Is the Transpose-AMIP approach useful for improving the CNRM model?

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METEO FRANCE
Toujours un temps d'avance

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1. Motivation

- Climate models have long-standing (often systematic) biases, which have been struggling the modeling community for years and decades:

  e.g., double-ITCZ, monsoons, warm bias in the tropical Atlantic, low clouds…

- Most of the time, these biases are diagnosed in climate simulations, where everything is at equilibrium (especially the dynamics).

- In the perspective of model development, strategies are needed to link these biases to the processes (parameterizations) themselves.

  -> top-down and intermediate (bias-oriented) approaches can help to fill in this gap, enhance our understanding of the origin of model bias and provide guidance (and priorities) for parameterization improvements

- Transpose-AMIP simulations, in which a climate model is used as an NWP forecast model, are a good tool/step for that, as many biases have been shown in a few models to be related to fast processes and reproducible in this NWP framework (e.g., Xie et al. 2012, Williams et al. 2013, Ma et al. 2014).

Outline

Objectives:

- Identify which CNRM-CM biases can be tackled trough the Transpose-AMIP approach.
- Use the Transpose-AMIP framework to start to understand the origin of CNRM old and new physics biases

1. Motivation
2. CNRM-CM old and new physics & simulations
3. Warm biases over continents in summer
4. Precipitation biases and the double-ITCZ
5. Conclusions and Perspectives

2. CNRM-CM physics and simulations

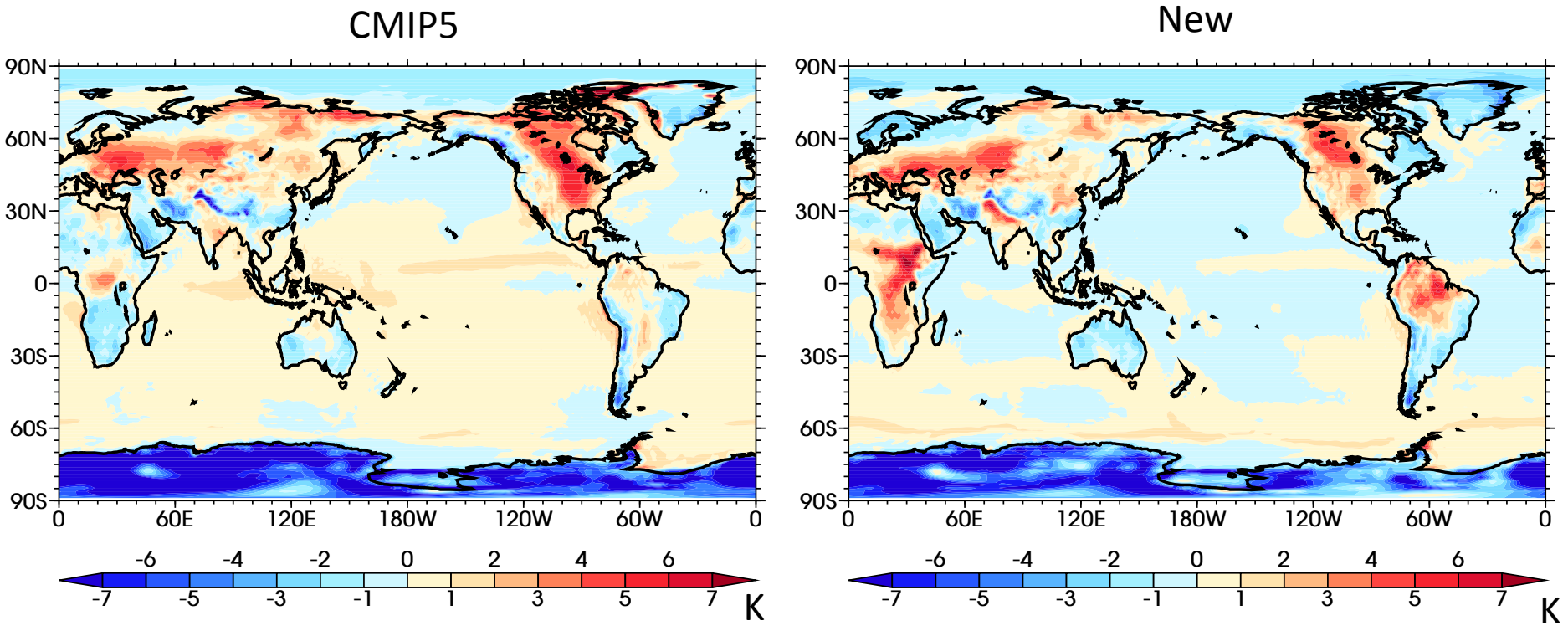
- **2 versions of CNRM-CM:**
  - **Old CMIP5 physics**:
    - T127 (~1.4°), 31 vertical levels
    - diagnostic equations for liquid/solid water species and TKE
    - Moisture convergence for the convective scheme
  - **NEW physics** still under development (both for NWP and climate applications):
    - T127 (~1.4°), 91 vertical levels
    - Prognostic equations for liquid/ice water, rain/snow, and TKE
    - New unified convective scheme:
      - detailed prognostic microphysics (same scheme as large-scale)
      - CAPE closure
      - developed with the objective to obtain the right sensitivity to free tropospheric moisture (Derbyshire et al. 2004)

- **Simulations:**
  - Typical AMIP simulations (1979-2008), forced by observed SSTs
  - Transpose-AMIP:
    - 31 hindcasts for July 2009: 20-day range
    - Initialized at 00:00 UTC with YOTC ECMWF analyses
    - Land surface:
      - YOTC ECMWF surface analyses
      - Offline simulation of the CNRM land-surface scheme with "realistic" forcings (ERA-Interim, precipitation rescaled with monthly GPCC)

3. Warm biases over continents in summer

CMIP5 and NEW physics - AMIP

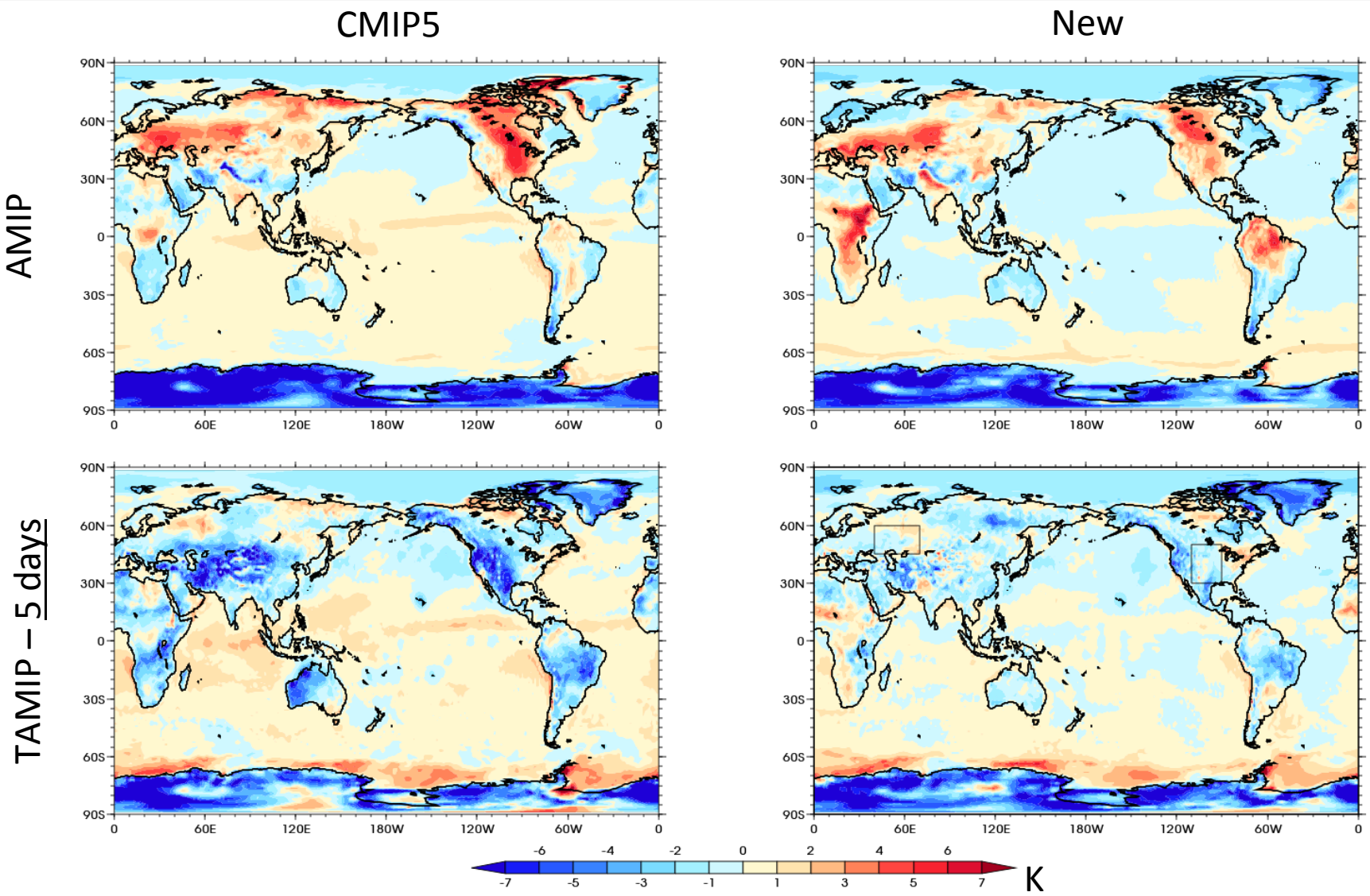
2-meter temperature bias (July) – Reference: ERA-Interim



