Des Aquaplanètes avec DYNAMICO

Masa Kageyama,
Thomas Dubos, Abdou Traoré,
Yann Meurdesoif, Pascale Braconnot

Aquaplanètes

- Configuration « terrestre »
- Un seul type de surface: l'océan, SST prescrites

3. Aqua-planet response to sea surface temperature distributions

Aqua-planet atmospheric GCMs are full GCMs but with the lower boundary simplified to that of an ocean covered earth with specified SST.

Aqua-planet experiments for prescribed simple SST distributions have two major uses:

I: They provide a means to develop hypotheses and to test and extend ideas developed in the context of simpler models with prescribed heating.

II: They provide a test-bed for studying the interaction of the dynamics and the parametrisations, particularly those for boundary layer fluxes, deep and shallow convection, and radiation.

The limitation in I is that the answers obtained may be very dependent on the GCM. However, this weakness is exploited as a strength in II, though in both uses it must be remembered that the "right" answer is not known. In use II, a standard suite of experiments, such as those described here, appear to provide a natural test-bed for new parametrizations, sitting between single column and full GCM tests, and complementing the dynamical core tests of Held and Suarez (1994) and Boer and Dennis (1997).

Hoskins et al, Tellus 1999

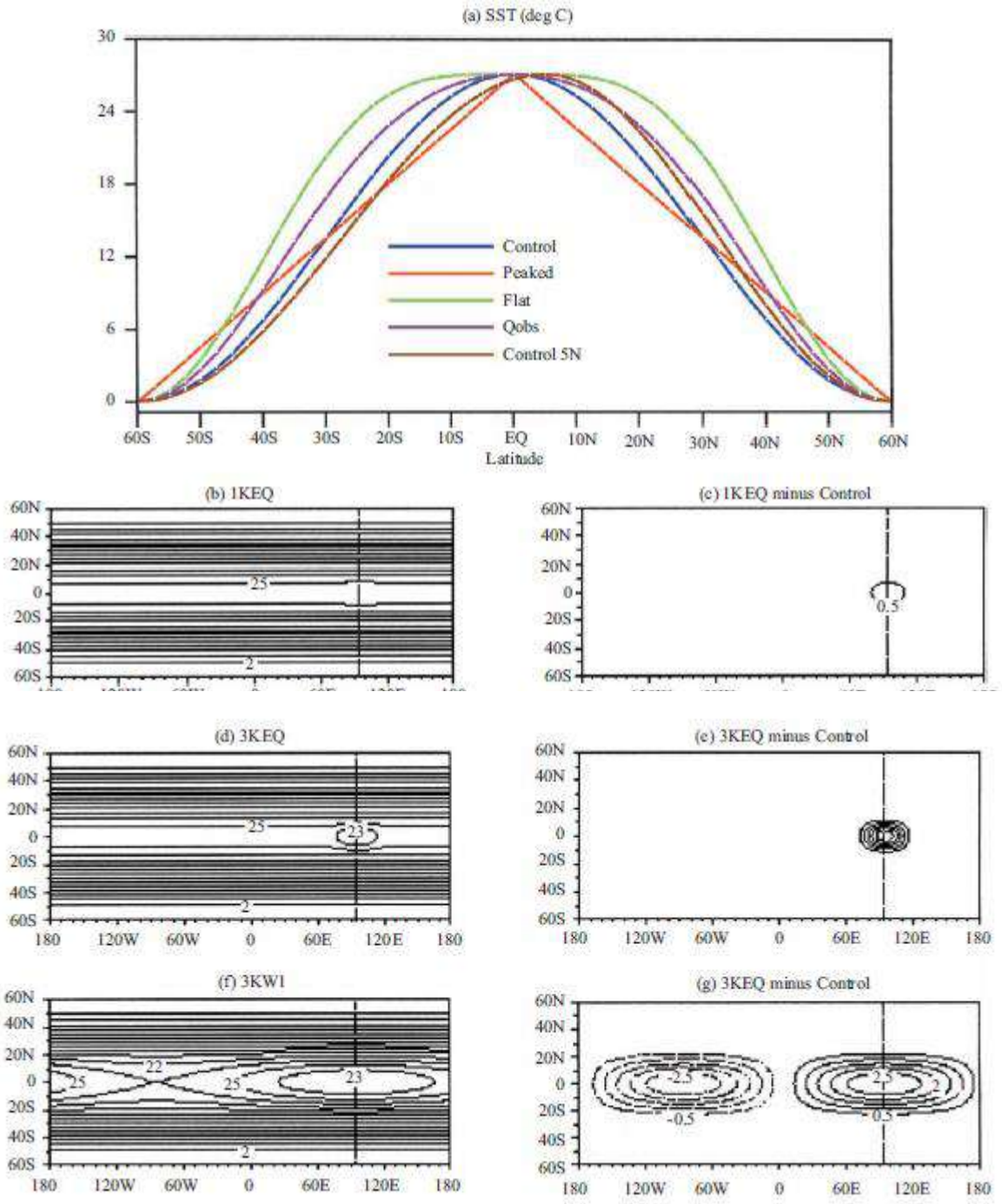
Aquaplanètes: utilisations

Neale & Hoskins 2000

Testent

-différents profils de SST zonalement symétriques

-l'impact d'anomalies de SST



Neale & Hoskins (2000): exemple de résultats

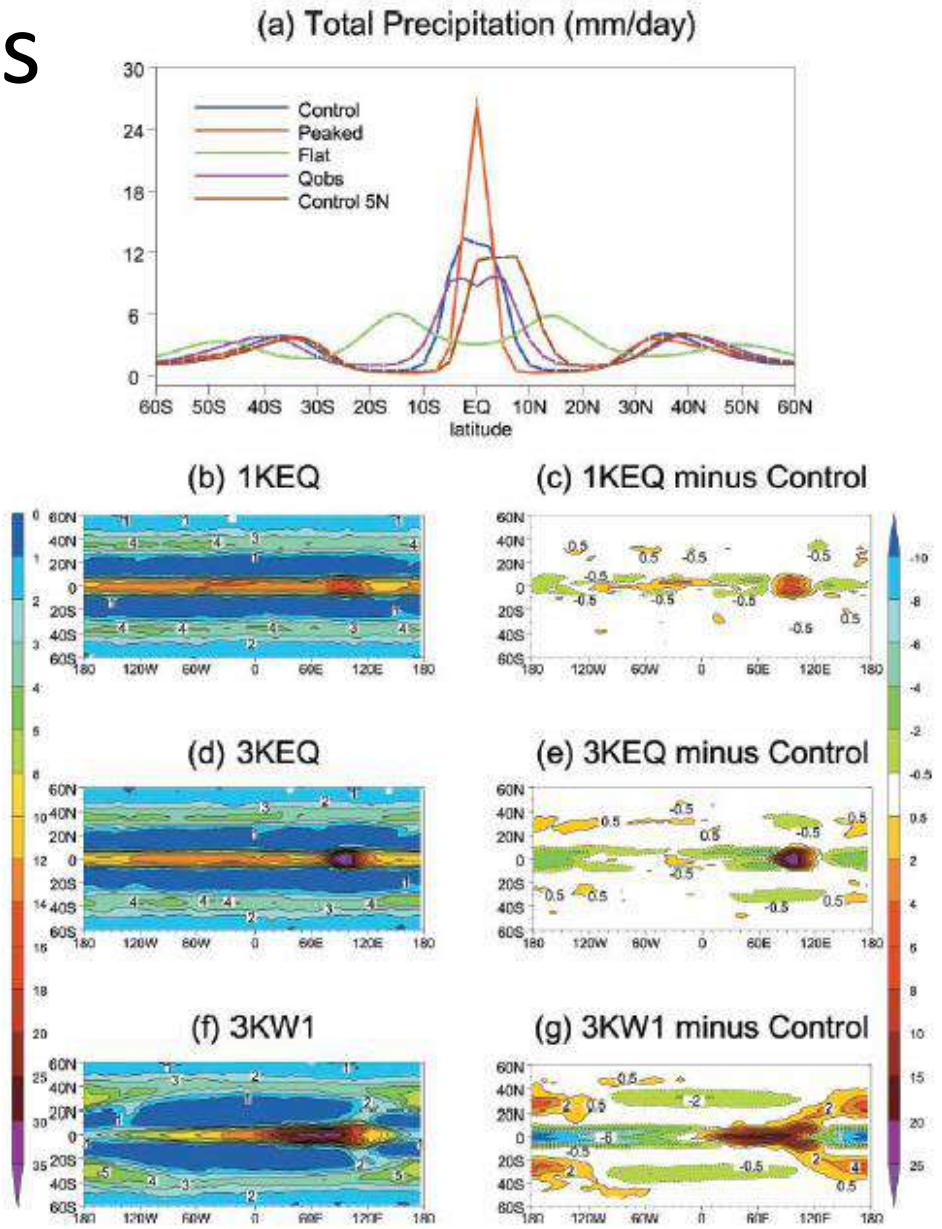
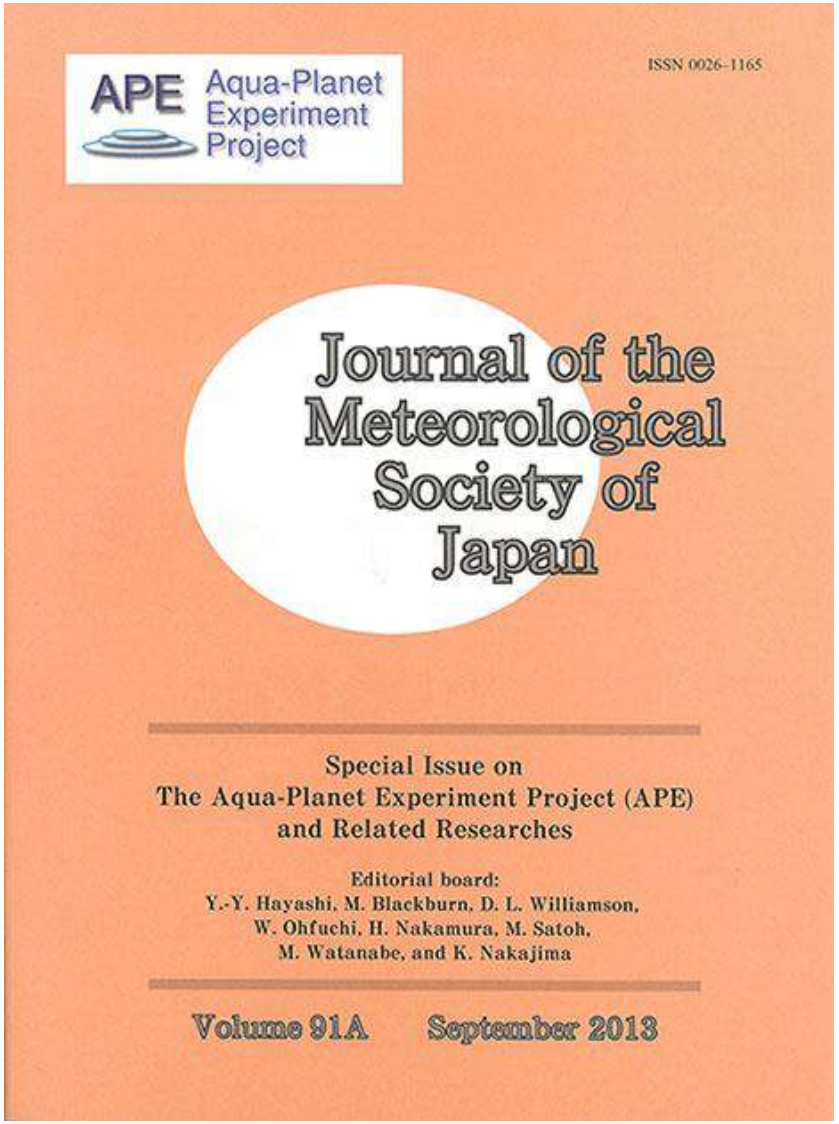


Figure 2. Total precipitation (in mm/day) from the suite of aqua-planet experiments; (a) zonal average from each of the axisymmetric experiments; (b) experiment 1KEQ; (c) experiment 1KEQ with the Control zonally averaged total precipitation removed; (d) and (e) as (b) and (c) but for experiment 3KEQ; (f) and (g) as (b) and (c) but for experiment 3KW1.

Aqua-Planet Experiment Project

- 2003 - 2013
- Suit le design experimental de Neale & Hoskins 2000
- Série de papiers dans JMSJ
- → possibilités de comparaisons pour nos expériences



Aquaplanètes et sensibilité climatique

- Medeiros et al 2008
- 2 modèles (NCAR et GFDL), multiples résolutions
- Set up identique aux expériences APE

+ expérience de sensibilité à une réchauffement:

SST + 2°C

→ Configuration aquaplanète utile pour analyser sensibilité climatique et nuages dans le cadre d'un réchauffement climatique

