Impacts of recent climate variability, CO2 concentration and land use change on African terrestrial productivity and soil moisture

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➢**Motivations**

➢**Model and simulations set up vs data product for evaluation**

➢**Some results**

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➢ New climate forcing (WFD) and latest versions of remote sensing data (GIMMS NDVI3g, SM-MW and MTE-GPP) for model evaluation.

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➢ What are the African eco-climatic regions that have the largest inter-annual variability and what are the underlying climatic drivers?

➢ Did land-use changes affect the inter-annual and decadal response of GPP over the last 30 years?

ORCHIDEE model

Meteorological variables
Prescribed or calculated by LMDZ model

rainfall, temperature, wind, solar radiation, CO2 concentration

Sensible and latent heat fluxes, albedo, roughness, surface temperature, CO2 flux…

Biosphère

STOMATE
Cycle du carbone
Végétation – Sol
Phenologie, allocation
$\Delta t = 1$ day

LAI, rugosité, albedo

SECHIBA
Bilan énergétique & hydrologique
Photosynthèse
$\Delta t = 1/2$ hour

Profils de température et d'eau du sol, GPP

NPP, biomasse, litière …

Types de végétation

Distribution de la végétation (PFT)
(prescrite ou calculée) $\Delta t = 1$ year

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Carte de végétation
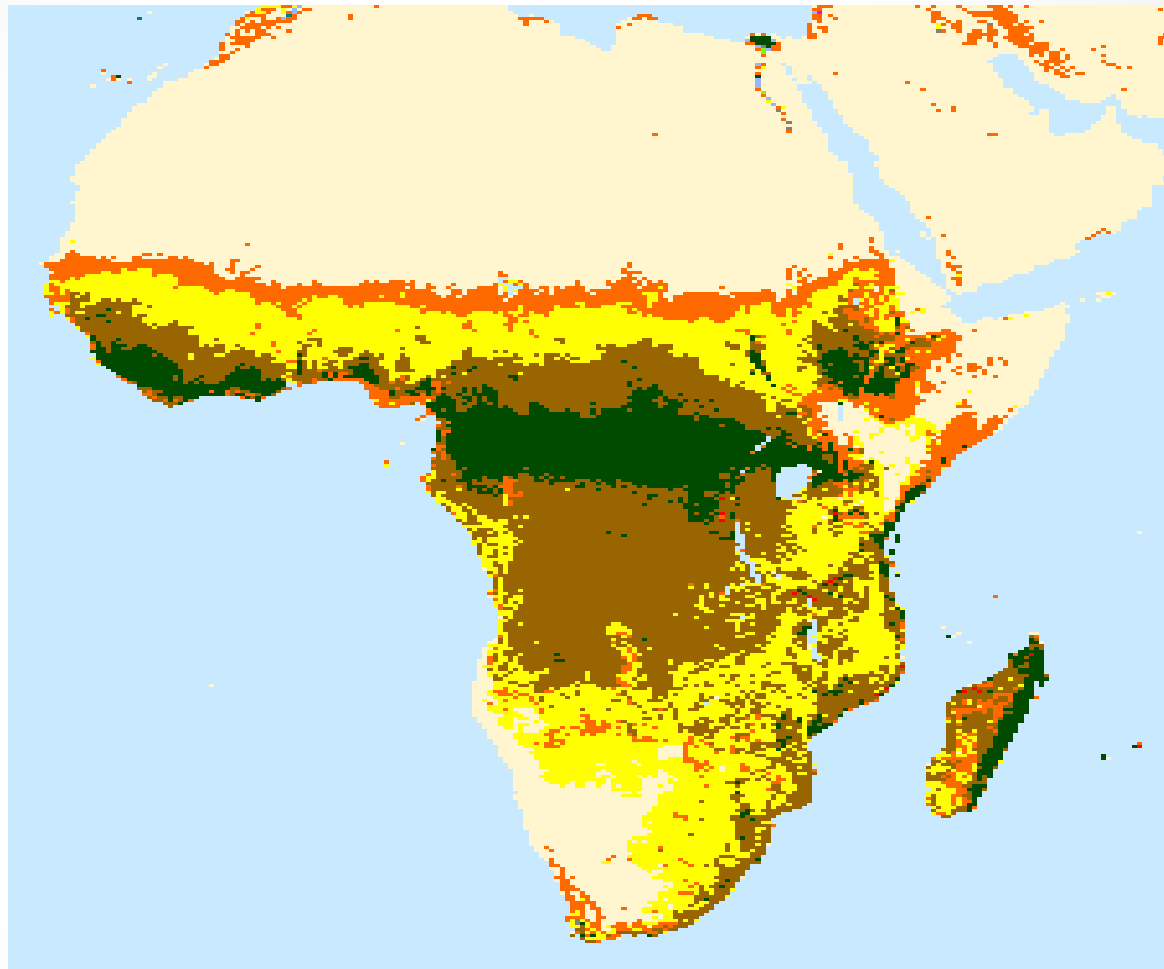
Legend:
- Woody Savannas
- Savannas
- Grasslands
- Croplands
- Bare Soil
- Evergreen Broadleaf Forests

