Using in-situ observations to identify sources of surface energy biases in climate models:focus on West Africa

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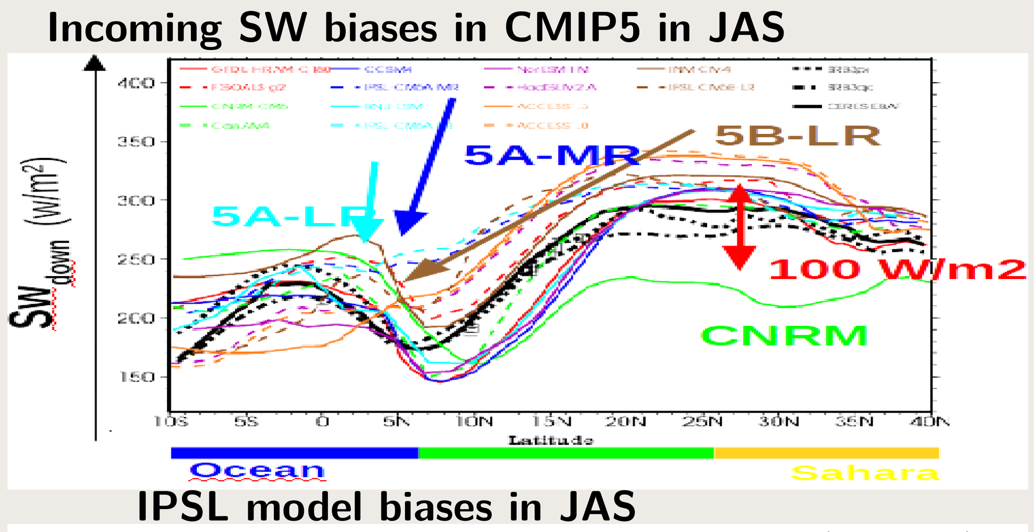
(1) Introduction

Context

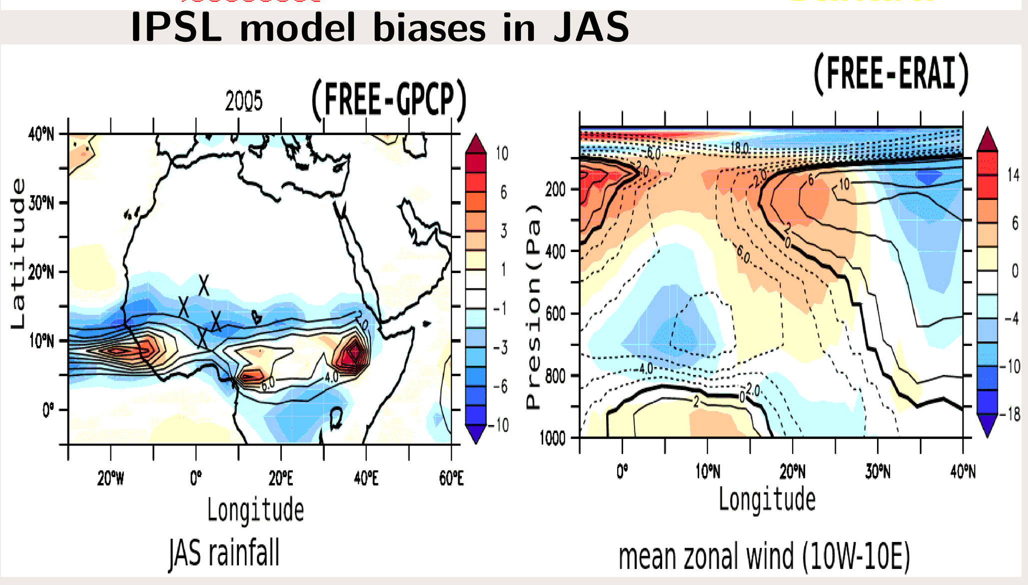
Systematic and large errors in the representation of the rainfall seasonality, near surface air temperature, and surface energy budget over West Africa even during the dry season persist in CMIP5 models. Most of these biases are in link with an incorrect latitudinal position of ITCZ and even persist in simulation with imposed SST.