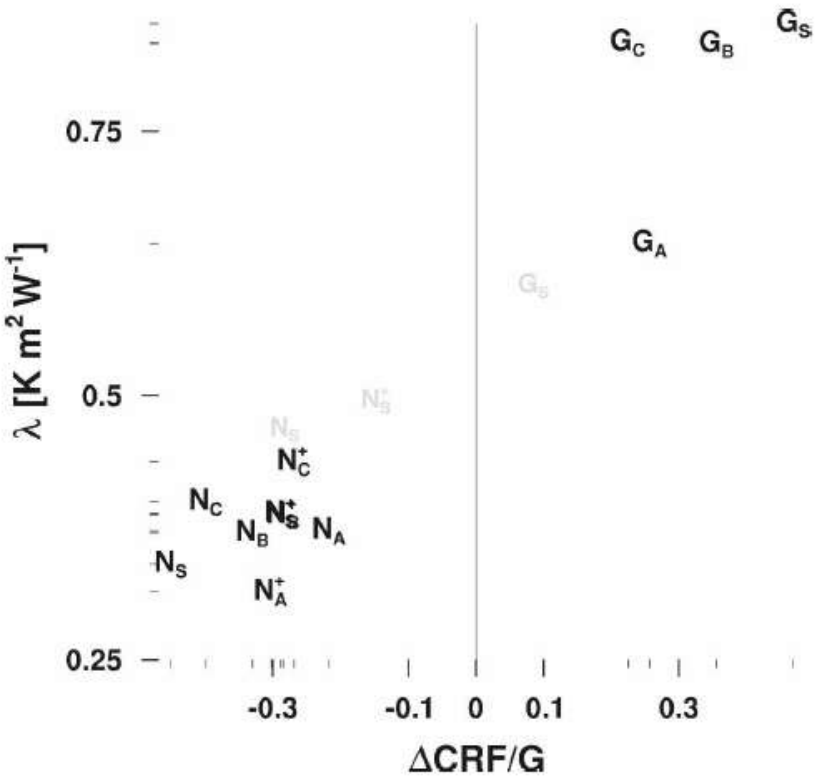


FIG. 4. Climate sensitivity parameter λ vs ΔCRF/*G* for all configurations of both GCMs; black symbols represent the tropically averaged values. The symbols correspond to abbreviations of each configuration, where the large letter gives the GCM being used (G = GFDL AM, N = NCAR CAM), the subscript is the SST configuration (S for standard, A–C for aquaplanets), and a superscript "+" denotes the T85 version of the NCAR CAM. The two nearly overlain symbols are the T85 versions of the standard and aquaplanet B configurations. Gray symbols denote the globally averaged values from the standard configurations.

Aquaplanètes dans CMIP5

	6.8a	Aqua-planet : control run	Consistent with CFMIP requirements, impose zonally uniform SSTs on a planet without continents.	5
	6.8b	Aqua-planet : cloud response to an imposed 4xCO_2 (Hansen-style diagnosis).	Consistent with CFMIP requirements, impose a 4xCO_2 on zonally uniform SSTs of expt. 6.8a (which is the control for this run).	5
	6.8c	Aqua-planet : cloud response to an imposed uniform change in SST.	Consistent with CFMIP requirements, add a uniform +4K to the zonally uniform SSTs of expt. 6.8a (which is the control for this run).	5

Taylor et al 2012, table 6

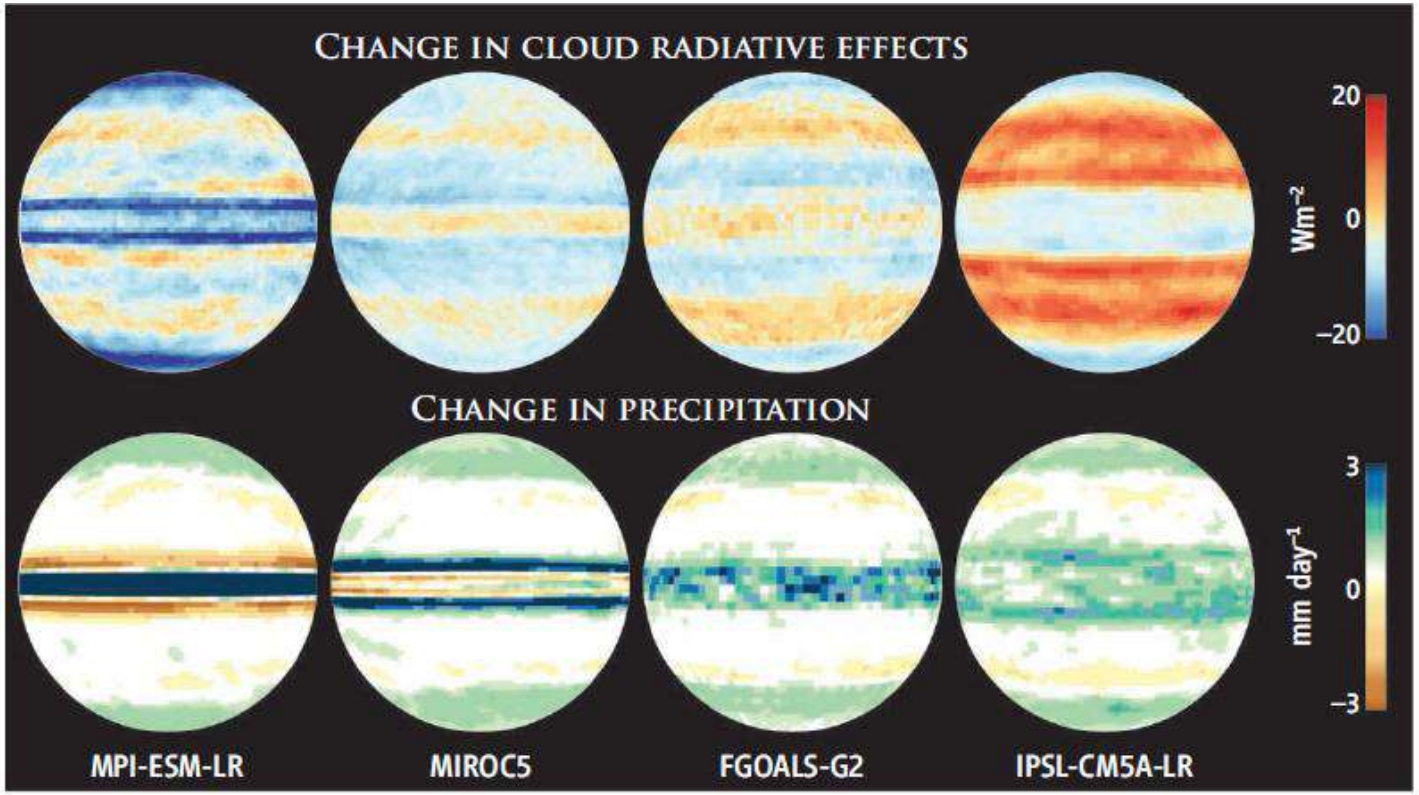
- Expériences dans CFMIP
  - Controle (SST zonalement symétriques, etc…)
  - SST + 4K
  - 4xCO2
- Protocole détaillé: page web Brian Medeiros

  http://people.atmos.ucla.edu/brianpm/cfmip2_aqua.html

Quelques résultats

Science
AAAS

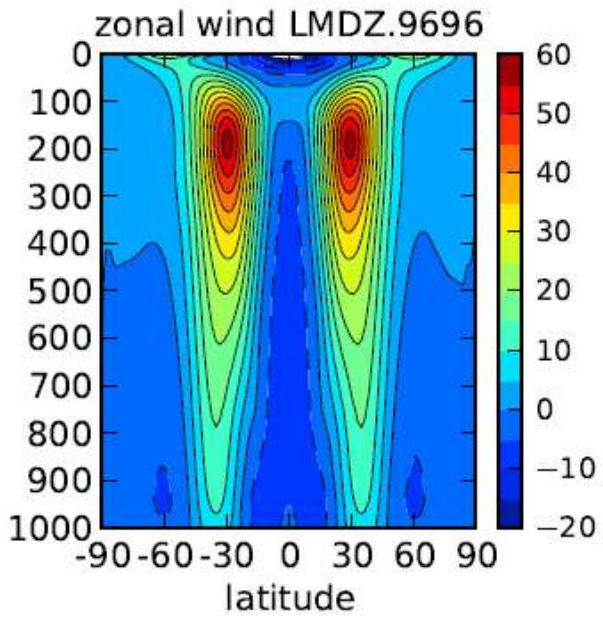
What Are Climate Models Missing?
Bjorn Stevens and Sandrine Bony
Science **340**, 1053 (2013);
DOI: 10.1126/science.1237554