- Slightly reduced bias over the US
- Similar over Europe
- New (or increased) biases over tropical Africa and Amazonia (all year long)

3. Warm biases over continents in summer

In Transpose-AMIP simulations



3. Warm biases over continents in summer

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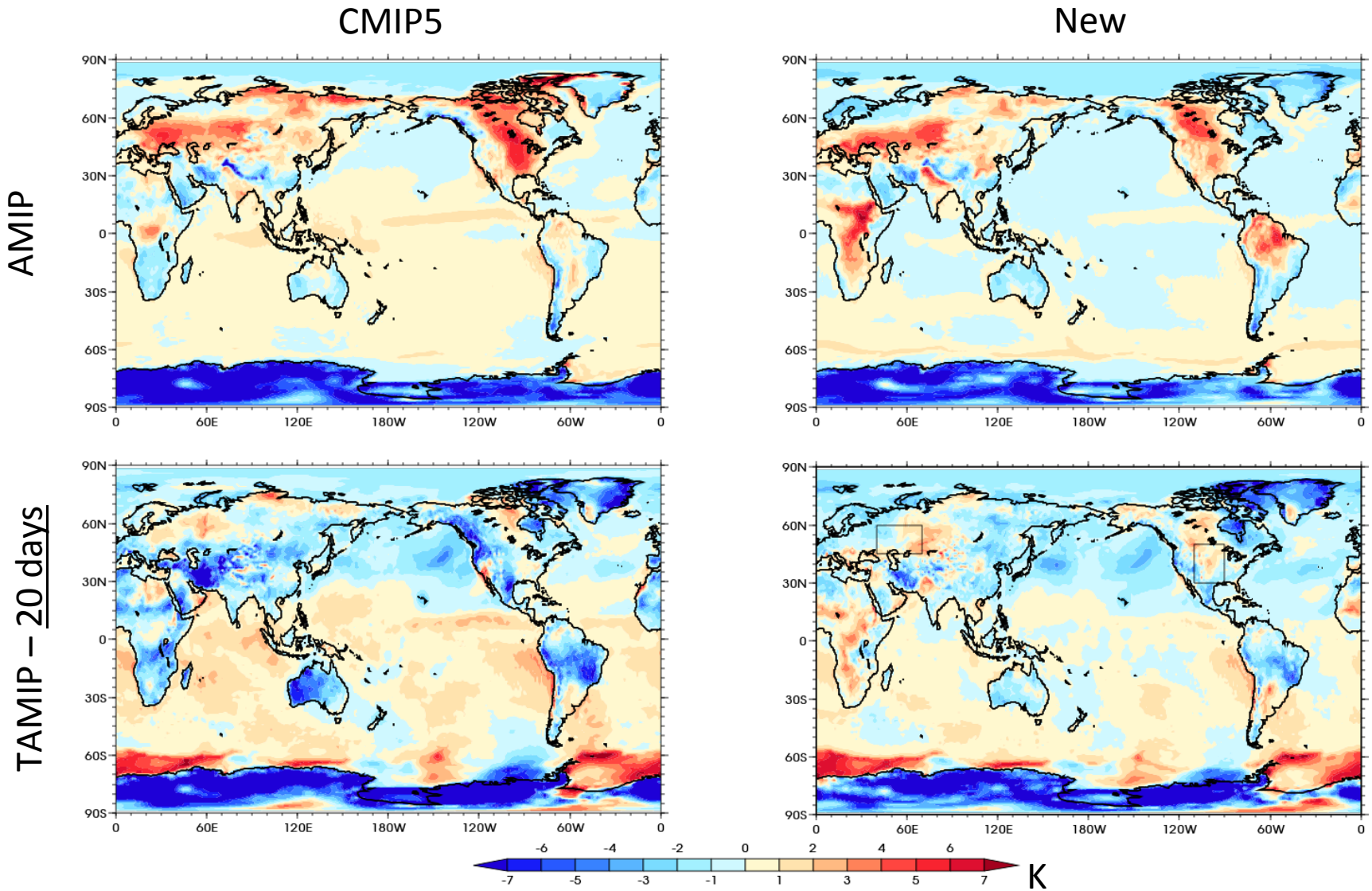


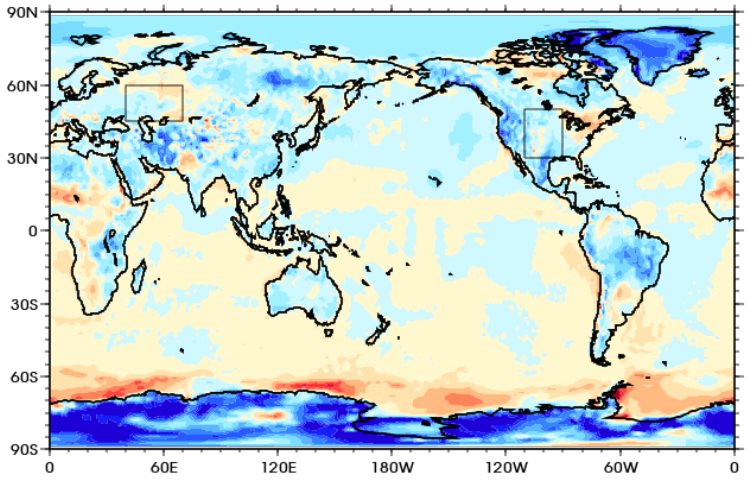
- Initializing the land-surface scheme with ECMWF analyses yields too moist land surface
  -> Tackling continental biases really needs a thought about land-surface initialization

Sensibility to land-surface initialization in NEW

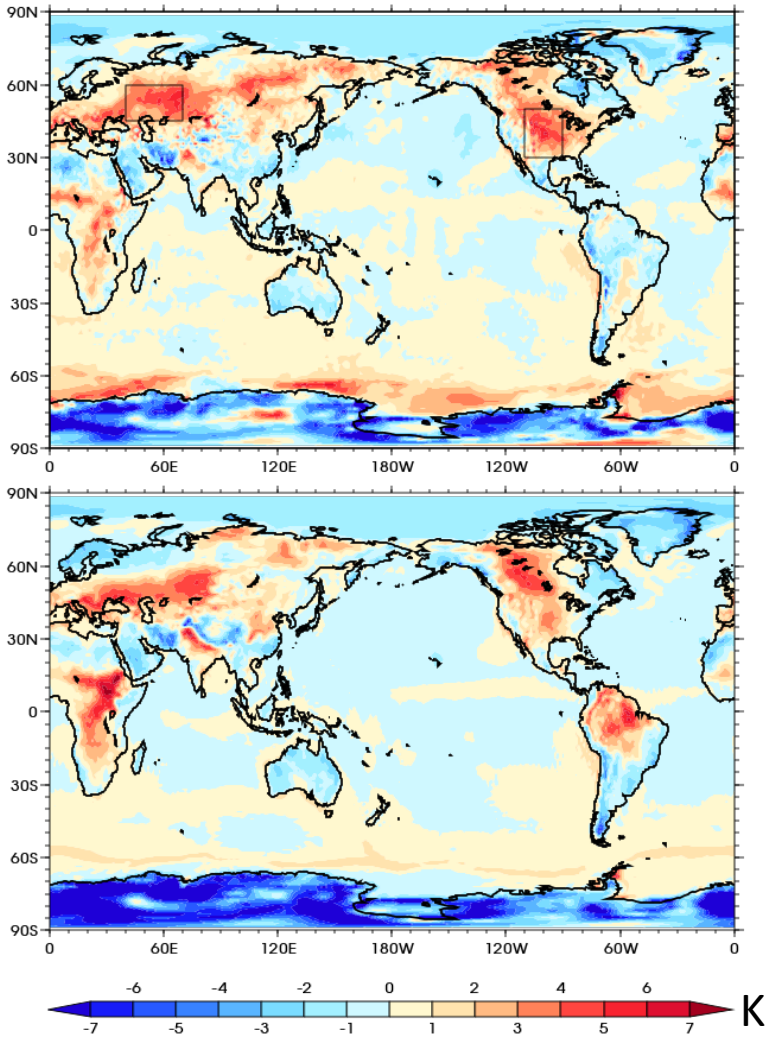
From ECMWF land surface analysis

From an offline run of surface scheme

TAMIP – 5 days



AMIP

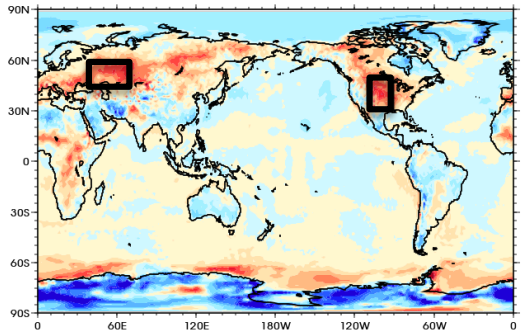


- Overall, better correspondence when the initial surface state is consistent with the surface scheme.
- Warm bias over Amazonia remains elusive in TAMIP (even at 20 days):
  -> slow drift of regional circulation ?

