

Fig.5: Graphical representation of the ESCAPE workpackages and their interdependencies

*WP1: Observation of environmental changes*

The purpose of WP1 is to detect the major past environmental changes impacting societies in West Africa. These issues are addressed at the regional scale when possible through satellite data and the local scale (basin catchments, production systems) where datasets and expertise ranging from climate to production systems and to societal perception and adaptation can be systematically collected and analysed. WP1 will provide the ground truth for assessing climate and resources simulations of WP3.



## Partenaires impliqués dans le WP1

GET (Géoscience Environnement Toulouse, ex LMTG)

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M. Gosset, M. Diawara

CNRM-GAME

F Guichard, **A. Gounou**, F. Favot, J-L. Redelsperger

LTHE

L. Descroix, K. Souley Yero, T Vischel, T. Lebel, G. Pantou + **Postdoc**

HSM

J Demarty, B. Cappelaere, L. Séguis, C Peugeot. + **½ Postdoc**

## Partenariat WP1

ICRISAT Niger

IER Mali

Université Moumouni Niamey

DNM Mali

AGRHYMET



ESCAPE, Kick-off meeting, 14-15 Mars 2011, Paris

WP1 'Détection et attribution des changements environnementaux

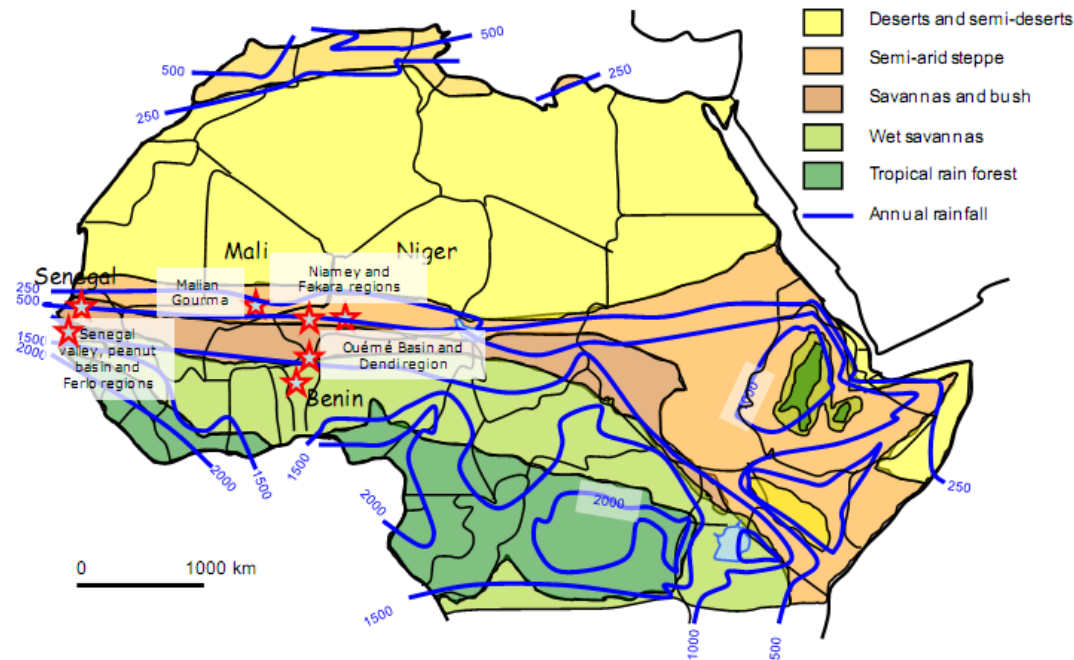


Fig.7: Map of ESCAPE target sites

Capitaliser sur

AMMA / CATCH

ECLIS

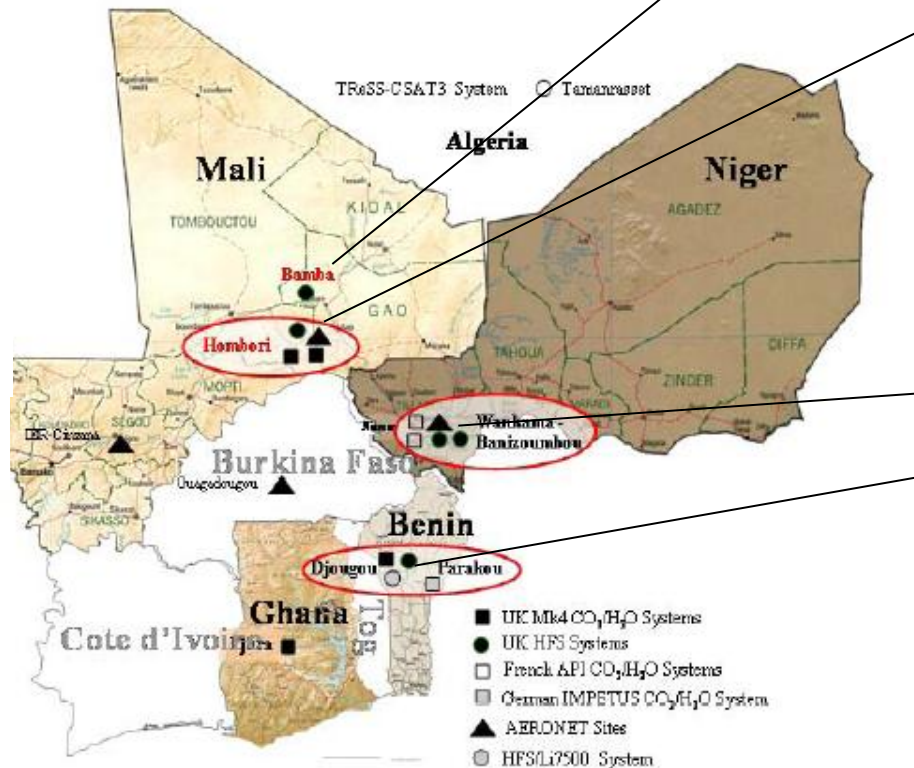
Sites déjà multidisciplinaires  
Avec un recul historique

# AMMA set up (starting 2005)

Eddy fluxes and radiation stations network  
vegetation, moisture...



17°  
15°30'  
13°40'  
9°40'



- UK Mk4 CO<sub>2</sub>/H<sub>2</sub>O Systems
- UK HFS Systems
- French API CO<sub>2</sub>/H<sub>2</sub>O Systems
- German IMPETUS CO<sub>2</sub>/H<sub>2</sub>O System
- ▲ AERONET Sites
- HFS/Li7500 System



**Task 1.1: Detection and patterns of climate change**

In view of the recent results identifying the most critical variables in terms of impact on resources, including outputs of the AMMA program (ASL special issue), the focus is put on the patterns of drought, especially in terms of dry spells occurrence, floods and heat waves, which impact rain-fed agriculture for instance and multi-year phenomena which impact production systems and may drive societal changes.

Different datasets will be scrutinized: this includes regional scale historical daily SYNOP data (AMMA database), the CILS (1950-present) through collaboration with AGRHYMET, GISS and CRU datasets, as well as NWP re-analyses (ERA40, ERA-Interim, NCEP), satellite estimates (EPSAT, TRMM, Megha-Tropiques) and meso-scale high resolution and dense networks of the AMMA-CATCH S.O. that provides up to twenty years of 5-minute rainfall densely spread over three sites of roughly 10000 km<sup>2</sup> surface in Mali, Niger and Benin.

Rainfall characteristics over the past decades will be analysed as well as their links to changes in larger scale features such as the monsoon flow and the inter-tropical front In addition to drought. The characteristics of rain systems will be analysed, with a focus on the evolution of their occurrence rate, intensity and the spatial extension, by merging CILSS, AMMA-CATCH and satellite datasets. Geo-statistical models, fed with climatological information. With the objective of feeding environmental and resource models (agriculture, rangeland models, water availability simulations) to be used in WP3, rain fields will be produced at meso and regional scale.

This task will also address a less studied phenomenon, namely rainfall intensification: is there a trend towards global warming triggered intensification in rainfall and floods? High time-resolution datasets from AMMA-CATCH will be compared to regional scale daily rainfall fields and trends or absence of trend will be analysed.

Besides, it is also important to detect warming trends and heat wave occurrence. It is especially critical in the pre-monsoon season, which is the hottest and more humid season and which provokes important mortality and during the growing season, when it combines with drought occurrence to provoke crop heat stress. Changes observed in surface air temperature, diurnal temperature range and rainfall over the past decades will be analysed as well as the links between thermodynamics, rainfall and surface fluxes. While Summer temperature are expected to be linked to monsoon rainfall on inter-annual time scales, other balances and trends may prevail at larger time scales in Spring when temperature reaches its yearly large maximum, prior to rainfall. Variations in the duration, mean properties and spatial coherency of this phase of the year will be analysed as well as the variations in the diurnal temperature range. Whether such changes in Spring are associated with a delay, shift and shortening of the rainy season will be studied.

Drought  
Dry spells  
Heat waves  
Persistence

Down scaling

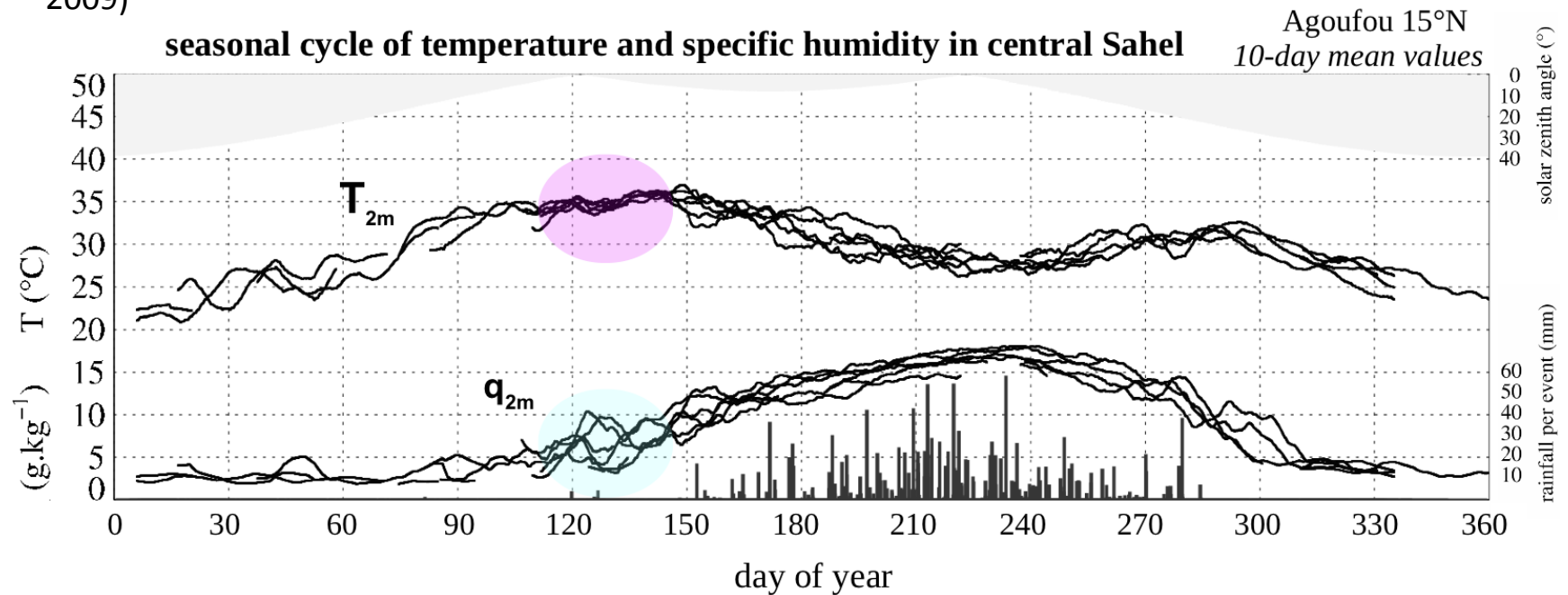
Intensification ?

