Etude des cycles avec LMDZ: contribution du groupe ORCHIDEE

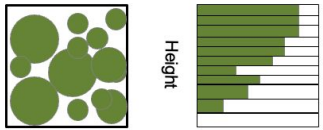
Reunion PEDALON - 2 Dec 2024

(Philippe Peylin. pour le groupe projet ORCHIDEE)

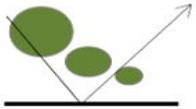
ORCHIDEE from CMIP6 to CMIP7-FT

Adding forest demography & forest management

Tree height varies !

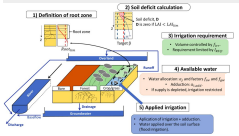


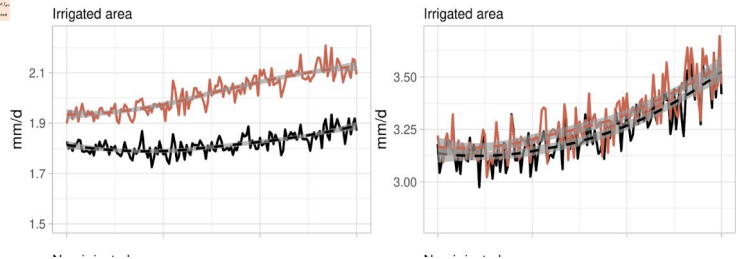
Forest has Gaps !



Two streams RT model !

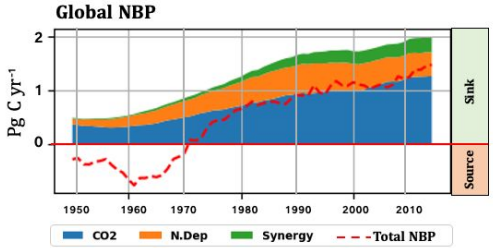
Improved water routing scheme & irrigation





Irrigated / *Non-Irrigated*

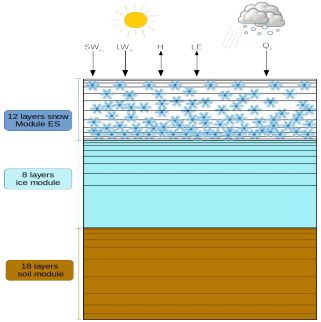
Including N cycle and C-N interactions



Strong link with chemistry of N-compound in the atmosphere

Updated snow scheme and snow albedo

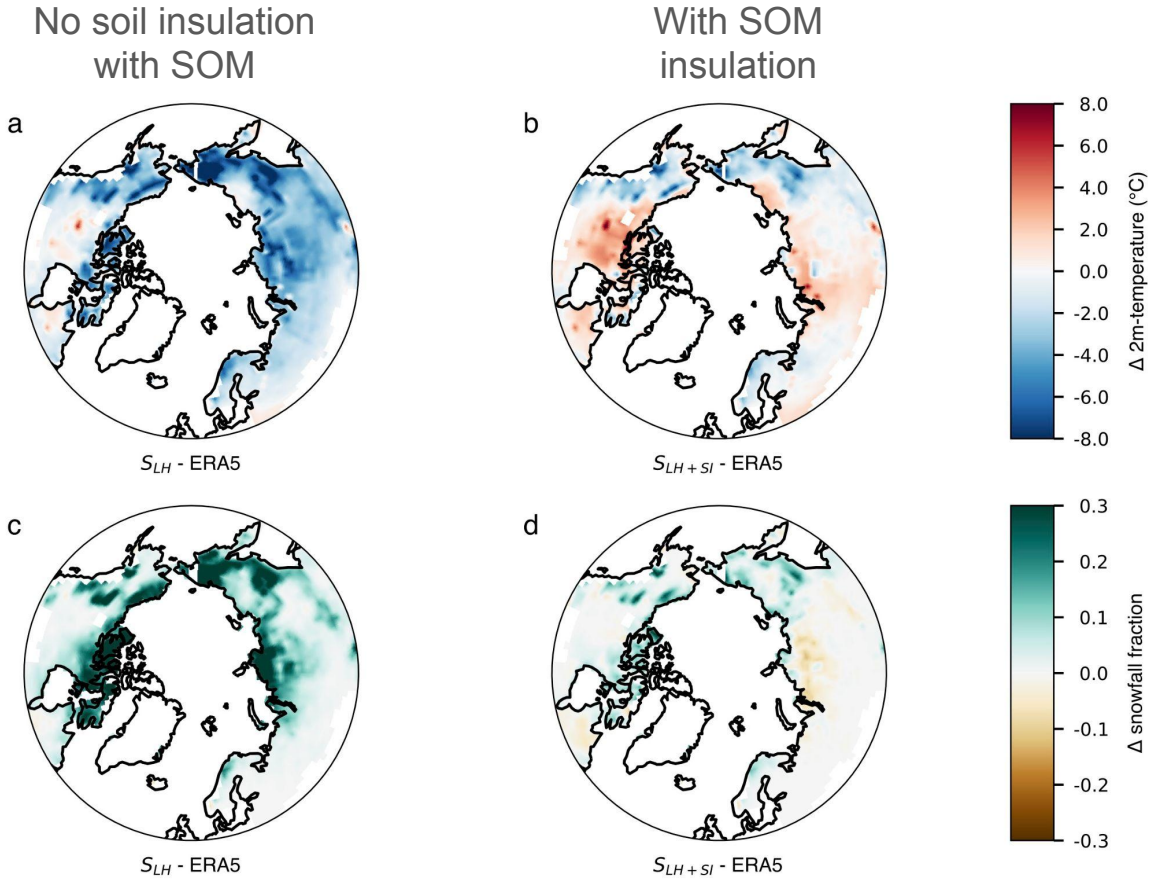
⇒ Soon same snow scheme for all land surfaces including icecap