3. Warm biases over continents in summer

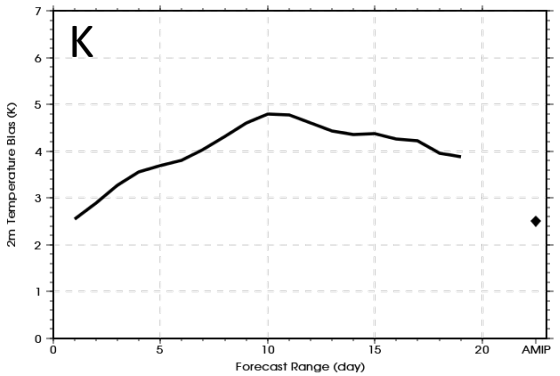
Radiation budget at the surface - NEW

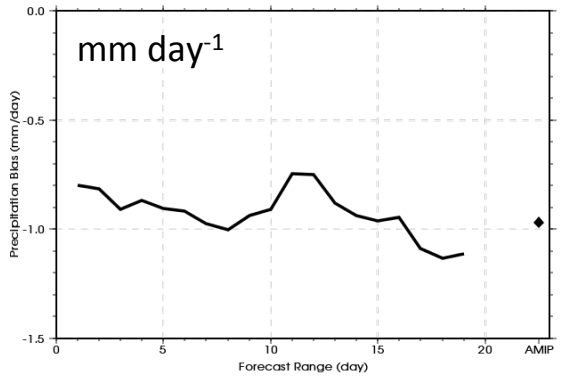
- Warm biases already here during the first day
  -> Initialization? Surface scheme? Atmospheric physics?
- Over Europe, increase of the warm bias likely due to the lack of precipitation (negative bias in SWdn).
- Over the North America, the overestimate of SWdn might be at play as well.