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Simulations set up and data product

> **Climate forcing**: WFD (1979-2001 ERA-40 bias corrected) and ERA-Interim (2002-2010)
> **Land use change**: based on Fader et al (2010).
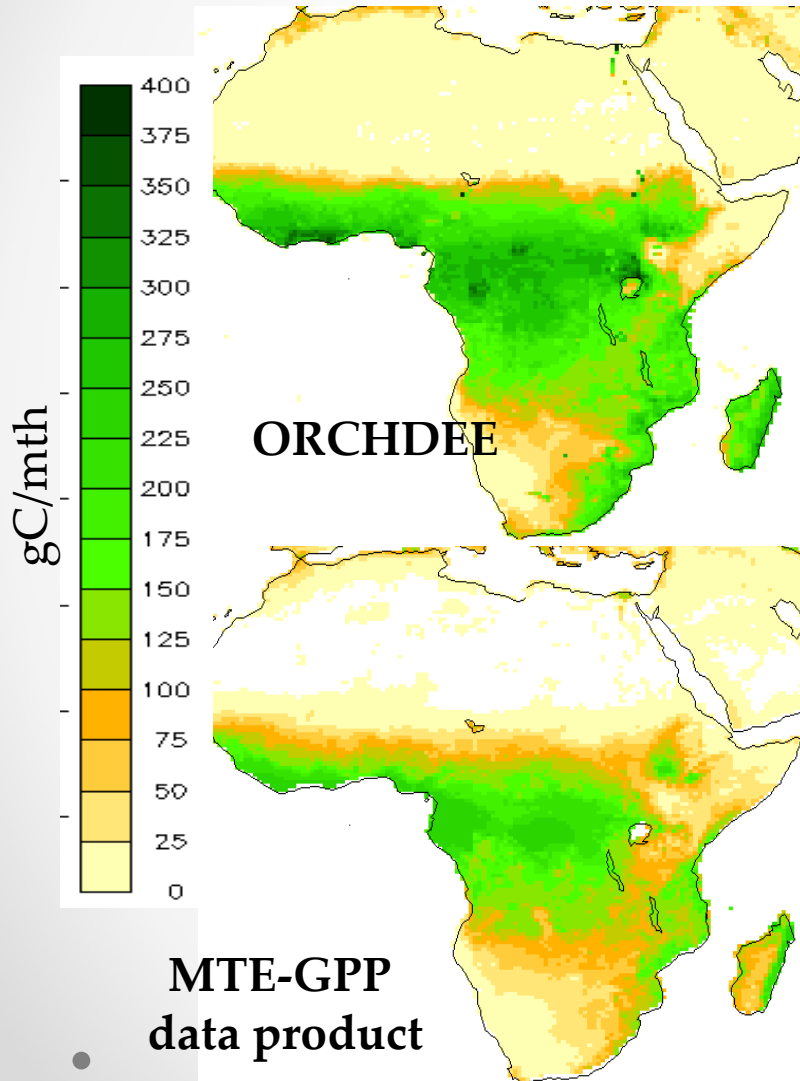> **Spatial resolution** : 0.5 degree

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➢ **NDVI3g & fPAR3g**: 1982-2010 (Zaichun et al. 2012)

➢ **SM-MW**: soil moisture microwave from ESA (Wagner et al 2012).