Warming ?



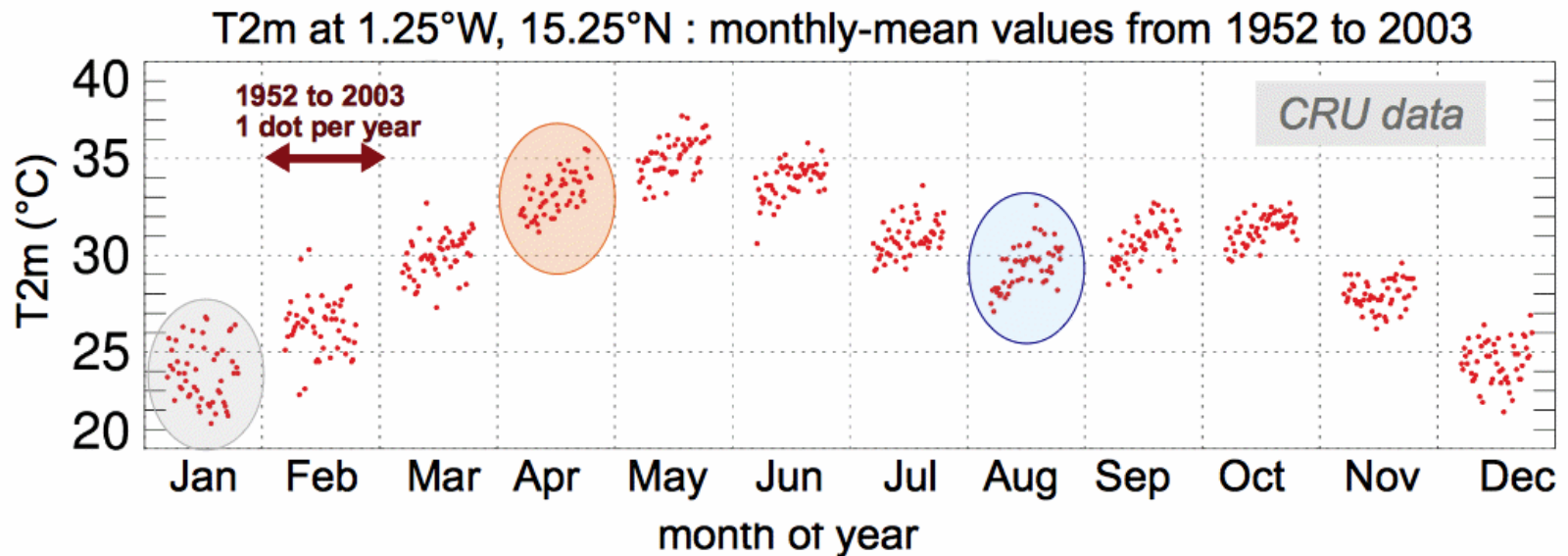
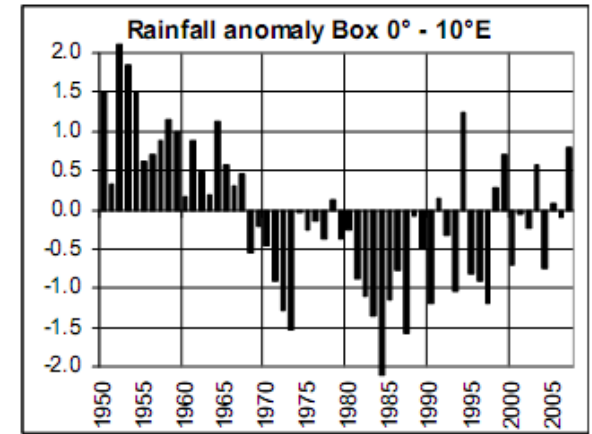
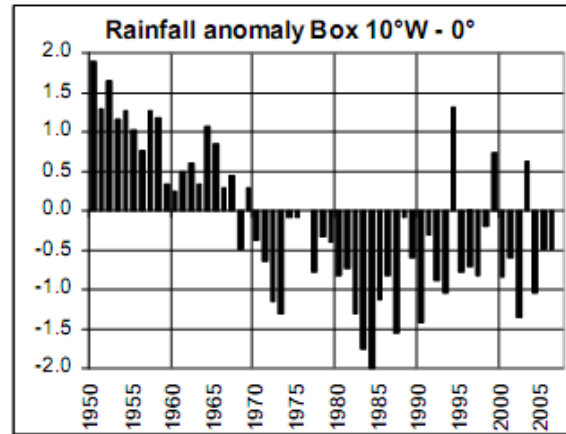
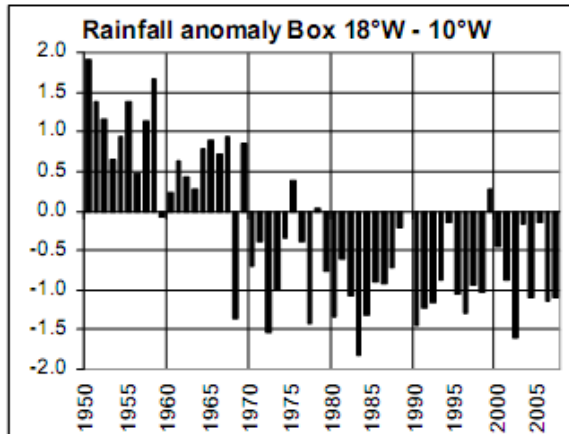
# CYCLE SAISONNIER EN AFRIQUE DE L'OUEST

**Pré-mousson** : très chaude, difficile, évolutions climatiques (Biasutti & Sobel - 2009)

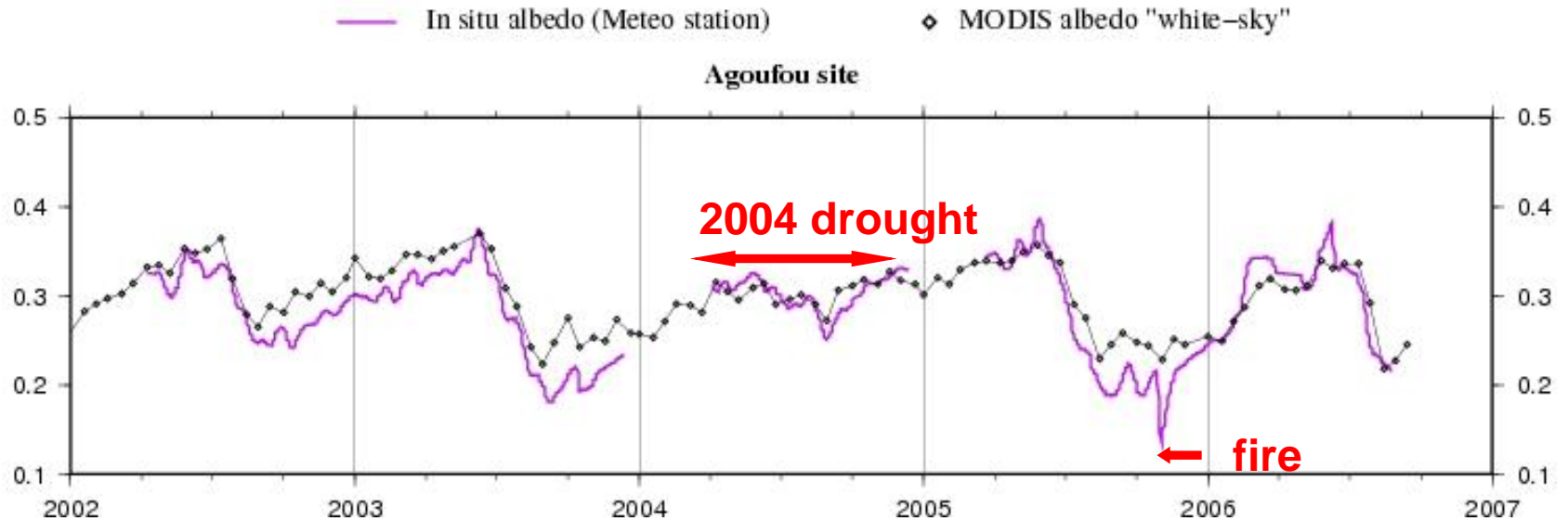


# SENSIBILITÉ CLIMATIQUE DU CYCLE SAISONNIER EN AFRIQUE DE L'OUEST

## évolutions multi-décennales



## Satellite vs ground measurements



***Samain et al. JGR 2008***

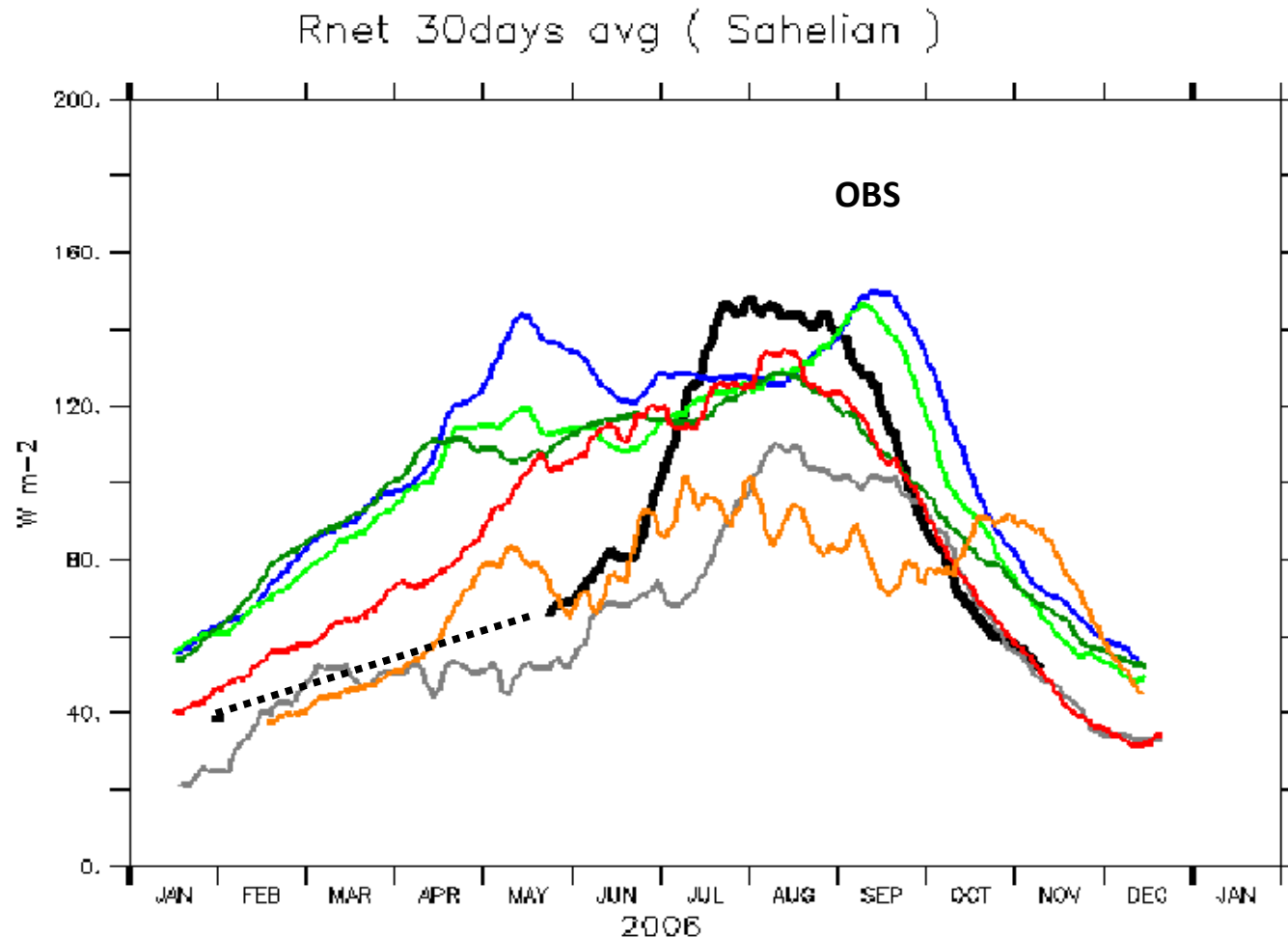
Satellite / in situ agreement on seasonal and interannual variability

Que donnent les modèles de climat ?