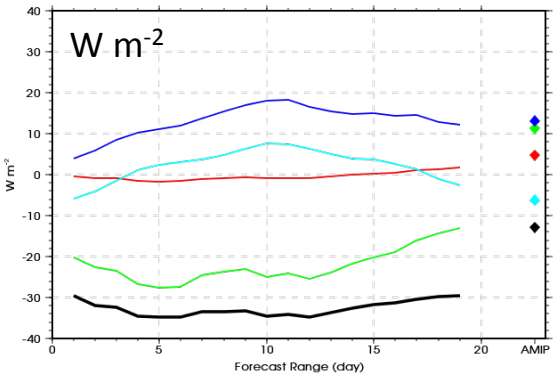


T2m Bias | Precipitation Bias | Surface Radiation Biases

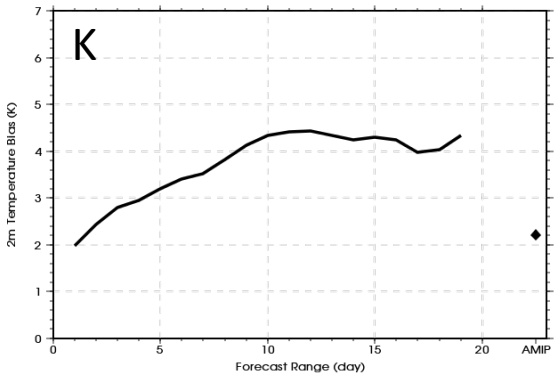
Europe

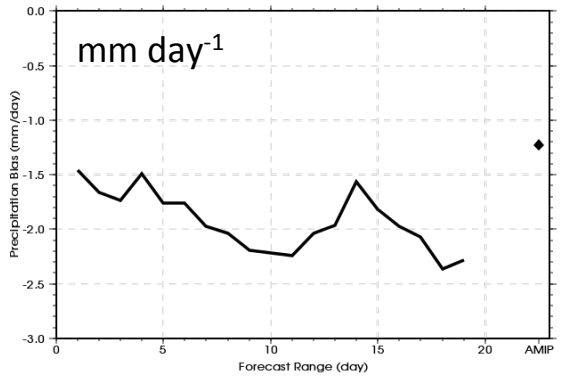


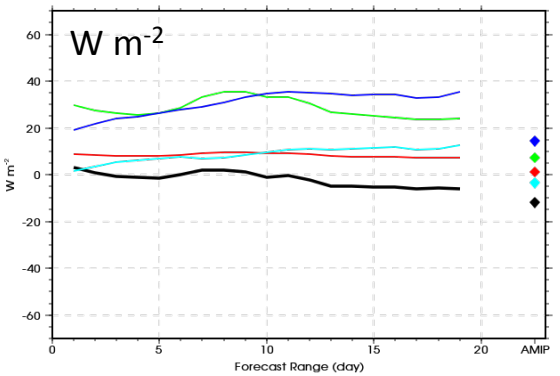




North America







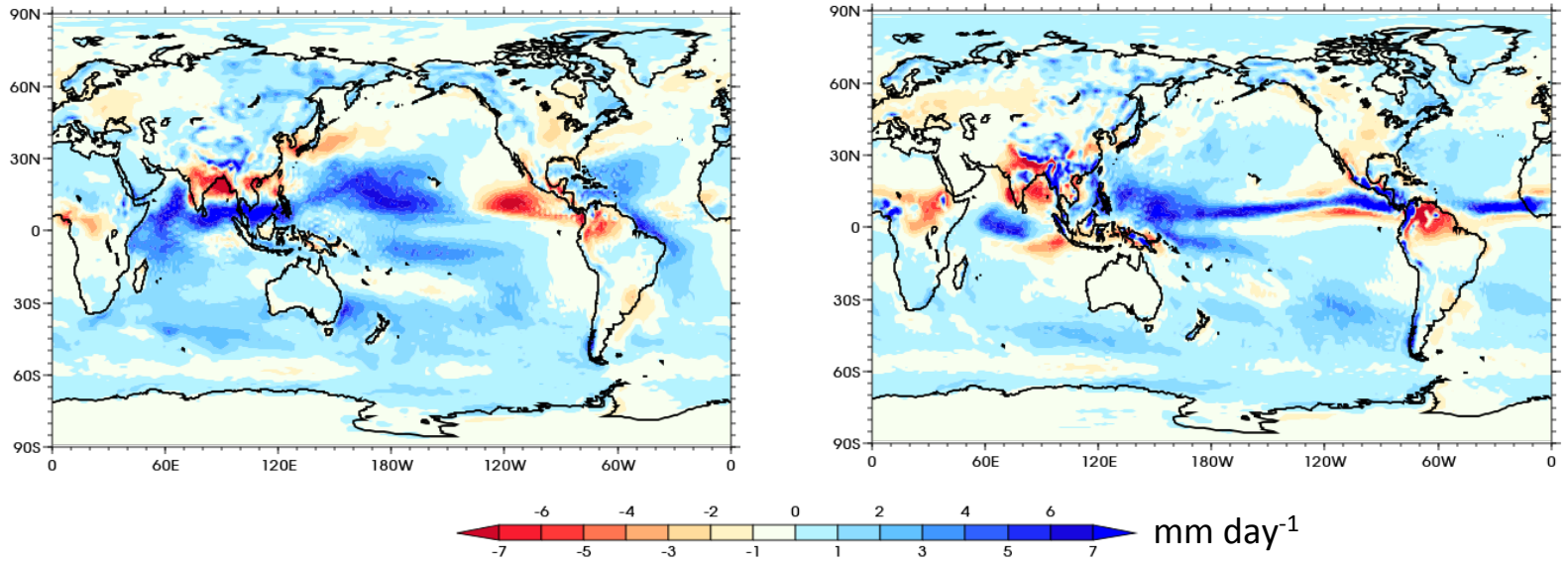
Rnet
SWup
SWdn
LWup
LWdn

CMIP5 and NEW physics - AMIP

Precipitation bias (July) – Reference: GPCP

CMIP5 | New

AMIP



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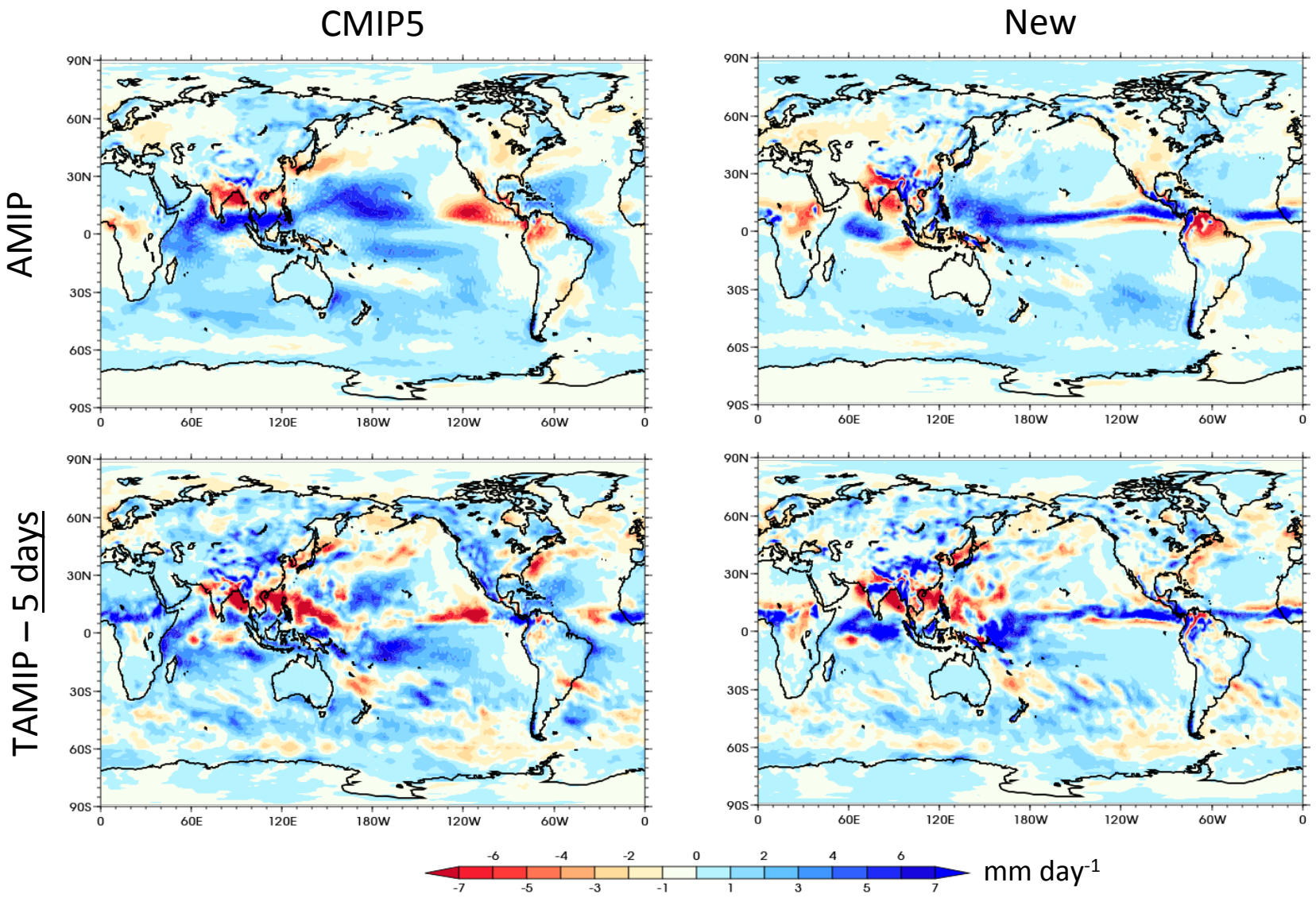
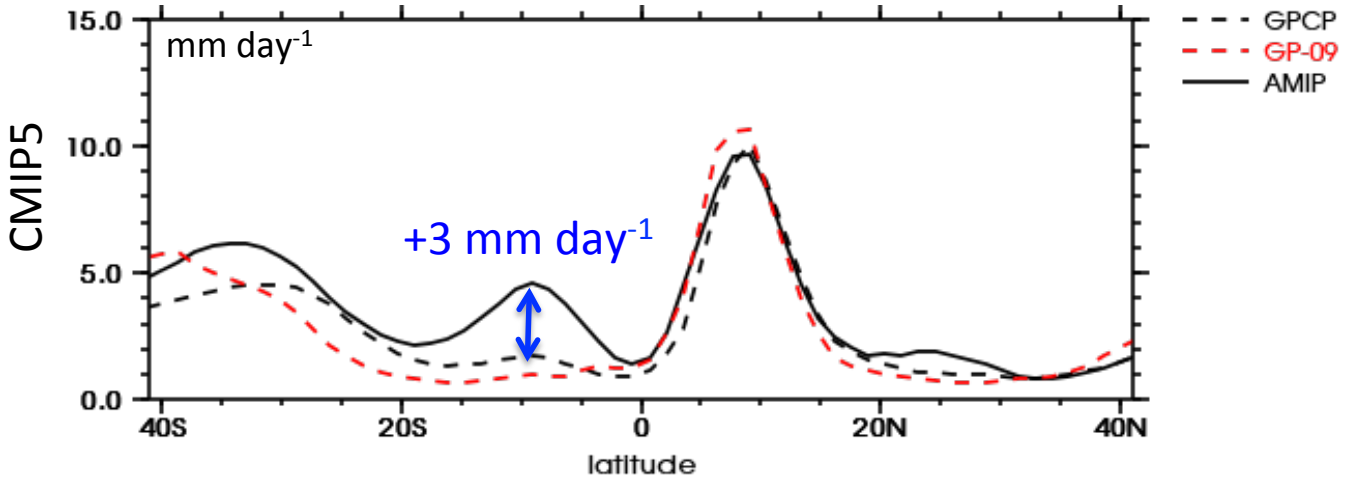
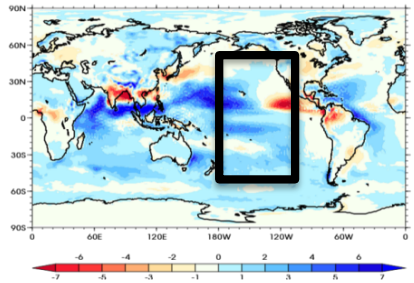


The double-ITCZ syndrome

Zonal average of precipitation [180°W-100°W]





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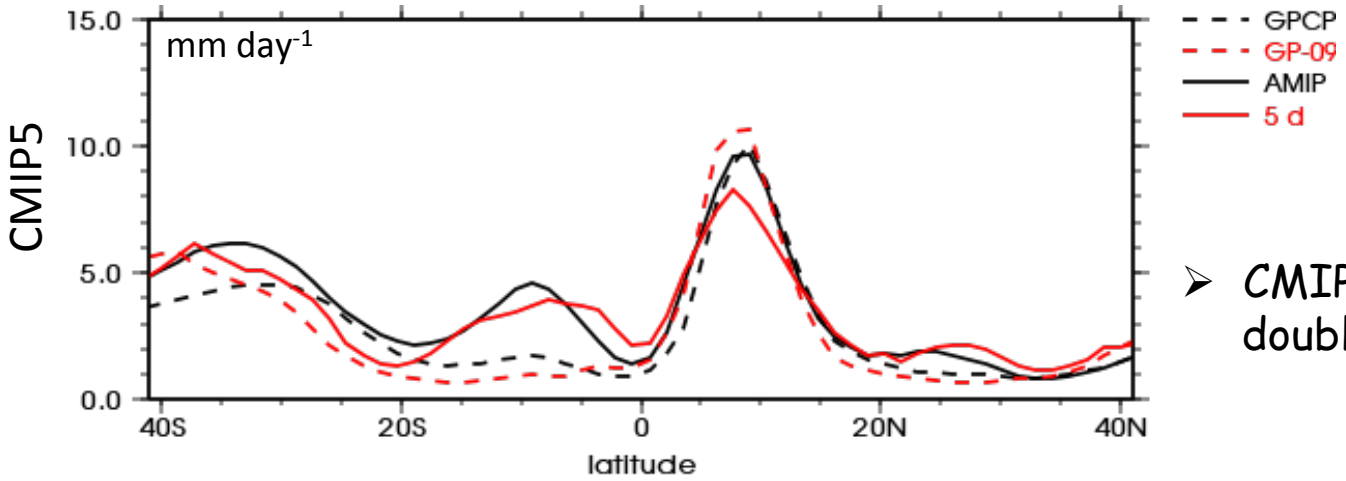

