Downscaling West African climate: uncertainties, sensitivity to the model physics and regional variability

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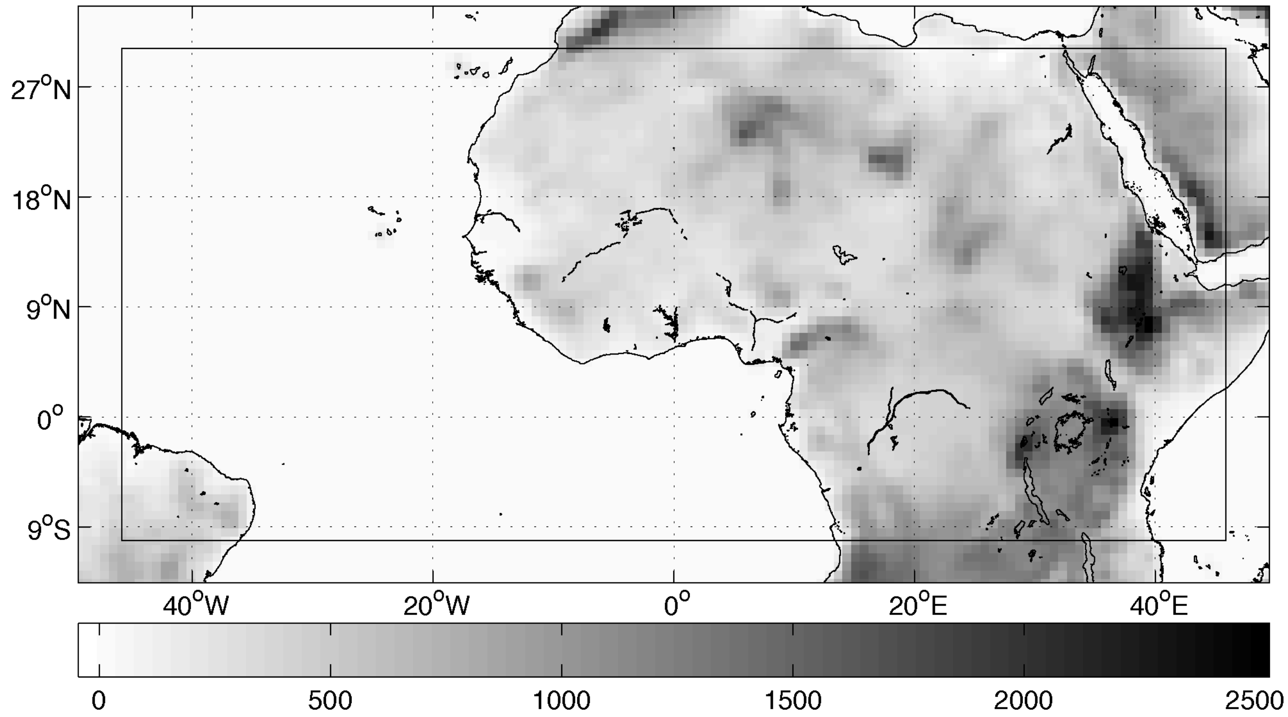
Introduction | Problematics



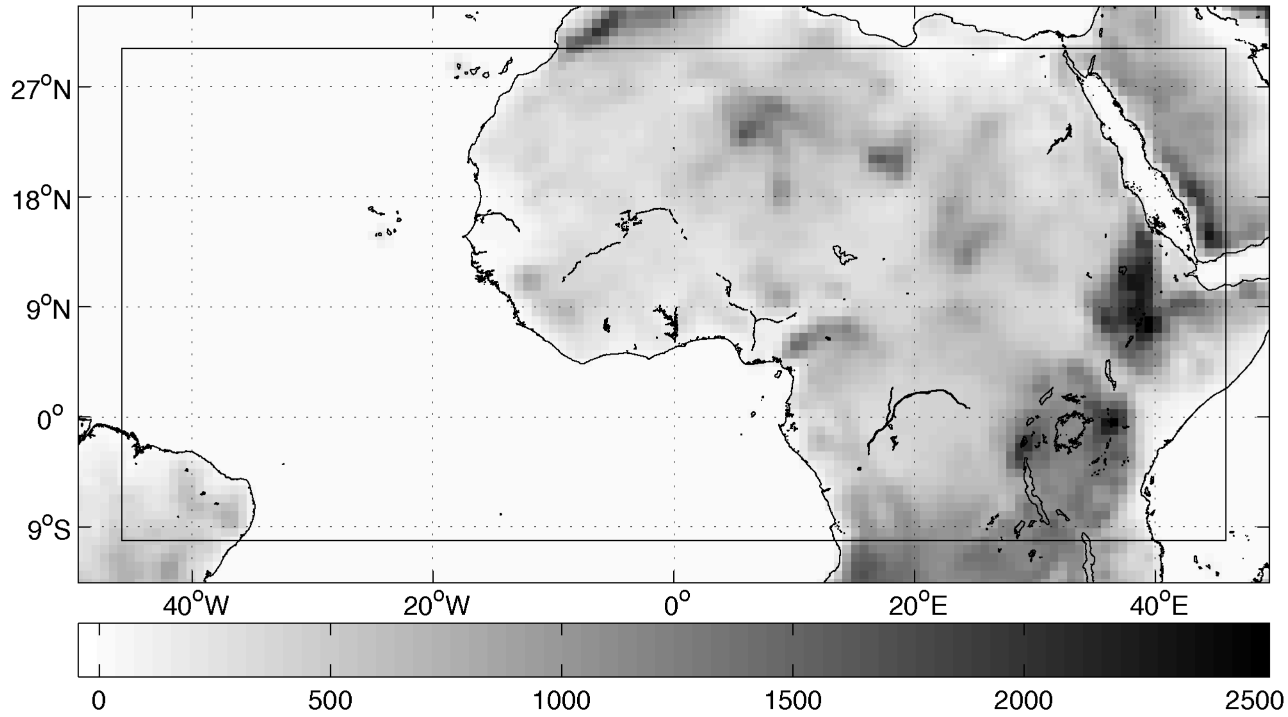
- Assess the capability of a current state-of-the-art RCM in simulating the **WAM climatology and variability**

- Quantify associated **uncertainties, biases and physic-dependency**

- Investigate which **timescales / modes of variability** are (are not) realistically simulated

… Are biases and uncertainties reduced in an RCM … ?

Data



- **FRIEND-AOC rainfall database** (136 daily rain-gauges, 1950-2000, located in Sénégal, Mali and Burkina)

- **GPCP** rainfall estimates (pentad, 2.5°, global)

- **ERA-Interim** (daily, 1.5°, global)