# Surface net radiation for climate models

## AMMAMIP intercomparison (forced SST)



*Traore, Hourdin et al BAMS 2010*

too flat, large biases, even or mainly before the rain season !

**Task 1.2: Detection and attribution of land use change**

Land use and land use changes (LULC) reveal the changes in production systems driven by societal changes and adaptation and it is also an active player in the resource production changes, and even to some extent in climate changes. As such, important efforts will be devoted to detect LULC and the drivers of it.

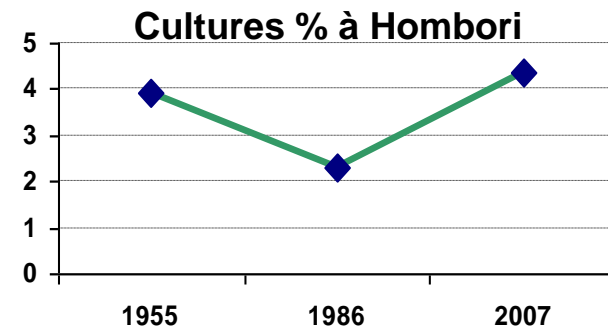
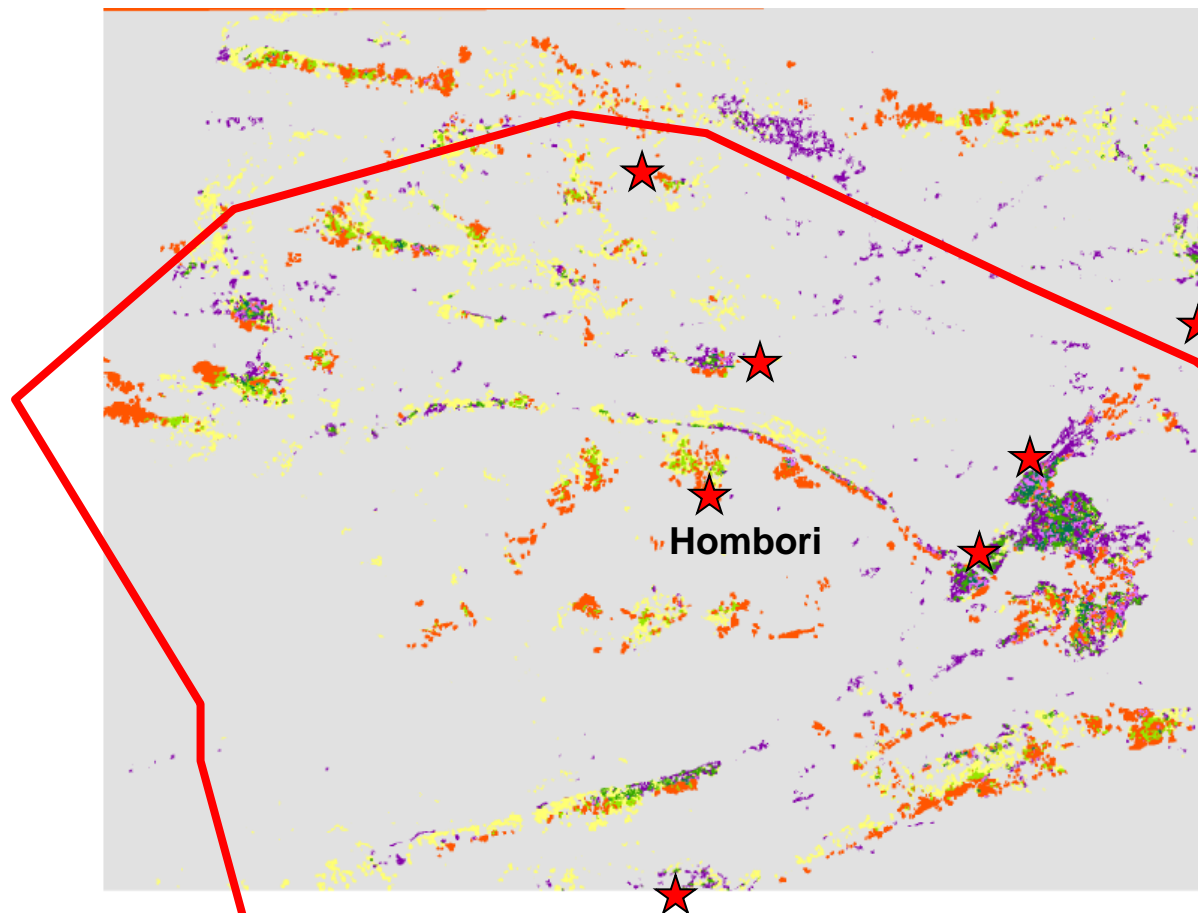
*- Detection and attribution at the district (meso-scale) scale*

LULC will be derived from historical remote sensing data over three well documented sites from the AMMA-CATCH Observation System (S.O.) spanning latitude gradient in West Africa (Ouémé in Bénin, Fakara in Niger and Gourma in Mali). Classification of land units from CORONA images (1965), aerial photographs (1949 to 1954) and SPOT/LANDSAT data (present) will be produce for the three sites. Features like crop/pasture/fallow/secondary forest/primary forest will be diagnosed. Diagnostics of the drivers of these changes will be collected (within WP2).

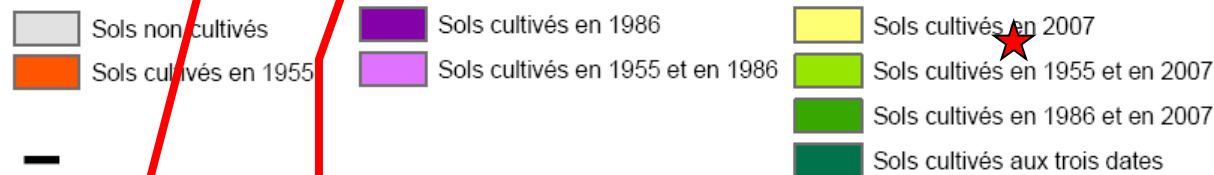
*- Detection of LULC at the regional scale*

This task aims at evaluating the existing LULC products with the objective of assessing the generality of the district scale features and to assess the LULC datasets used in climate simulations.





#### Légende

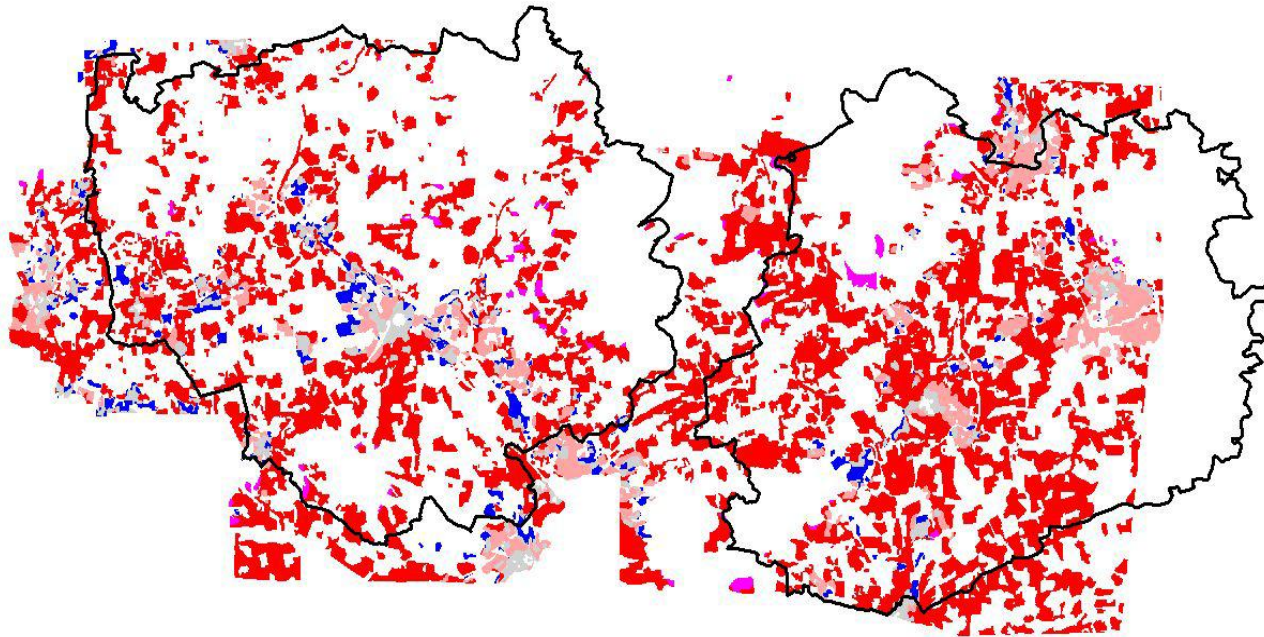


0 2 154 300 8 600 12 900 17 200 Meters

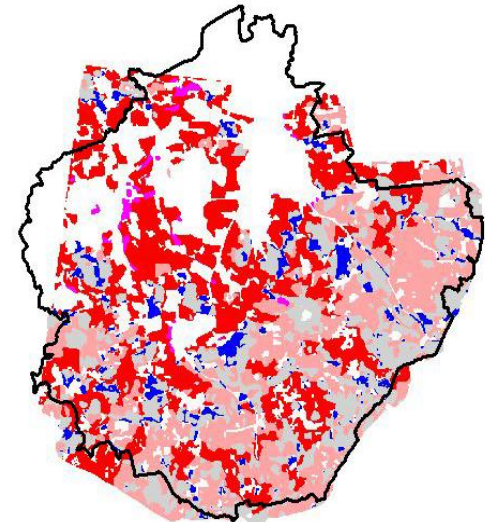
Dynamique de  
l'occupation agricole  
des sols de la commune  
de Hombori

Source: Cheula, 2009

# Landuse changes in 3 Fakara village territories from 1954 to 1994



- Grey: Cropped in 1950 and 1994
- Blue: Cropped in 1950, fallow in 1994
- Red: Uncropped in 1950, cropped in 1994
- Pink: Fallow in 1950, cropped in 1994



