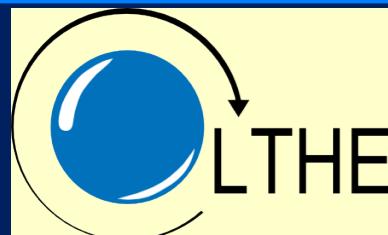


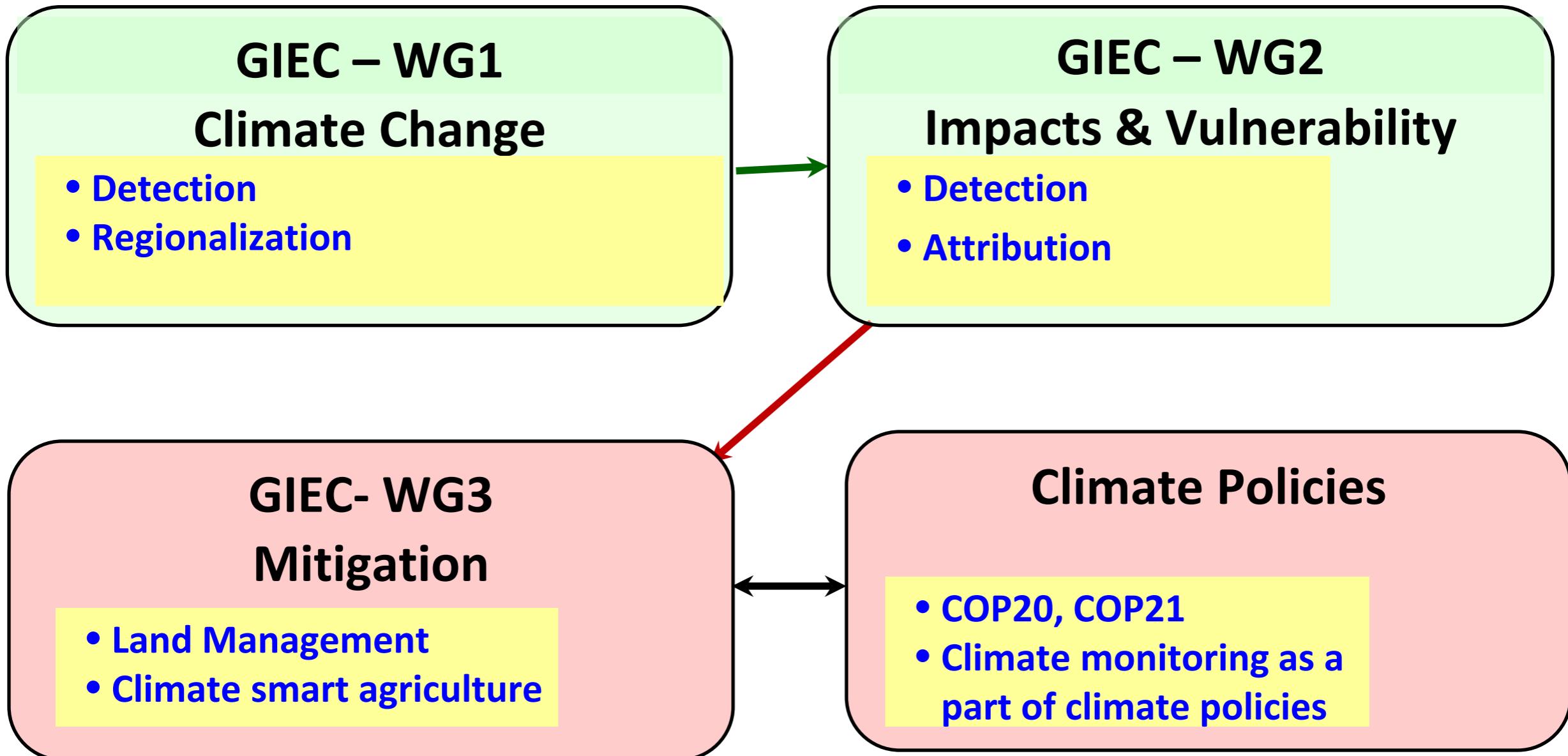
Rainfall modifications in the context of climate change: The puzzle of the tropical regions

Thierry LEBEL
IRD

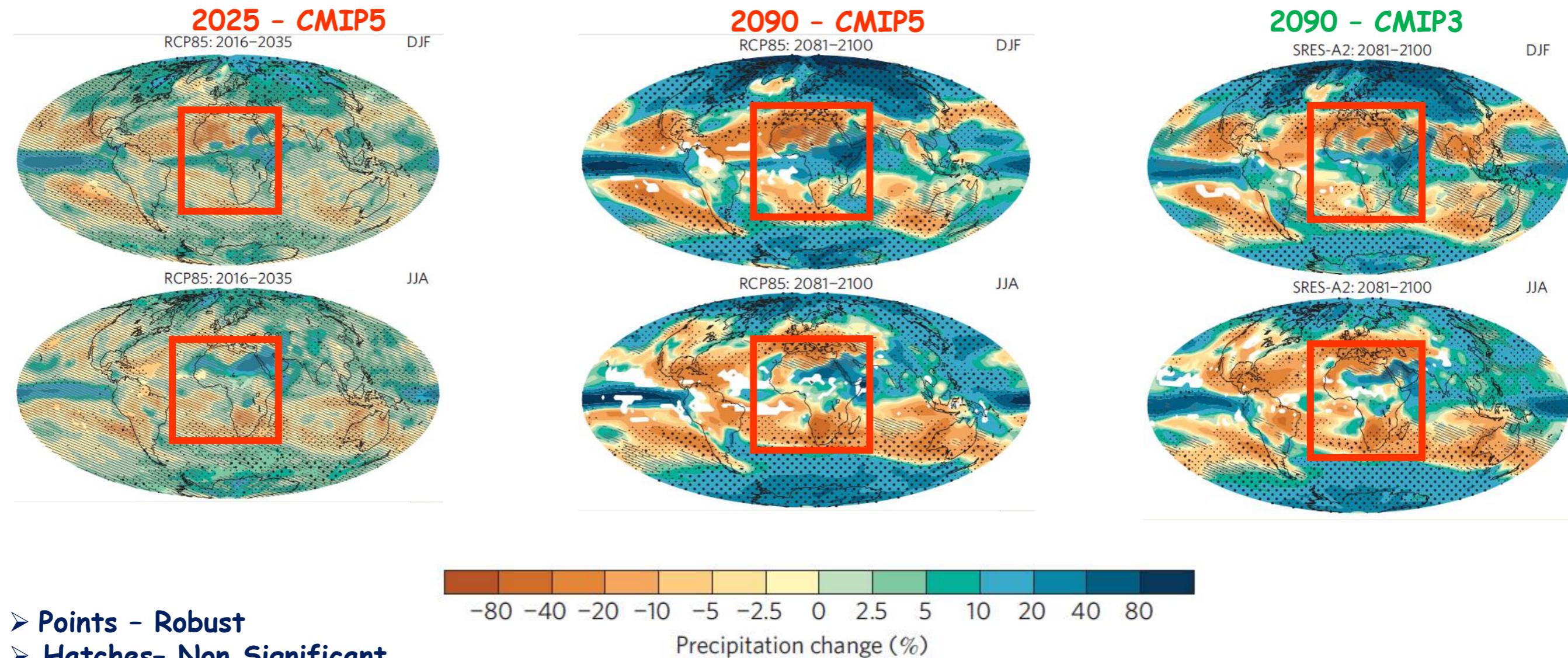
Laboratoire d'étude des Transferts en Hydrologie et Environnement
Observatoires des Sciences de l'Univers de Grenoble - OSUG



The deadlocks of the moment



Models : Robustness of Uncertainties



Patterns of precipitation change relative to 1986–2005

Rainfall modifications in the context of Climate Change

➤ Scale issues

From climate scales to impact scales: water resources, agriculture
Spatial variability is too often underestimated

➤ Trends and Natural Variability

Signal to noise ratio

Trend in what ?

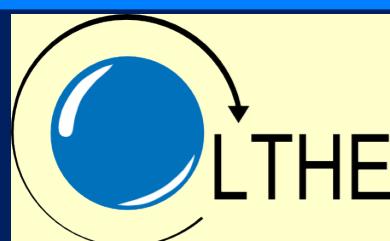
The need of a global and integrated vision

The case for specific observations

➤ Intensification of the hydrological cycle

Tricky and yet vital

Trend in what ?



1. Scale issues

- Rainfall displays a strong variability at all scales
- ✓ Uncertainties in assessing the “true” value
- ✓ Makes difficult to detect significant trends