Incoming SW biases in CMIP5 in JAS



Even in AMIP simulations with imposed SST, CMIP5 models have difficulties to represent correctly the incoming SW, with dispersions of one model to another to order can reache 100 w/m^2 (Roehrig et al., 2013)

IPSL model biases in JAS



- **Deficit of precipitation** over the central and northen Sahel.
- **Southern shift of AEJ** indicating that the monsoon system is located too far south

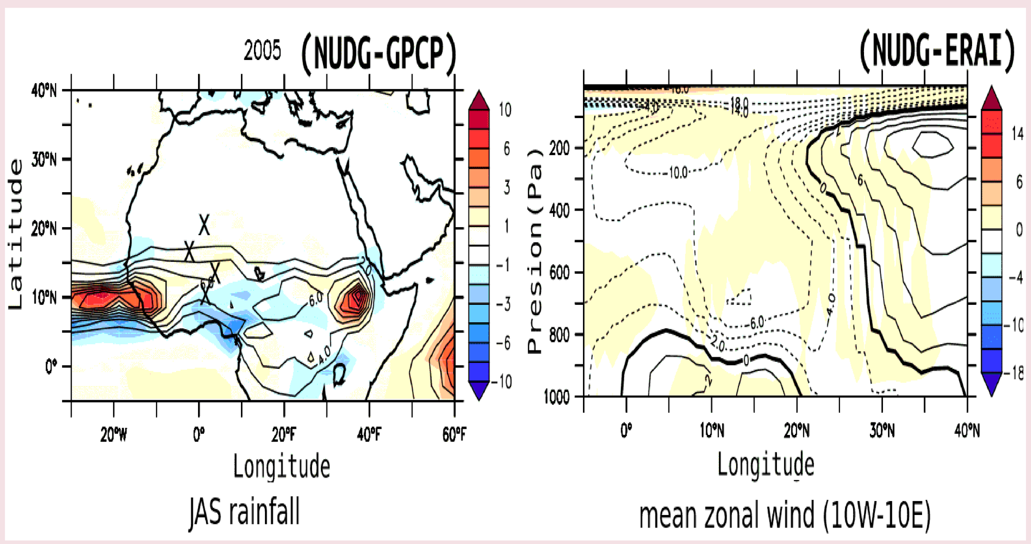
Aim

Distinguish whether the energy biases are responsible for the bad positioning or the opposite and to relate the energy biases to the parameterizations of the climate model.

(2) Methodology

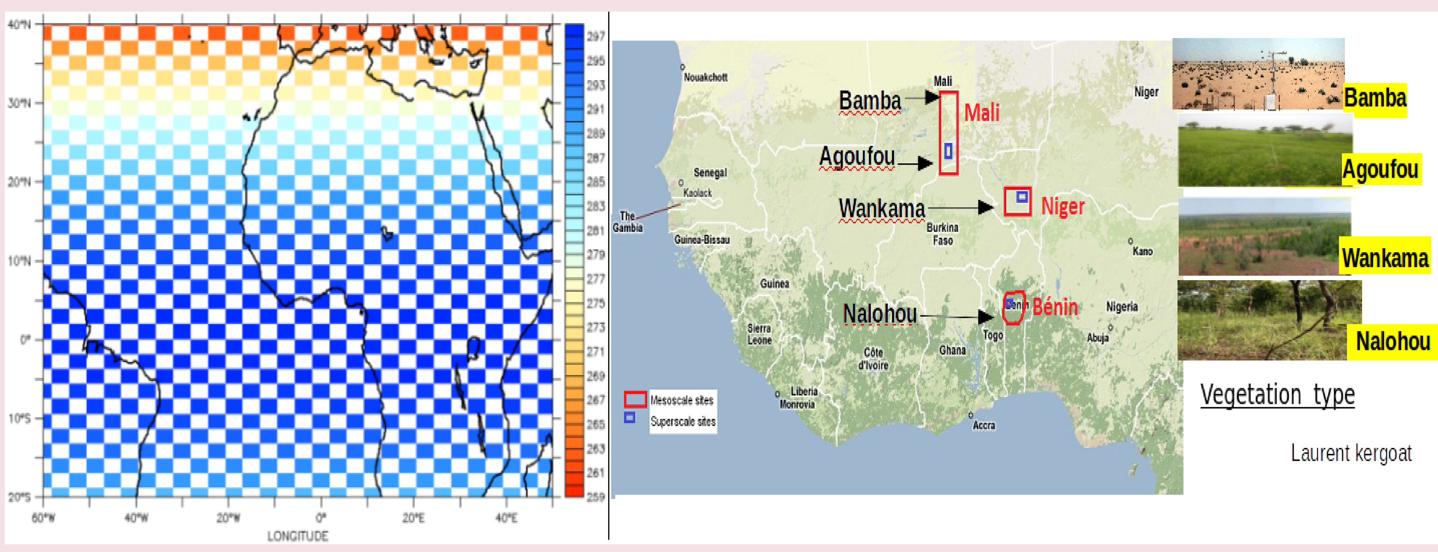
1) Constrain the large-scale dynamics by relaxing the horizontal winds of the atmospheric LMDZ model toward those of ERAI reanalysis with a 3 hour time constant (3 hours).