0 10 20 Kilometers

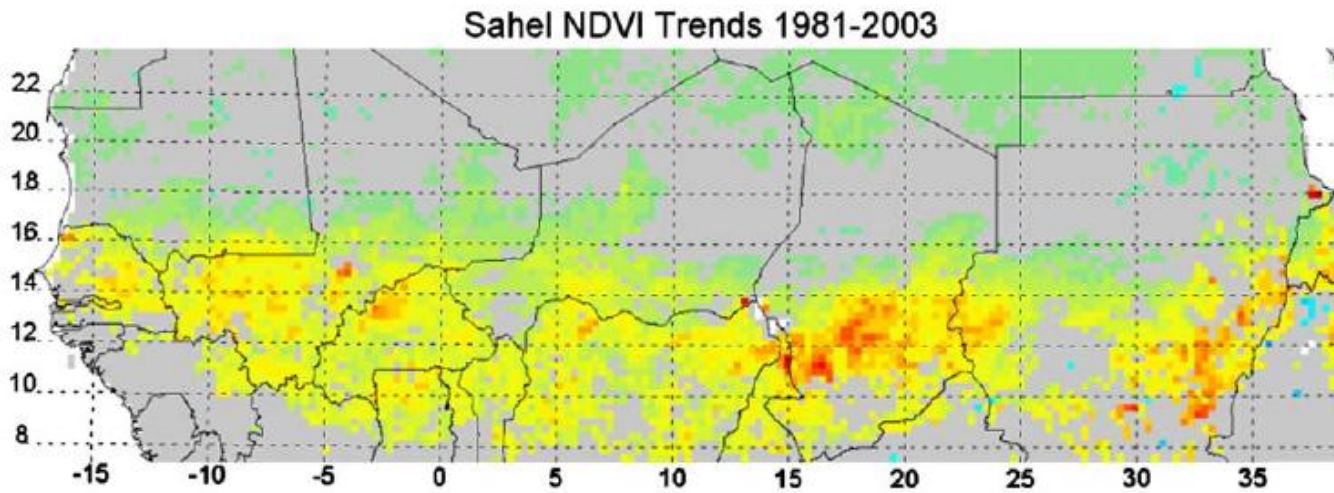
**Task 1.3: Detection and attribution of ecosystems and agrosystems changes from long term series**

As soon as trends and decadal variability are addressed, it is critical to analyse the long term datasets, which are unfortunately extremely rare. ESCAPE has a unique opportunity of accessing two long term dataset, from which the dynamics of rangeland ecosystems: rapid and lagged response to drought, dynamics of the different Plant Functional Types, coupled water/plant systems, coupled plants/LULC systems. Similarly, for crop/livestock production systems: trends in yields, trends in livestock inventories, coupled production/LULC systems, coupled production/societies systems will be analysed. These datasets will be used for the validation of resource simulations over 1950-present.

The large scale trends and patterns, (satellite greening trends, desertification areas) will be assessed in view of the previous analyses, with the objective of rejecting or reconciling these theories. Satellite signal will be carefully analysed in terms of vegetation and surface properties changes over time (AVHRR LTDRv3 and VGT dataset).







Reverdissement ?

Désertification ?

Un débat toujours pas tranché

Rendez-vous dans 2 ans !

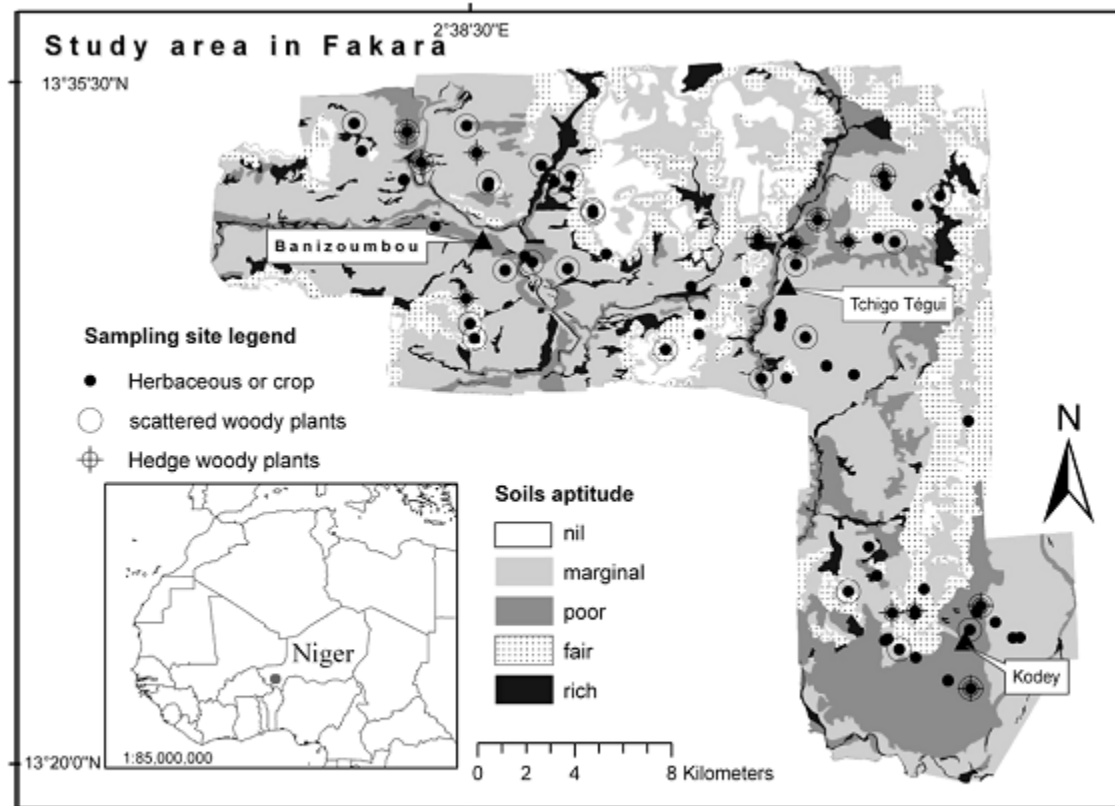
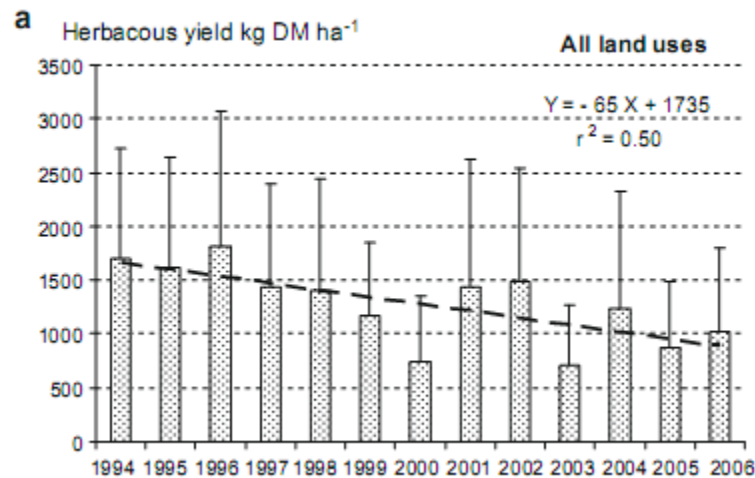
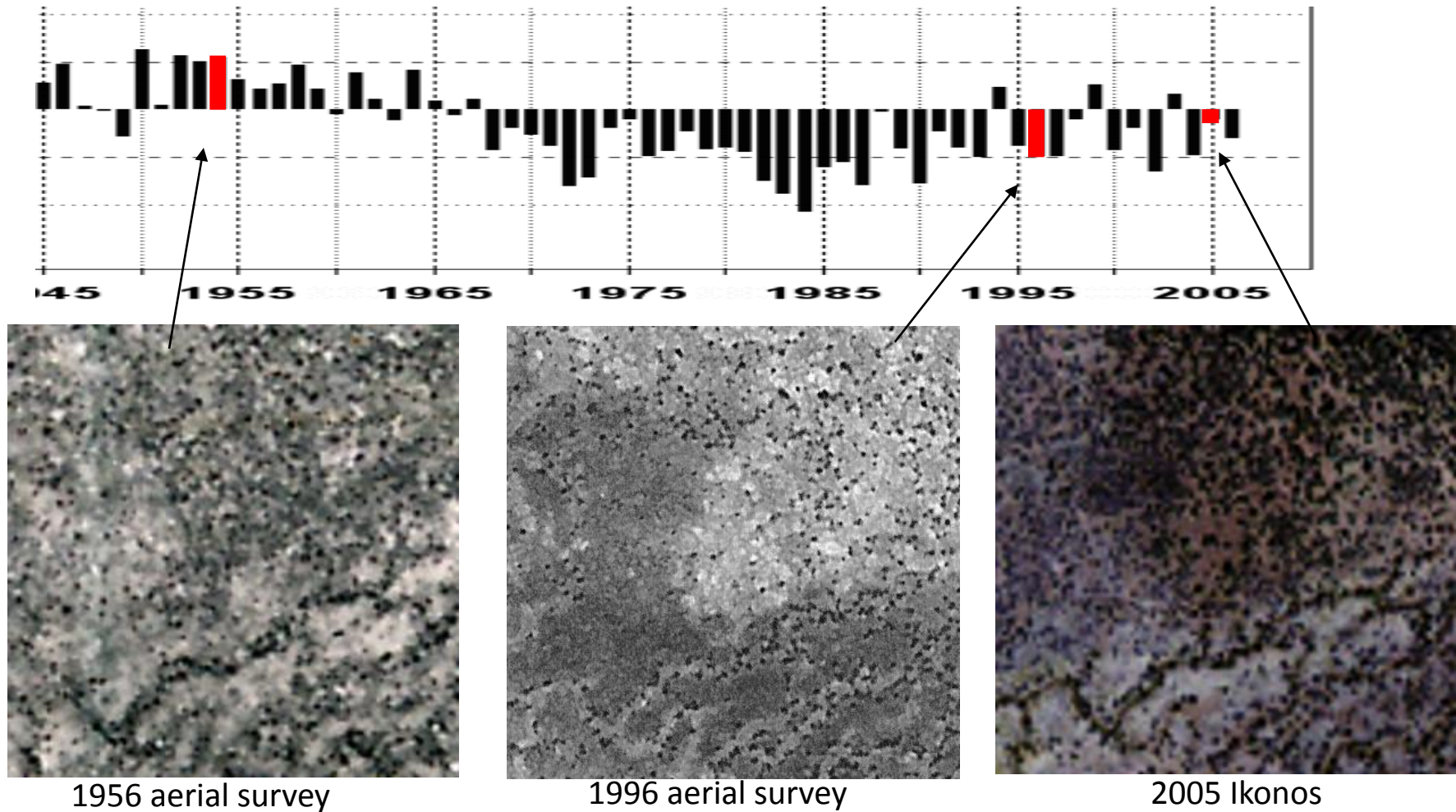


Fig. 1. Location of the field study sites within three agro-pastoral territories of the Fakara district in South-western Niger, West Africa: Banizoumbou, Tigo Tégui and Kodey. The five class of soil aptitude to cropping are based on geomorphology, soil texture and soil surface features (Hemaux and Ayantunde, 2004).