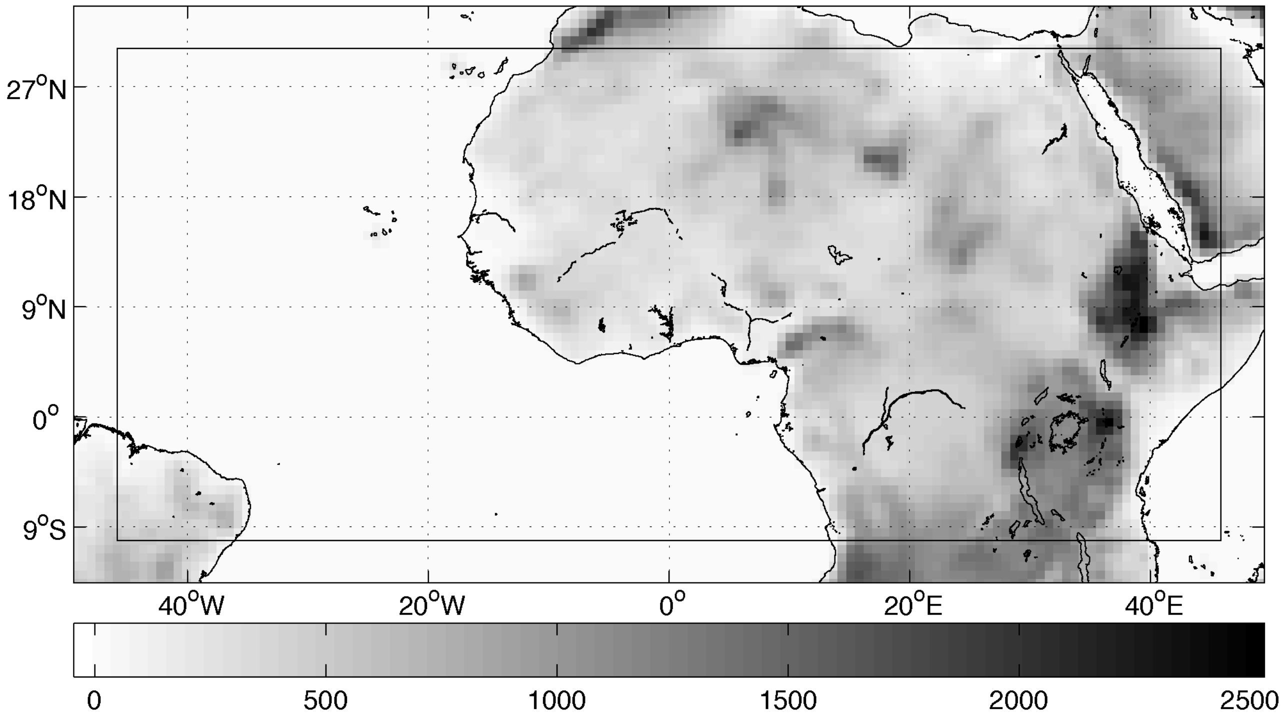
Experimental set-up

- **WRF/ARW** v3.3.1, 80km horizontal resolution, 28 levels, domain [10°S-30°N, 45°W-45°E]

- **20-yr long simulations** (1990-2011) after 1-yr long spin-up (1989)

- **Forcings: ERA-Interim**, 1.5°, every 6h + ERA-Interim monthly SST (interpolated daily)

- **Common Physics:** Yonsei Univ. PBL, WSM6 microphysics, RRTM LW radiation



3 sets of experiments (so far):

- Set #1: convective and radiative schemes

- Set #2: land surface (LSM & land-use)

… in progress … ➔ • Set #3: internal variability (ensemble simulation, same physics)

Set #1 | Convective & radiative schemes

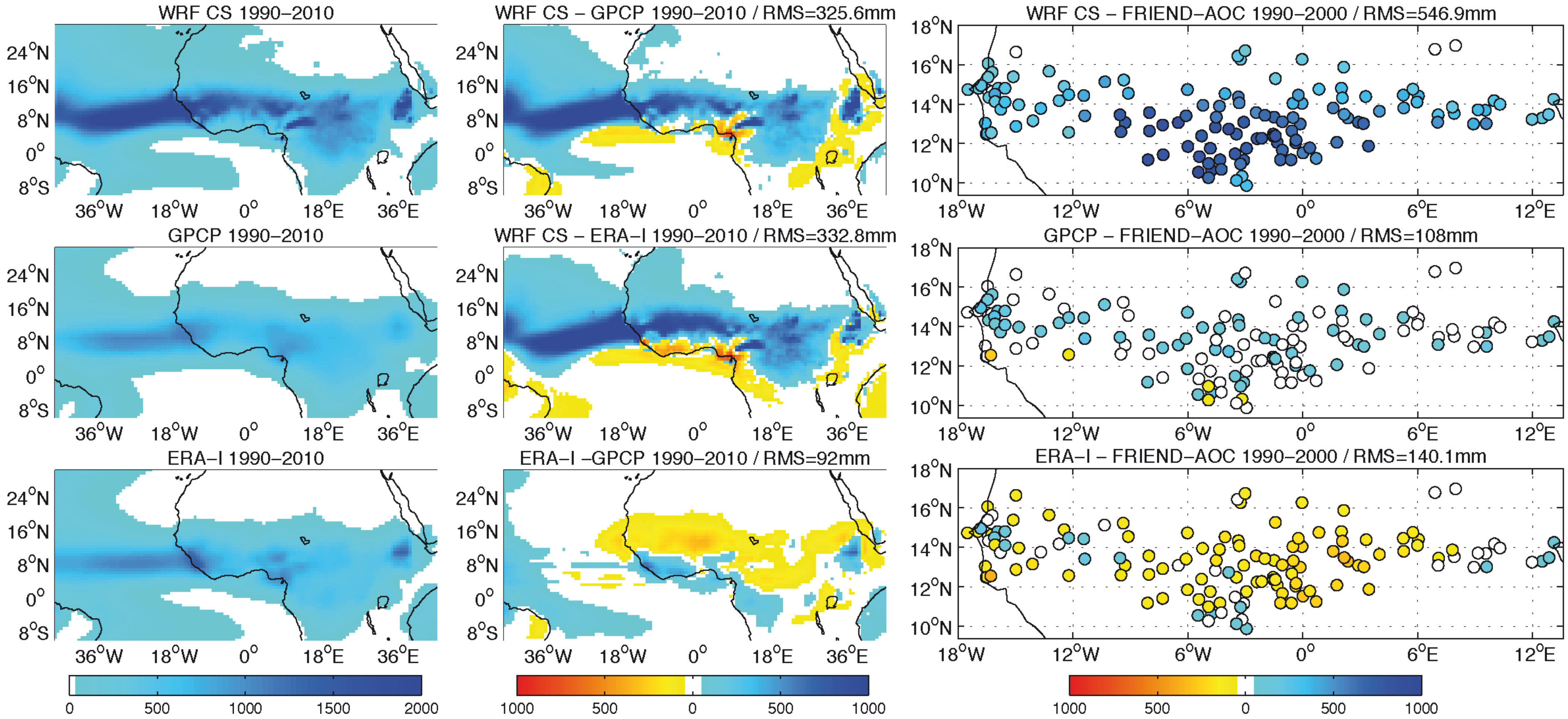
- **12 experiments** (4* cumulus schemes x 3 radiative schemes: all possible combinations**)

		Radiatif SW		
		Dudhia	**RRTMG**	**Goddard**
Convectif	**Kain-Fritsch**	CS1	CS2	CS3
	Fain-Fritsch Moist. Adv. Trigger	CS1b	CS2b	CS3b
	Betts-Miller-Janjic	CS4	CS5	CS6
	Tiedtke	CS7	CS8	CS9

* 3 + 1: Kain-Fritsch with two distinct trigger functions (including a new moisture advection-based trigger developed by Ma and Tan [2009]).