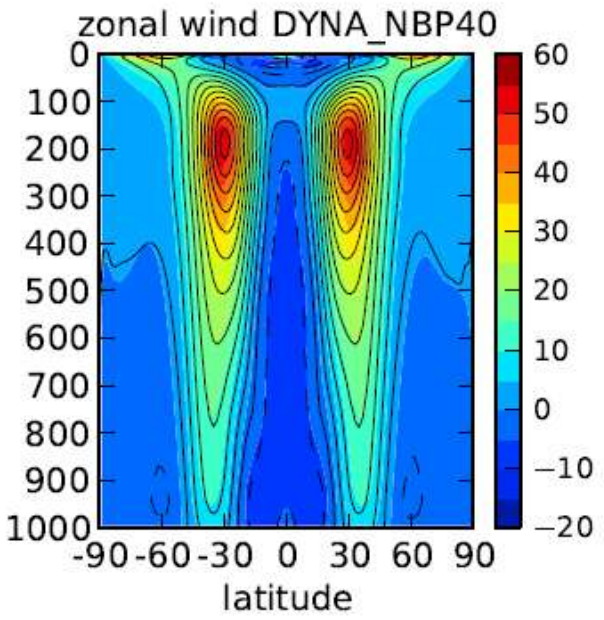


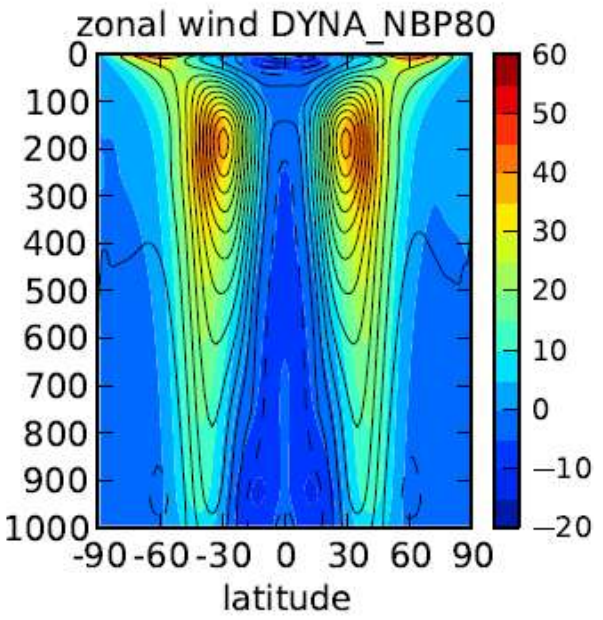
Wide variation. The response patterns of clouds and precipitation to warming vary dramatically depending on the climate model, even in the simplest model configuration. Shown are changes in the radiative effects of clouds and in precipitation accompanying a uniform warming (4°C) predicted by four models from Phase 5 of the Coupled Model Intercomparison Project (CMIP5) for a water planet with prescribed surface temperatures.

1. Expériences LMDZ et DYNAMICO

- Expérience LMDZ(96x96) vs. DYNAMICO en NBP40 et NBP80
- Profil de SST « Qobs »







2. expériences DYNAMICO

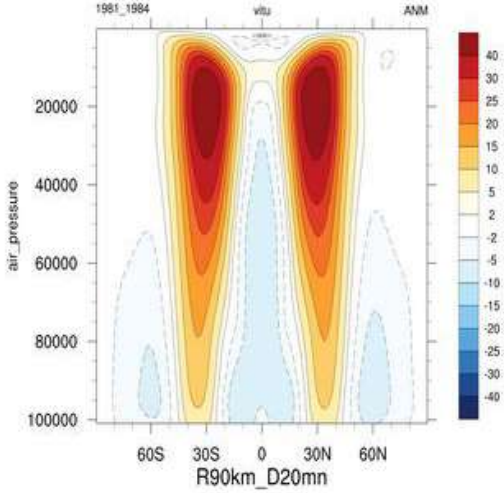
3 résolutions (180, 90, 45 km)

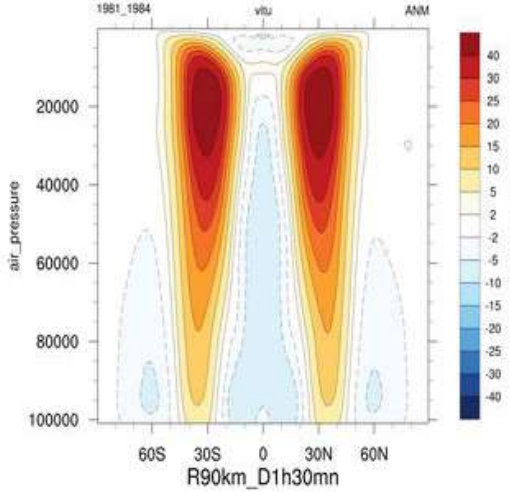
x

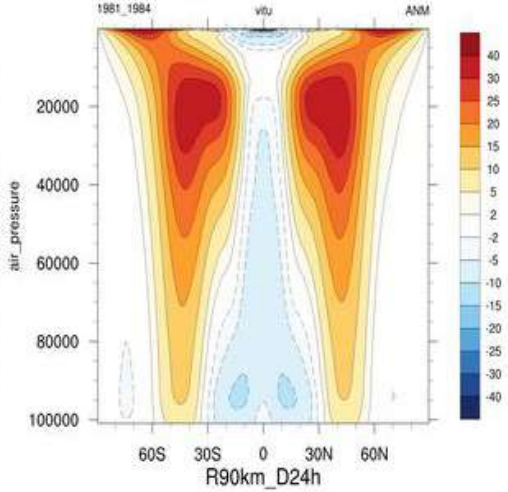
3 dissipations (20min, 1h30, 24h)