## Looking backward



lowland acacia woodland in the Gourma (15°N), tree cover 2005 >> 1956 > 1996  
consistent with increased runoff in the 80-90  
mass mortality in 1984, regeneration in the late 90'

*Trichon, Hiernaux*

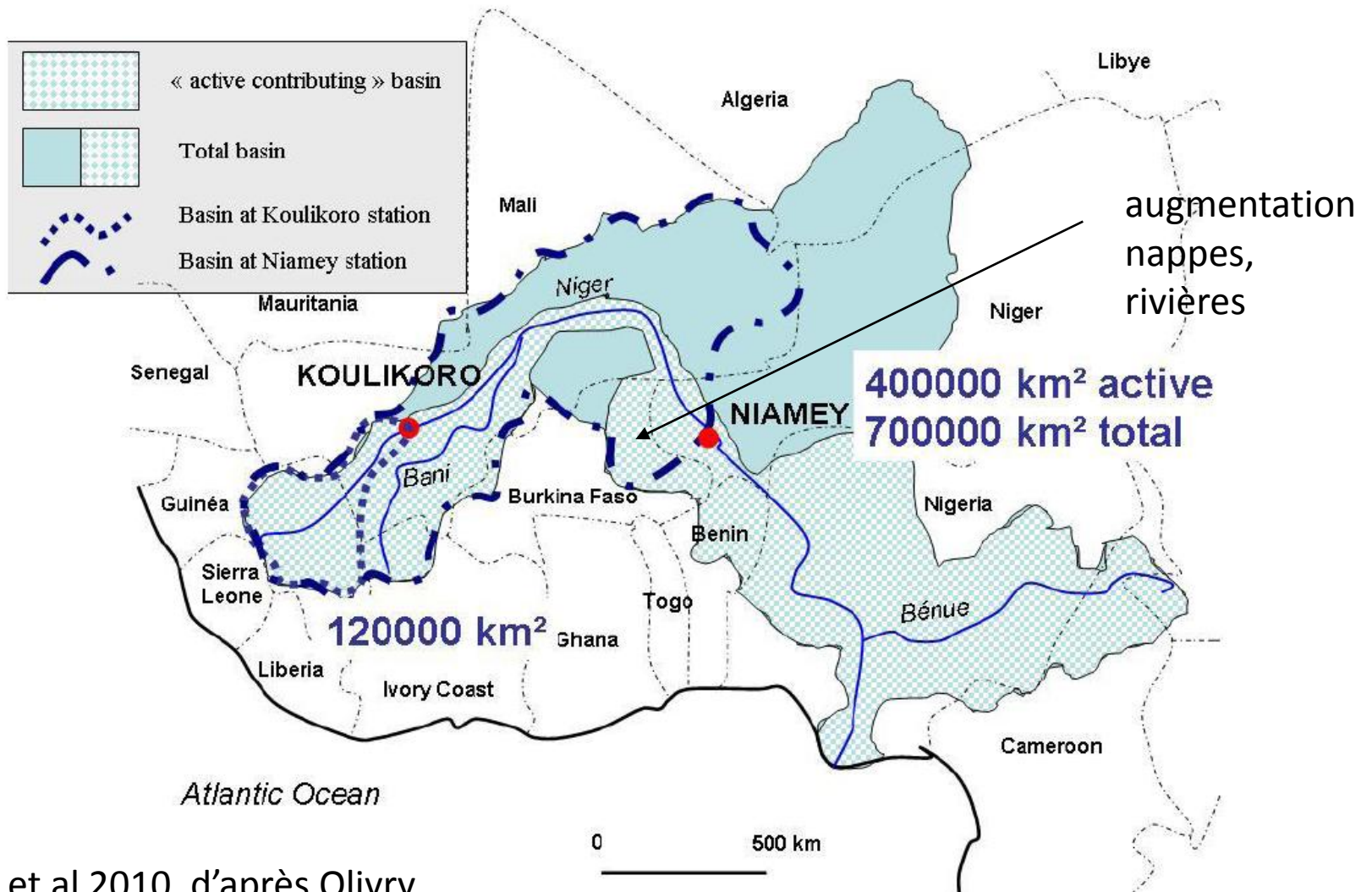
## **Task 1.4: Detection and attribution of surface water and run-off changes over 1950-present**

This task aims at diagnosing the long term changes in surface water availability and at attributing these changes to either climate or man-made LULC, or presumably to a combination of these factors. It requires an assessment of surface water (ponds, wetland) and run-off (gullies, erosion patterns) systems derived over the Fakara and Gourma sites as well as corresponding eco-hydrological and LULC changes.



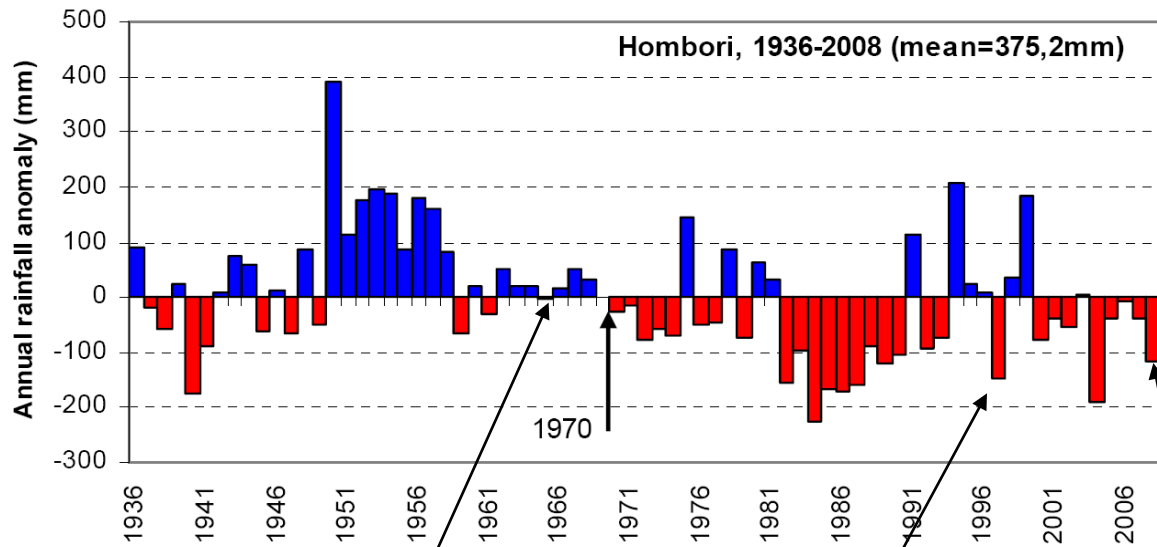


Ecoulements au Sahel: augmentation du ruissellement  
(Albergel, Leduc, Favreau, Descroix....)  
Effet de land use change, peut-être effet de la sécheresse



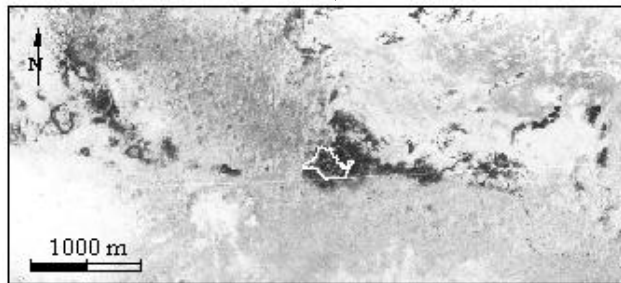
Amogu et al 2010, d'après Olivry

However, at decadal time scales, other processes become important  
« less rain, more water in ponds »

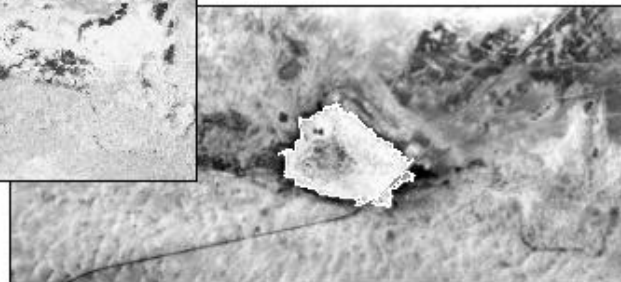


+ 100 increase in  
pond surface (n=91)

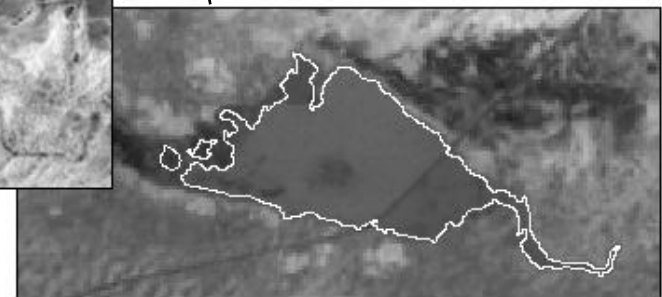
increase tree cover in  
valleys



1966



1996



2007

Del. no.	Deliverable name	WP no.	Nature	Responsible partner	Delivery date
D1.1	<p>D1.1a: Report and article on the assessment of changes in the seasonal cycle of temperature at multi-decadal scales across West Africa in observations and in re-analyses data</p> <p>D1.1b: Report on the signature of climatic changes in surface thermodynamic and energetic couplings</p>	WP1	Report	CNRM	Month 12



D1.2	D1.2a: Report on drought patterns inter-annual variability, intra-seasonal dry spell, intensification  D1.2b: Report on the generation of rainfall fields from climatological information and techniques to be applied in WP3 simulations	WP1	Report	LTHE	Month 18
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D1.3	<p>D.1.3a: Report on land use maps series from 1950s to present and corresponding digital maps for the Gourma (Mali) site (resp: LMTG)</p> <p>D.1.3b: Report on land use maps series from 1950s to present and corresponding digital maps for the Niger site (resp: LTHE)</p> <p>D.1.3c: Report on land use maps series from 1950s to present and corresponding digital maps for the Ouémé (Bénin) site (resp: HSM)</p>	WP1	Report	HSM	Month 12
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D1.4	Assessment of LULC historical datasets: consistency at the regional scale, accuracy from comparison at the district scale	WP1	Report	LTHE	Month 18
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D1.5	Report on Multi-decadal dynamics of ecosystems and crop/livestock production systems at the district scale in Gourma (Mali) and Fakara (Niger)	WP1	Report	LMTG	Month 18
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D1.6	Report and article on the assessment of the greening and desertification theories	WP1	Report	LMTG	Month 36
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D1.7	D1.7a: Report on the evolution of surface water and run-off systems at the district scale for the Mali site (resp: LMTG)  D1.7b: Report on the evolution of surface water and run-off systems at the district scale for the Niger site (resp: LTHE)	WP1	Report	LMTG	Month 18
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Month	1	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48
WP1 Observed major environmental changes																	
T1.1: Climate changes							1.1										
T1.2: Land use changes							1.3										
T1.3: Agro-ecosystems changes																	
T1.4: Water availability changes																	

recrutements en cours (Hiernaux, Gounou)

### Links with other WPs

Task 1.1 is mirrored in WP3 for the climate model counterpart. Tasks 1.2 to 1.4 will feed the simulations of WP3. Tasks 1.1 to 1.4 will be completed with parallel effort over the same sites in WP2.