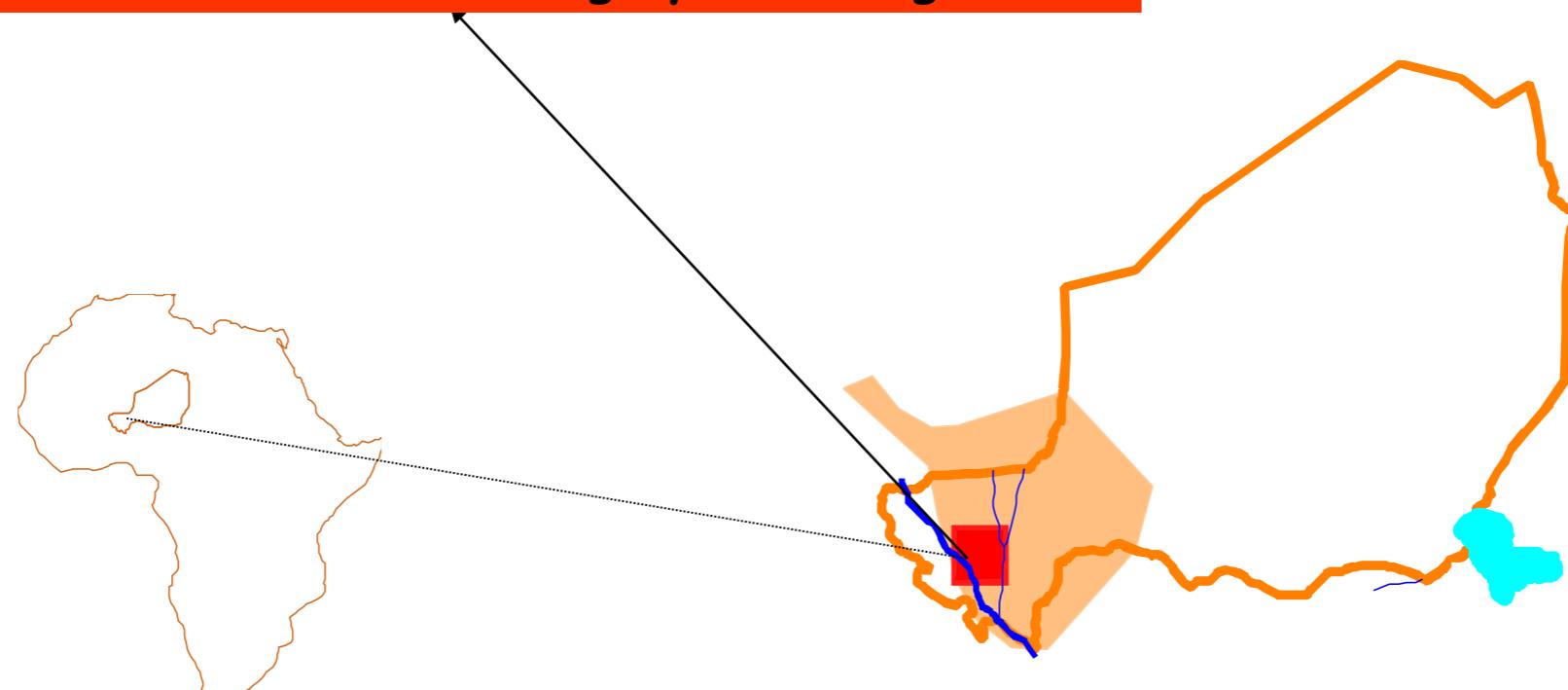
Scale issues related to the Water Cycle

$$P = E + Q + \Delta S$$

- In tropical regions E runs from 80% to 95% of P at regional scales
- However at smaller scale Q may represent up to 50% of P

➤ And the values of these terms are pretty much scale dependent

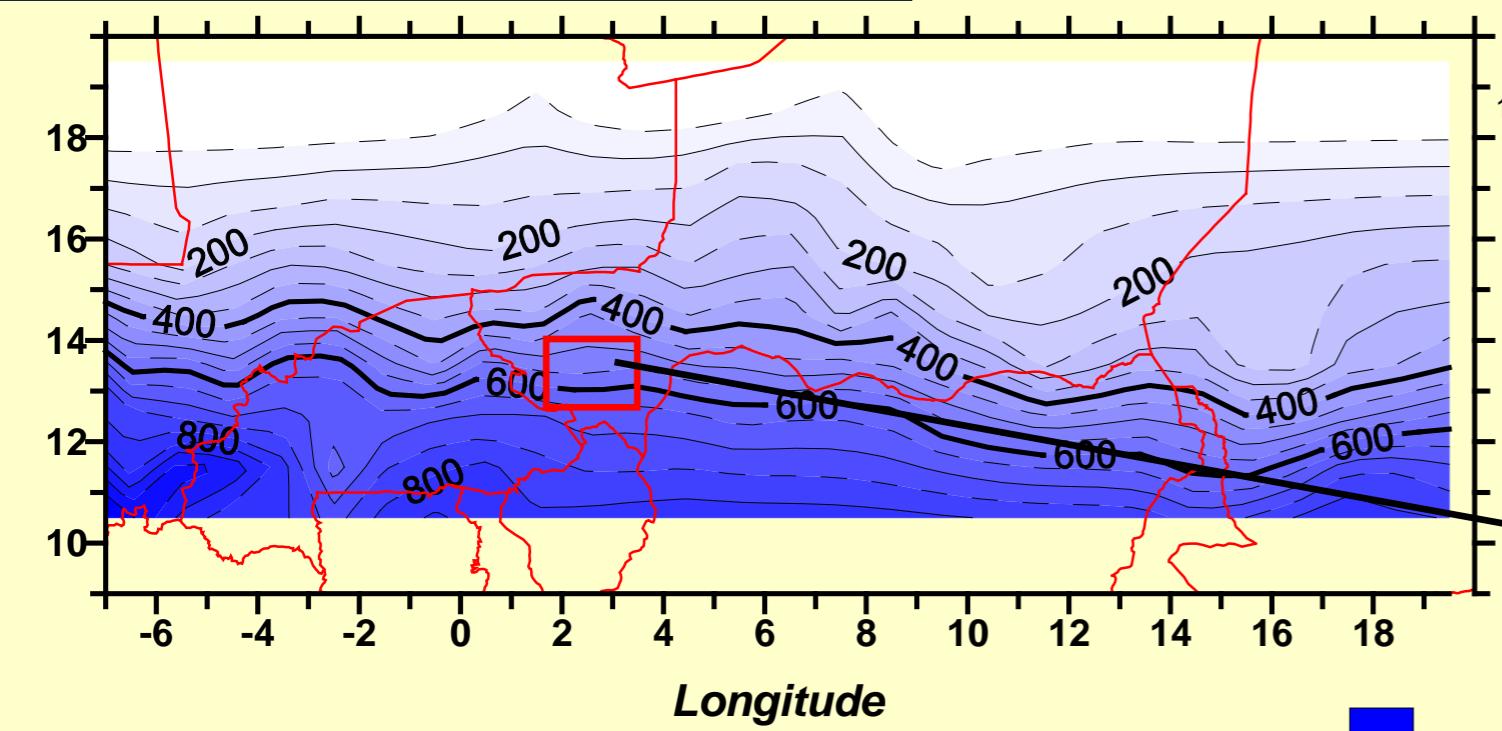
The AMMA-CATCH observing system: Niger site



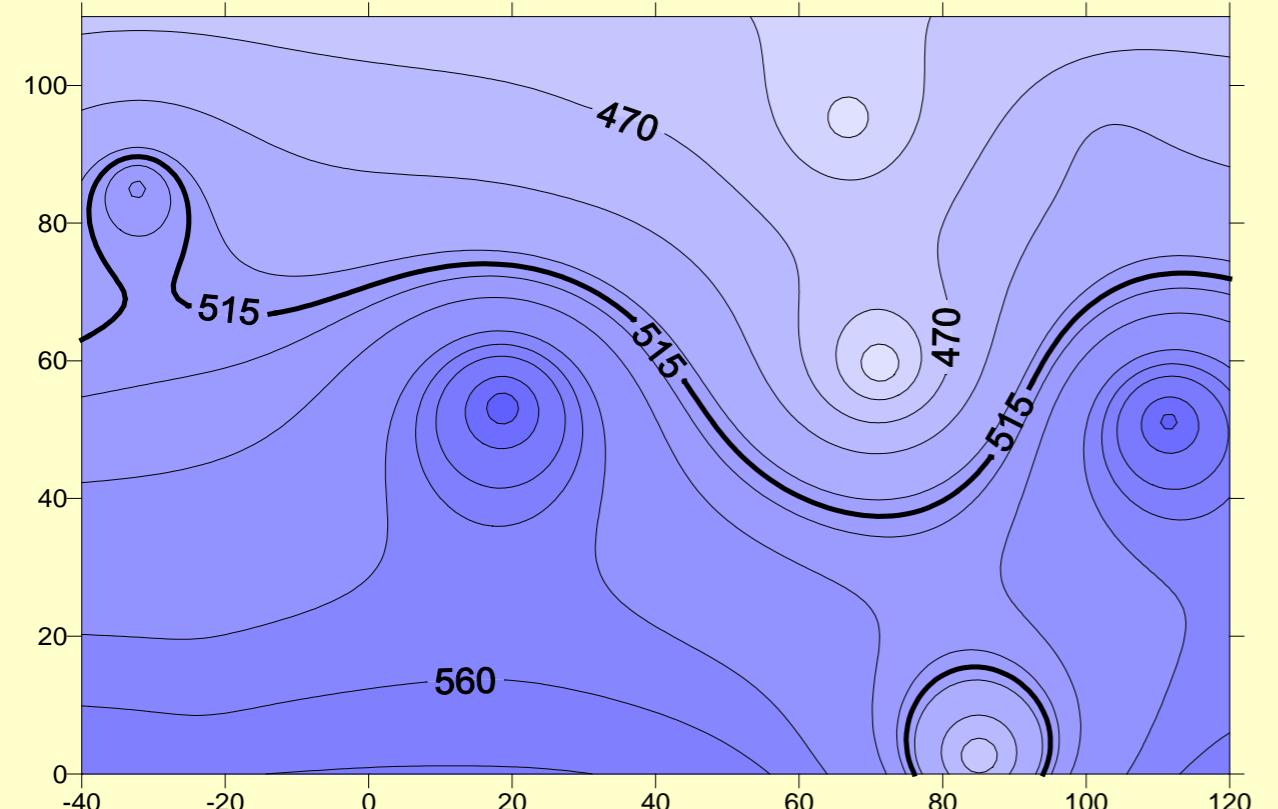
Small scale variability

Rainy season 1992 (mm)