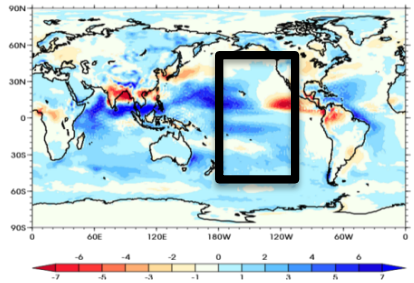

- CMIP5: TAMIP capture the double-ITCZ in the first days

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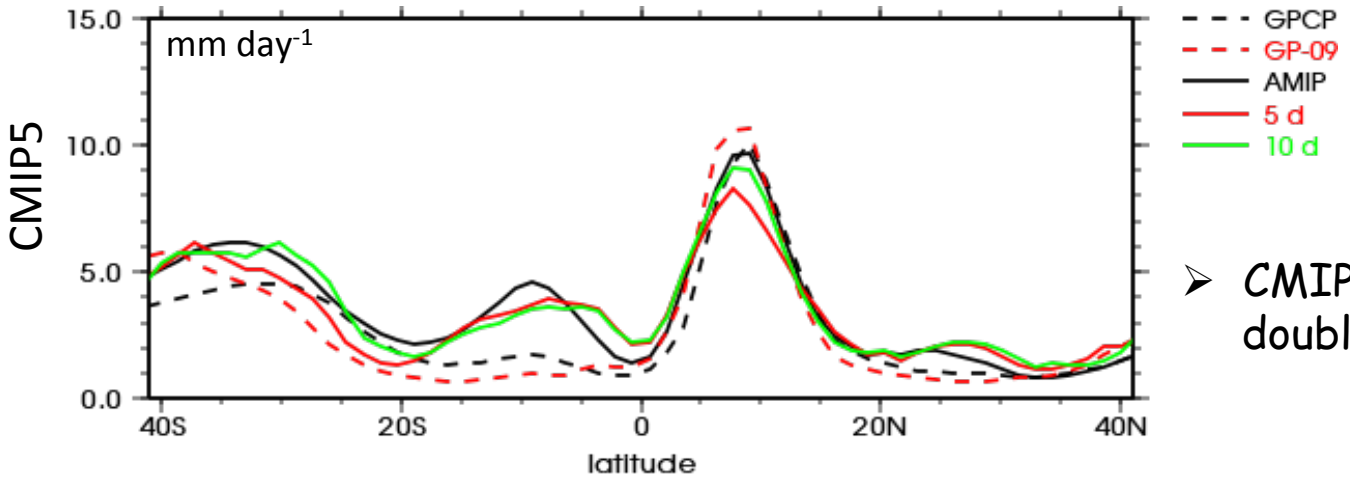

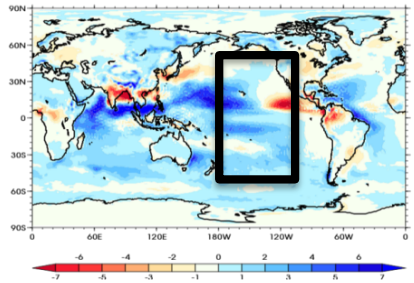

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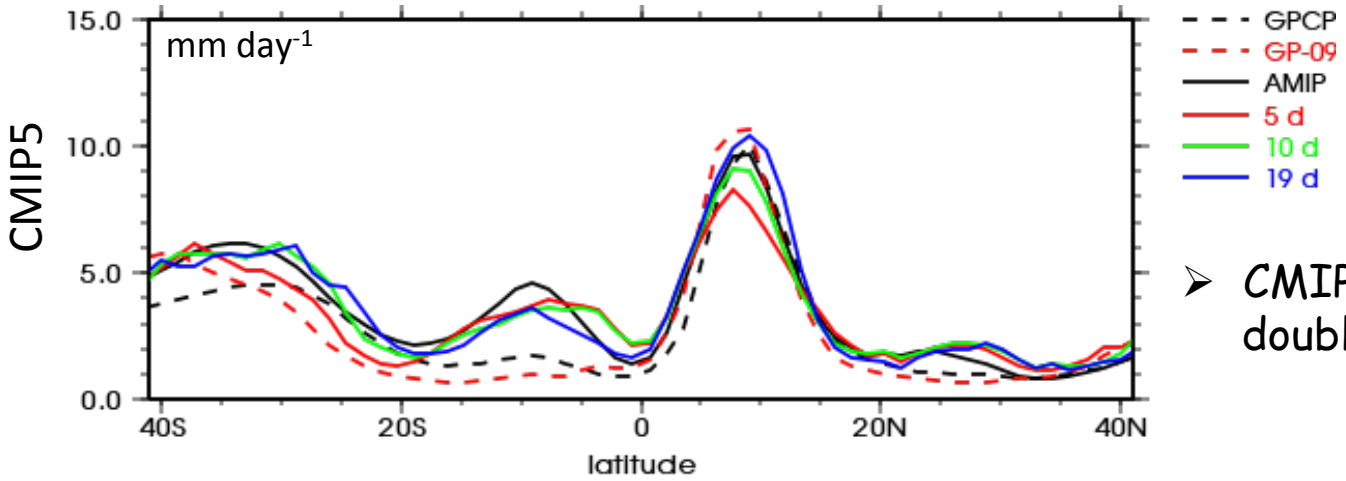

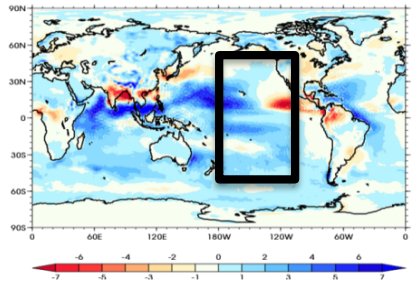

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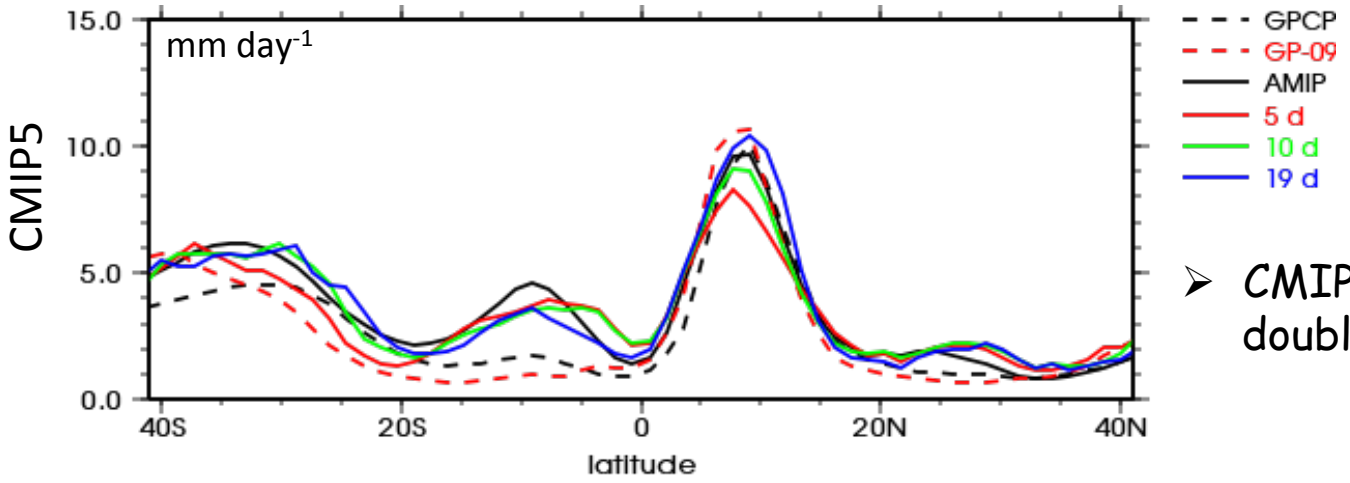