FIN

merci. Pour votre attention

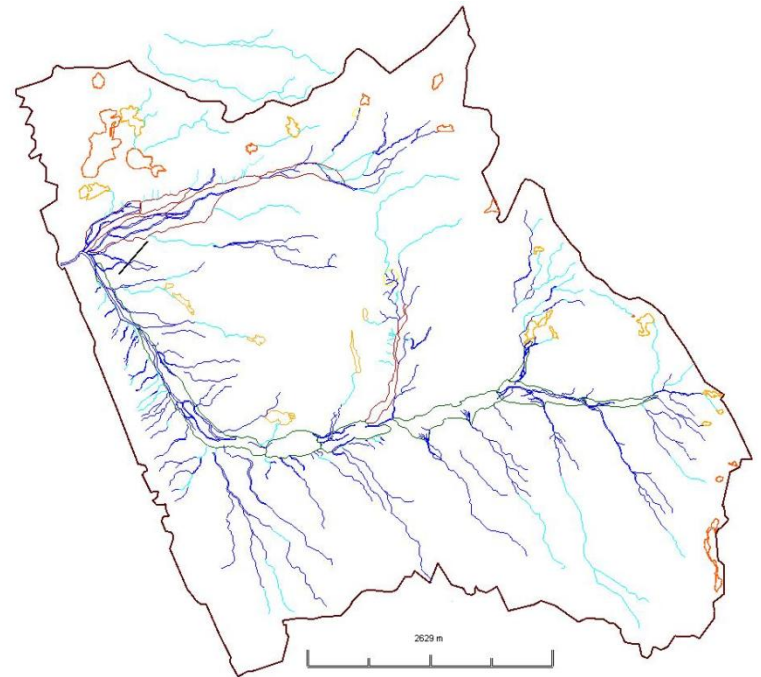
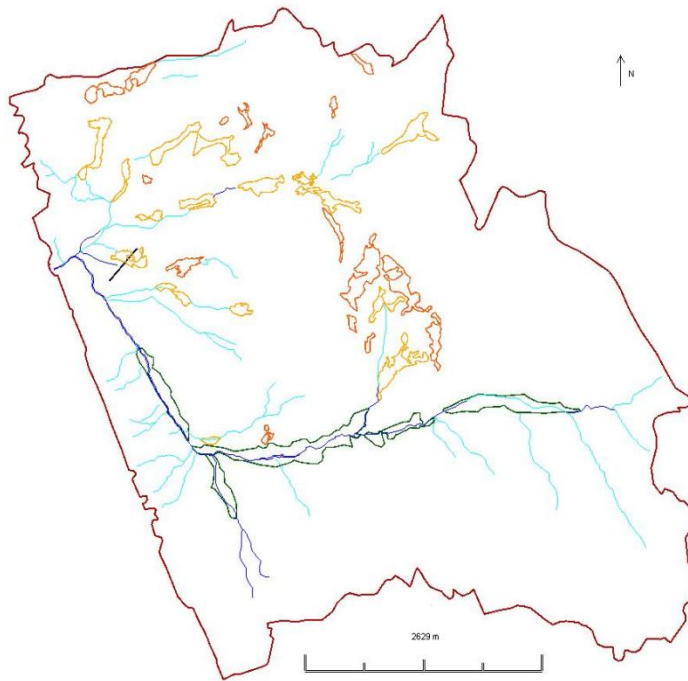


ESCAPE, Kick-off meeting, 14-15 Mars 2010, Paris  
WP1 'Détection et attribution des changements environnementaux

## shallow soils: Changes in Tin Adjar catchment, 16° N, 1954 - 2008

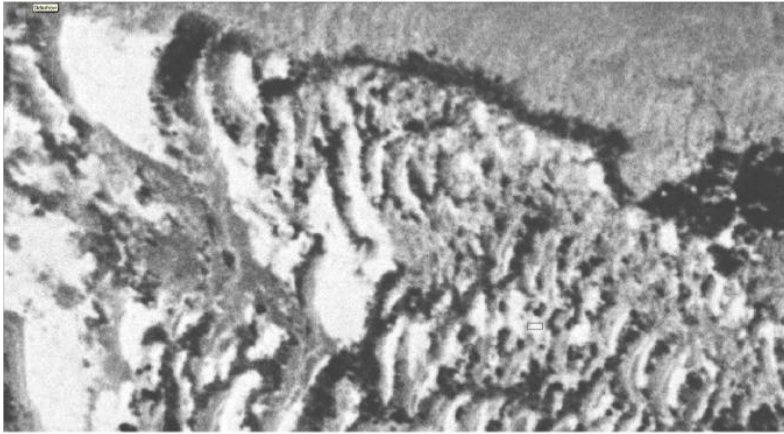
1954

2008



Ramarohetra 2010

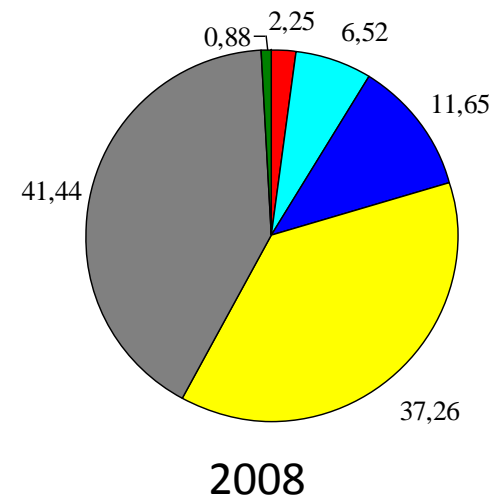
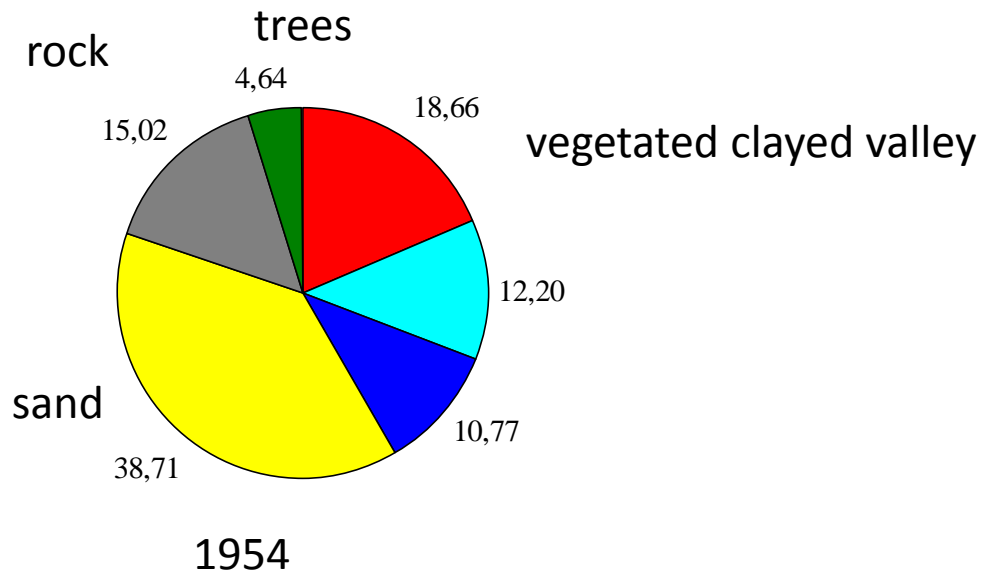
On shallow soils, increased runoff, vegetation decay, soil erosion



**CORONA. 15/10/1965**

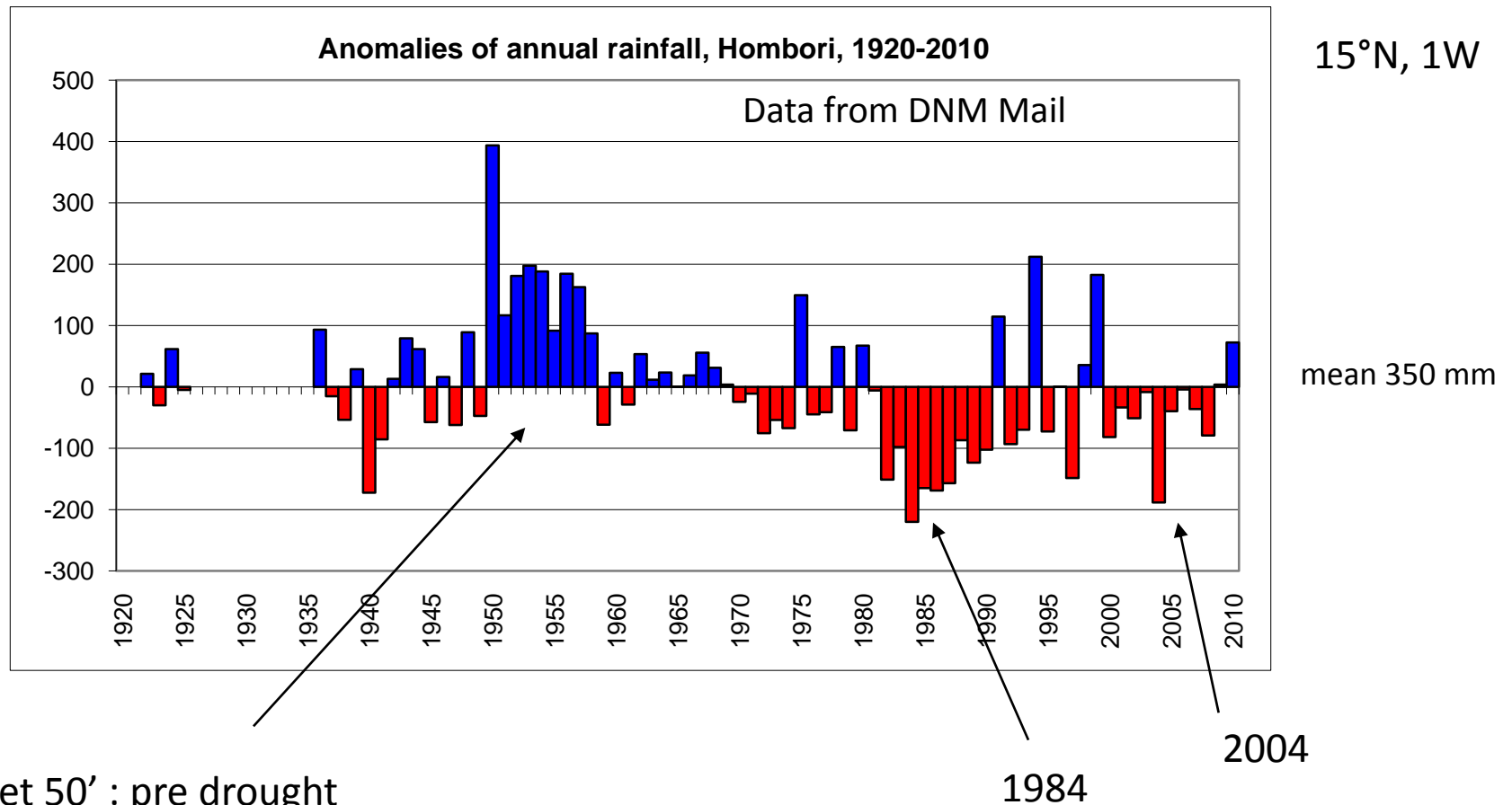


**SPOT 28/12/03**



# Monitoring the Sahel drought

Largest multi decadal precipitation change,  
huge impact on population (water, food)