Nudging impact on regional rainfall



- **Correction** of the main model biases associated with the position of the monsoon system.
- **Improvement** of the spatial distribution of rain over Sahel

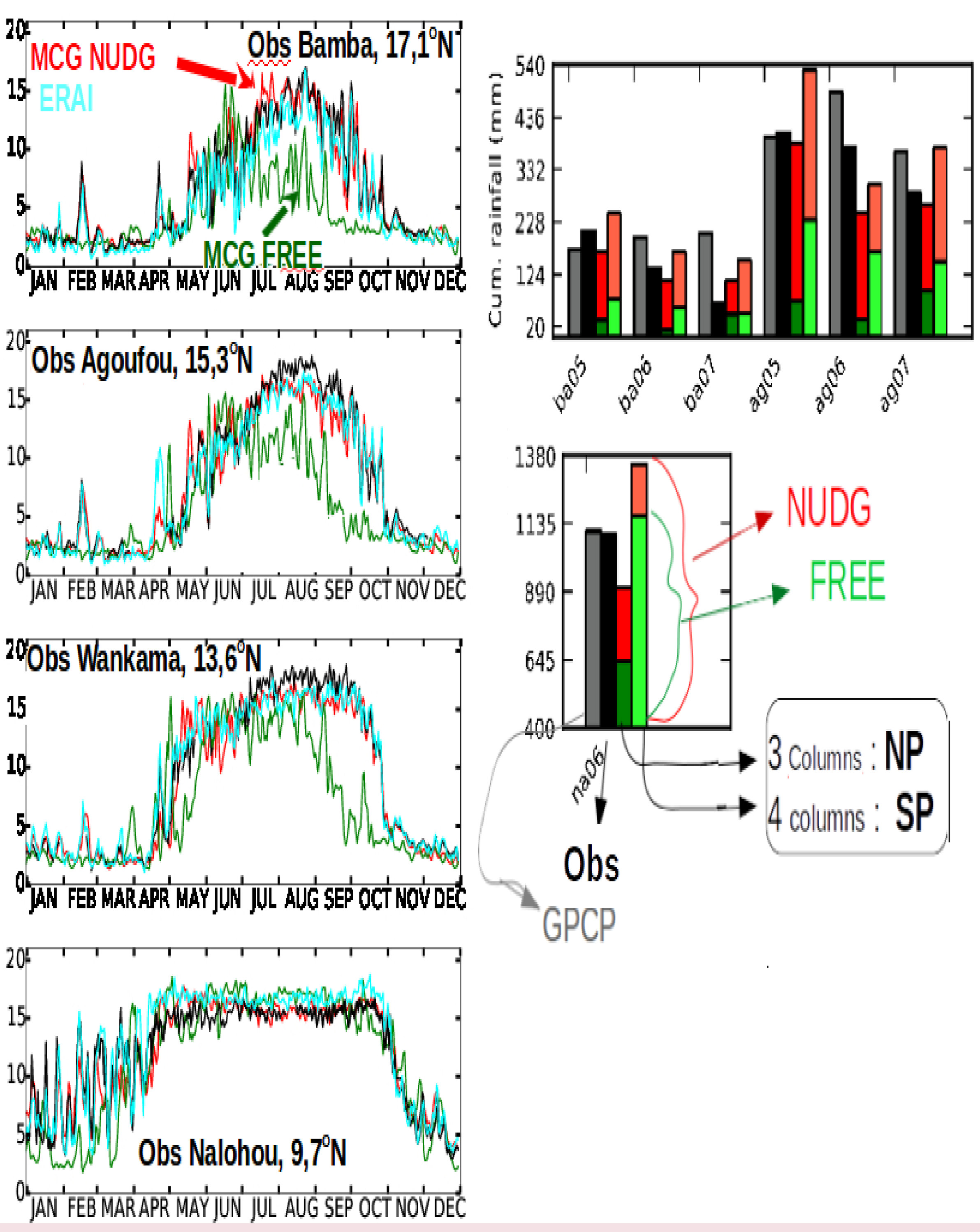
2) Set GCM grid cell face to in-situ data (AMMA-CATCH)



(3) Assessment of the nudging methodology

- The effect of nudging on the rainfall seasonality is closely related to the control of water advection, which is much better represented in the NUDG simulations.
- The uncertainty due to measurement and representativeness errors is small enough to assess the effect of nudging and demonstrate that the nudged simulations perform better than the free ones.
- Dry bias in summer over the Sahel in the FREE simulations are corrected in NUDG simulations.