Vent Zonal

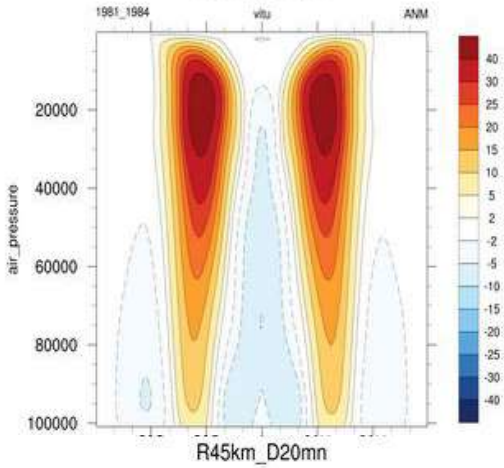
180 km

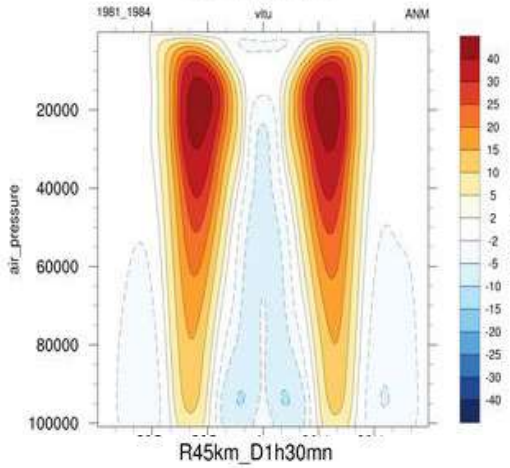


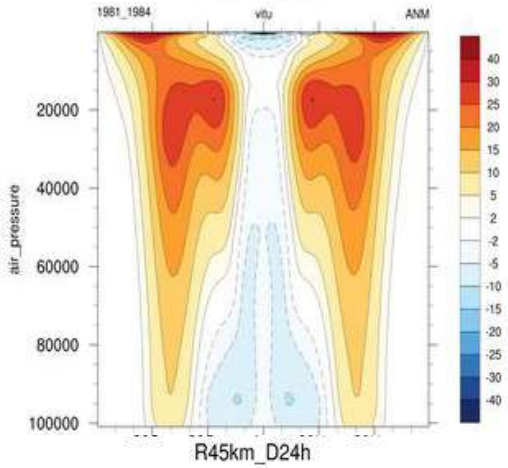




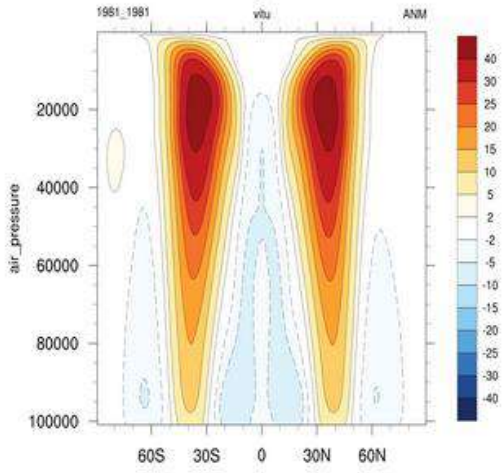
90 km

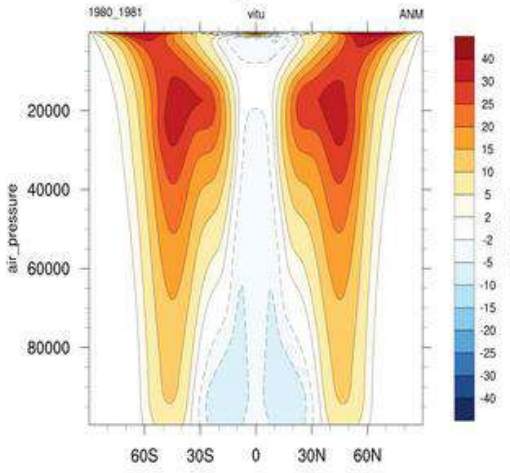


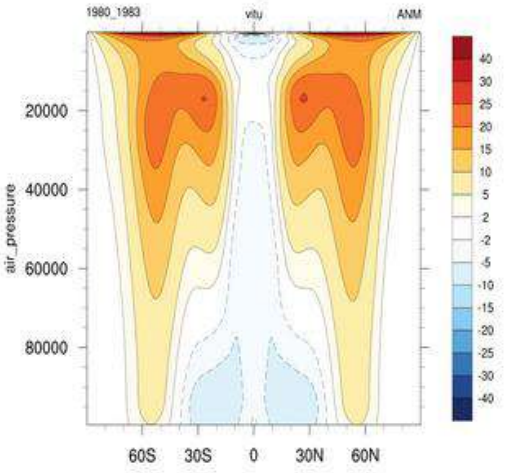