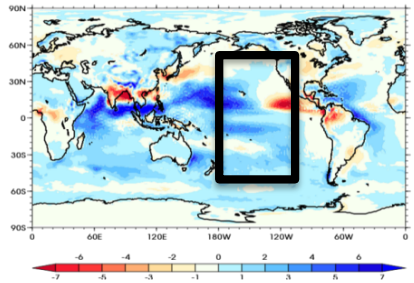

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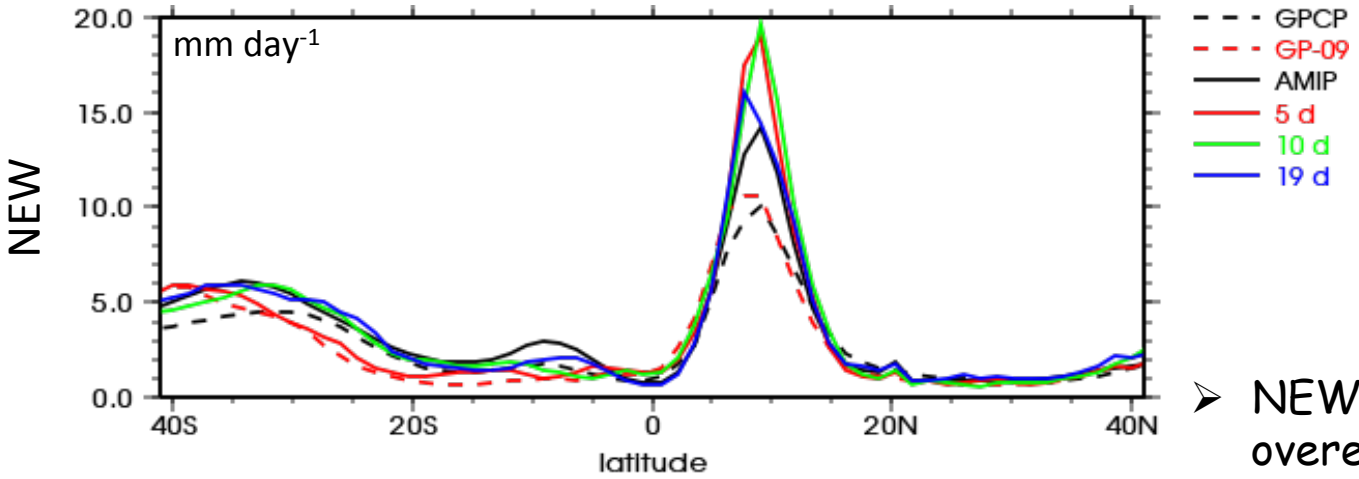
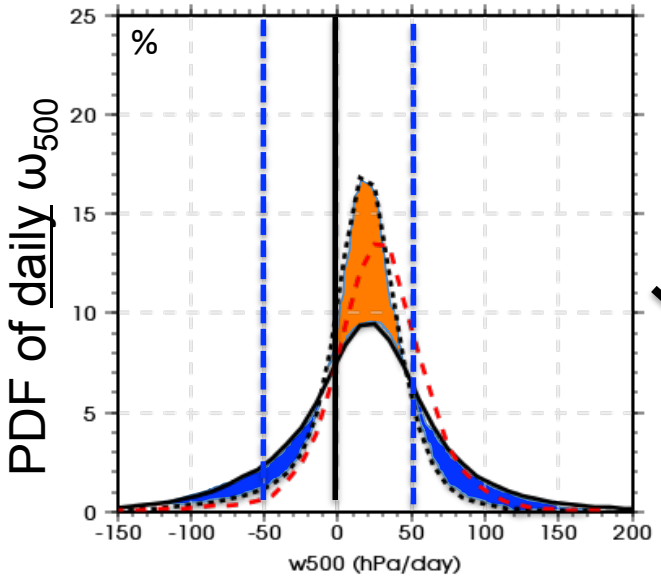


- NEW: reduced double ITCZ, but overestimate of precipitation within the ITCZ
- Strong spin-up

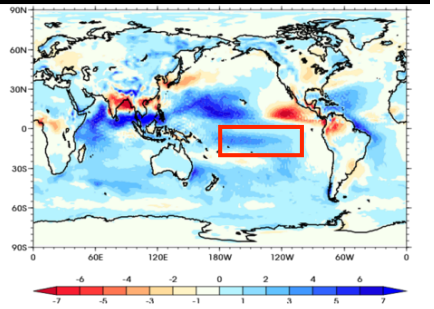
The double-ITCZ syndrome – Dynamical regimes

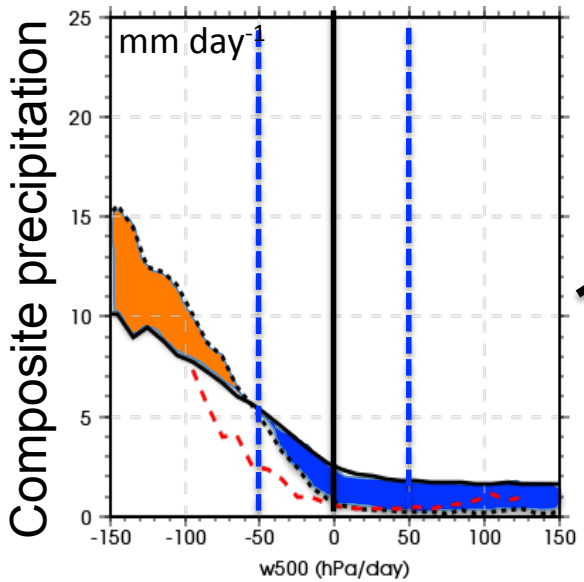


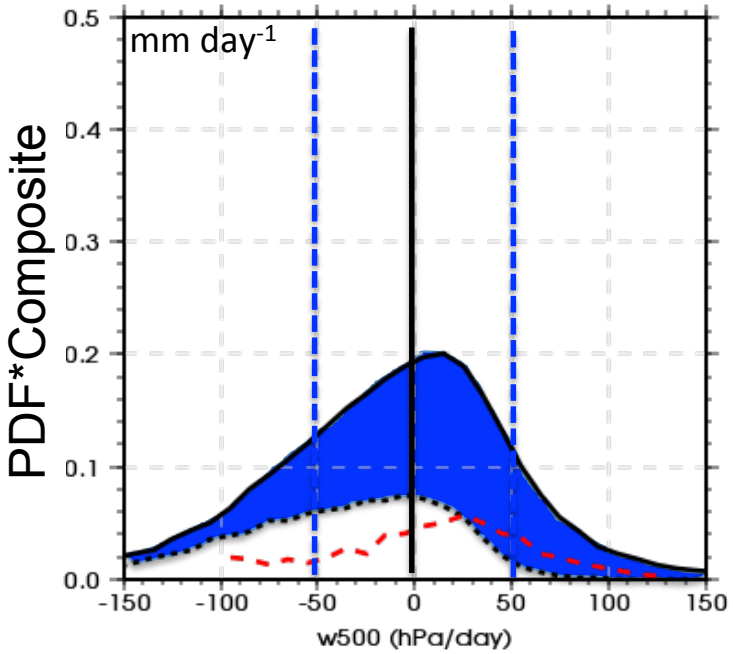
CMIP5

GPCP/ERAI (1999-2008)

GPCP/YOTC (2009)

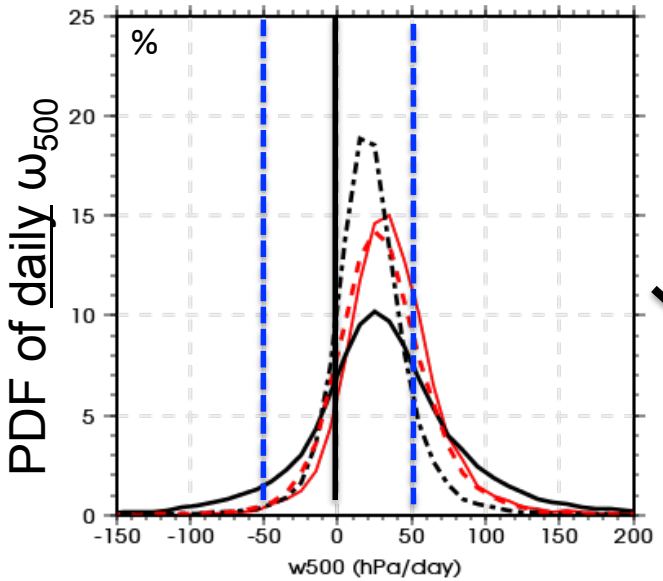


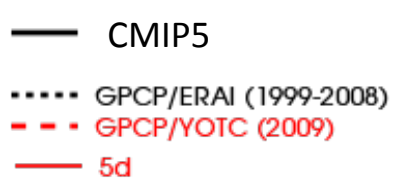


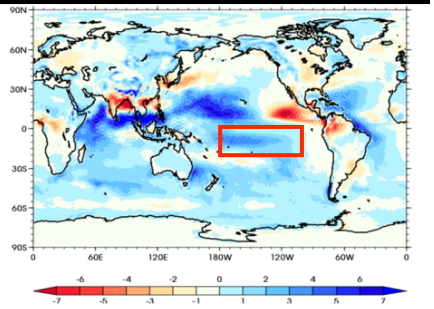


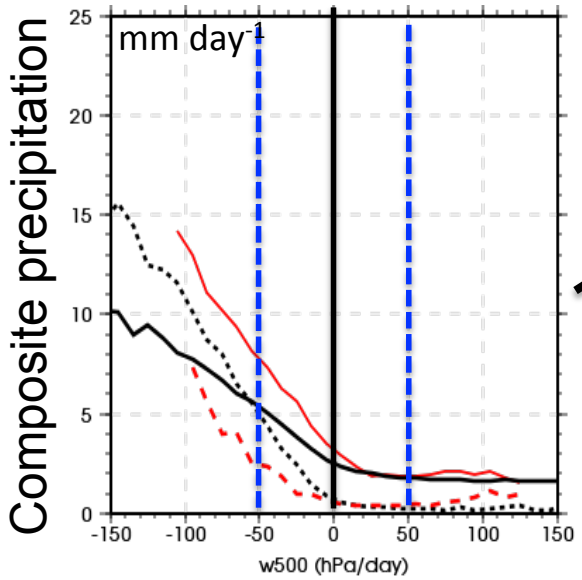
- CMIP5 mostly outside the range of uncertainty