Adding physical and biogeochemical permafrost !

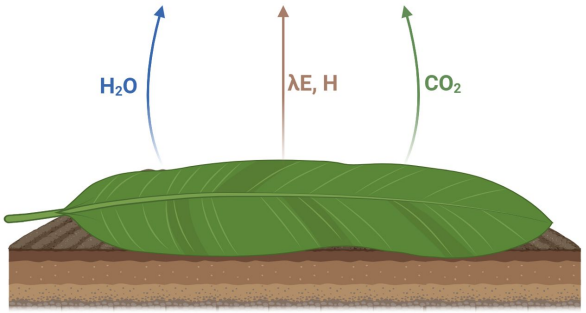
ORC-LMDZ simulation:
Diff with ERA5 reanalysis !
(ex: Juin - Juillet - Aout)

⇒ Large feedback loop late spring between frozen soil and surface atmosphere air temperature (via snowfall fraction)



Coupling between the land surface and LMDZ

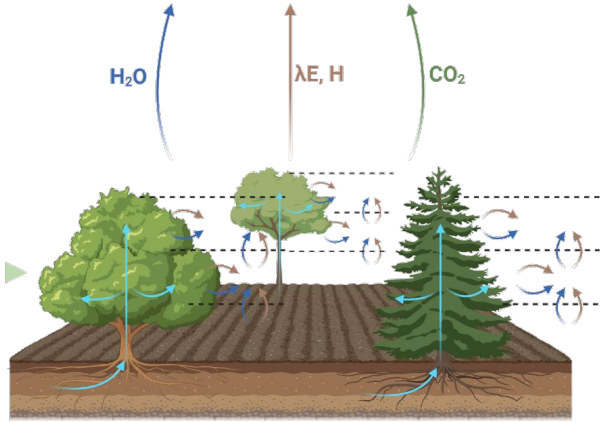
ORC today !



Currently adding :

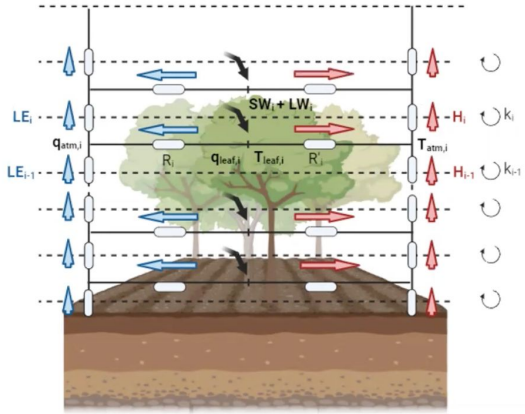
- Multiple Energy budget (for each PFT)
- Multi-layer canopy budgets

ORC tomorrow !



⇒ Need to re-define the coupling between Vegetation canopy and the PBL ?

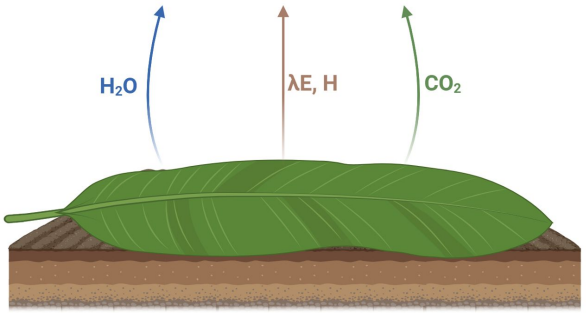
Alleon et al., in prep



- Canopy discretized in N layers;
- One big leaf energy budget per layer;
- Multi-layer SW and LW radiation transfers;
- Turbulent transport model between layers;
- Implicit resolution.