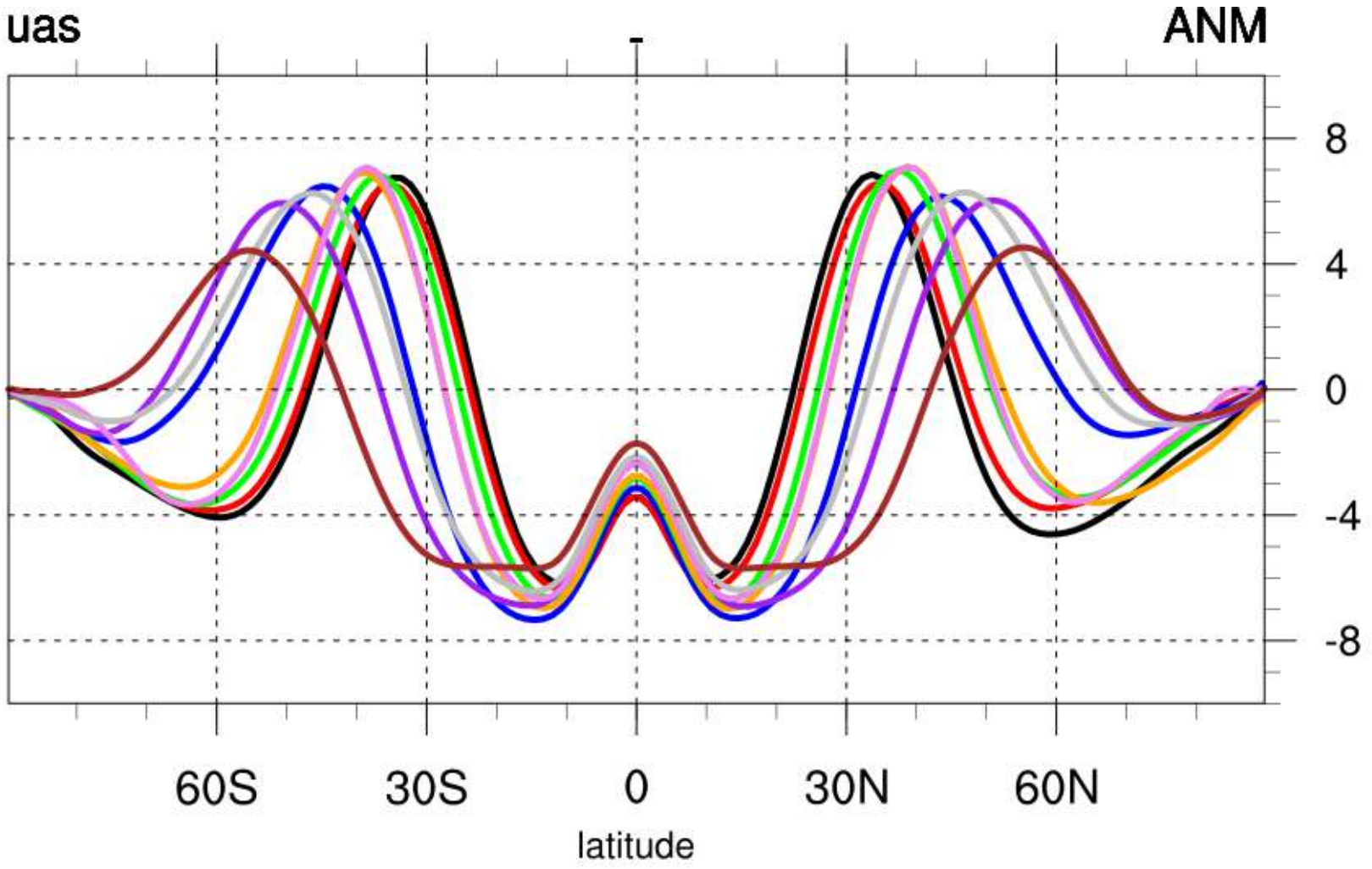
45 km





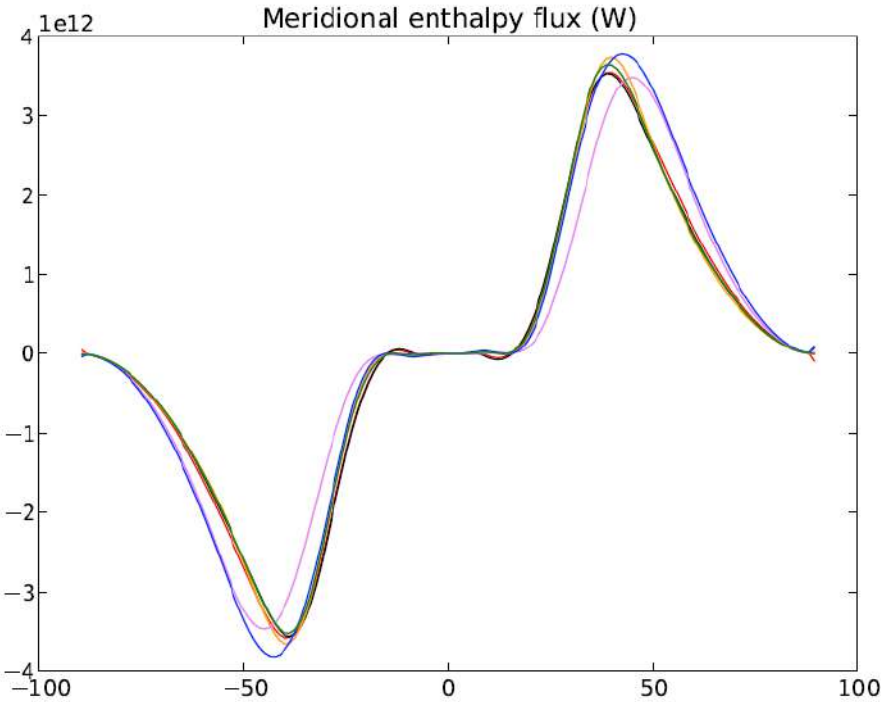


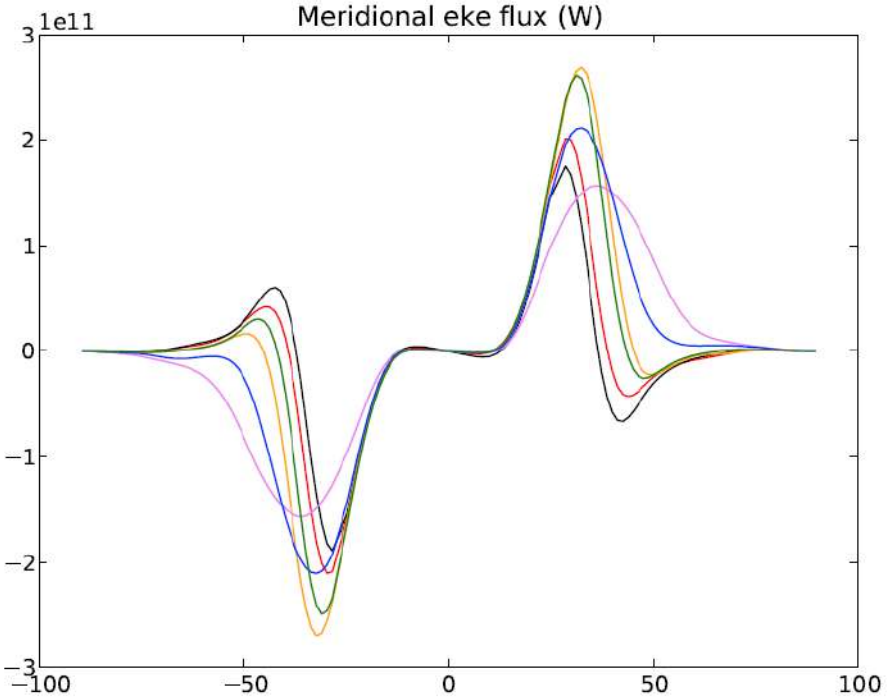
Vent Zonal à la surface



R180km_D20mn
R90km_D20mn
R45km_D20mn
R180km_D1h30mn
R90km_D1h30mn
R45km_D1h30mn
R180km
R90km
R45km

Flux turbulents
(simulations
180 km et 90 km)