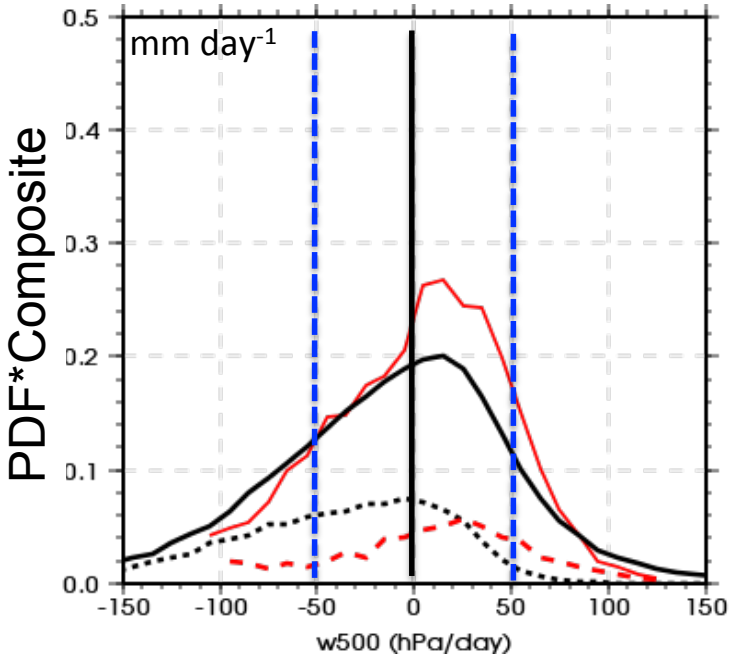
The double-ITCZ syndrome – Dynamical regimes





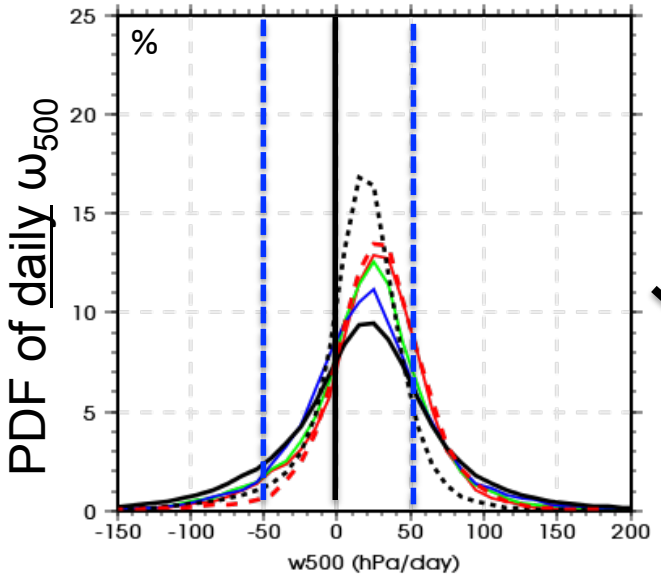


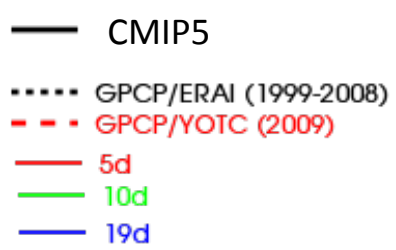


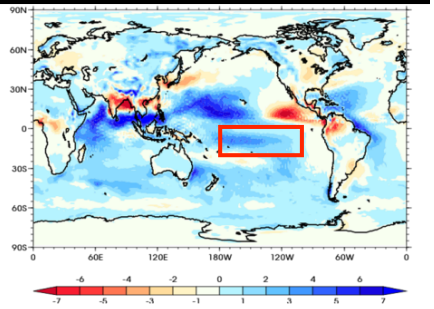


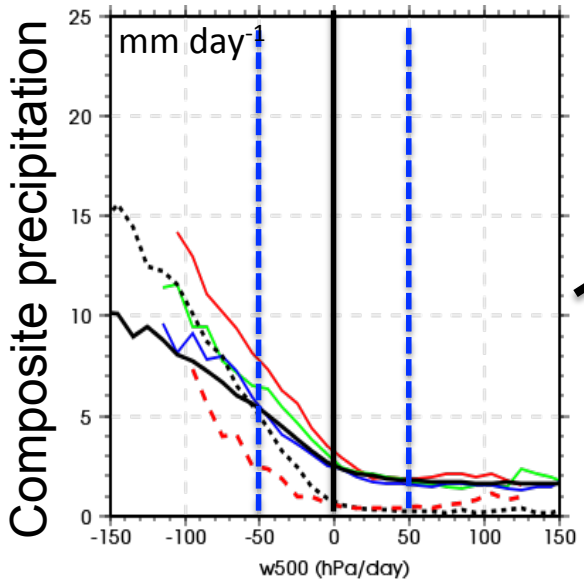
- CMIP5 mostly outside the range of uncertainty
- Strongly-convective component of the double-ITCZ bias is different between AMIP and short-term TAMIP runs

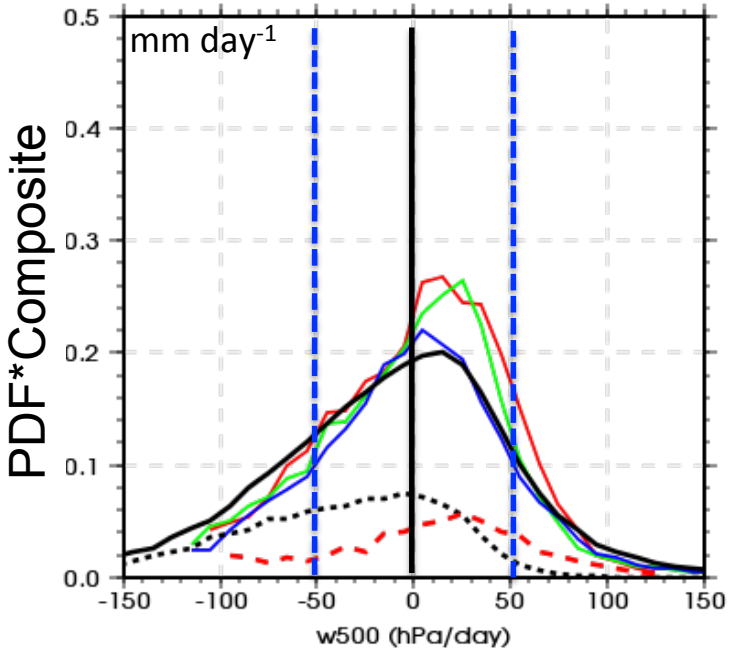
The double-ITCZ syndrome – Dynamical regimes