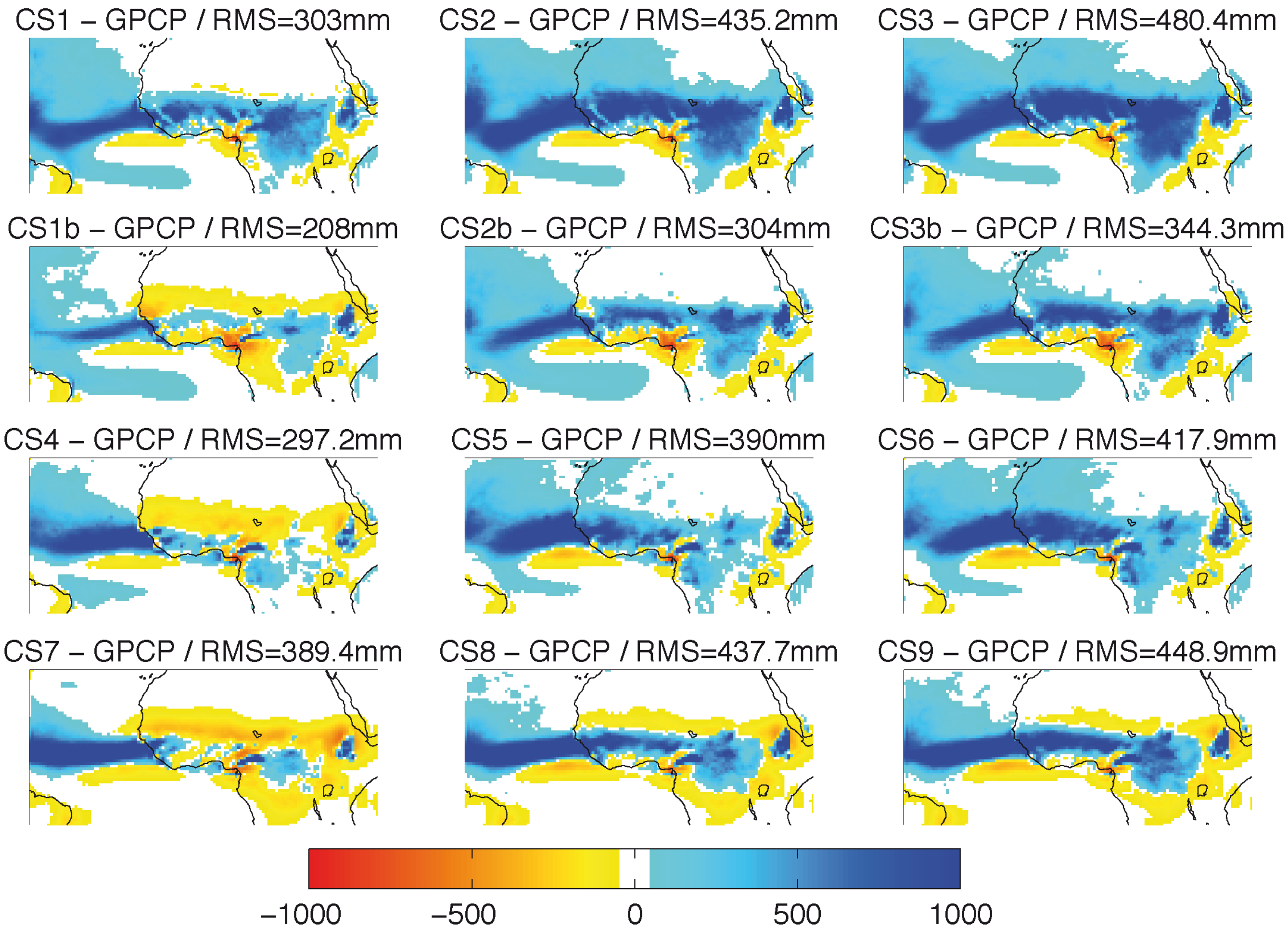
** All schemes are inter-compatible

Set #1 | Convective & radiative schemes



- **WRF wetter** than GPCP and ERA-Interim
- **ERA-Interim too dry and WRF too wet** against rain-gauges
- WRF corrects the location of rainfall maxima (ITCZ) over West Africa in summer

Set #1 | Convective & radiative schemes

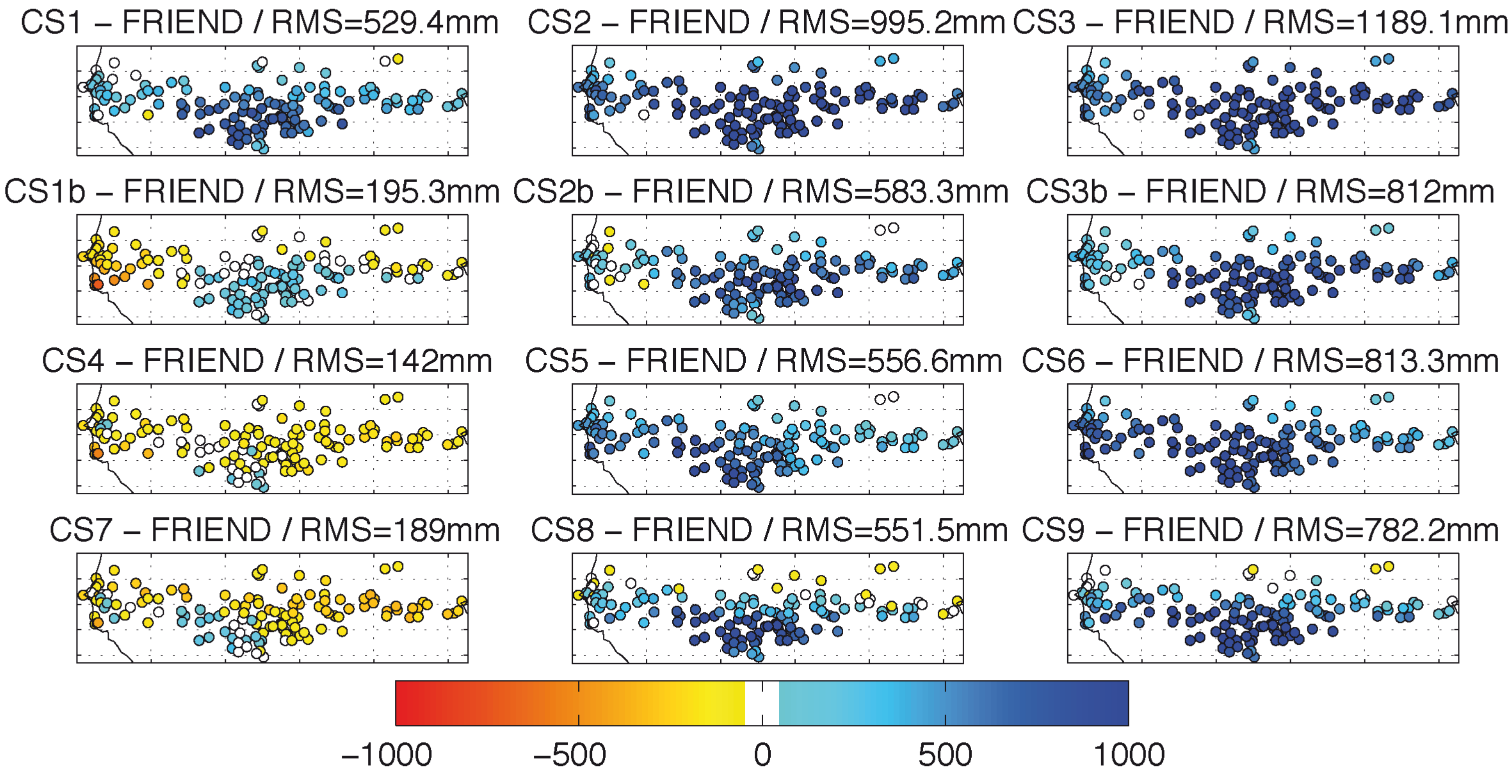


- **Rainfall amounts strongly modulated by the model physics**: Dudhia SW (left) drier; KF convection (1st row) wetter due to its trigger function (differences with 2nd row)

- **Wet biases due to a stronger monsoon flow** penetrating over the landmass (not shown)

- Tropical Atlantic (East African Highlands and Gulf of Guinea) systematically too wet (dry)