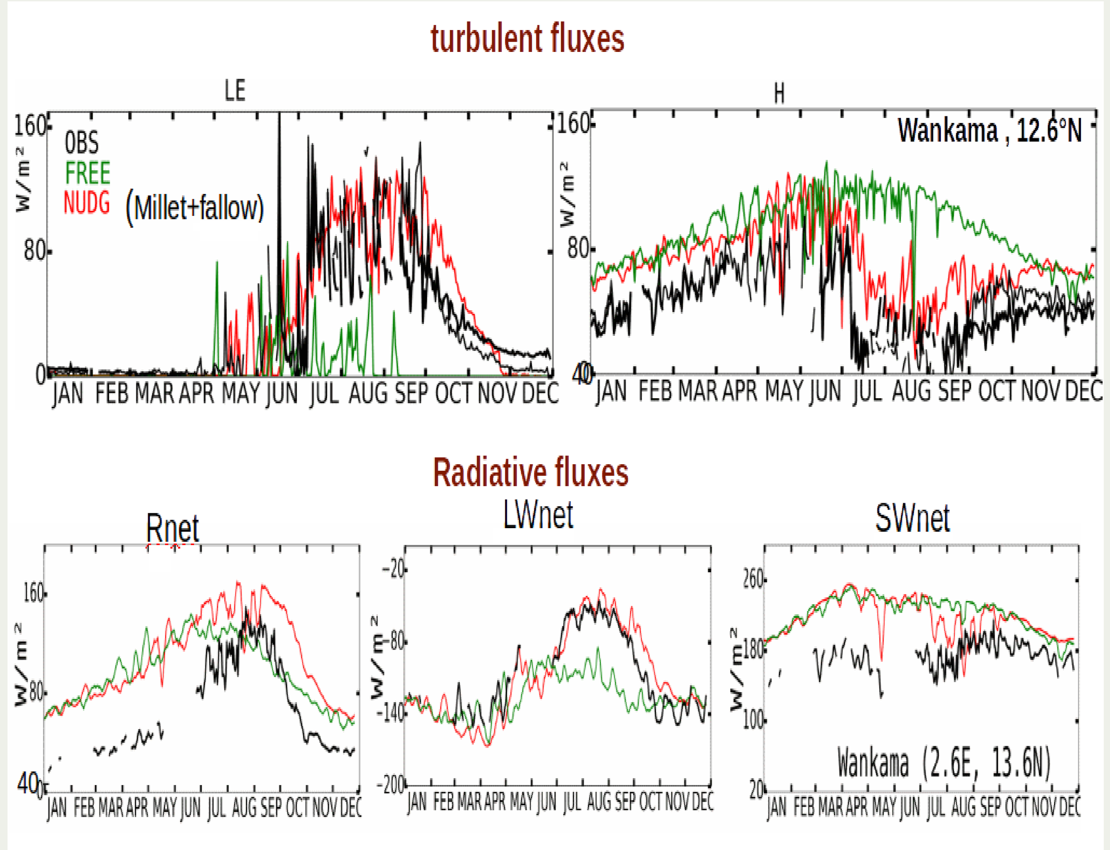
Nudging allows to make comparison with in-situ measurements relevant.