Coupling between the land surface and LMDZ

ORC today !



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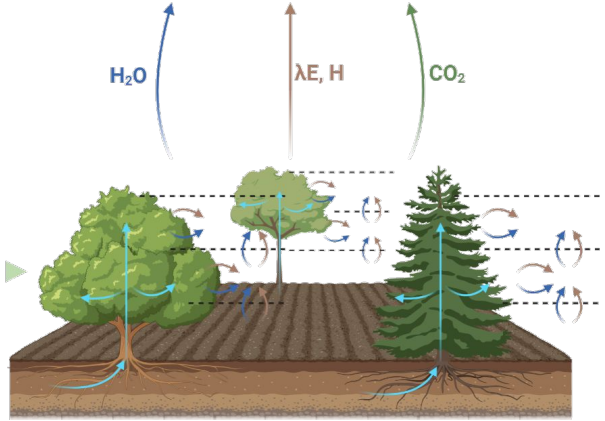

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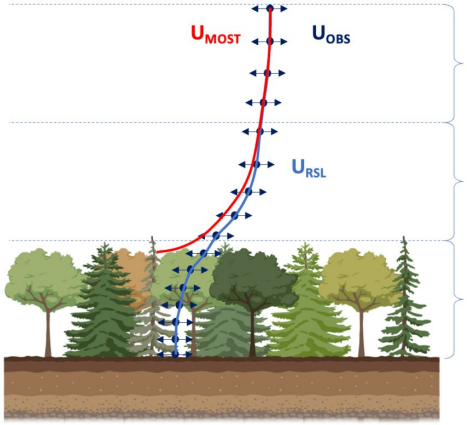


- **Théorie de Monin-Obukhov :**

$$\frac{\kappa . z}{u_*} \cdot \frac{\partial u}{\partial z} = \phi_M \left(\frac{z-d}{L} \right)$$

- **Théorie de la sous-couche rugueuse :**

$$\frac{\kappa . z}{u_*} \cdot \frac{\partial u}{\partial z} = \phi_M \left(\frac{z-d}{L} \right) . \varphi_M \left(\frac{z-d}{z_*} \right)$$

- Modélisation intra-canopée (relations flux/gradient, RANS …).

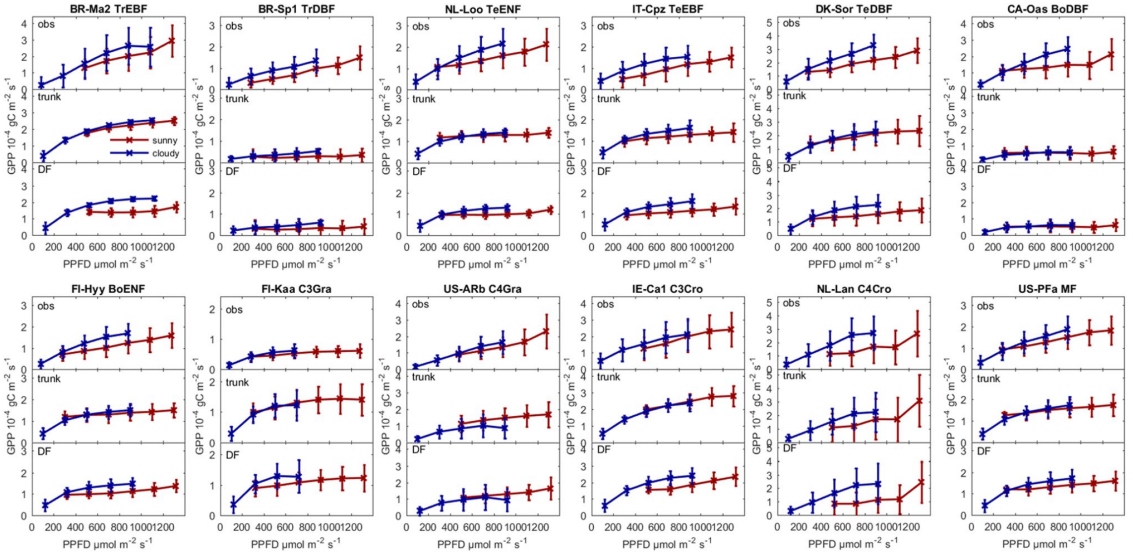
Coupling between the land surface and LMDZ

⇒ Need to account for direct vs diffuse light fraction

⇒ Significant impact on the GPP

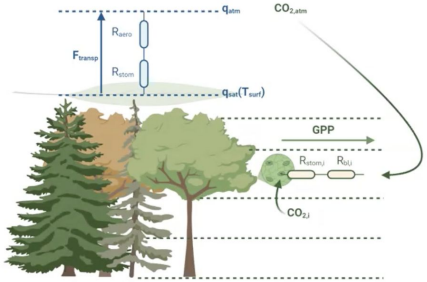
(Yuan Zhang et al. 2023)

sunny
cloudy



⇒ Intra-canopy CO2 concentration should also impact GPP !