Set #1 | Convective & radiative schemes



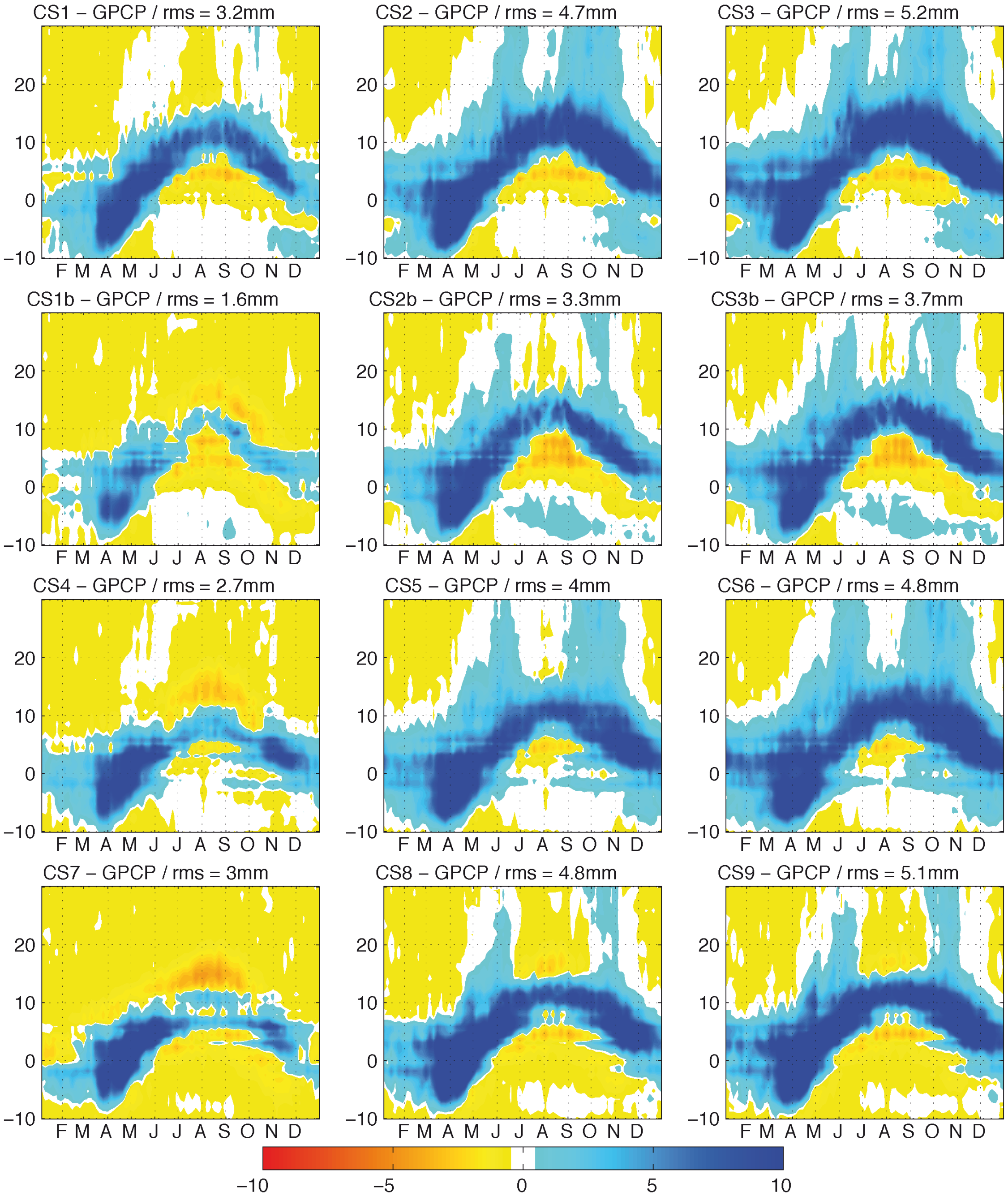
- Previous results confirmed by rain-gauges

- **WRF wet biases due to a too large number of rainy days** for all configurations (less clear with Dudhia SW), too dry with Dudhia SW and Tiedtke convection

- The drier conditions favoured by Ma and Tan (2009) trigger function mostly due to a **lower number of rainy days**: improves thus seasonal and daily rainfall

Set #1 | Convective & radiative schemes

Time - latitude cross-sections of rainfall biases averaged between 15°W and 15°E over the annual cycle (period 1990-2011)



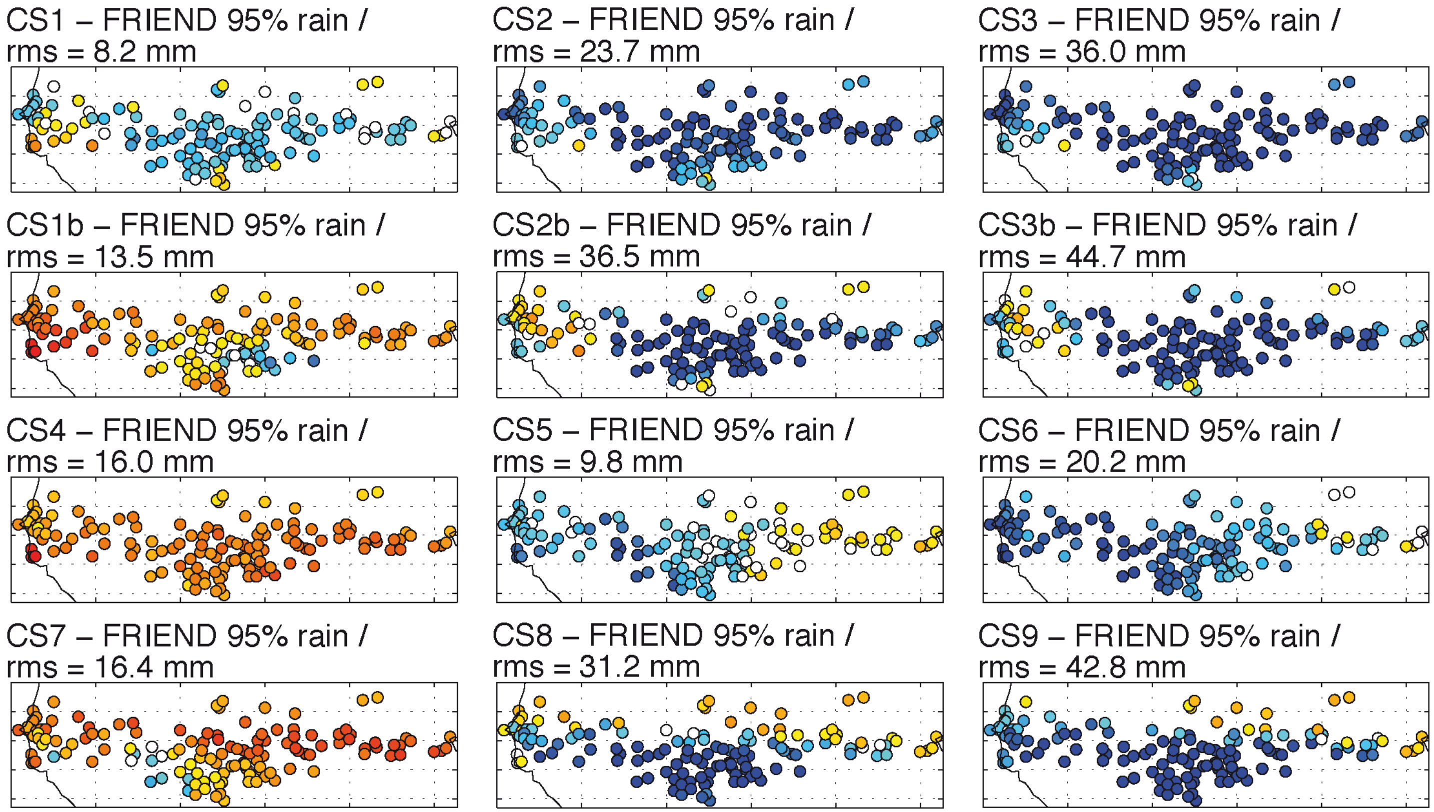
- Rainfall seasonality over West Africa: **realistic migrations of the ITCZ** even in summer

- Corrects the location of the ITCZ in ERA-Interim

- **ITCZ associated with too large rainfall amounts in all experiments** (particularly in MAM) but too small latitudinally

- Dudhia shortwave favors dryness

Set #1 | Convective & radiative schemes



- Extreme events too wet with KF convection (1st row) and other schemes when combined with RRTMG and Goddard SW (2nd and 3rd columns)

- Geography of biases modulated by model physics

Statistical distribution of daily rainfall strongly sensitive to the physics

Set #2 | Land surface

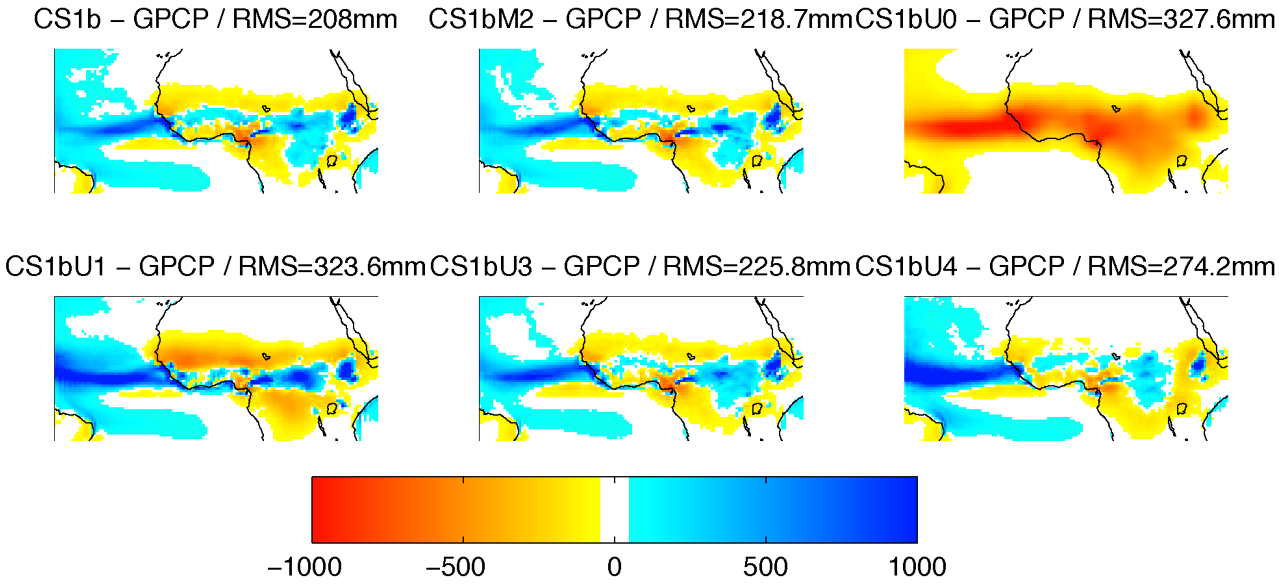
- **6 experiments** (5 LSM* + 1 LSM with 2 land-use categories**)