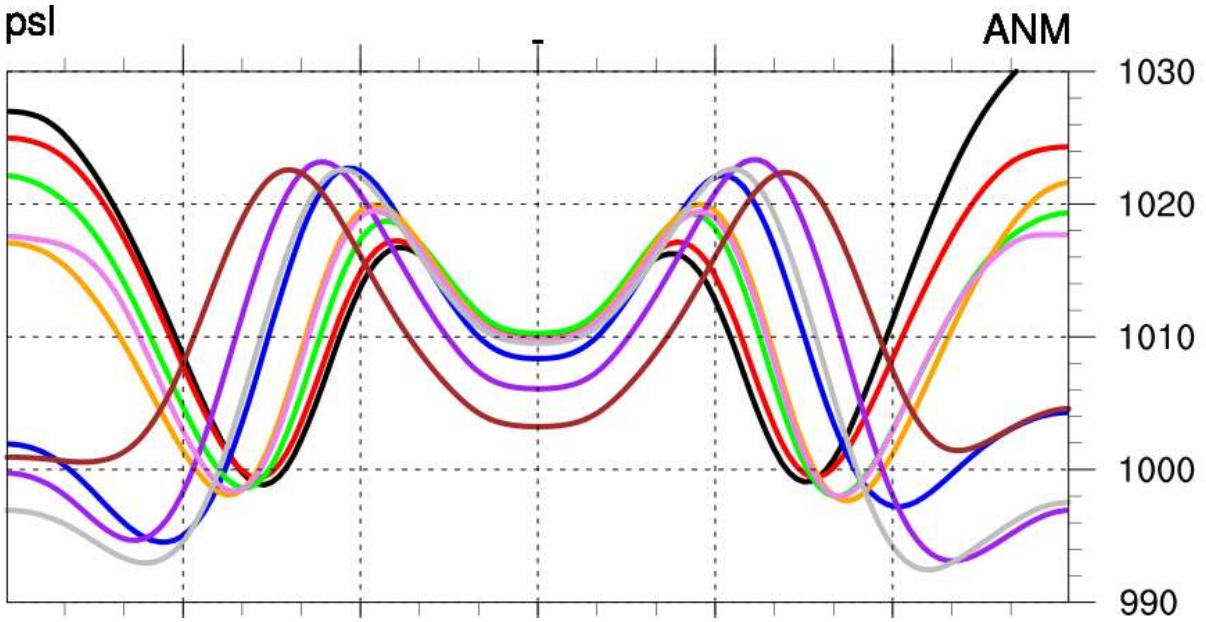




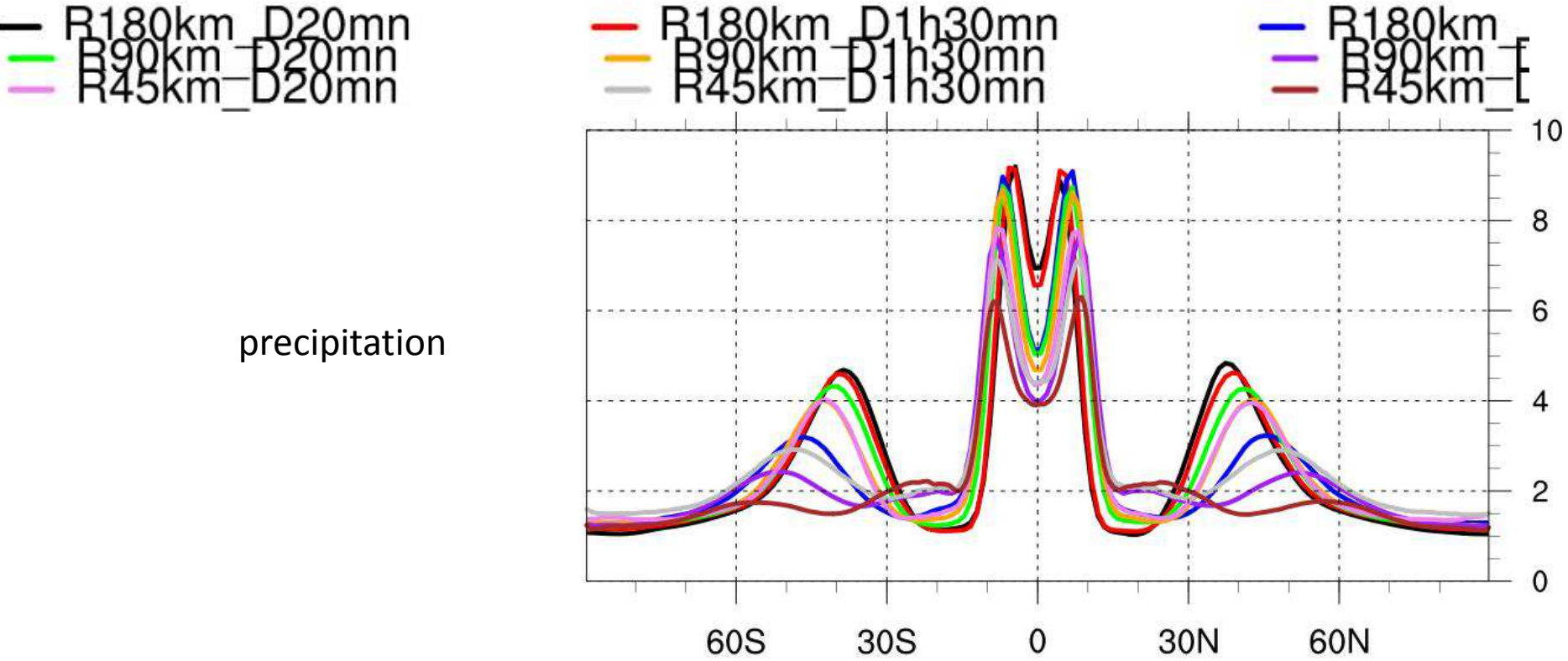
travail à poursuivre
(flux d'Eliassen-Palm
etc)