⇒ Possible with futur multi-level energy model



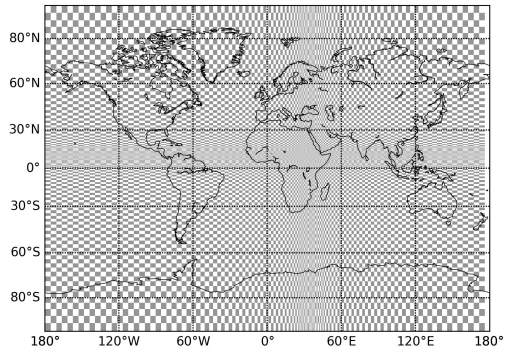
Current representation in ORCHIDEE

CO2 free air

decrease in the canopy

Use of LMDZ Zoom : case of High Resolution Land Cover project

ORC-LMDZ simulation: Zoom over Etiopia



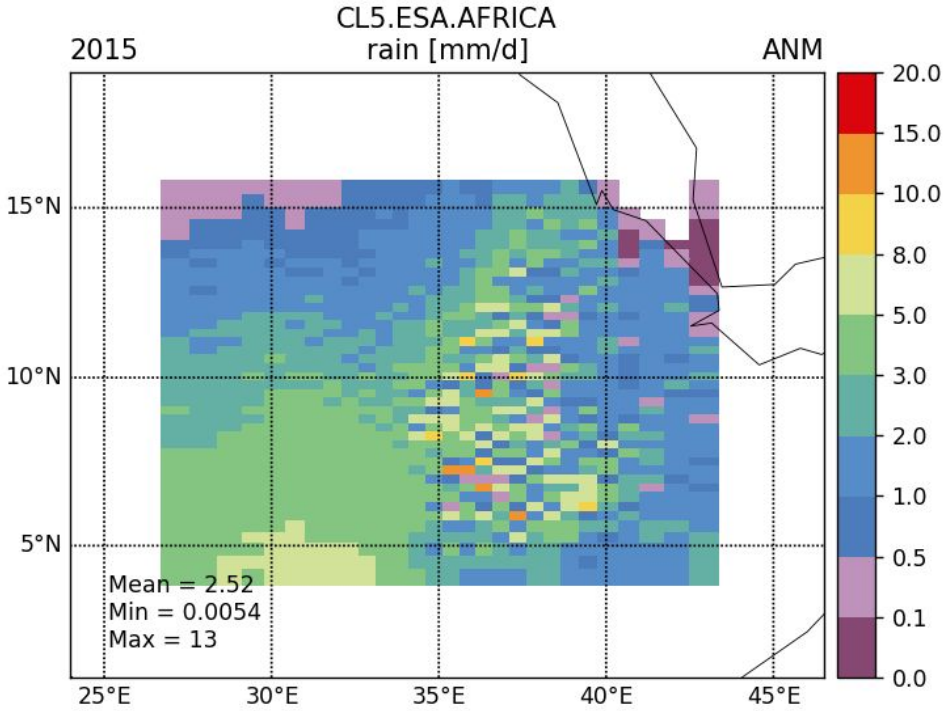
AFRICA ZOOM

LMDZOR (version 6.1.9, resolution 142x144, NPv6.1.3)
Nudged simulation for 1966-2015
Configuration (changes from the standard set):

- day_step=3360
- iperiod=7
- tetagdiv=1200.
- tetagrot=1200.
- tetatemp=1200.
- iphysiq=35
- clon=35.25
- clat=10.
- grossismx=5.0
- grossismy=5.0
- dzoomx=0.046
- dzoomy=0.066

Grid cell size in the zoom center : dx = 54.8 km, dy = 28.2 km

https://orchidas.lsce.ipsl.fr/dev/esa-hrlc/africa.php



Expérience de déforestation avec IPSL-CM6

Artificial deforestation

(Boysen et al. 2020)