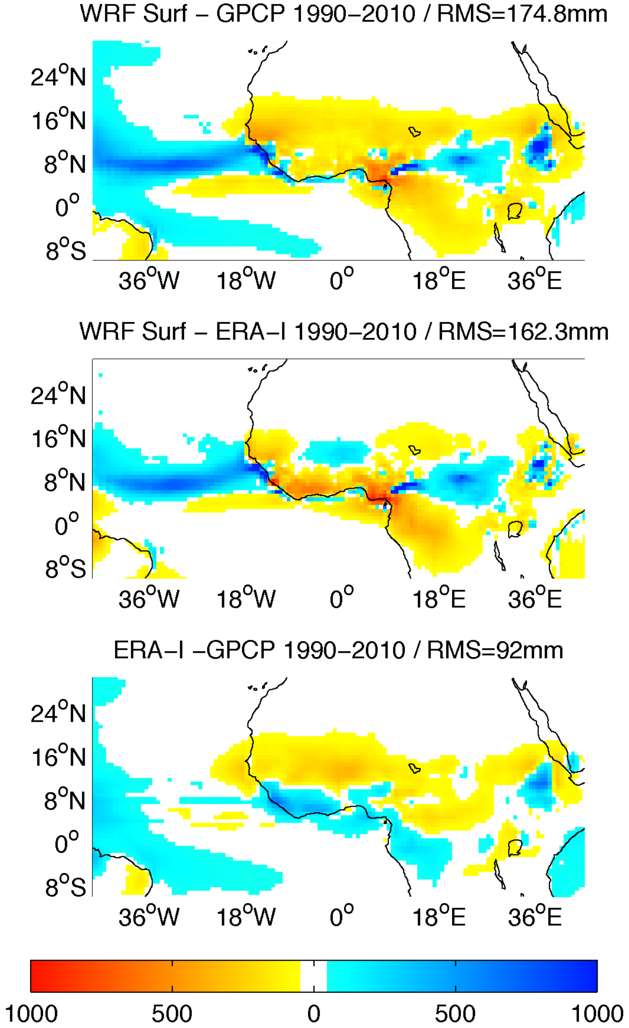
Expérience	Modèle de surface (LSM)	Occupation du Sol
CS1bU0	0 - contrôle "no surface temp. prediction"	USGS
CS1bU1	1 - thermal diffusion	USGS
CS1b	2 - NOAH	USGS
CS1BM2		MODIS
CS1bU3	3 - RUC	USGS
CS1bU4	7 – Pleim-Xiu	USGS

* including one "control experiment" with no LSM.

** based on AVHRR (1991-92) and MODIS (2000-01)

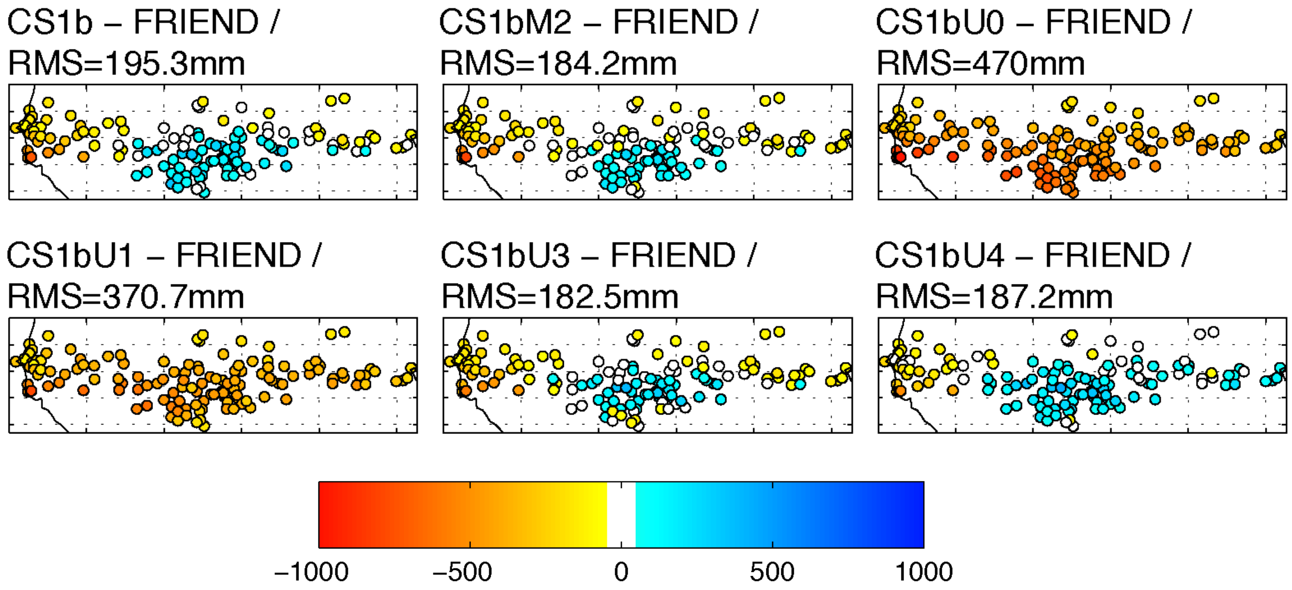
Set #2 | Land surface

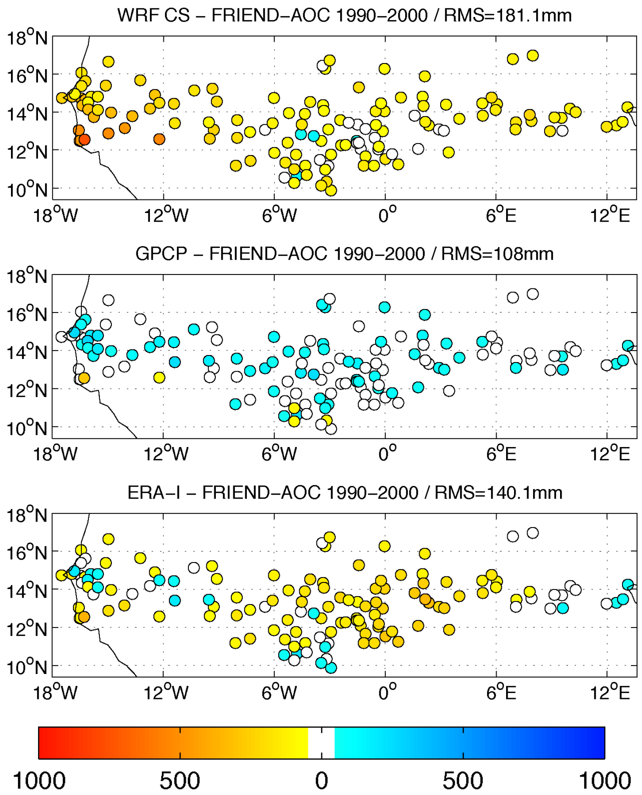




- **WRF_Surf : drier than ERA-I and GPCP**
- mostly due to the "no LSM" experiment at ITCZ latitudes
- land-use categories seem to have a very small influence at the climatological timescale