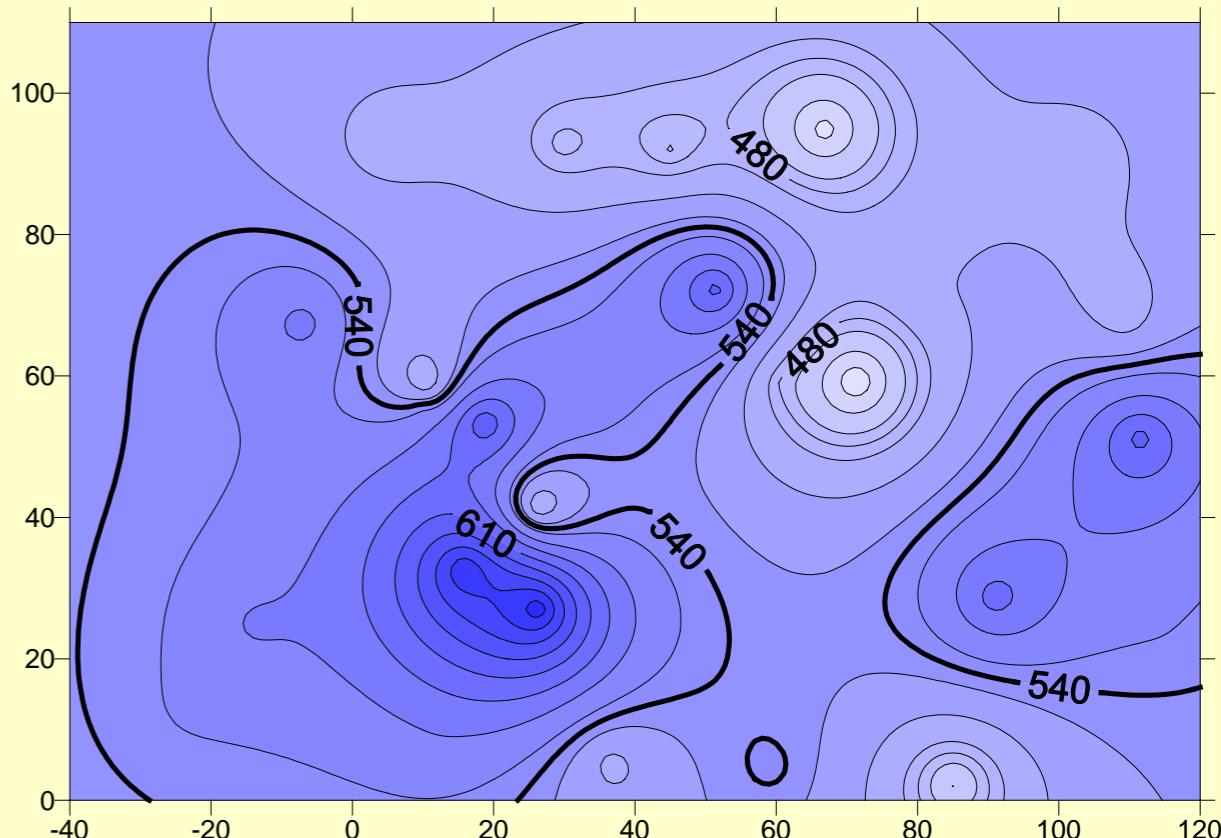
109 stations
Average= 513 mm



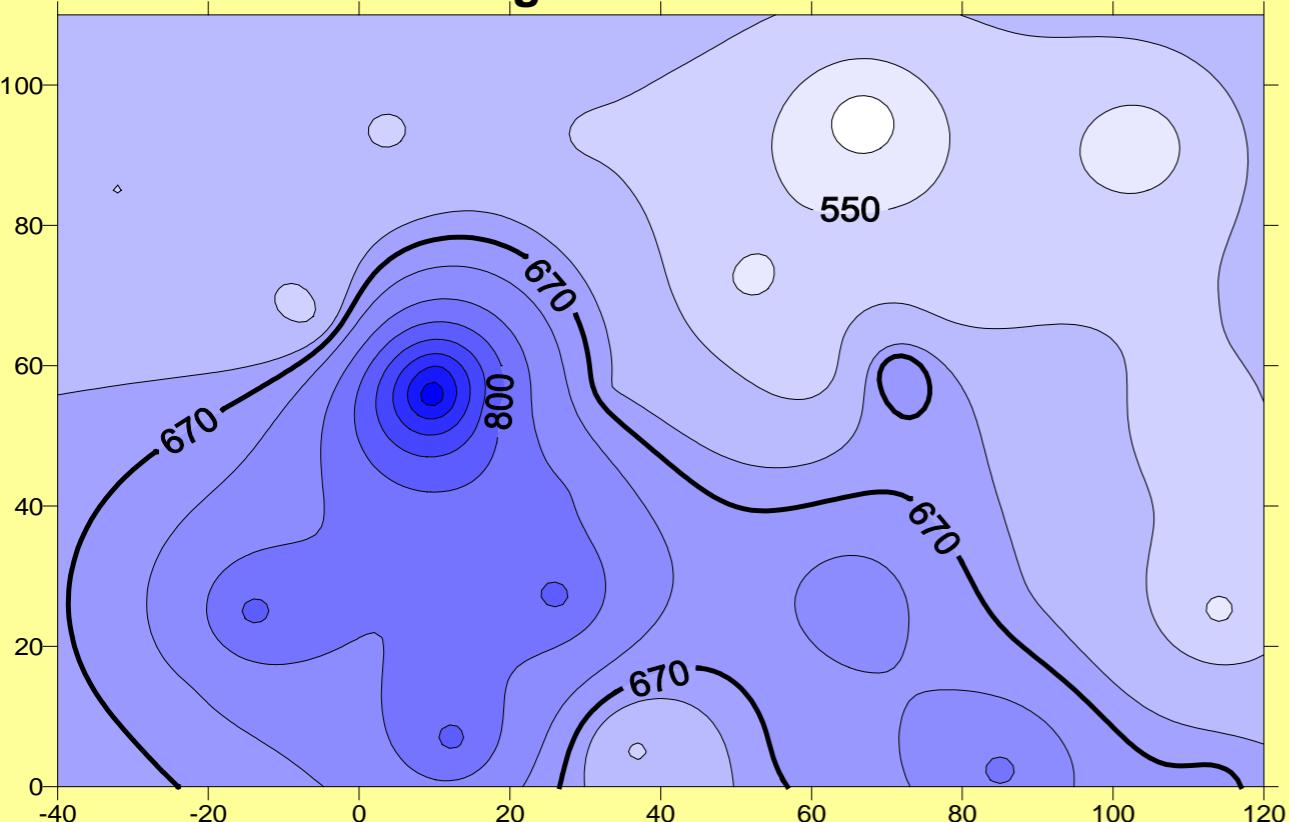
11 stations
Average= 515 mm



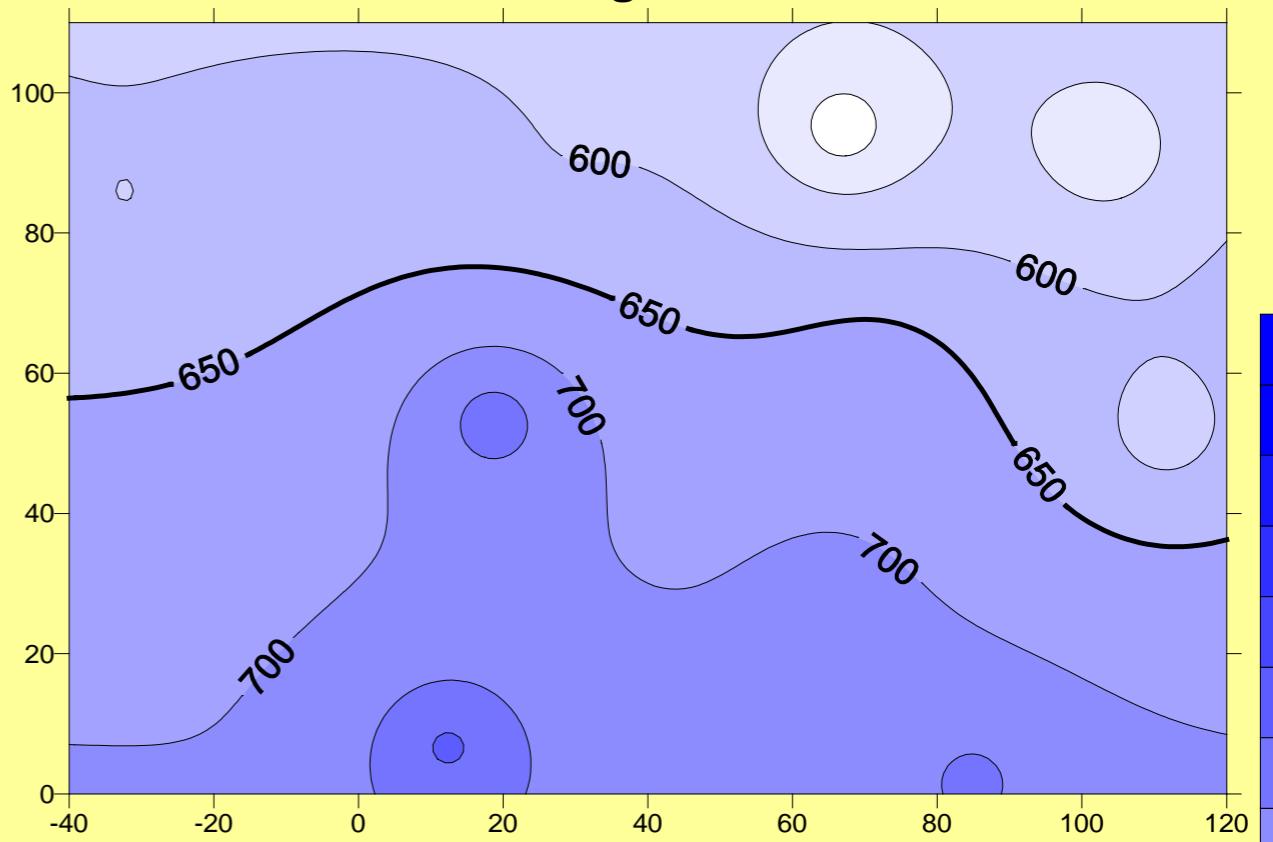
30 stations
Average= 537 mm



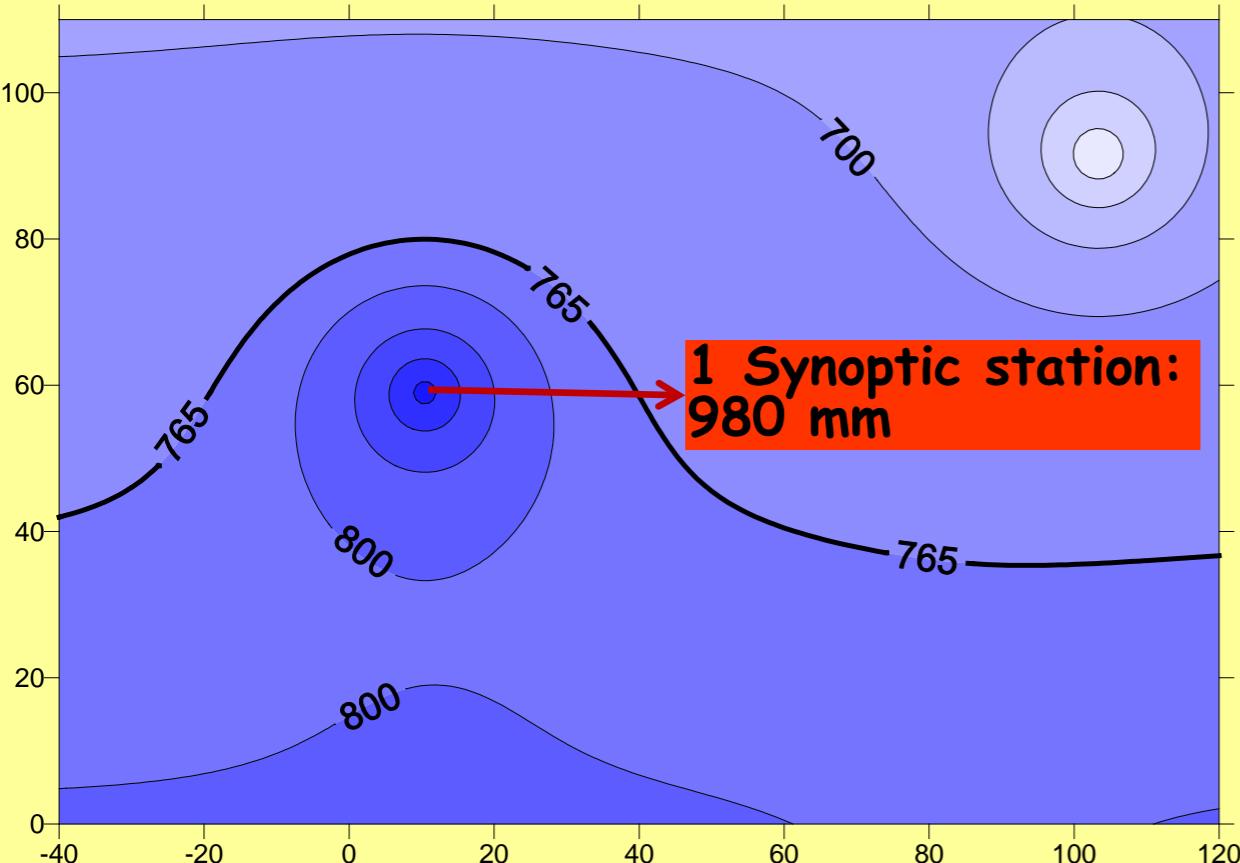
30 stations
Average = 672 mm



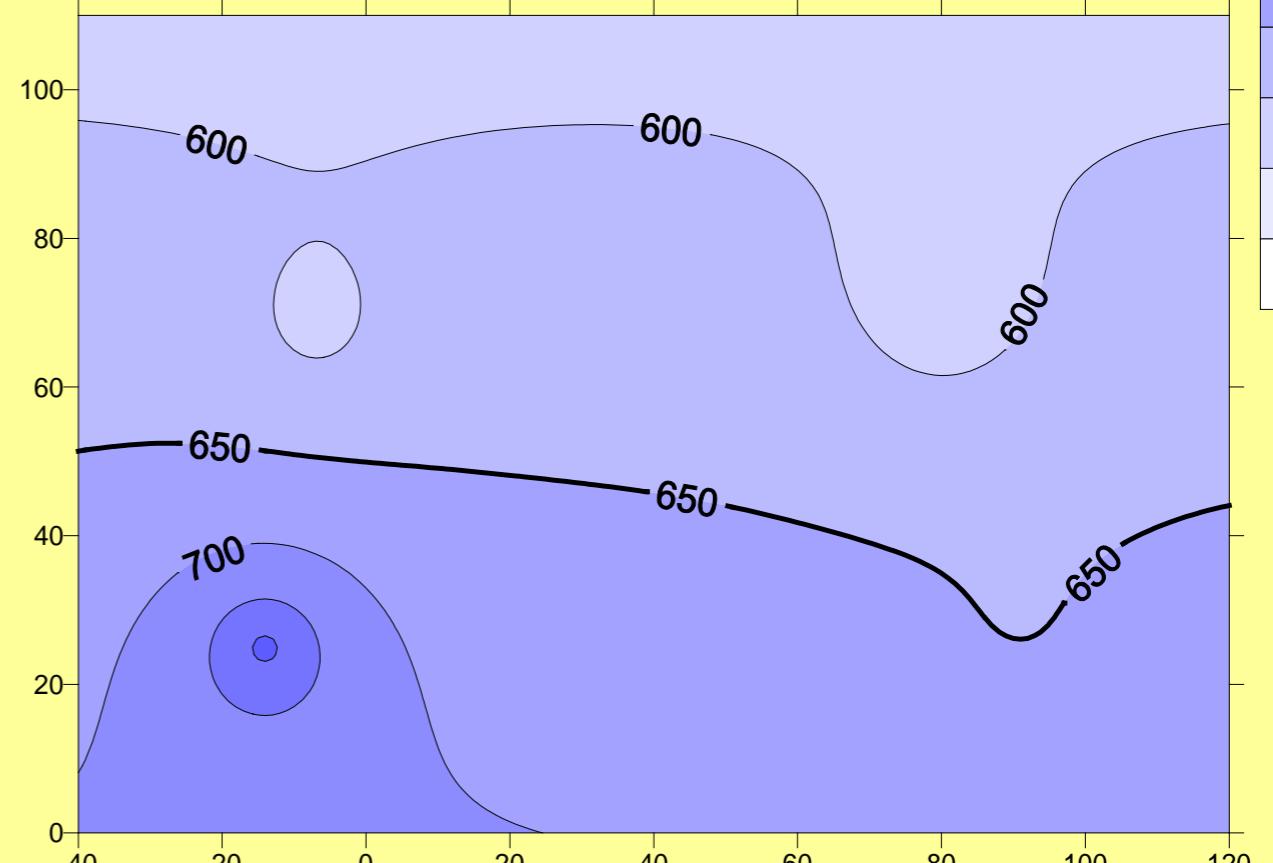
11 stations
Average = 655 mm



4 stations
Average = 765 mm

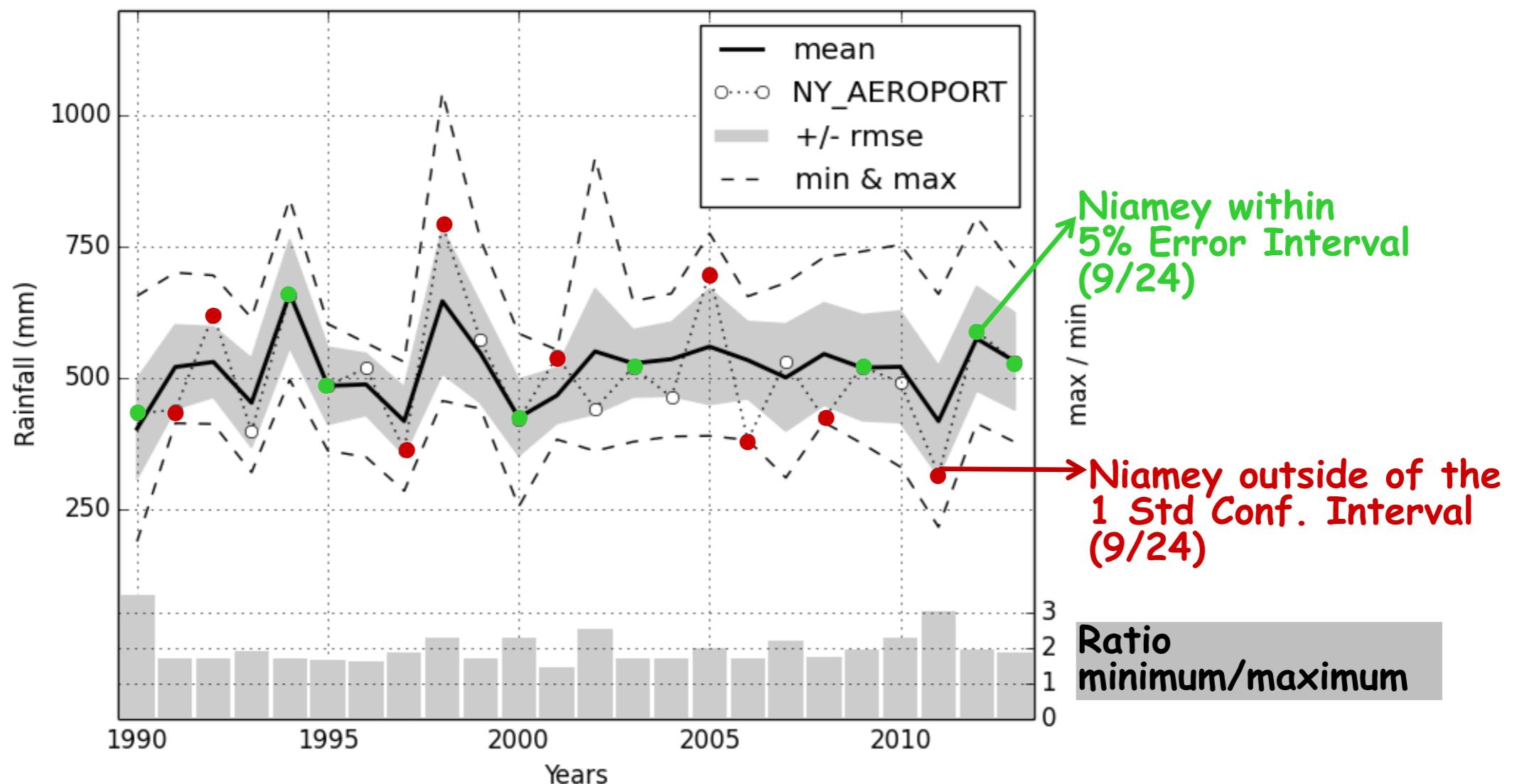


4 stations
Average = 649 mm



24 years of fine scale rainfall observations in the Sahel

Seasonal rainfall over the ACN area



Comparing point values (Mini / Maxi / Synop) to an accurate areal estimate