➢ **MTE-GPP** : 1982-2010 (Jung et al. 2008, 2011)

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experiment	Transient CO2	Dynamic land use	Irrigation
CO2LUCIRR	Yes	Yes, to 2005	Yes
CO2LUC	Yes	Yes, to 2005	No
CO2IRR	Yes	No, year 2000	Yes
IRR	No, 1901's value	No, year 2000	Yes

Evaluation de la GPP et du fPAR

1982-2010 average

GPP

ORCHDEE

MTE-GPP
data product

Evaluation de la GPP et du fPAR

1982-2010 average

GPP

fPAR

ORCHDEE

MTE-GPP
data product

ORCHDEE

fPAR3g

Evaluation de la GPP et du fPAR

1982-2010 average

GPP

fPAR

ORCHDEE

ORCHDEE

gC/mth

MTE-GPP
data product

fPAR3g

ORCHIDEE succeeds in representing the geographical pattern of GPP and thus the fPAR but overestimates these two variables
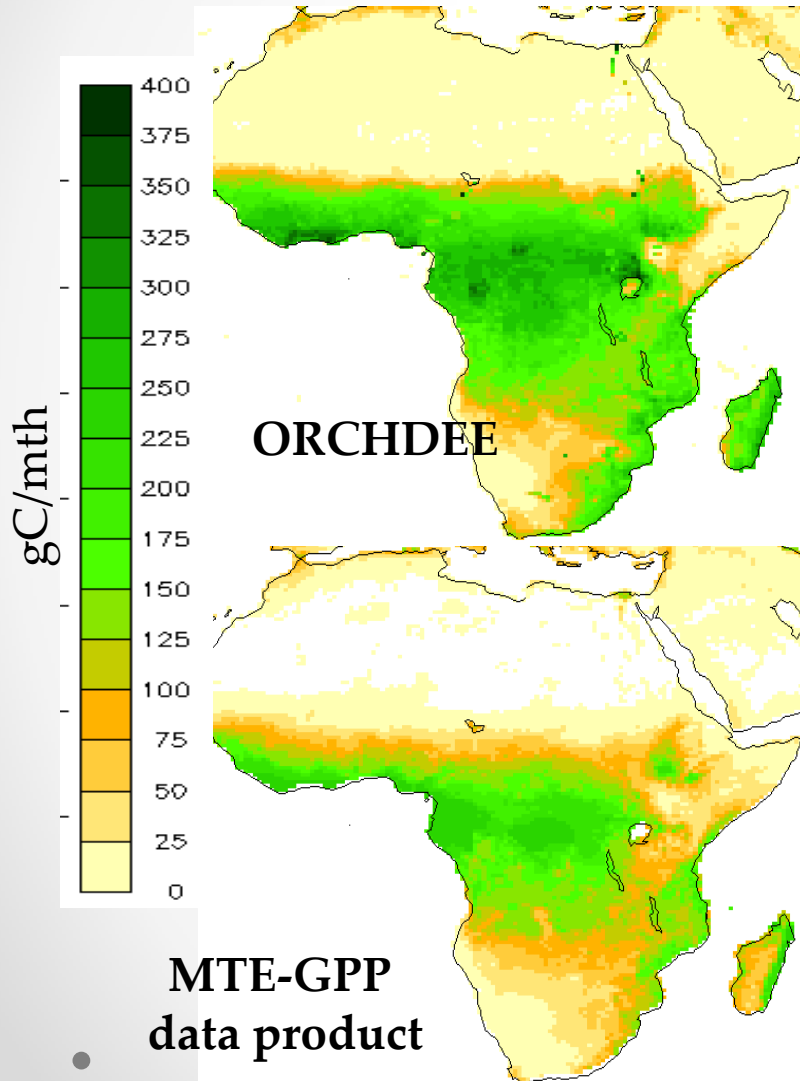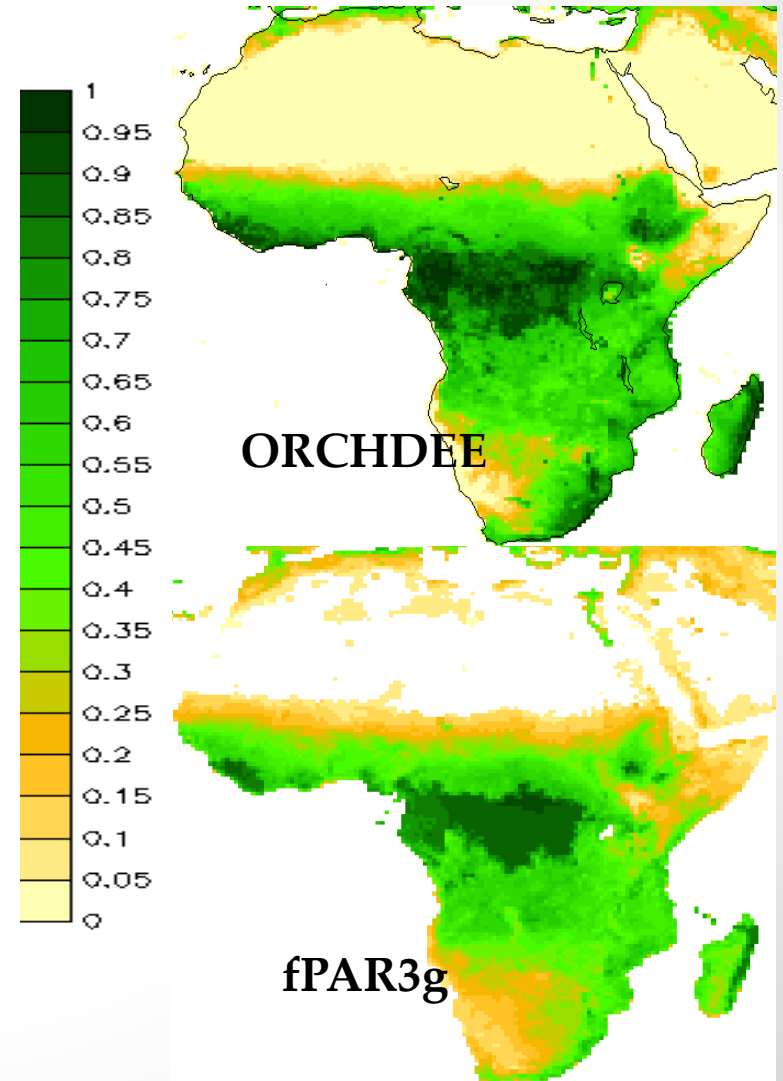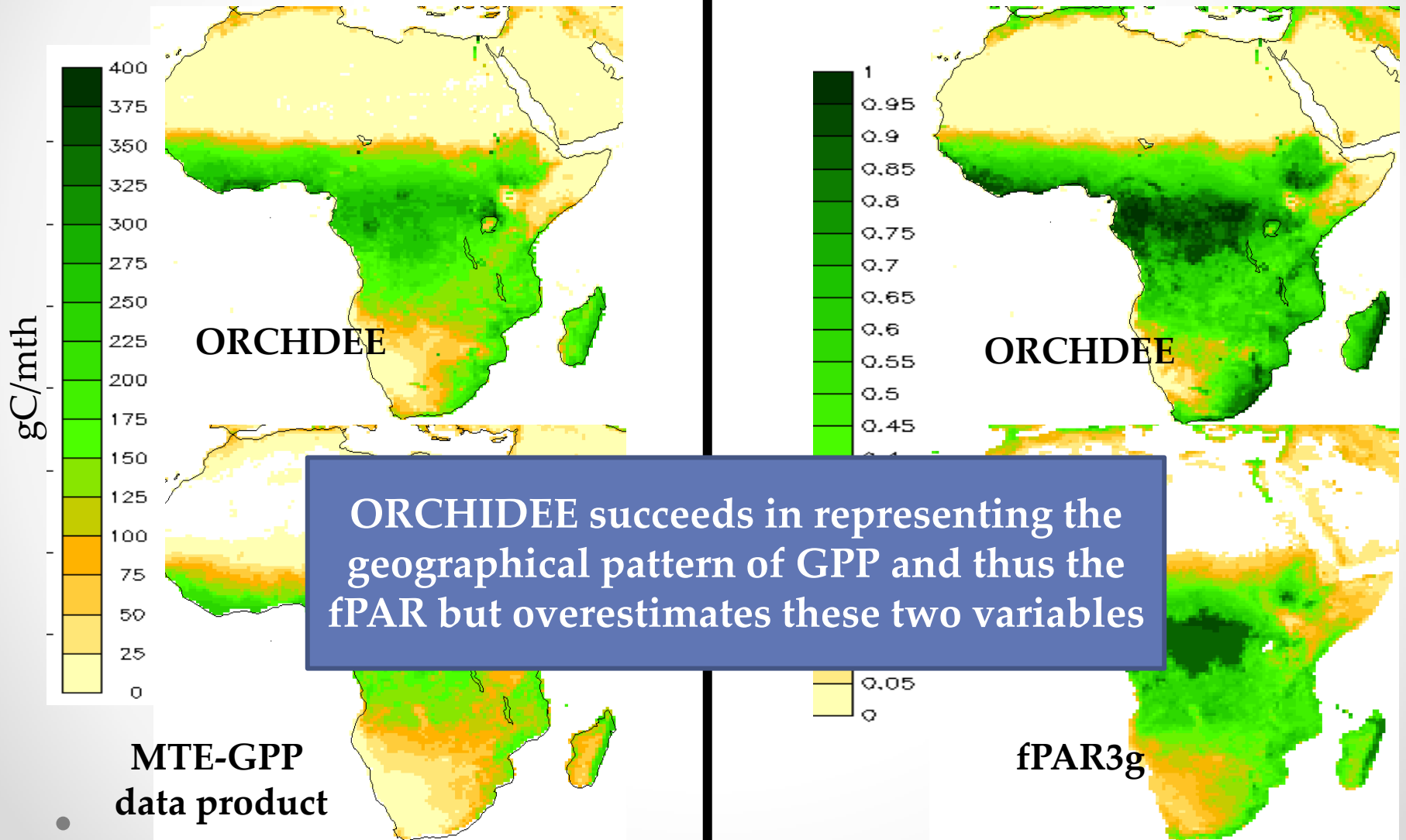
Inter-annual fPAR, GPP and SM
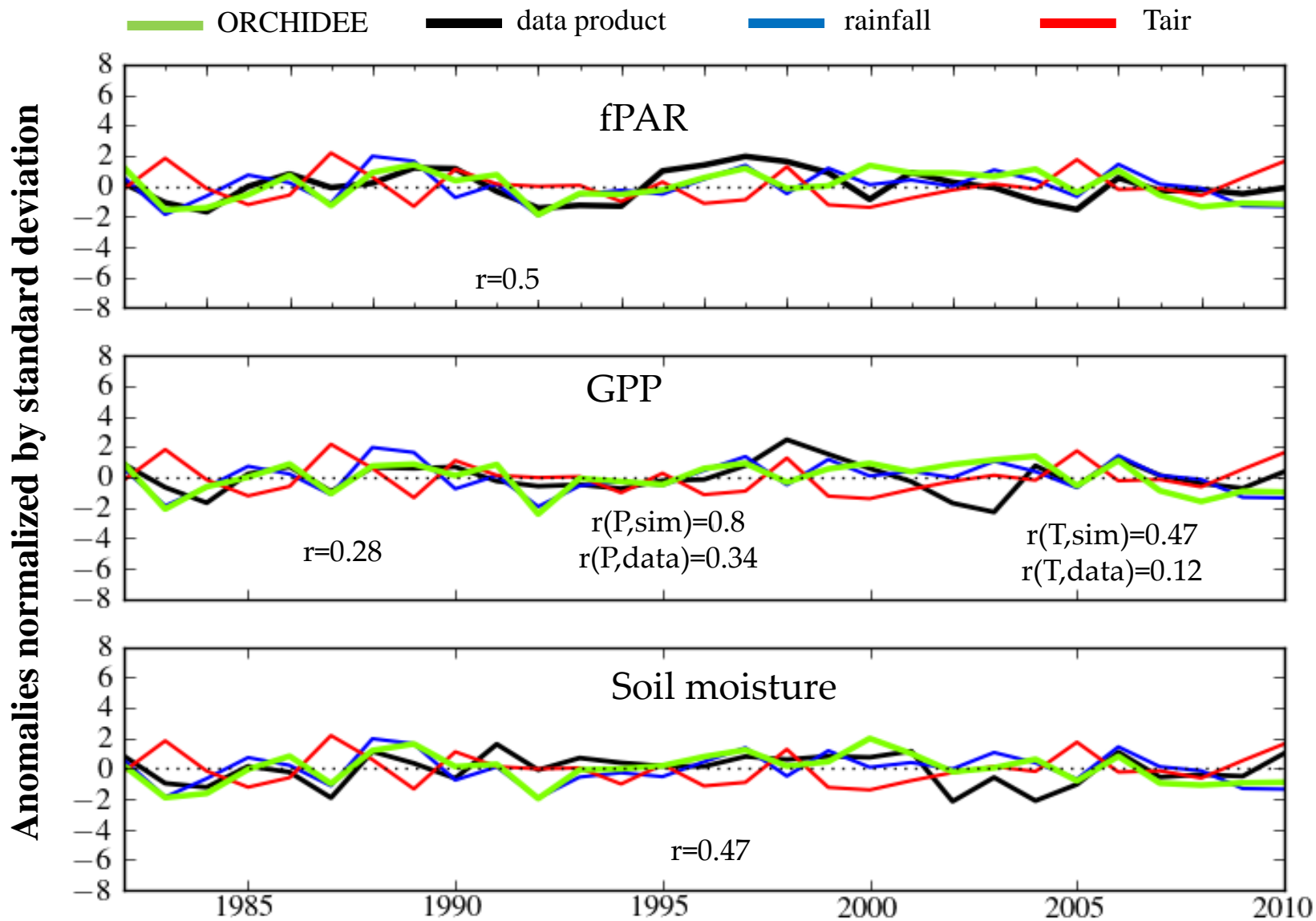
Inter-annual fPAR, GPP and SM