Set #2 | Land surface





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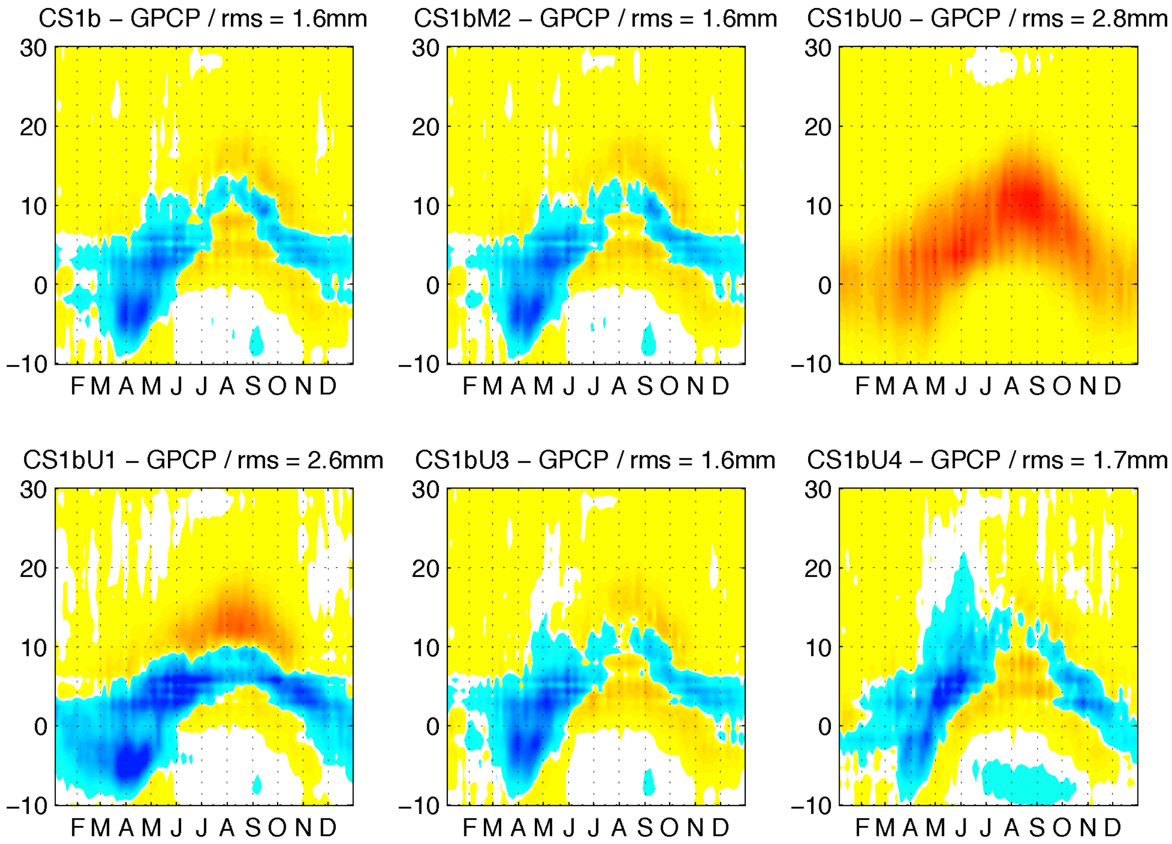

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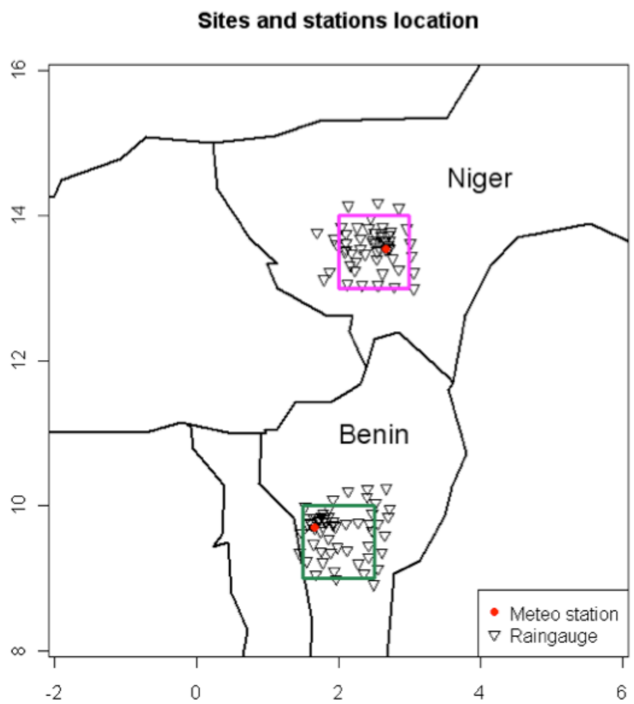
… What about other fields (T2m, E, …) ?

Model evaluation through impacts | Agronomic yields



SarraH

3 varieties of pearl millet:
- Hainy Kire (local, early)
- Somno (MTDO) (local, late)
- Souna 3 (improved, early)

EPIC

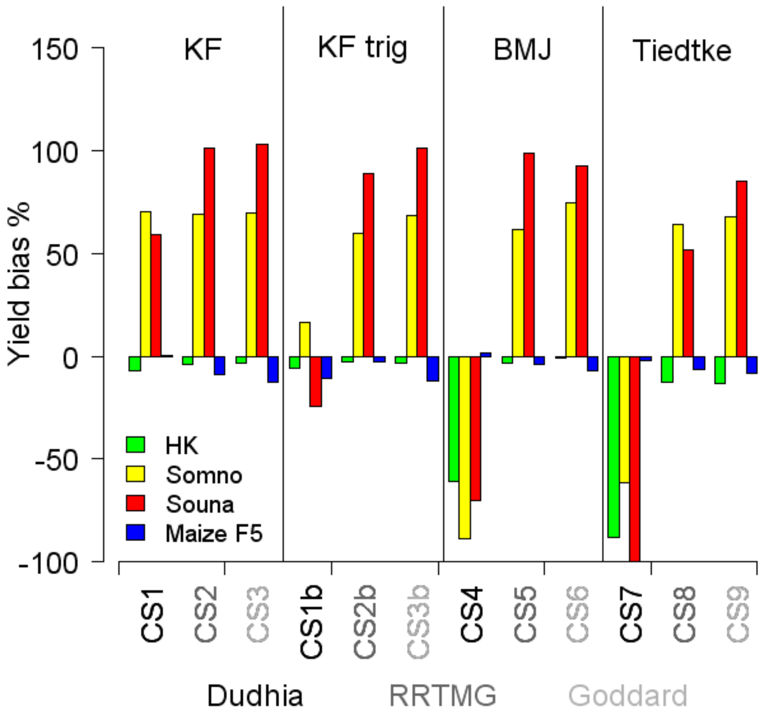
Maize with low fertilization (5kg of N per year).

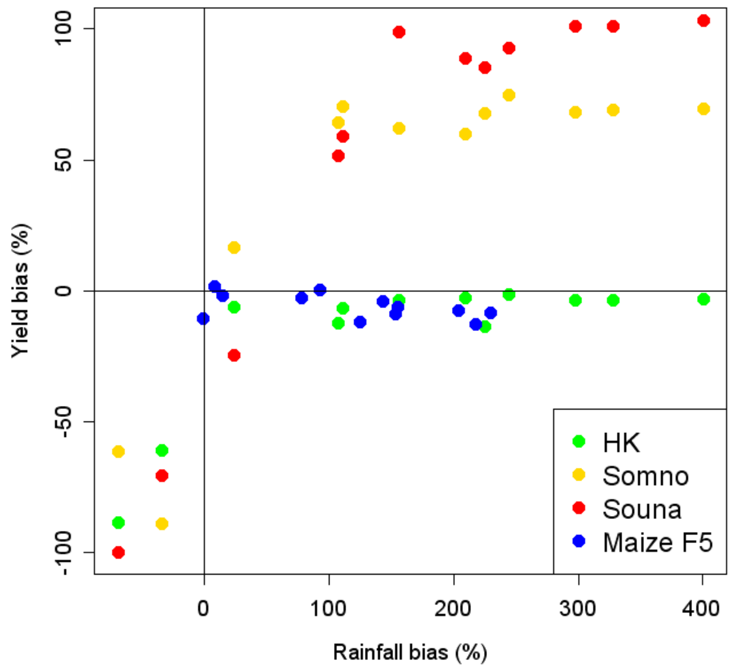
Crop simulation period :
2003-2009

- Focus on 2 sites of ~ 1° x 1°, corresponding to the **AMMA-CATCH sites in Niger and Benin**
- Meteorological data taken from AMMA-CATCH observing system