Impact on Tair surf

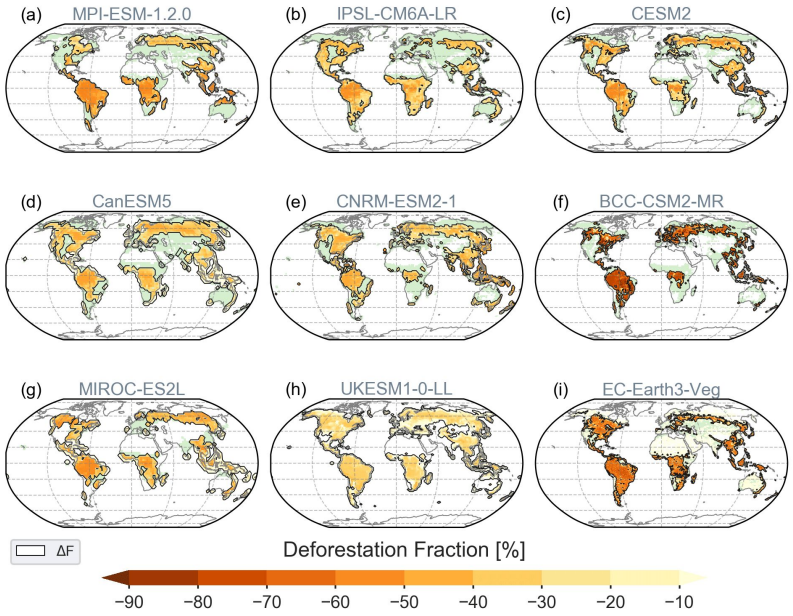


Figure 1Deforestation fractions Δ*F* in percent (%) of the grid cell area after the forced forest clearing is finished, shown in orange; green colours display the remaining forest extent. A map of the initial forest fractions can be found in the Supplement (Figs. S1 and S2). Contours of the deforestation areas (Δ*F*) with deforested grid cell fraction exceeding 0.001 % are used in all maps of the analysis.

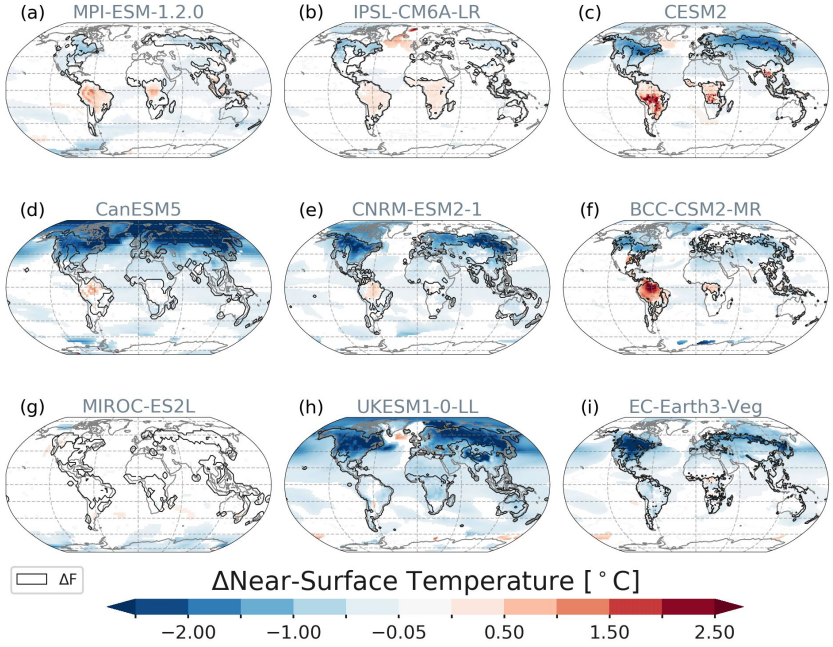
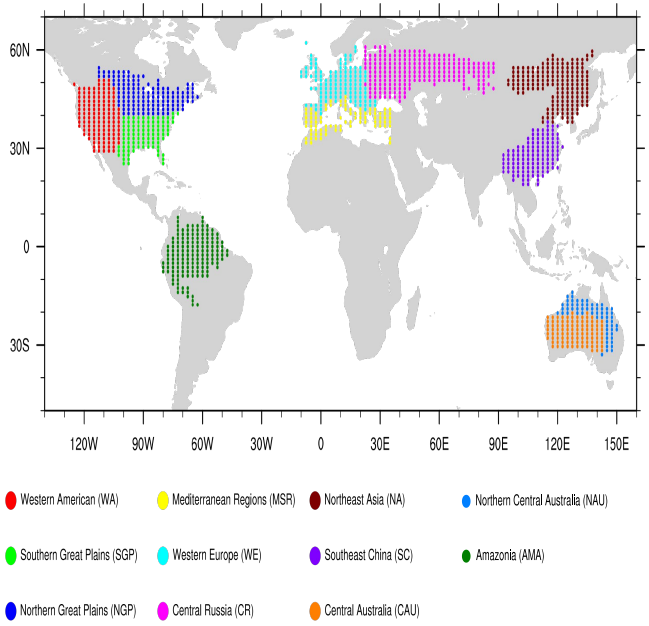