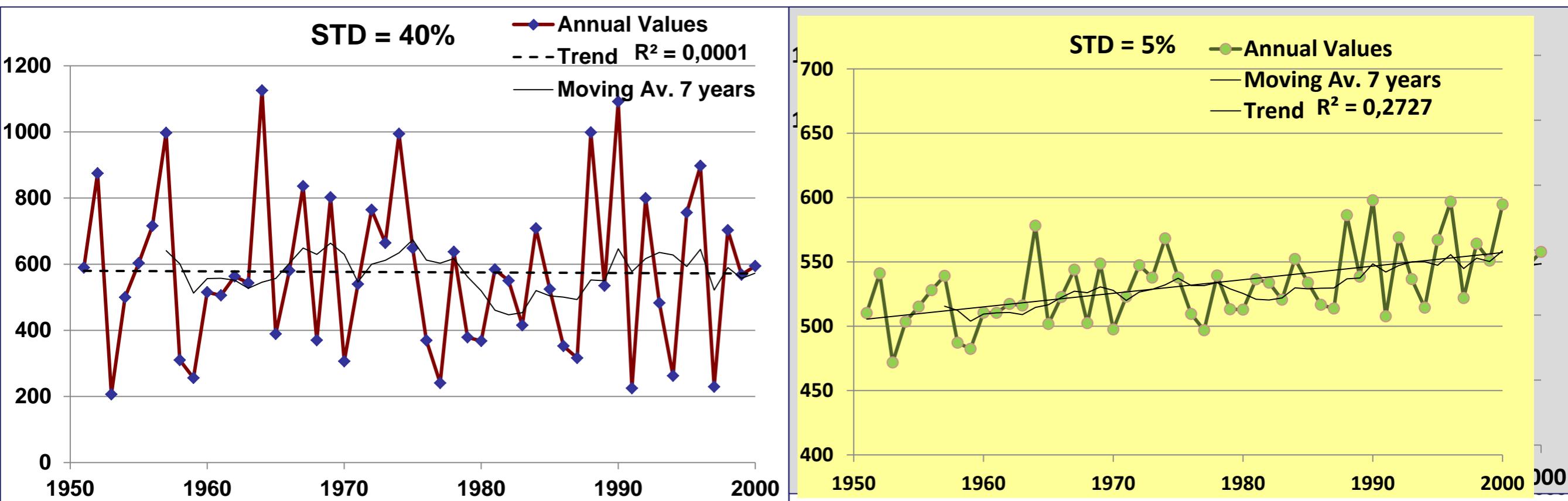
1. Scale issues, concluding remarks

- Rainfall displays a strong variability at all scales
- ✓ Even at large time scale (e.g. one rainy season) huge spatial gradients of rainfall are observed
- ✓ What are the implications for the detection of trends ?

2. Trends versus *Natural* Variability

- Decadal scale variability ... or ... Trend ?
 - ✓ The diagnostic heavily depends on the interannual variability
 - ✓ The smaller is the spatial scale of integration, the highest is the interannual variability

Signal to noise ratio