Liens avec d'autres variables

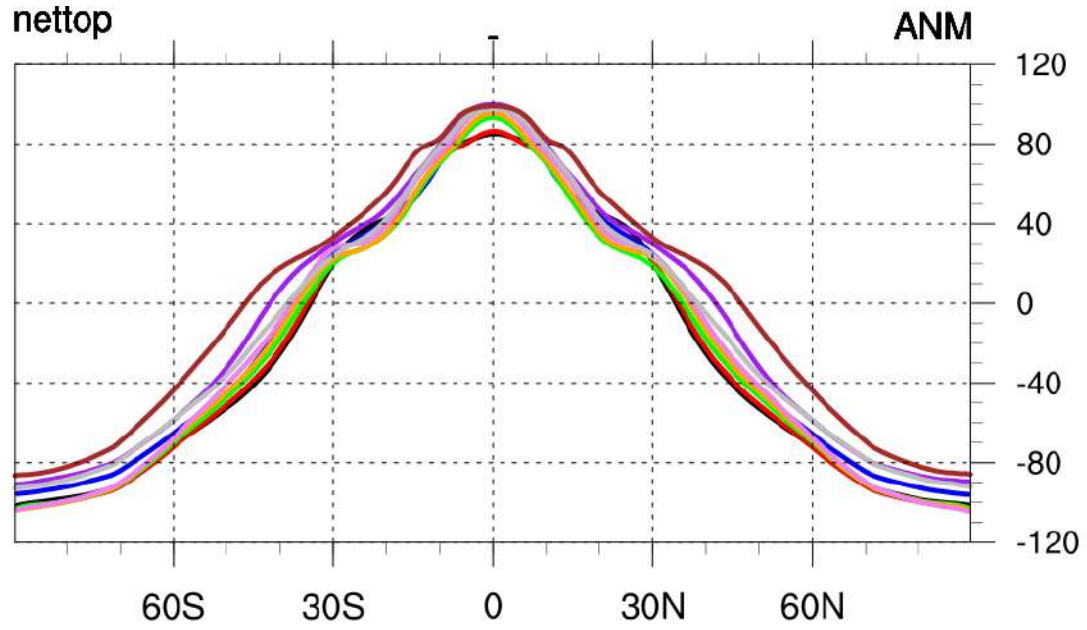
pression de surface



precipitation

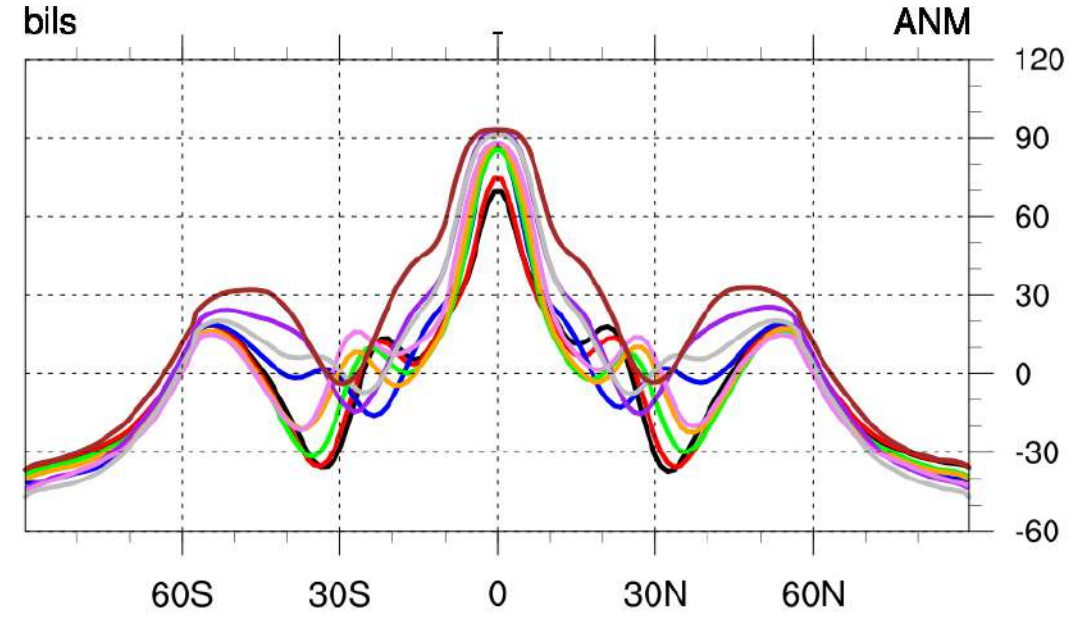


bilan radiatif au sommet de l'atmosphère



R180km_D20mn
R90km_D20mn
R45km_D20mn
R180km_D1h30mn
R90km_D1h30mn
R45km_D1h30mn
R180km
R90km
R45km

bilan radiatif à la surface



Nos projets

- DYNAMICO en configuration aquaplanète dans des configurations déjà testées par d'autres modèles: protocole CMIP5-6
- Sensibilité:
  - Climats chauds:
    SST+4K, 4xCO2
  - Climats froids:
    SST-4K (ou 2K), ½ CO2 ou CO2_DMG (185ppm)
- Sensibilité de cette sensibilité à la résolution/dissipation: choix d'états de références différents

Autres configurations intéressantes

- Couplage océan de surface au repos et forçage par flux d'énergie plutôt que par prescription de SST
- Kang et al, JClim, 2008

Heating is imposed poleward of 40°S, with equal and opposite cooling added poleward of 40°N. The form of the heating is

$$H = -A \sin\left(\frac{\theta + 40}{50}\pi\right) \quad \text{for} \quad -90 < \theta < -40,$$

$$H = -A \sin\left(\frac{\theta - 40}{50}\pi\right) \quad \text{for} \quad 40 < \theta < 90, \quad \text{and}$$

$$H = 0 \qquad \text{otherwise,}$$

where A is the strength of the forcing (W m^{-2}). The imposed forcing neither adds nor subtracts heat from the global system. Thus, the forcing can be described completely by an implied ocean flux F_0 from one hemisphere to the other, with $H = -\nabla \cdot F_0$. Distributions of the heating/cooling (H) and associated heat flux (F_0) are plotted in Fig. 1.

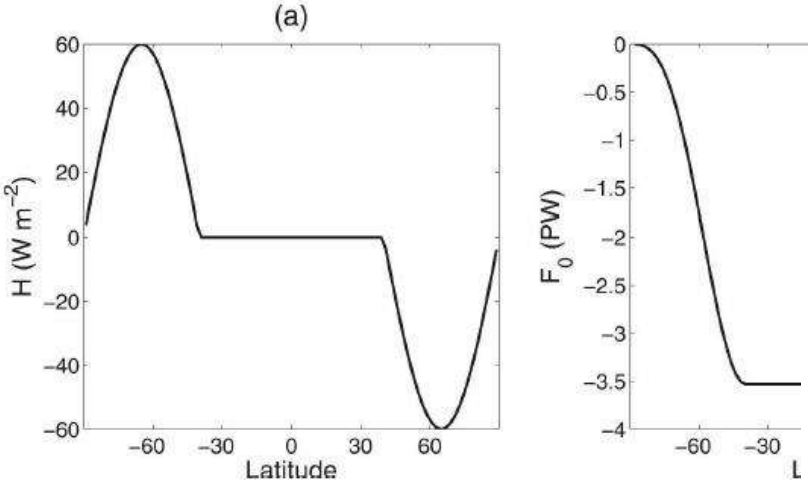


FIG. 1. (a) Latitudinal distribution of imposed forcing H (W m^{-2}) implied ocean flux F_0 (PW) when A = 60 W m^{-2}

→ Position de l'ITCZ en fonction des flux d'énergie imposés

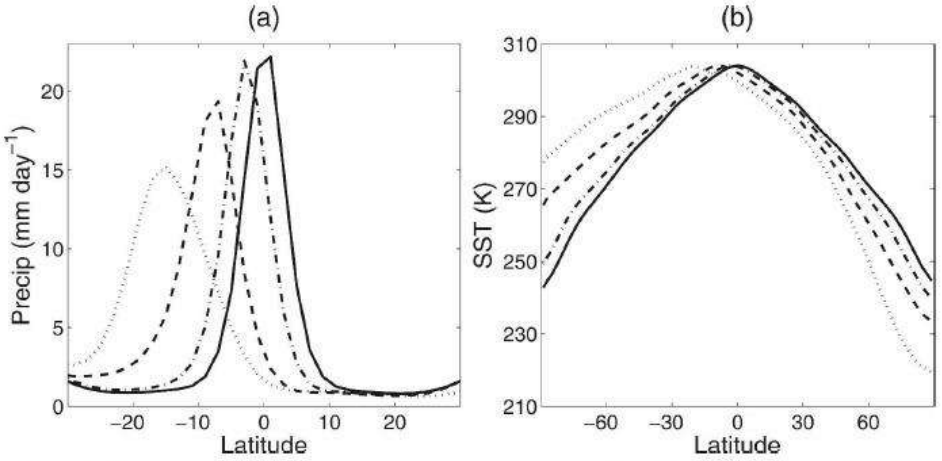


FIG. 2. Time mean, zonal mean (a) precipitation (mm day^{-1}) in the tropics, and (b) SST (K) for A = 0 (solid), 10 (dashed–dotted), 30 (dashed), and 60 W m^{-2} (dotted), with a control value of α (=1X).

Conclusions

- Des résultats prometteurs pour plusieurs études:
  - sensibilité de la circulation et de la physique à la résolution
  - sensibilité des changements climatiques pour les différents états initiaux obtenus (avec 1 ou 2 courants-jets, pour les différentes structures de circulation atmosphérique)
  - configuration aquaplanète-slab???
  - autres configurations idéalisées ou réalistes: impact des continents, de la topographie, etc.

MERCI!