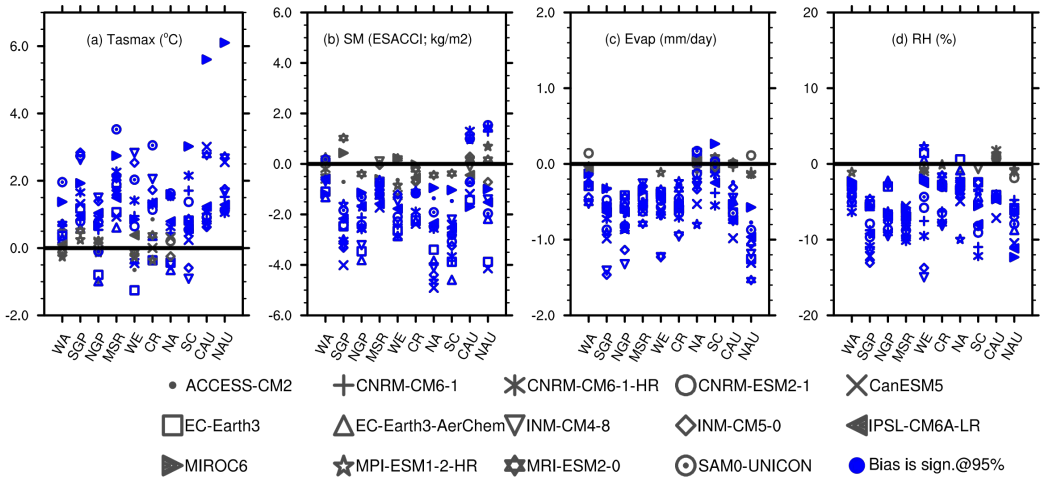
Figure 2Spatial patterns of near-surface air temperature (ΔTas) responses averaged over year 50 to year 79. Only statistically significant changes at the 5 % significance level are shown (modified *t* test, Zwiers and von Storch, 1995). Contours depict the areas of deforestation (Fig. 1).

Etude exhaustive des vagues de chaleurs présentes et future (CMIP6, LS3MIP)

Heatwave characteristics in the recent climate and at different global warming levels: a multimodel analysis at the global scale



Biais HW days – noHW days (3 warmest months, AMIP)



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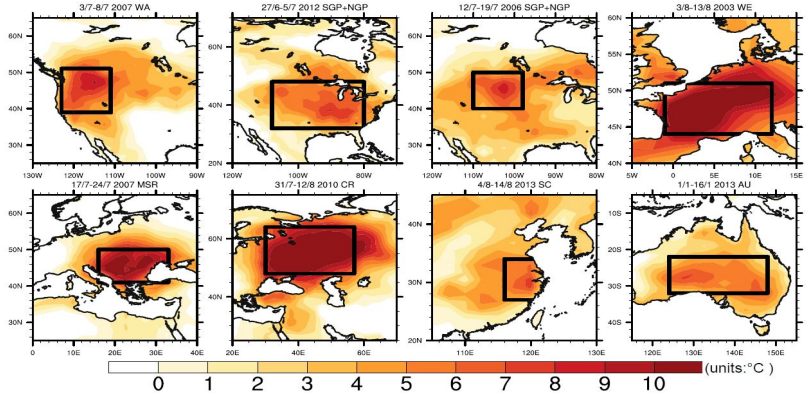
⇒ **Assèchement excessif pendant les vagues de chaleur?**

CONTRIBUTION OF CIRCULATION AND SOIL MOISTURE TO RECENT HW TEMPERATURE ANOMALY

Recent HW (temperature anomaly, wind nudged)