Simulation of a trend : $P(\text{mm}) = 500 + Ny \cdot 1 \rightarrow 10\% \text{ increase in 50 years}$
Interannual variability varying from 5 to 40%

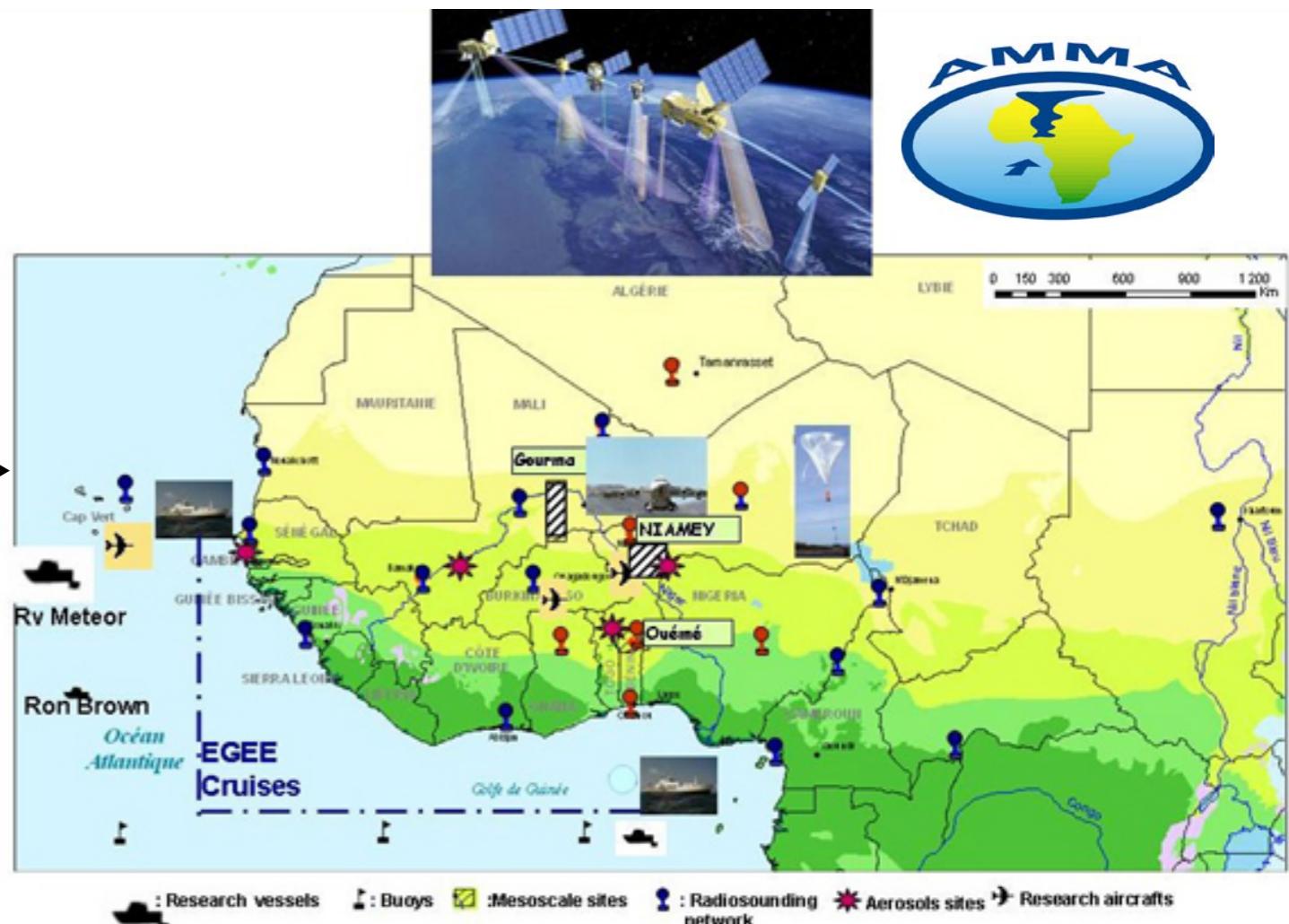
The signal to noise ratio increases with the scale of integration:

- 5%: regional rainfall
- 20%: mesoscale rainfall (depending on the annual rainfall)
- 40%: point rainfall

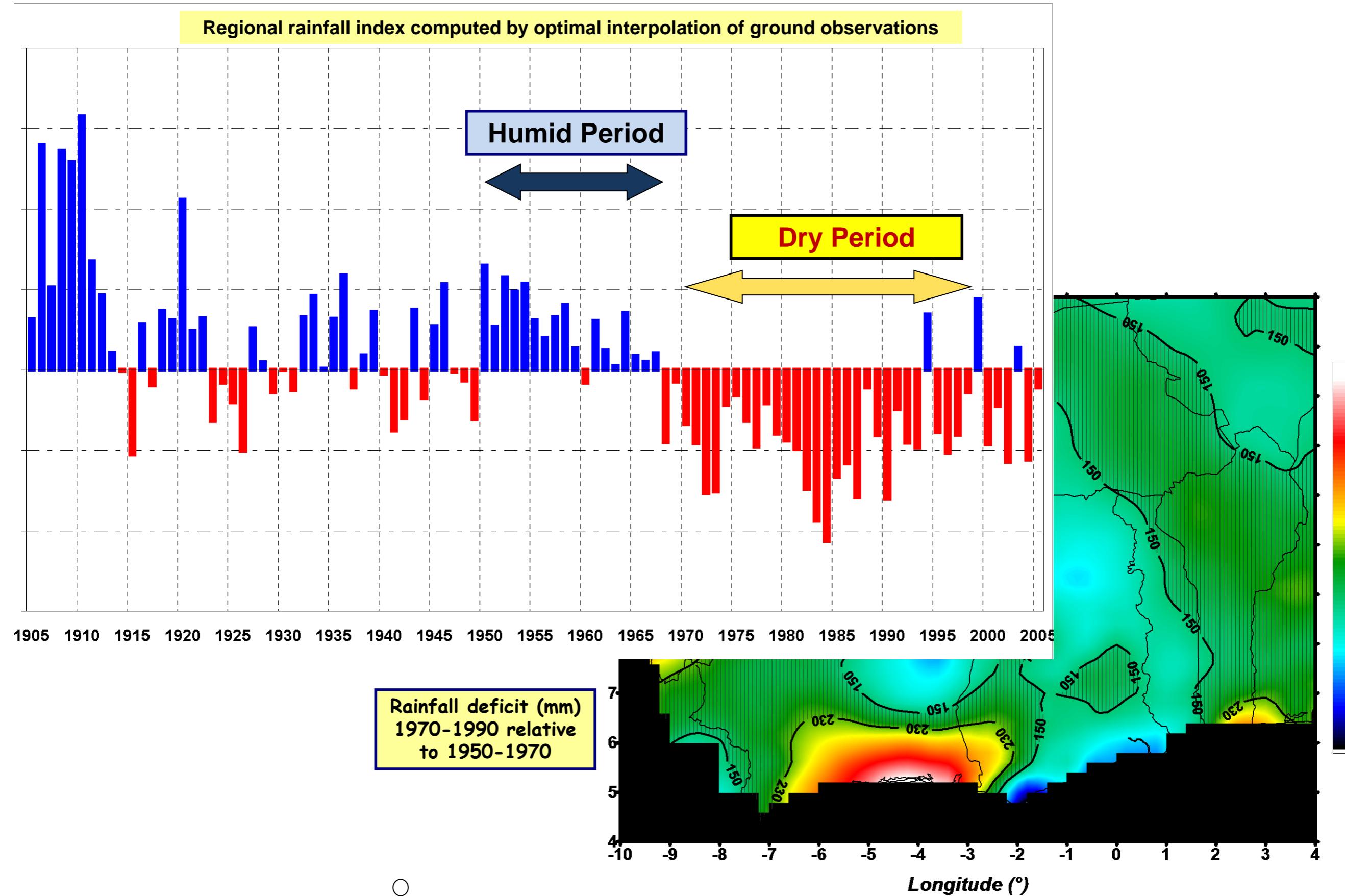
The need for specific observations

- Fine scale Observations are essential for Climate Science
 - ✓ Climate description - Model validation - Documenting Changes
 - ✓ Estimating space and time variances