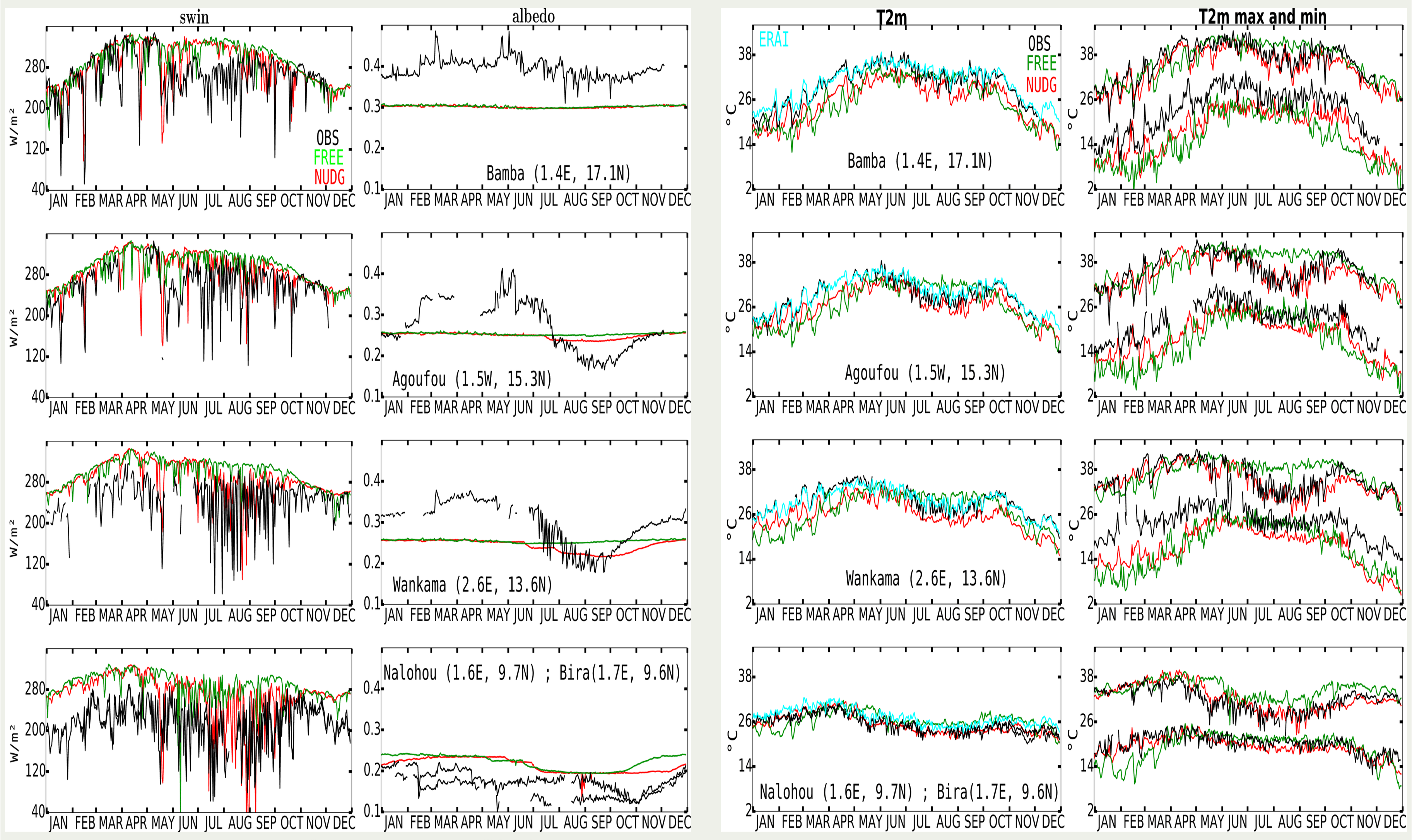


(4) Characterization of surface energy biases

However surface energy biases persist in nudge simulations:

- Overestimation of the sensible flux (H) during the dry season associated with an overestimated Rnet (absence of latent heat LE).
- The net radiation Rnet biases in the NUDG simulations are mainly explained by the SWnet biases (better representation of LWnet).