- **Crop yield simulations: 2 complementary models**
  - **SARRAH:** based on water balance, used for **3 varieties of pearl millet** (Hainy Kire, Somno, Siuna) in Niger
  - **EPIC:** comprehensive agro-ecosystem model capable of simulating the growth of crops in complex rotations and management operations including fertilization, used for **maize** yield in Benin

Model evaluation through impacts | Agronomic yields



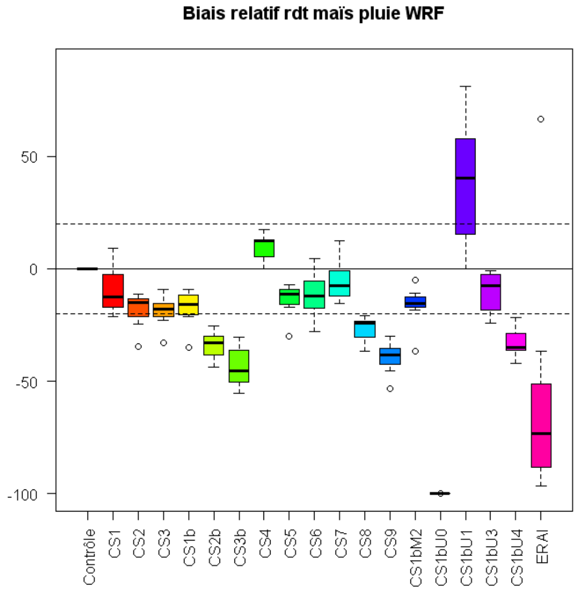


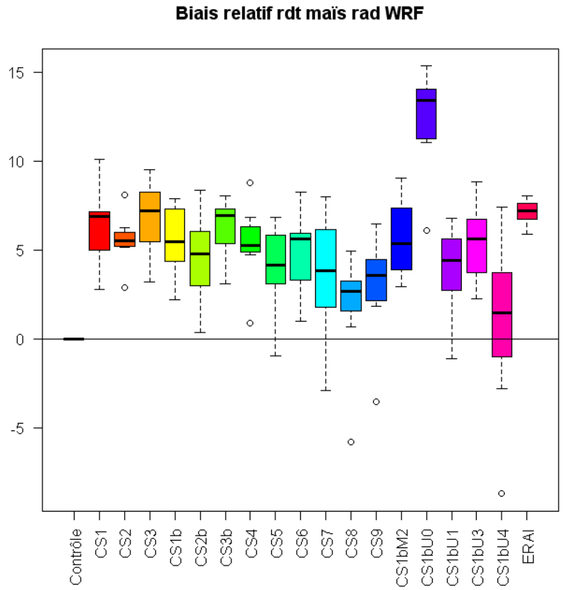
- **Biases in yields strongly physic-dependent** (due to huge variations in rainfall amounts); less true for maize
- Dudhia SW always drier than other schemes
- *CS1b (Didhia + Kain-Fritsch with new trigger) performs remarkably well (as for rainfall)*

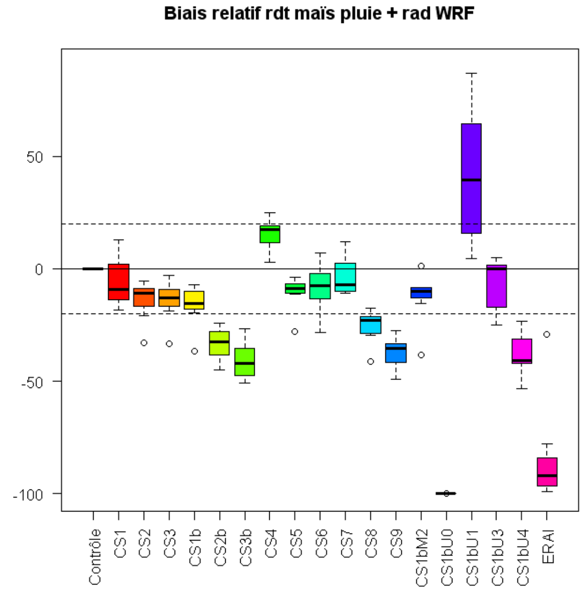
- strong modulation of yield biases by rainfall biases (dry biases inducing strong negative yield biases)

!!! Not a multi-variate evaluation of RCM outputs yet: only RCM rainfall used to drive agronomic models

Model evaluation through impacts | Agronomic yields







- Use here WRF simulated rainfall and radiation to force the crop models :

WRF rain (rad obs) **WRF rad** (rain obs) **WRF rain and rad**

Simulated rainfall, not radiation, responsible for most yield biases

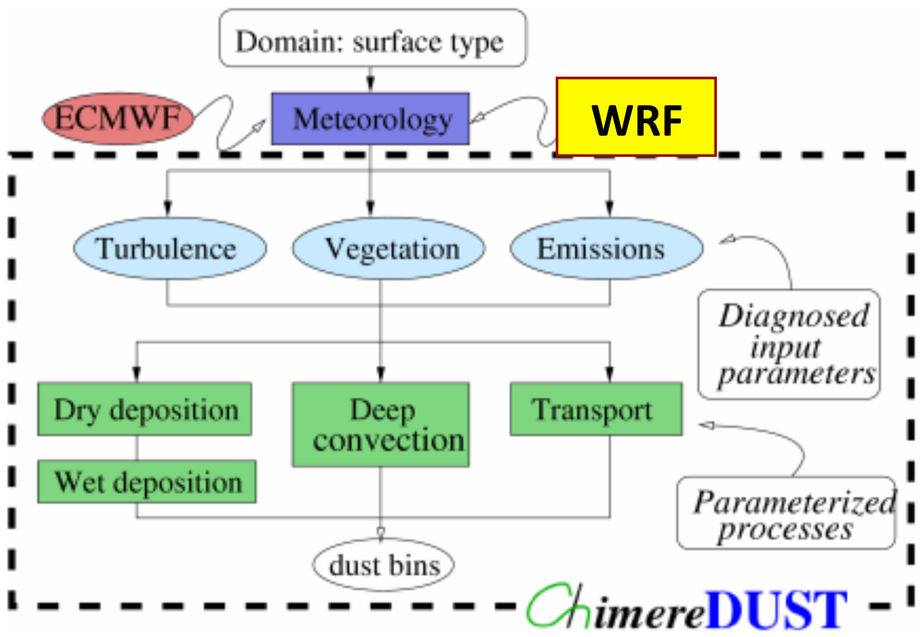
Model evaluation through impacts | Dust events

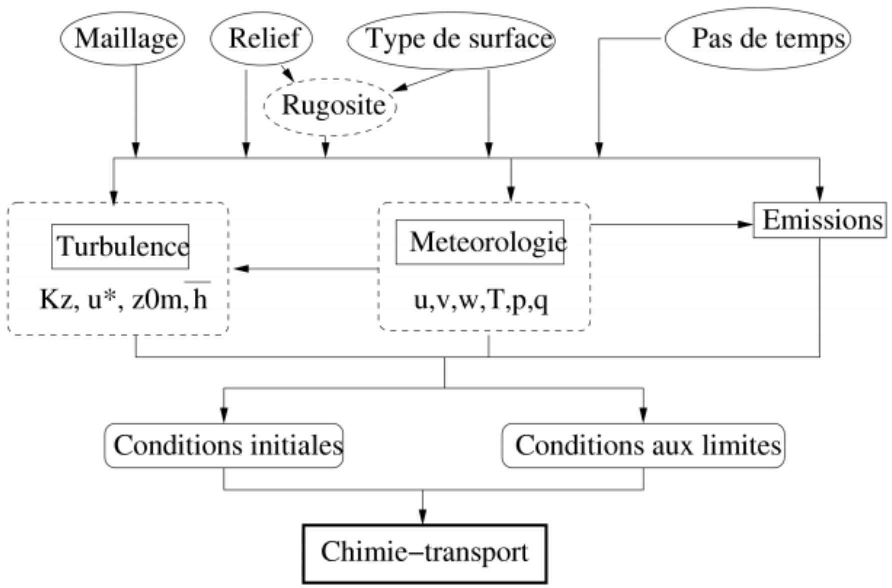
CHIMERE-DUST: chemical transport model including dust developed at IPSL (LMD, LISA) and INERIS