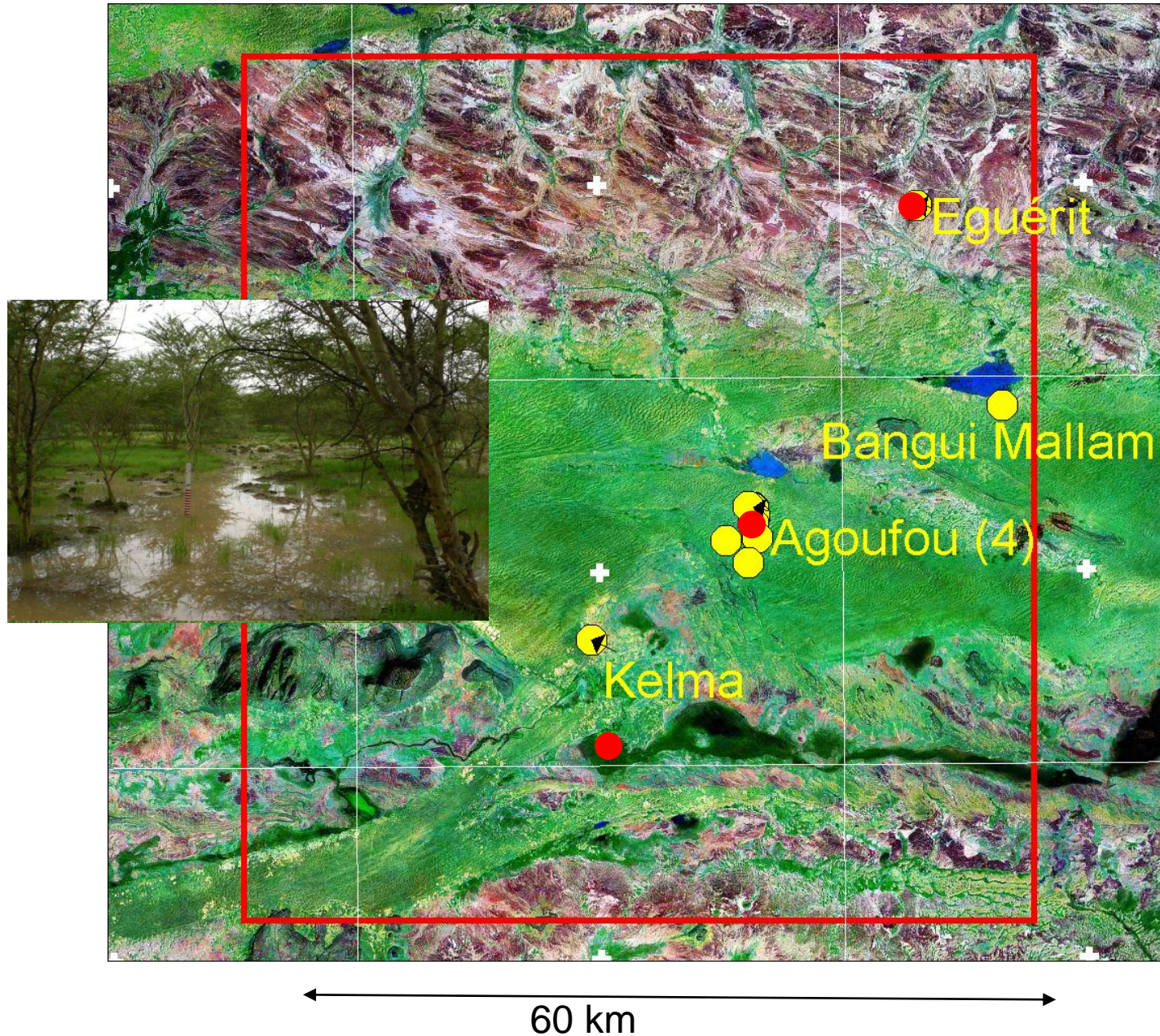


wet 50' : pre drought

drought still important, maybe a recent trend towards recovery

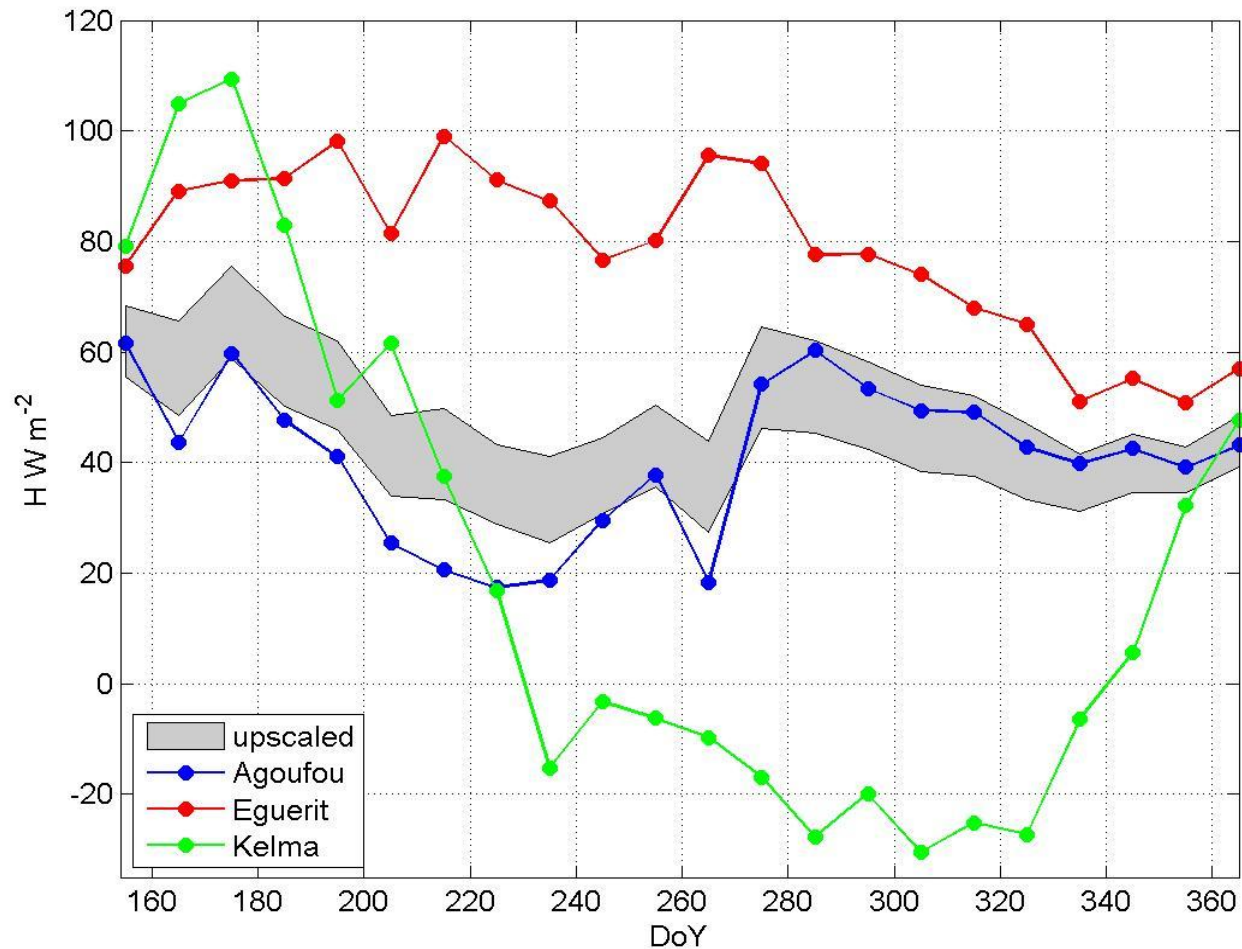


# The Hombori supersite : 3 main landscape units





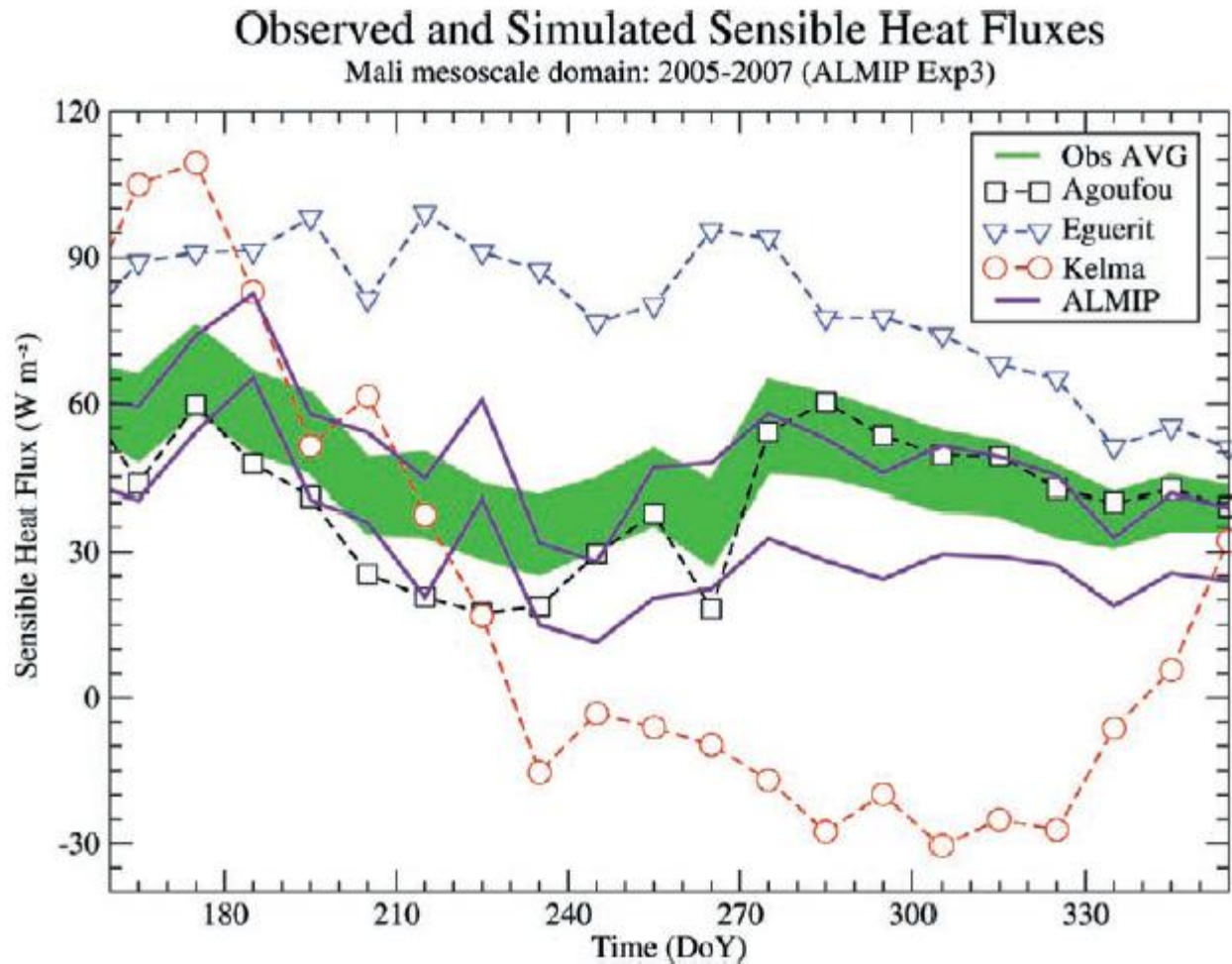
# Seasonal cycle : sensible heat flux. Importance of surface runoff