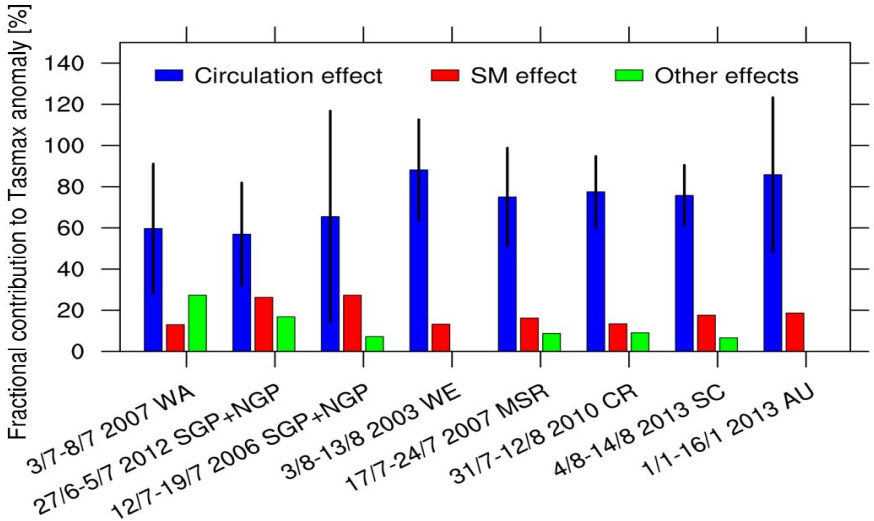


- 21 SST, SIC forced (AMIP/IPSL-CM6) : atmF_smF
- LMDZOR, SST forced, wind forced , SM climato forced : atmN_smclim
- LMDZOR,SST forced, wind forced, SM daily « obs » forced : atmN_SMN

Circul effect = atmN_smclim - atmF_smF

SM effect = atmN_smclim - atmN_smN

ANO_{atmN_smN} = 100% signal (after Wehrli et al. (2019))



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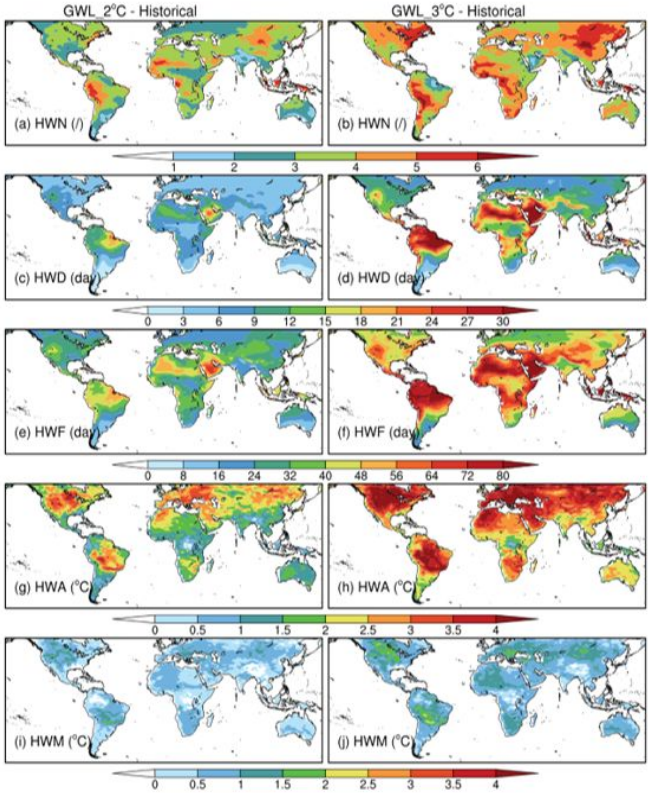