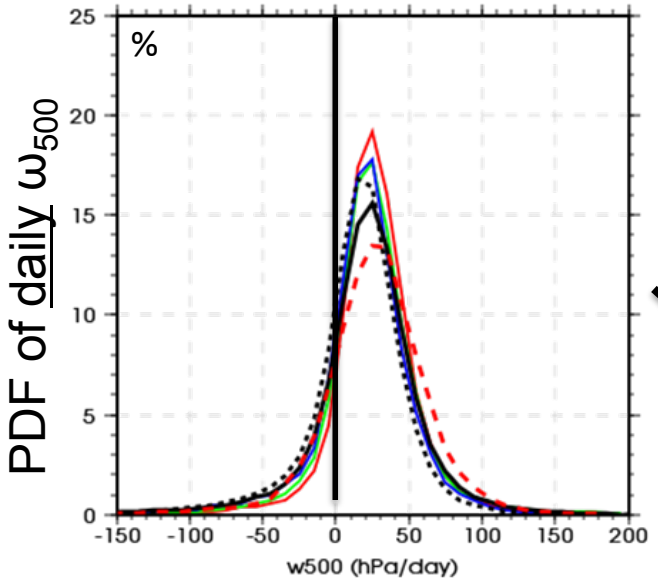


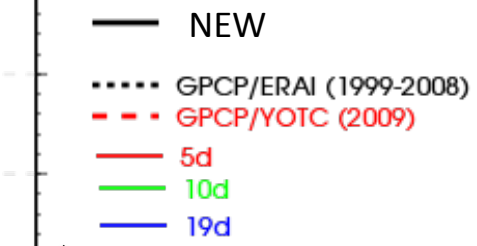


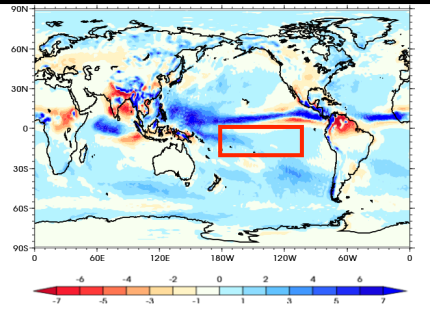


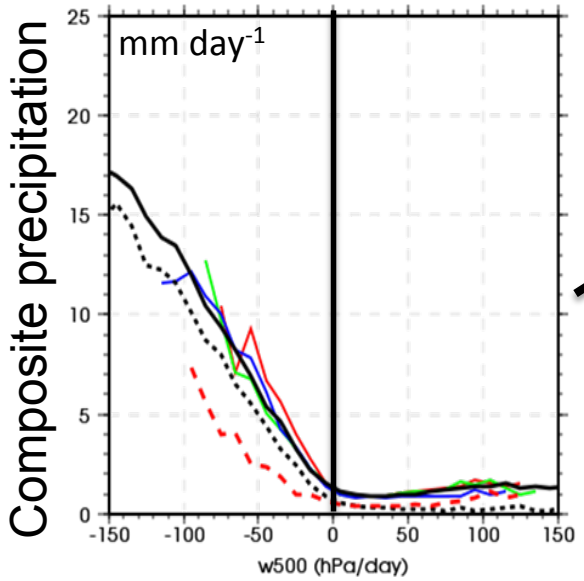
- CMIP5 mostly outside the range of uncertainty
- Strongly-convective component of the double-ITCZ bias is different between AMIP and short-term TAMIP runs
- Bias in the dynamics needs more than 20 days.

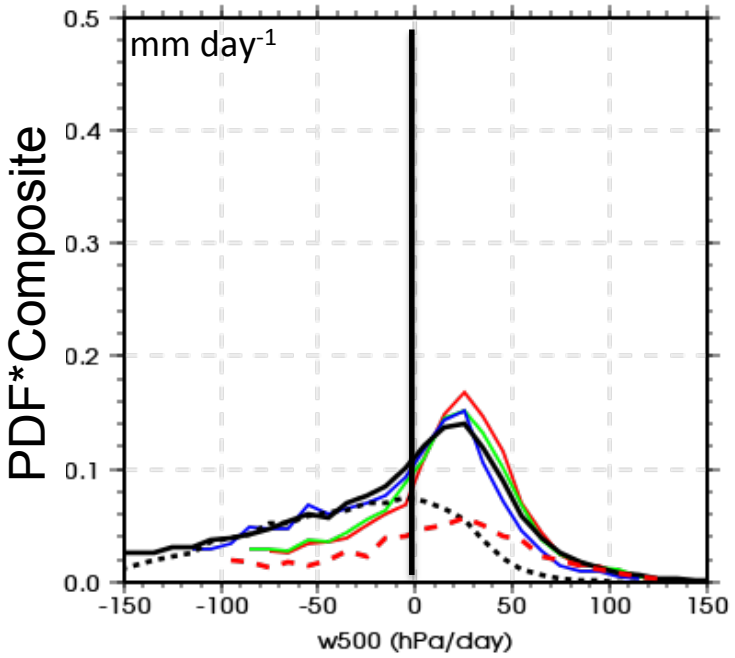
Reduced double-ITCZ in NEW





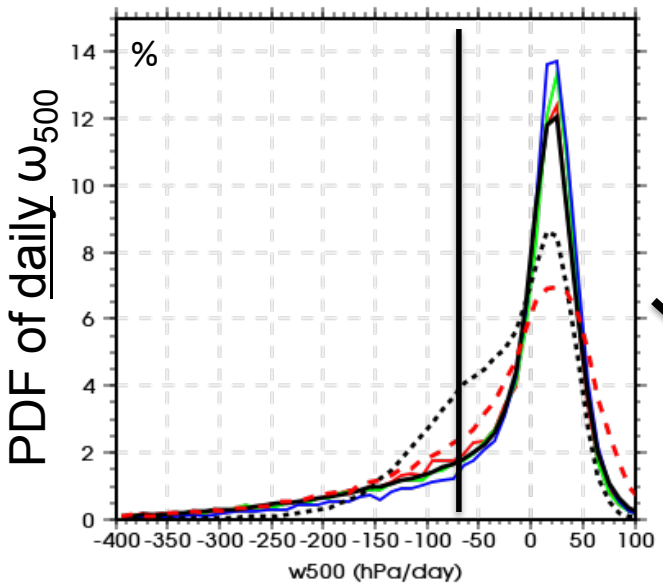


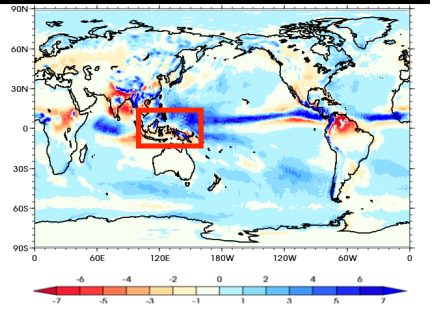


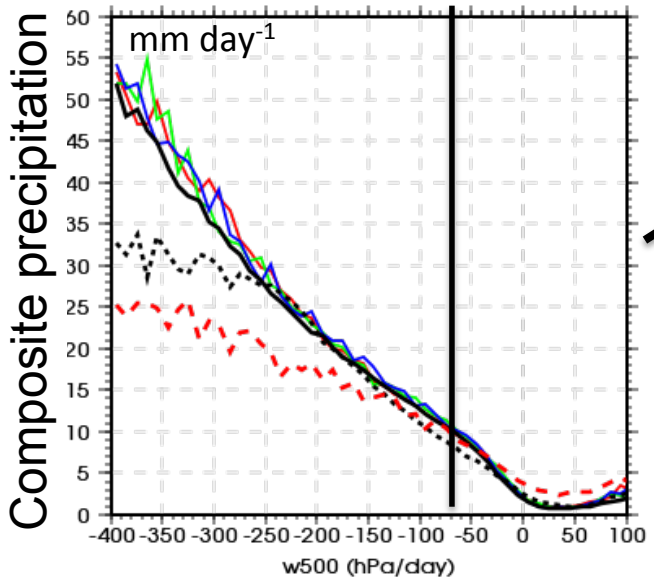


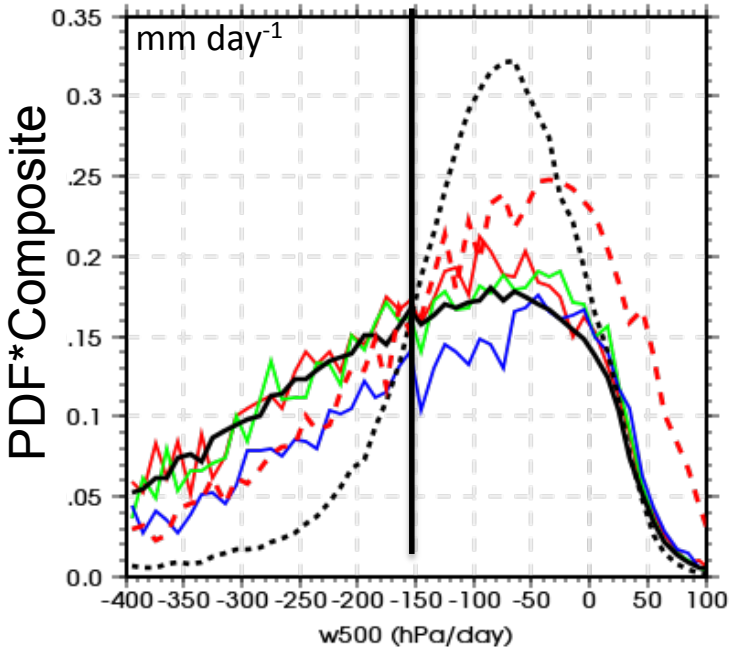
- NEW mostly within the range of uncertainty
- Still too much rain in subsiding regimes
- Strong spin-up

Over the West Pacific with NEW









- YOTC and ERA-Interim disagree quite strongly in convective regime…
- NEW precipitates too much in strong convective regimes

5. Conclusions and perspectives

- **Conclusions**:
  - The Transpose-AMIP framework is relevant for many biases of the CNRM models (CMIP5 and NEW), for various aspects of the climate systems (precipitation, clouds, surface and tropospheric temperature and humidity, jets…)
  - Over continent, land-surface scheme initialization is crucial
  - Decomposition of rainfall biases between "thermodynamics" and "dynamics" components provides interesting insights in their origins, and shows that they might be different between AMIP and TAMIP
- **Future work**:
  - Use this framework to analyze more thoroughly the behavior of our new model version and identify key processes to be improved.
  - Focus also on biases in the large-scale circulation