pour température, contenu en eau et propriétés de la neige
- Modèle de **turbulence** : couche limite de surface (Monin-Obukhov) + couches au-dessus (2 équations pronostiques énergie cinétique turbulente + dissipation). Production d'énergie cinétique turbulente due aux changements de phase de l'eau.
- Nuages et précipitations (**microphysique nuageus**e) avec 6 équations pronostiques : concentration en vapeur d'eau, gouttelettes nuageuses, particules de neige, gouttes de pluie, concentration et nombre de cristaux de glace nuageux
- **Convection** atmosphérique : modèle de flux de masse de Peter Bechtold
- Modèle de transfert **radiatif** = CEP (idem ré-analyse ERA-40)

HISTORIQUE

1980, Méso — Université de Jérusalem
- coeur dynamique basé sur leap – frog

1981, sigma — Université Catholique de Louvain
- Adaptation à la « calculatrice » de l'IAG (64 ko mémoire vive)

1992, MAR — Université Catholique de Louvain
- nouveau coeur dynamique (Brown-Campana)
- paramétrisations physiques:
  - surface (Deardorff),
  - turbulence,
  - microphysique nuageuse,
  - (rayonnement – ERA15)

1997, MAR — Université Catholique de Louvain/CEN/LGGE/LTHE
- nouveau coeur dynamique basé sur RK2 (Mesinger)
- paramétrisations physiques:
  - neige et transport de neige par le vent
  - dynamique de la glace de mer
  - couplage chimie atmosphérique
  - couplage neige – végétation
  - (schéma en flux de masse – convection)
  - (nouveau schéma de rayonnement – ERA40)

2012, MAR — LGGE/ULg/LJK
- nouveau coeur dynamique basé sur RK2 (Mesinger, Lax-Wendroff, Bott)
- F90 + parallélisation (MPI, Open-MP)

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