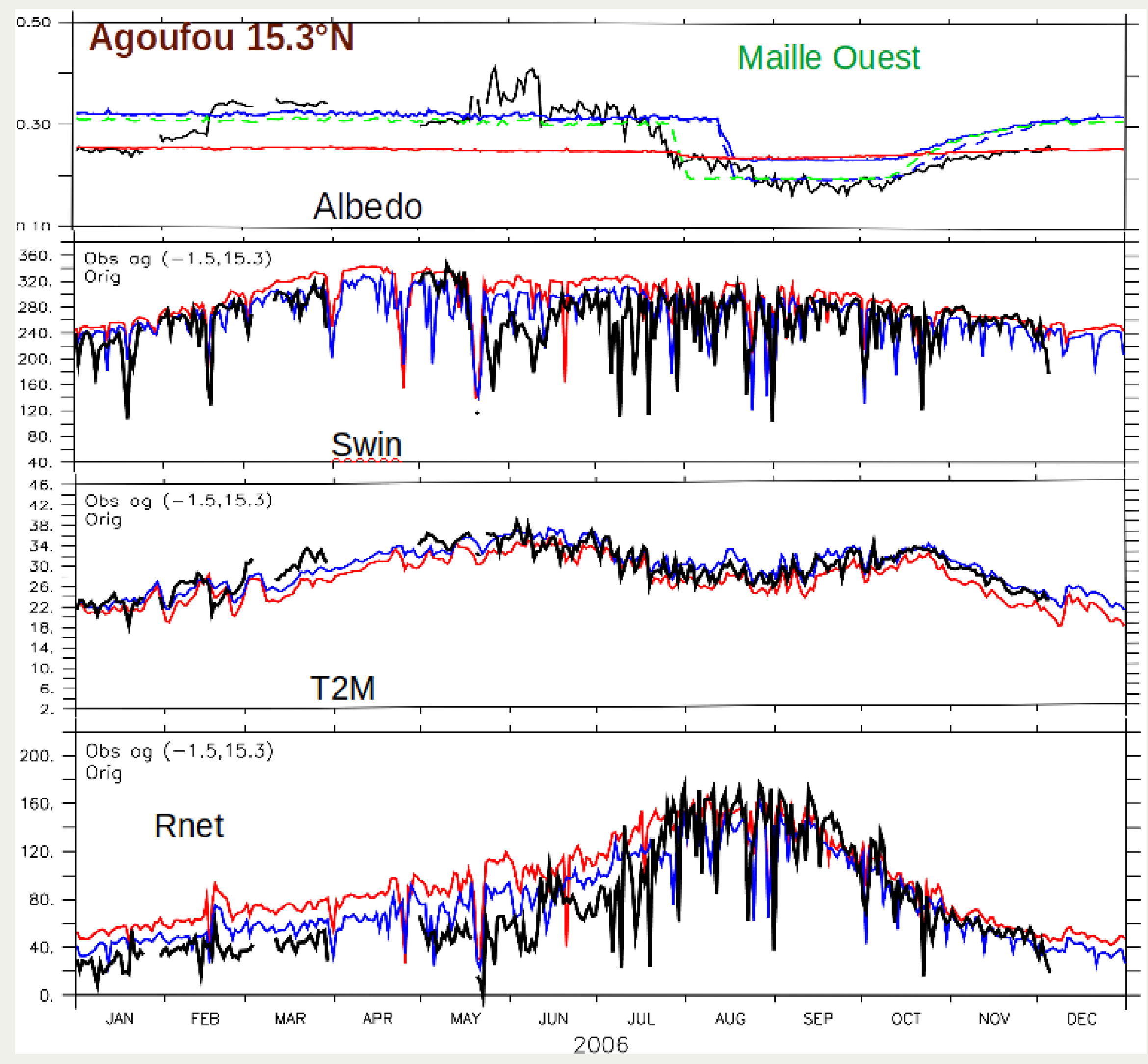




- Overestimation of incoming SW
- Albedo cycle flat and underestimation of surface albedo at the three Sahelian stations during the dry season.
- Cold bias (night-time bias) at the three Sahelian stations during the dry season.

(5) Pathways towards a improvement of the representation of the surface energy budget

The figure shows for the Agoufou station a sensitivity experiment, with nudging where: i) the albedo formulation is changed by an extreme approximation, ii) the bare soil albedo is increased by a constant factor of 1.26, iii) the albedo of the Savannah plant functional type is decreased from 0.2 to 0.15, iv) the load of aerosols is increased by a factor 2, v) the life-time of high clouds is increased, vi) thermal inertial is imposed for a water saturated soil .



- Improvement of the representation of the albedo cycle
- Improvement of varibility and reduction of biases on incoming SW
- The Sahelian cold bias of the NUDG simulation in the dry season is strongly reduced
- Reduction of Rnet biases (40 W/m^2 in dry season)

(6) Conclusion and reference

Conclusion:

- With nudging method, rainfall biases are reduced so that the latitudinal stratification of West African climatic regimes is well captured, making the comparison with in-situ observations relevant.
- Using in-situ data allowed to identfy the cold bias during the dry season over Sahel, the bad representation of surface albedo cycle and an overestimation of the solar incoming flux. With that, we founded the key processes at the origin of these biases and Pathways towards a improvement of Surface energy.

Reference:

Roehrig et al ,2013 (The present and future of the WAM: a process-oriented assessment of CMIP5 simulations).

Article in submit in JAMES : The surface energy budget of a climate model grid cell facing station data in West Africa
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