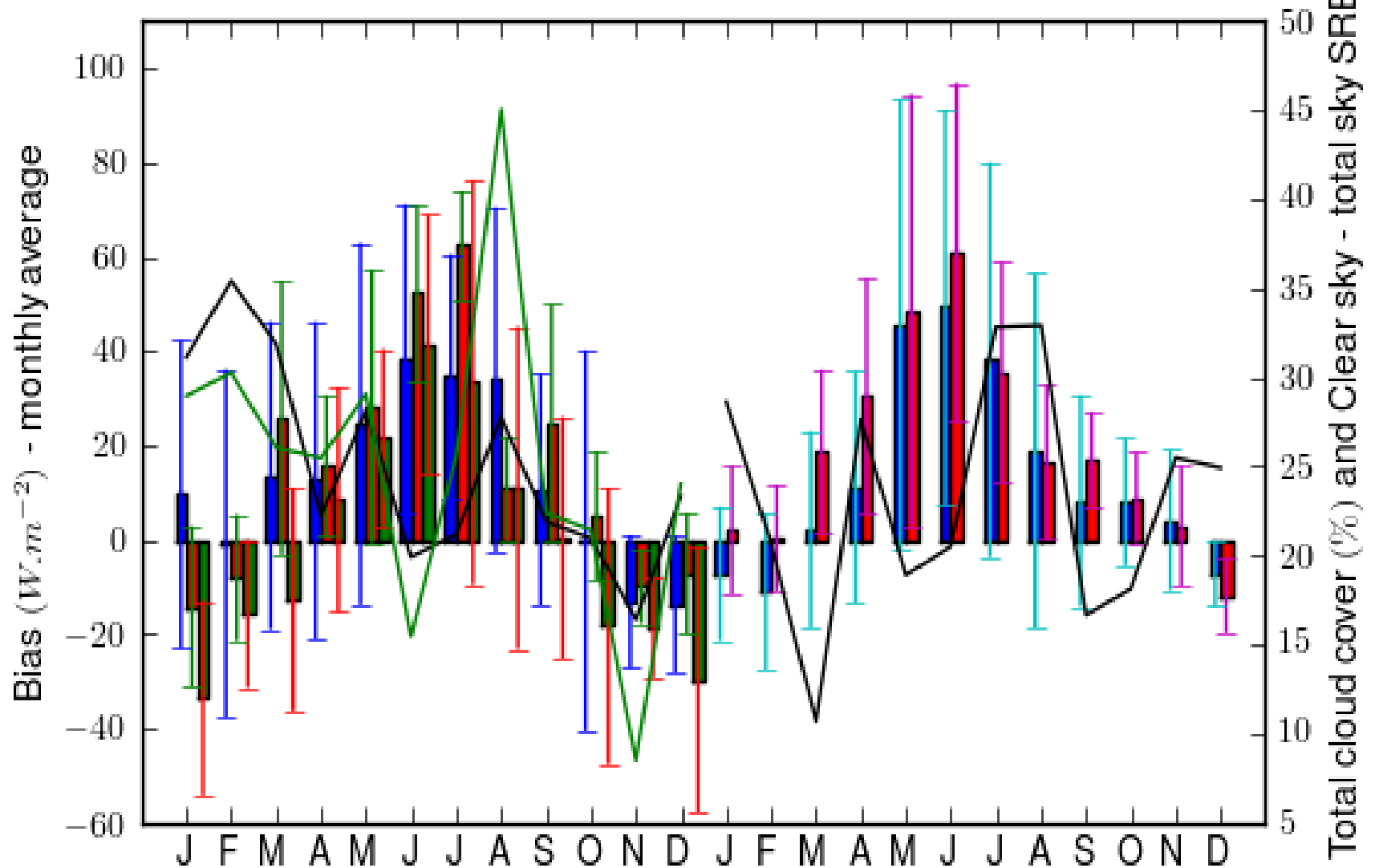
# Evaluation of LSM: ALMIP exercise

fair agreement for H flux but ....



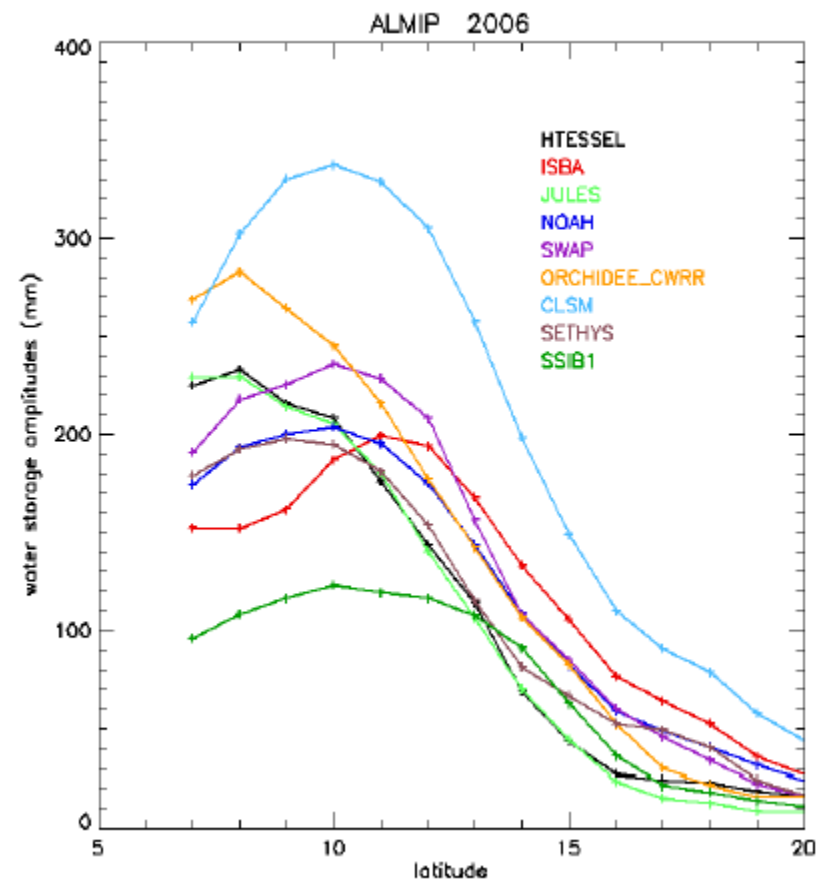
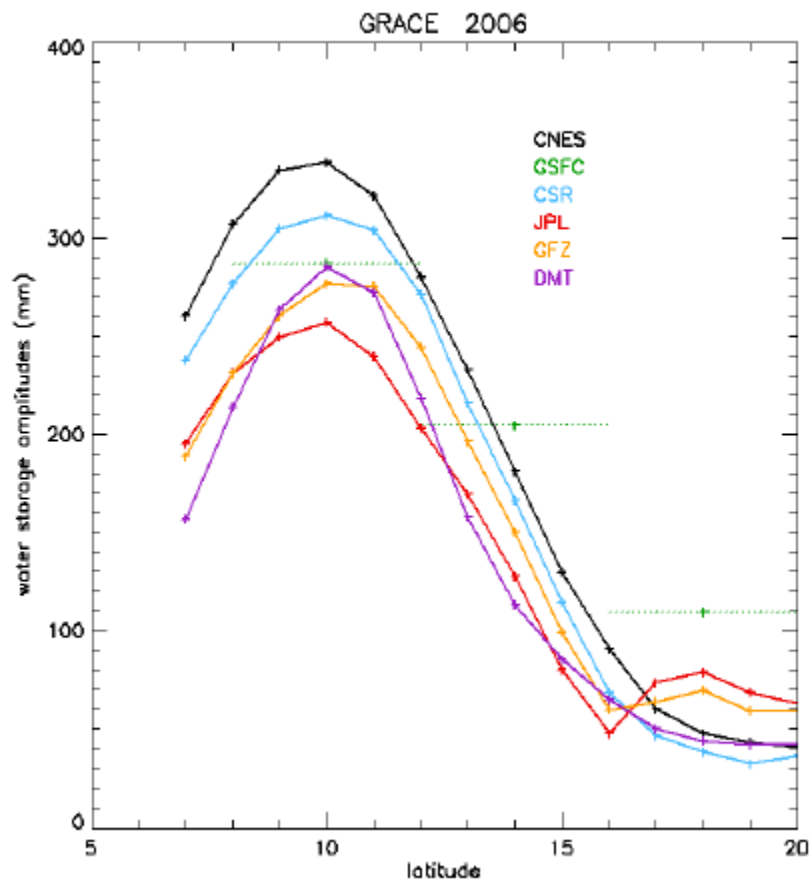
# Evaluation of satellite LandSAF and gewex-SRB products, ECMWF ISF and AMMA re-analysis surface incoming radiation

**large** overestimation of SWinc mainly due to dus (reverse for LW !)



and ...

**ALMIP / GRACE significant differences in annual amplitude of soil moisture, partly due to dry season ETR.**

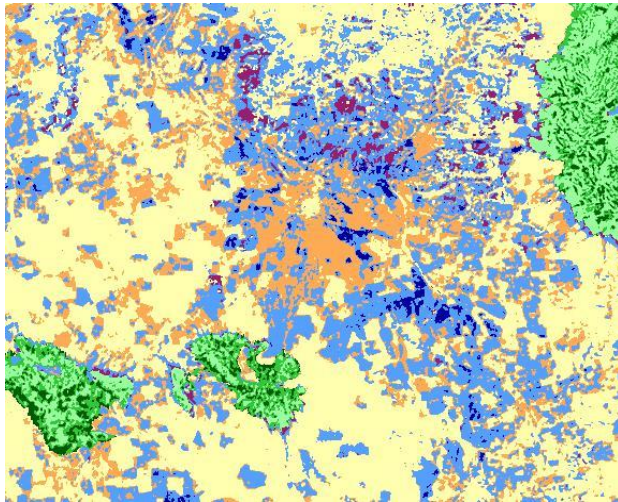


Grippa et al 2010, WRR, in revision

**ALMIP 2 : mesoscale LSM model/data comparison, starting 2011 !**

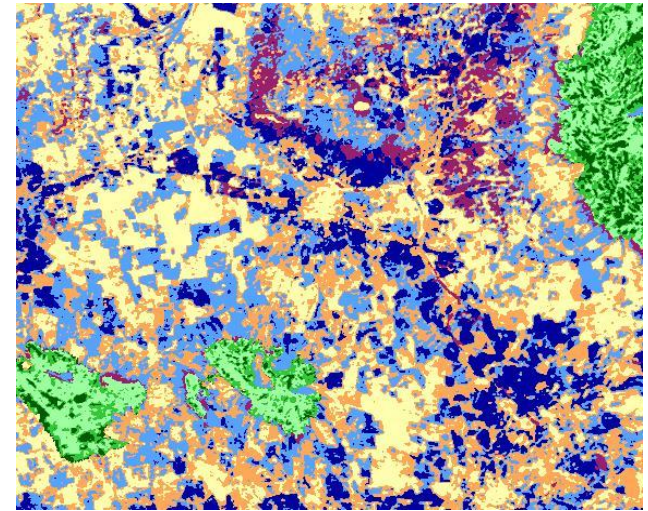
# Land surface Remote sensing : Extending surface properties in space and time

## Looking backwards



crop extension  
in Niger

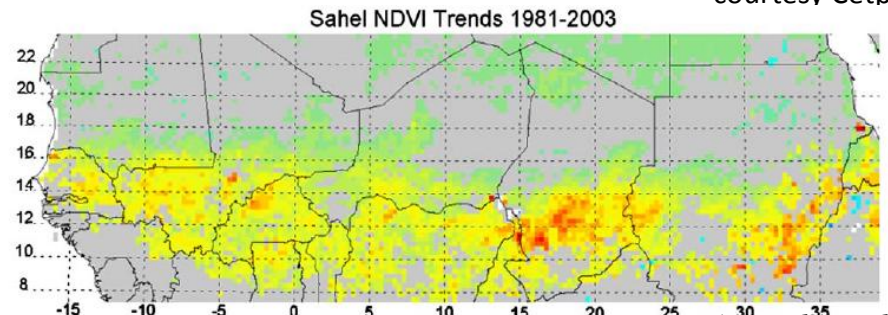
1986 - 2002



courtesy Cetp Hsm

historical data : AVHRR  
Sahel vegetation partial recovery ?

## Preparing the future



SMOS mission : contribution from AMMA = unique network for Cal/Val