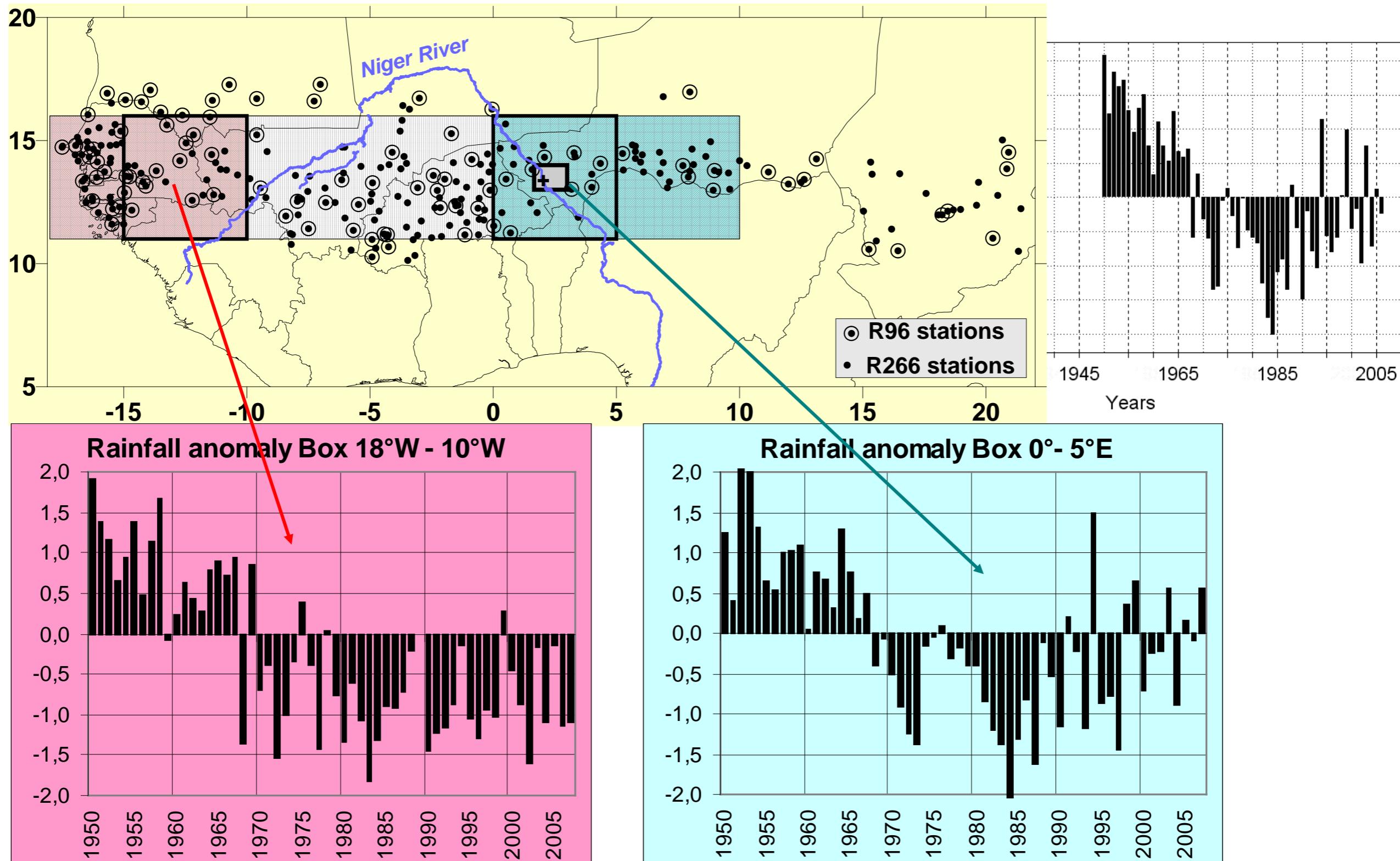
AMMA observing system
Imbedding long term
observations with special
observing periods



Decadal scale trend versus longer scale trend

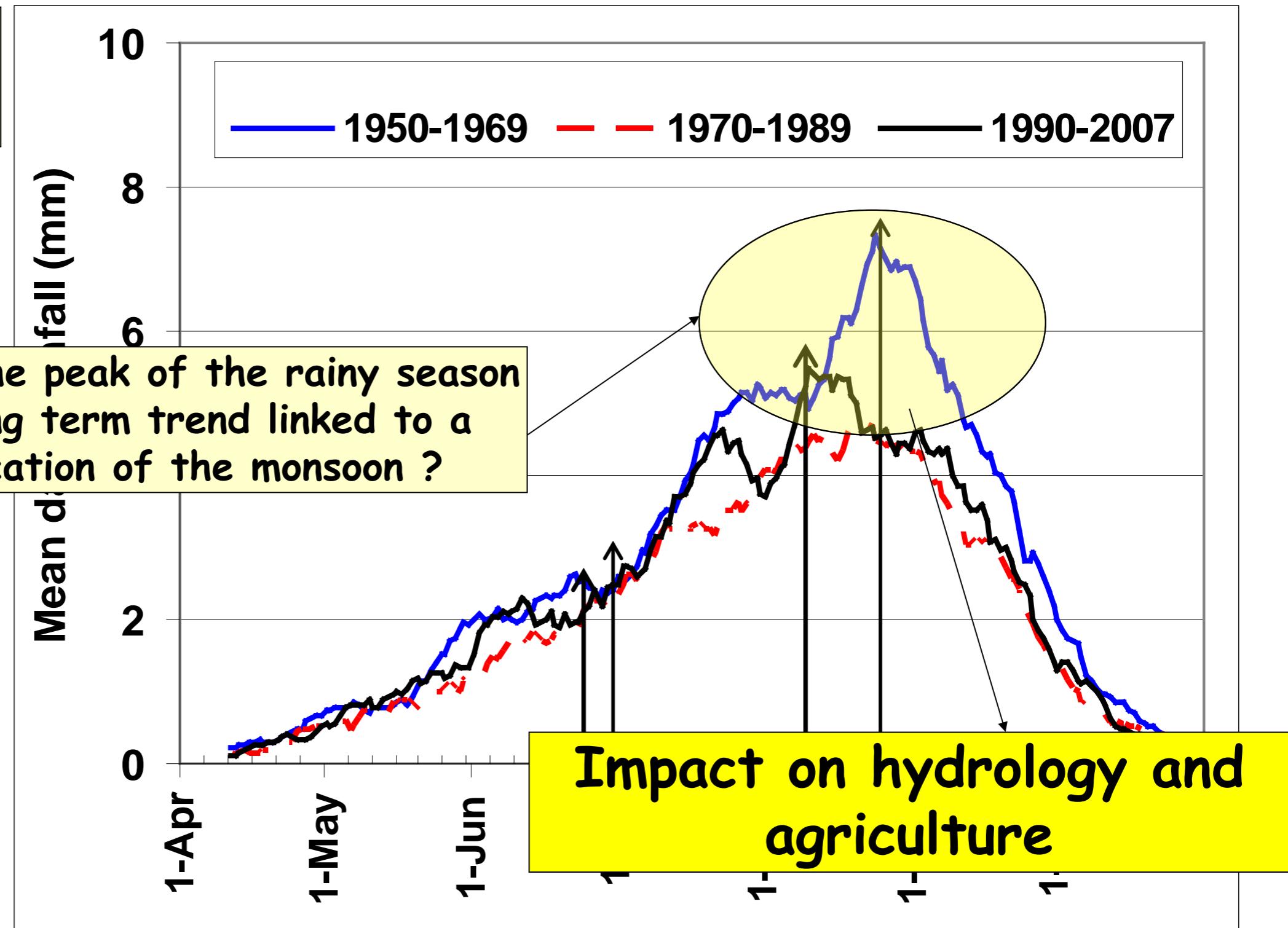


Decadal variability in the Sahel



Decadal Variability or long term trend : looking at the seasonal cycle

Box, 0° - 5° E ;
 11° N – 16° N



2. Trends versus *Natural* Variability, concluding remarks

- ✓ The diagnostic heavily depends on the interannual variability
- ✓ The smaller is the spatial scale of integration, the highest is the interannual variability, the longest should be a series for detecting a trend
- ✓ Estimating space and time variances is essential for assessing whether the detection of rainfall regime changes is feasible
- ✓ One should keep in mind that it is elusive to distinguish between a decadal scale trend and a longer scale trend

3. Intensification of the hydrological cycle

➤ A physical consequence of global warming (Clausius – Clapeyron)