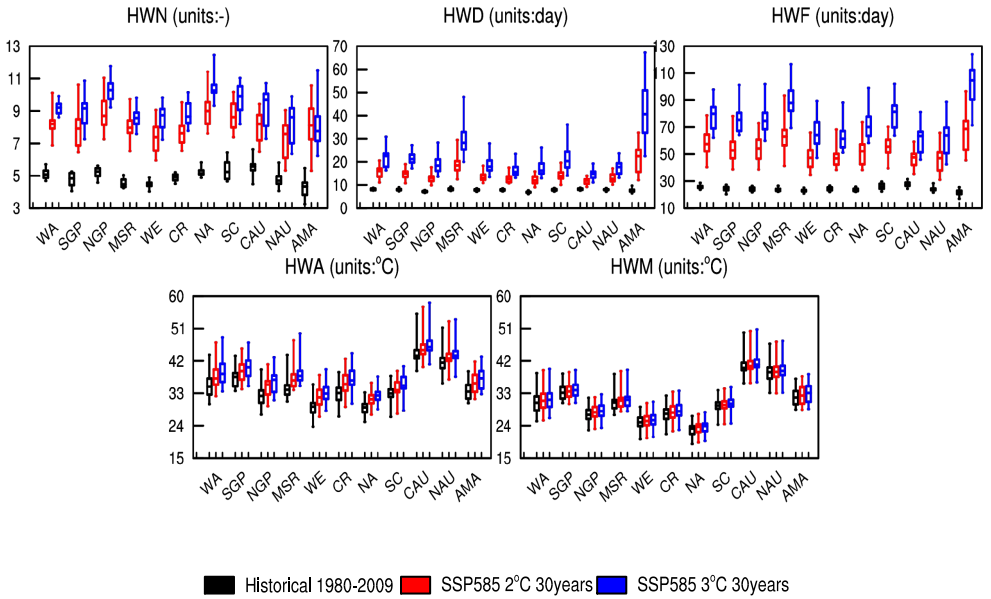

daily values of SM, evap, rh not provided by most models
=> difficult to evaluate the impact of bias in present time on the future HW

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Bilan des demandes spécifiques

- Revoir ensemble le couplage Canopée - PBL (hauteur arbres variables !)
  - Stabilité de la PBL : cas régions arctiques !
  - A terme couplage avec modèle multi-layer

- Rayonnement :
  - Besoin d'inclure séparation direct / diffus pour la Photosynthèse !
  - Compatibilité modèle 2 stream dans la canopé avec RT de LMDZ ?

- Multi-tiling (bilan energy séparé par PFT / Lac / glaciers / ….)
  - Mélange des flux de surface dans la PBL : instantané ou progressif ?

- Albedo de surface ORCHIDEE
  - Dépendance à l'humidité du sol ? (potentiallement important)
  - Si déforestation => Quel albedo pour le sol nu ?

Bilan des demandes spécifiques

- Couplage avec modèle de feux : “éclairs” sont potentiellement important (see Patricia’s talk)

- Mortalité des forêts par “tempêtes” !
  - Besoin d’avoir les “coup de vent locaux” en surface (“gust”) ?

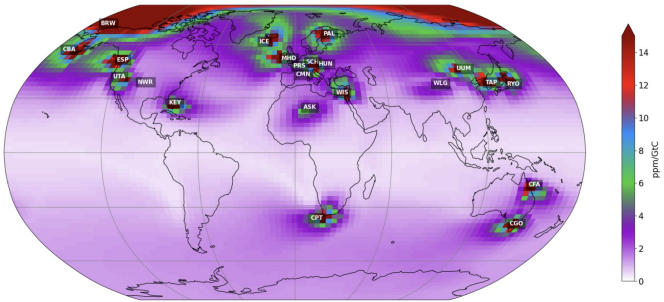
- Spin-up of LMDZ-ORCHIDEE pour le C devient plus compliqué !
  (A cause de la discretisation verticale : plus de solution analytique)
  - Utilisation possible d’émulateurs d’ORCHIDEE (en cours; D. Goll)

- Optimisation des paramètres ORCHIDEE en mode ORC-LMDZ :
  ⇒ activité croissante..

Optimization du modèle couplé ORC - LMDZ

- Parameter calibration of the coupled model ORCHIDEE - LMDZ
  - Test of ORCHIDEE alone with History Matching (Simon Beylat PhD)
    ⇒ Difficult when considering a large number of parameters (> 100)

  - Ongoing test with a 4DVar-ensemble method
    (pseudo data test using atmospheric CO2 concentration data to optimize ORCHIDE Vcmax parameters)



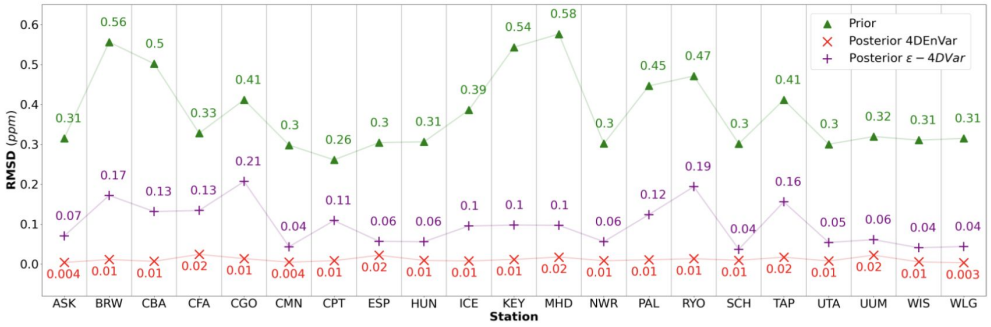


Figure 4. The Root Mean Squared Differences (RMSD) scores of the simple case for each of the 21 atmospheric stations between synthetic observations and prior simulations are represented by the green triangle. The RMSD scores between synthetic observations and posterior simulations given by the ϵ-4DVar (4DEnVar) method are represented by the purple + symbol (red × symbol)