3D forcing variables (from WRF outputs): U, V, T, Q, P

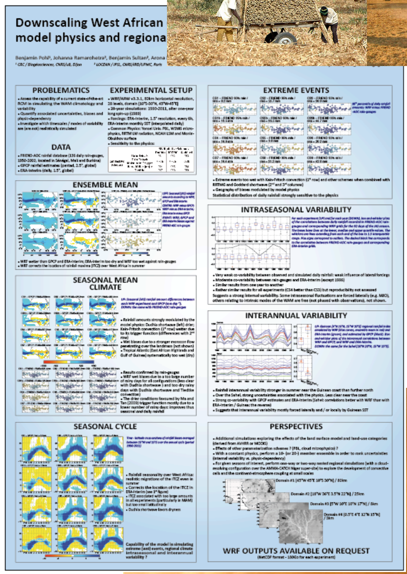
2D forcing variables (from WRF outputs): cloud water content, T2, convective and stratiform rainfall

>> includes variables strongly physic-dependent (rainfall, lower-layer T and turbulence, …)





Conclusions



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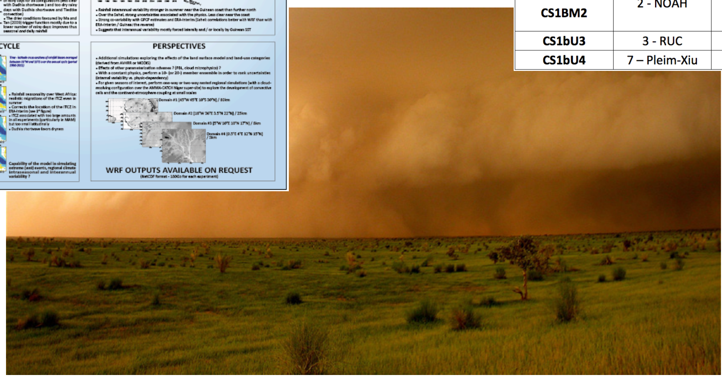

What we did so far…

Perspectives

- extensive CHIMERE-DUST, SARRAH and EPIC evaluations of WRF outputs

- Additional regional simulations:

- Set #3: ensemble simulation (IV)
- nudged cloud-resolving ensemble simulations during key seasons (2006 ?)
- use CMIP5 as forcings:

CNRM-CM5	&	IPSL-CM5
RCP2.6	&	RCP8.5
2035-2055	&	2080-2100
CS1bM2	&	CS3b

What we'd like to do…

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ACCUEIL

AIC 2014 - 27e colloque de l'Association Internationale de Climatologie

2-5 juillet 2014 - Dijon, FRANCE

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Le 27e colloque de l'Association Internationale de Climatologie se déroulera du mercredi 2 au samedi 5 juillet 2014 à Dijon, France

Le thème principal du colloque est « Climat : système & interactions »

5 sous thèmes :

- Interactions et changement d'échelles
- États de surface
- Changement climatique
- Impacts du climat
- Variabilité et aléas climatiques

Avec une large assise internationale (de vingt à trente pays représentés), le colloque de l'Association Internationale de Climatologie (AIC) rassemble à chaque édition, et ce depuis vingt-cinq ans, de cent à deux cents chercheurs.

Une des vocations de ce colloque est d'encourager les échanges, avec le français comme langue de travail, entre des chercheurs des sciences du climat relevant de différentes disciplines : géographie, sciences de l'atmosphère, sciences de l'environnement… .

L'édition 2014 aura pour thème « Climat : système et interactions ». Le système climatique intègre désormais les activités humaines (gaz à effet de serre, occupation des sols…) aux côtés des composantes naturelles (océan, biosphère….). Les interrogations sur la dynamique de ce système portent sur l'échelle globale. Mais cette dynamique présente des spécificités à tous les niveaux d'échelles. Le défi, outre la compréhension des forçages eux-mêmes, est d'évaluer les déclinaisons régionales, voire locales, des variations et changements climatiques actuels et à venir. Interactions et rétroactions entre les différentes composantes du système climatique (cryosphère, relief, végétation, surfaces artificialisées…) atténuent ou accentuent effectivement les effets régionaux à locaux des changements globaux. Pour cela, les changements d'échelles (spatiales et temporelles), s'appuyant sur des modèles numériques ou des outils statistiques, mais aussi simplement sur des analyses multi scalaires, sont au cœur des réflexions actuelles sur le climat.

L'édition 2014 du colloque de l'AIC vise à apporter des éclairages sur ces questions. Le colloque est ouvert à des exposés et posters portant sur tous les thèmes de la climatologie contribuant à notre connaissance du climat, de son fonctionnement et de ses impacts sur les hommes, les territoires et les écosystèmes. Le colloque fera l'objet d'une publication d'actes, remis aux participants à l'ouverture des journées. Une sortie dans des zones viticoles de Côte-d'Or, permettant d'illustrer différentes problématiques des relations climat-vigne, sera proposée à l'issue du colloque.

Responsables du colloque :

Pierre Camberlin et Yves Richard, uB (CRC-Biogéosciences)

Congrès AIC 2014

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2-5 juillet 2014 – Dijon – France

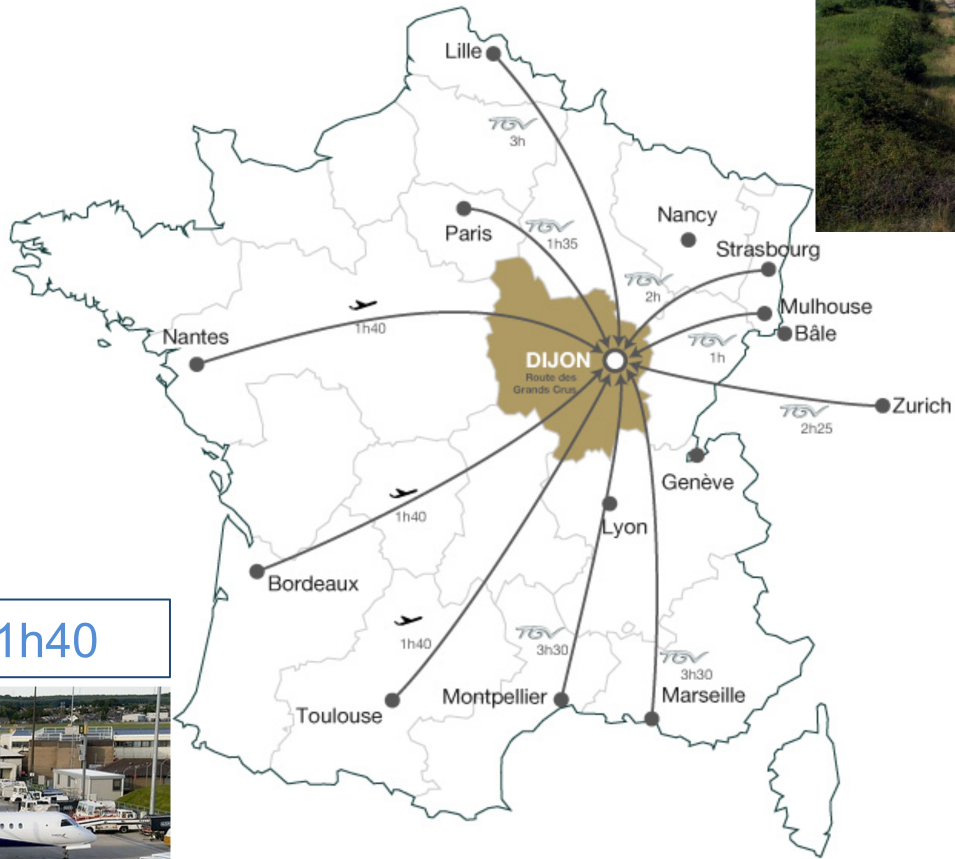
2012 Grenoble

2013 Cotonou

2014 **Dijon**

2015 Iguaçu

Depuis Paris: 1h35



Depuis Toulouse: 1h40

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