- ✓ Strong impact events

Ouagadougou 2009



Dakar 2009

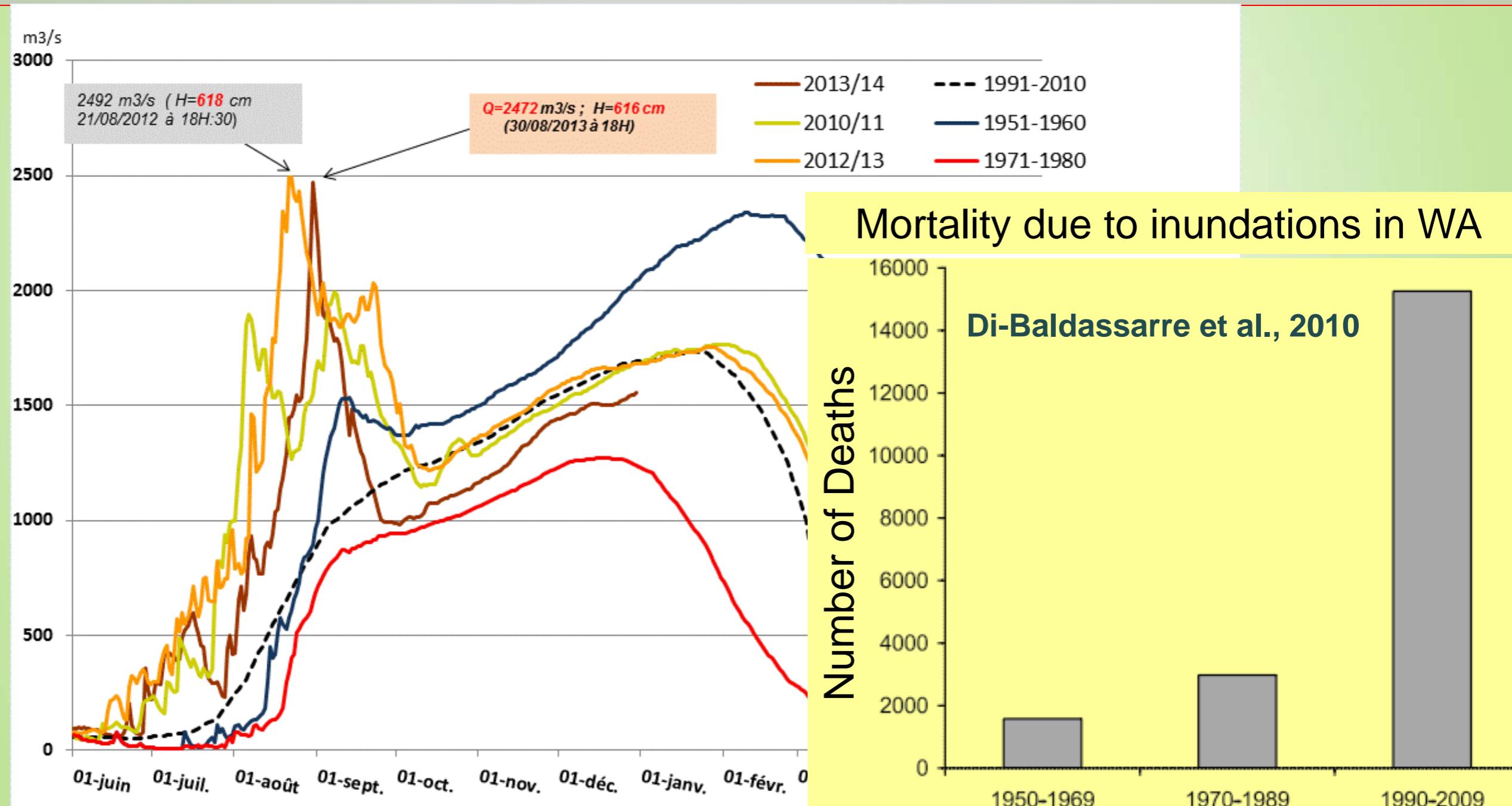


- ✓ Detecting trends in the extremes is more difficult than in the mean values
- ✓ The regional approach is the only way ...

A changing hydrological regime

A lasting drought and yet

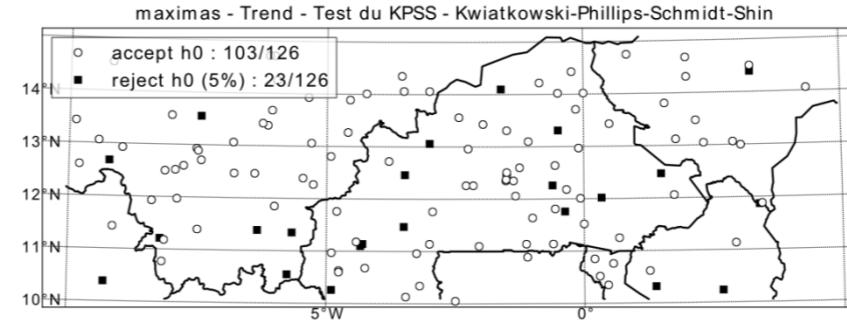
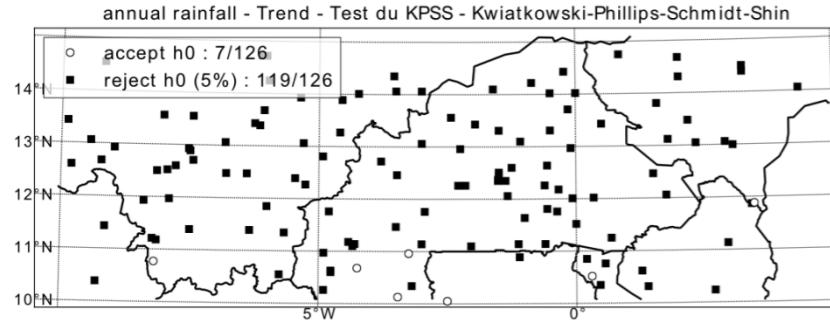
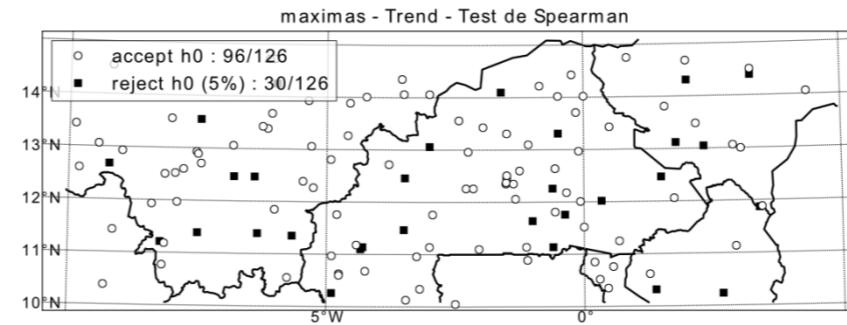
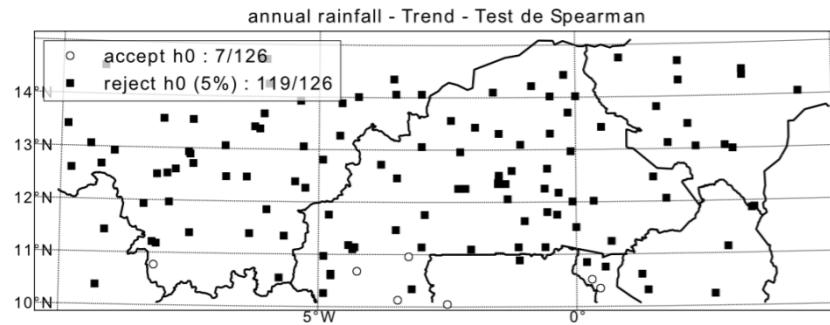
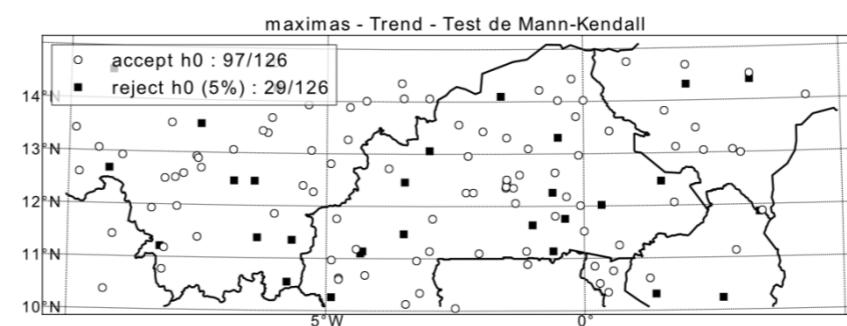
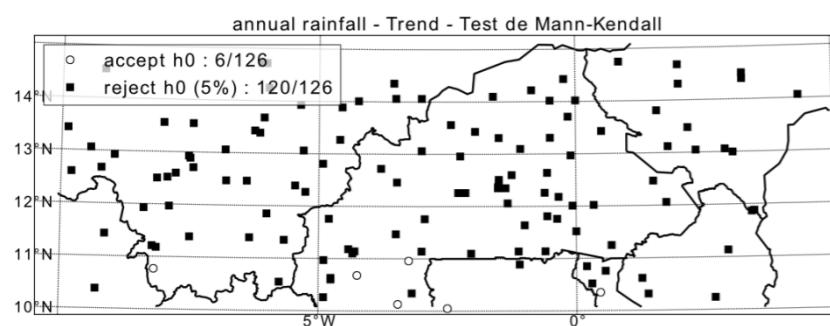
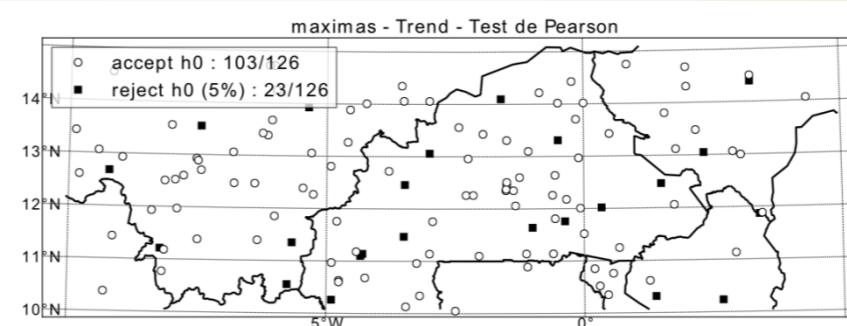
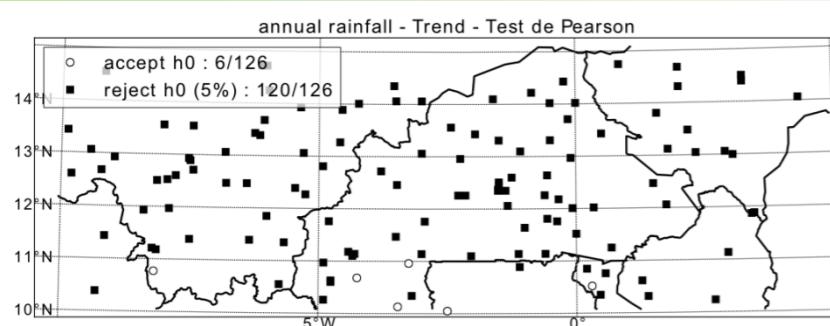
More catastrophic floodings since the beginning of the 21st century



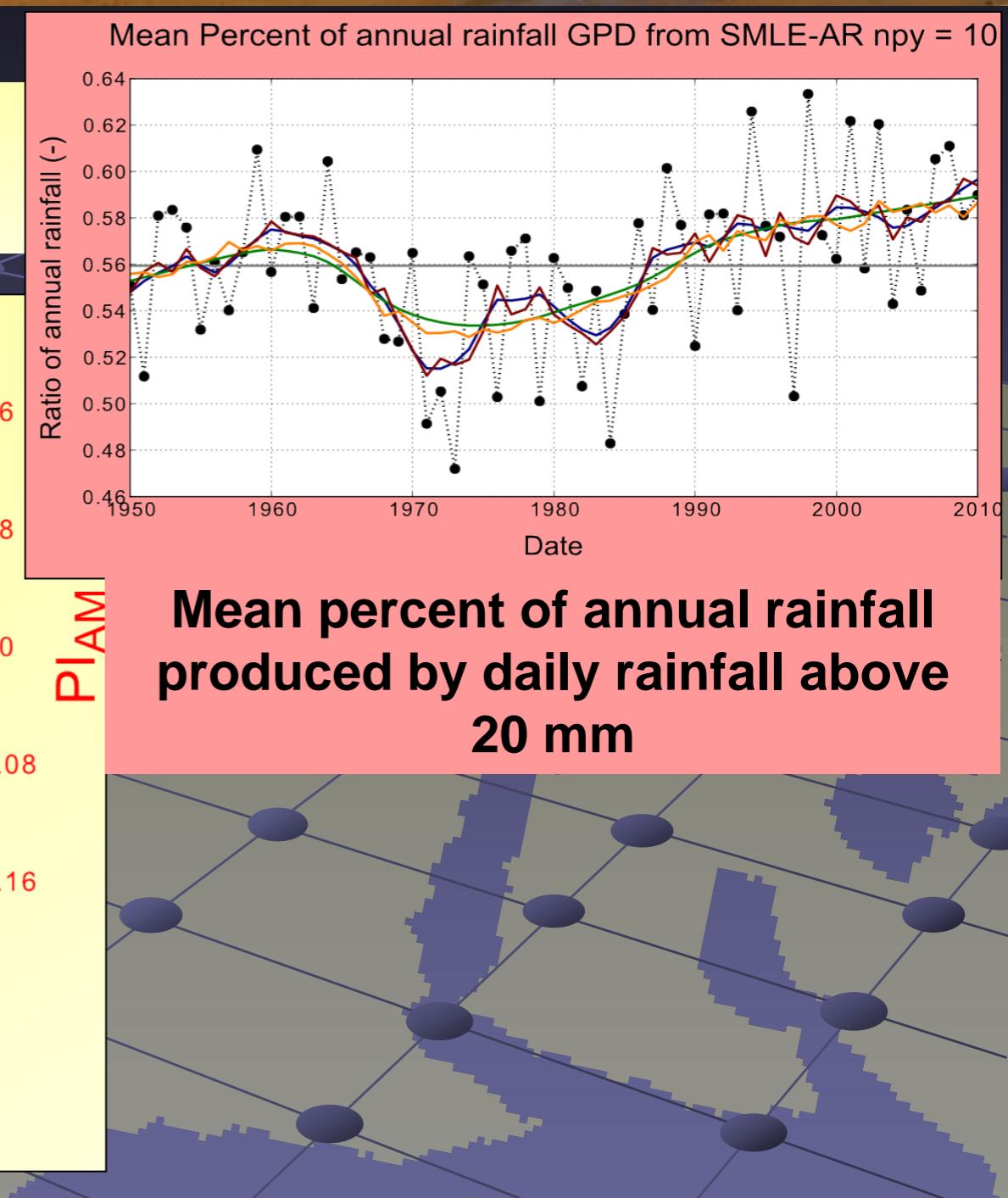
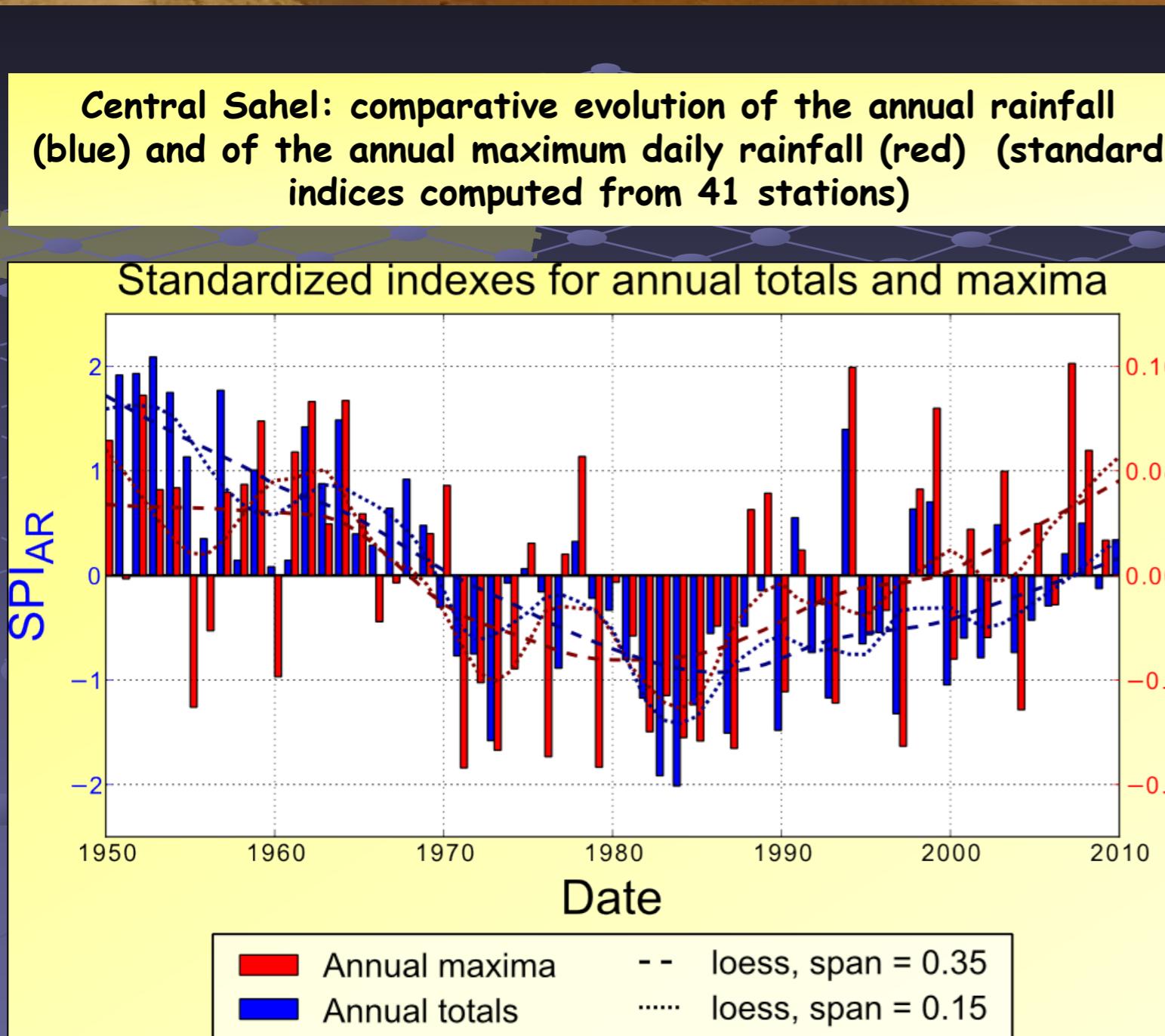
No significant changes on individual stations



Very difficult to detect a statistically significant trend in the regime of the extremes : rejection for 50 to 80% of the stations



Intensification of the hydrological cycle



Typical of a more extreme climate (less rainfall occurrences and stronger rainfall)

Concluding remarks

- There are a lot of unfounded ideas wandering around regarding rainfall variability in West Africa
- Climate models do not yet allow to deliver certainties
- A rationale and systematic use of regional information provide precious insight on the ongoing changes ... but yet this does not tell whether these changes are a long term trend or pertain to decadal variability

Interfacing land surface models with climate models in order to deal adequately with scale issues remains a frontier

Effets de seuil de stockage dépassés dans les années 70

Stockage de chaleur dans les premières couches (quelques dizaines de m de l'océan; effet regard. Changement sensible seulement à partir des années 1990.

CMIP5, exercice préparatoire au GIEC

Les modèles, un savoir qui rassemble des milliers de personnes, qui confrontent leurs expériences et recourent à des exercices de validation et d'intercomparaison

La question des scénarios : aucun des scénarios des GIEC3 et GIEC4 ne respectent le seuil de 2°C

GIEC5 décide donc de travailler par objectif et non pas par trajectoire; donc on formule les choses à l'envers. Quel trajectoire pour ne pas dépasser ces 2°C: quelle trajectoire d'émission pour rester sous ce seuil. Il faut avoir diminuer les émissions de moitié d'ici 2050 et zéro émission à horizon 2100

On traduit cette quantité d'émissions en forçage radiatif. RCP2.6 « garantit » de rester au pic de +2; RCP 8.5 produit un réchauffement de 4-5°C

Food requirements per continent (2050 compared to present): x5,14 en Afrique; 2,34 en Asie ; par comparaison: x0,91 en Europe Mousson chinoise; since 1980 diminution d'intensité → plus de pluie au Sud; moins de pluie au Nord qui est le grenier céréalier du pays → irrigation pour compenser, ce qui n'est pas neutre: adaptation versus mitigation

Bassin de La Plata: plus de pluie actuellement, grosse augmentation de production céréalière et surtout Soja. Chauffage convectif amazonien; apparemment cette hausse de pluie serait lié au réchauffement de la planète d'après certains modèles; malgré tout signal tenu.

Effet retard des effets du changement climatique: quelques dizaines d'année. Ce n'est pas beaucoup mais c'est le temps de la démocratie.

Passer d'une science de l'alerte à une science de la gestion ou de la prise de décision implique un saut qualitatif et quantitatif:

Difficulté du passage du diagnostic global à local

Passage d'une prévision déterminante à une culture du risque

Mise en parallèle du risque climatique avec d'autres risques (choix également éthiques, culturels

Ceci implique l'articulation des outils de la science et de ceux du débat public.

Ceci implique de s'appuyer sur un suivi partagé du diagnostic scientifique