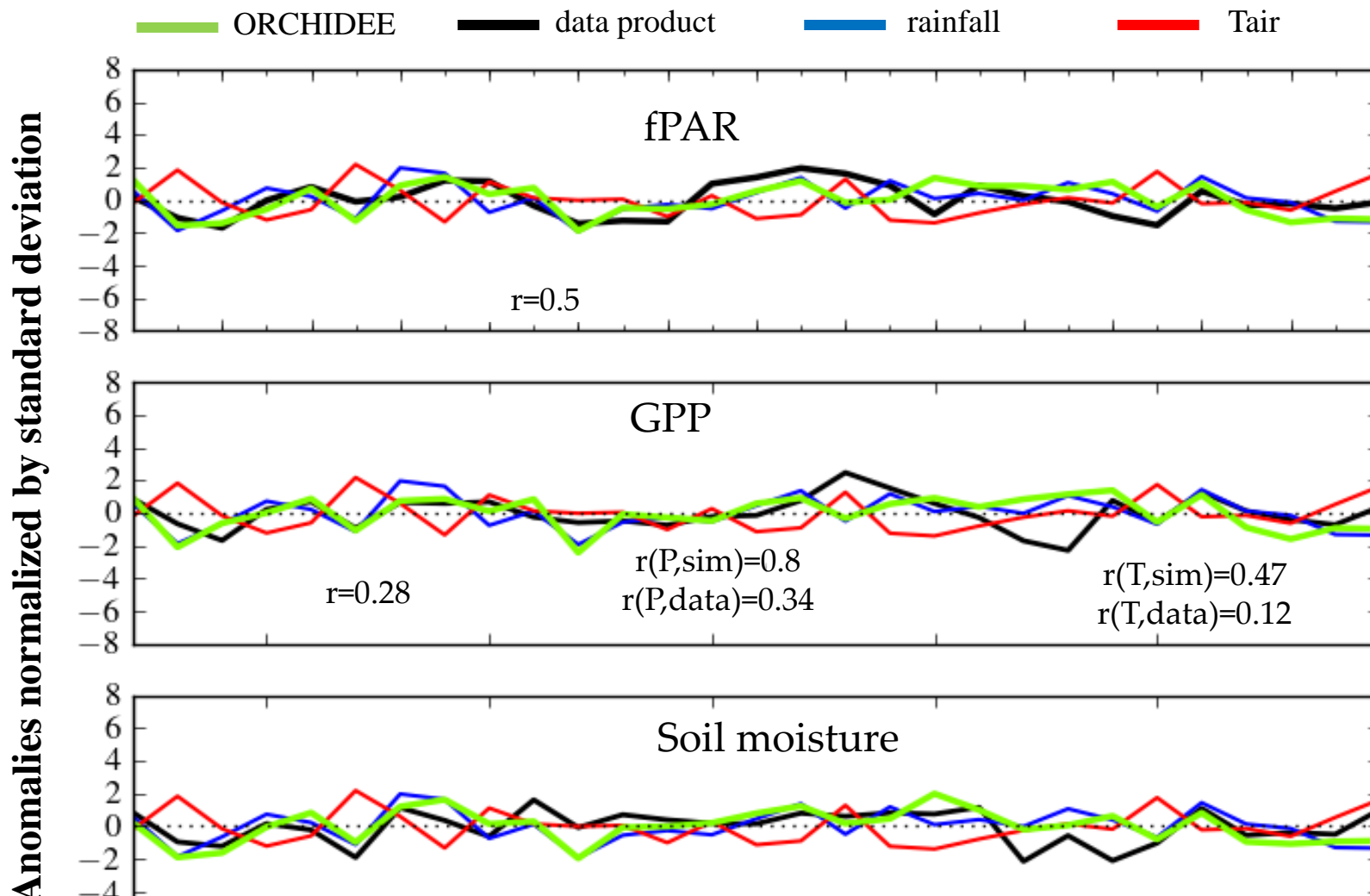
- ➤ Good representation of the inter-annual variability per standard deviation unit.
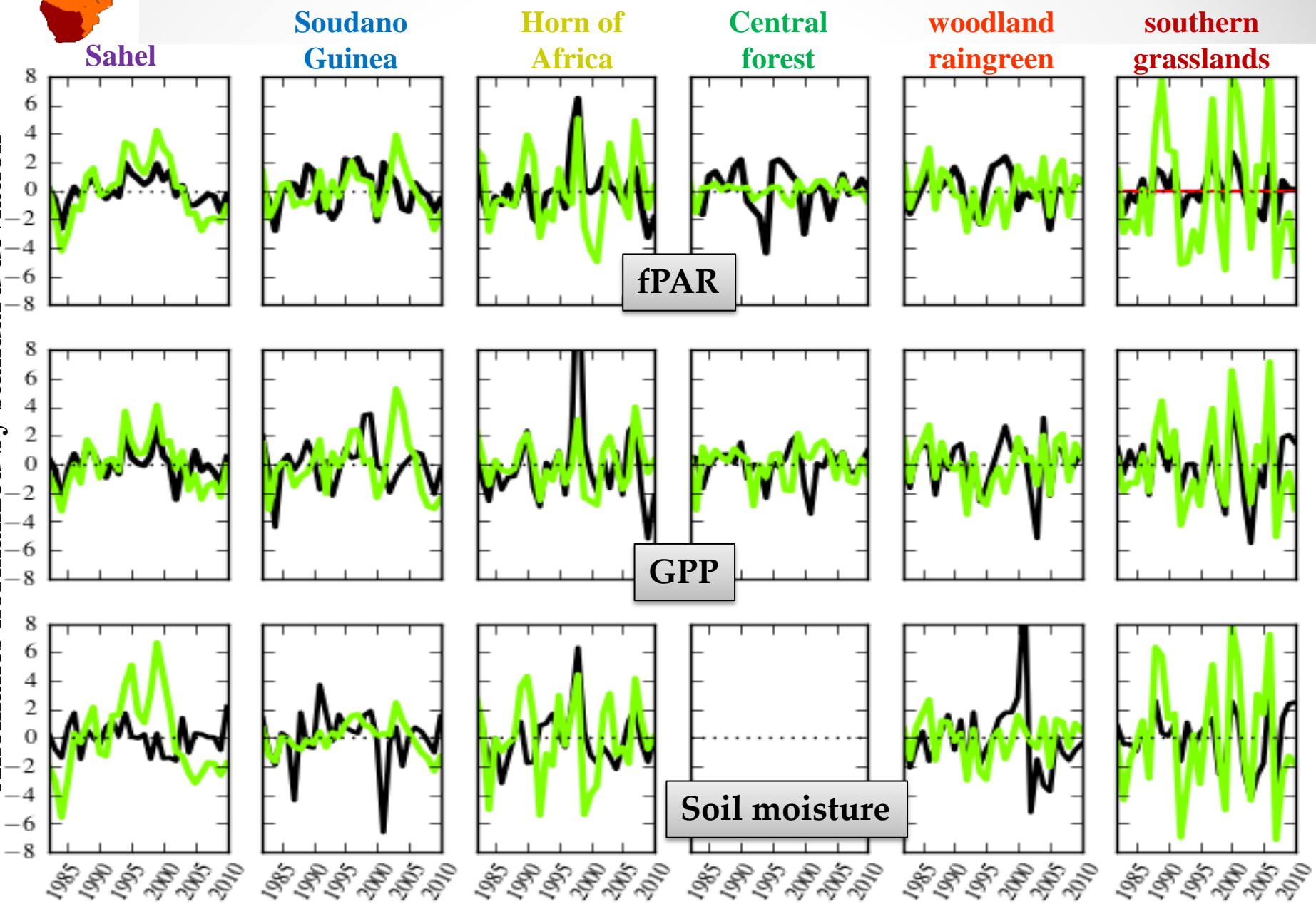- ➤ Over sensitivity to inter-annual rainfall forcing
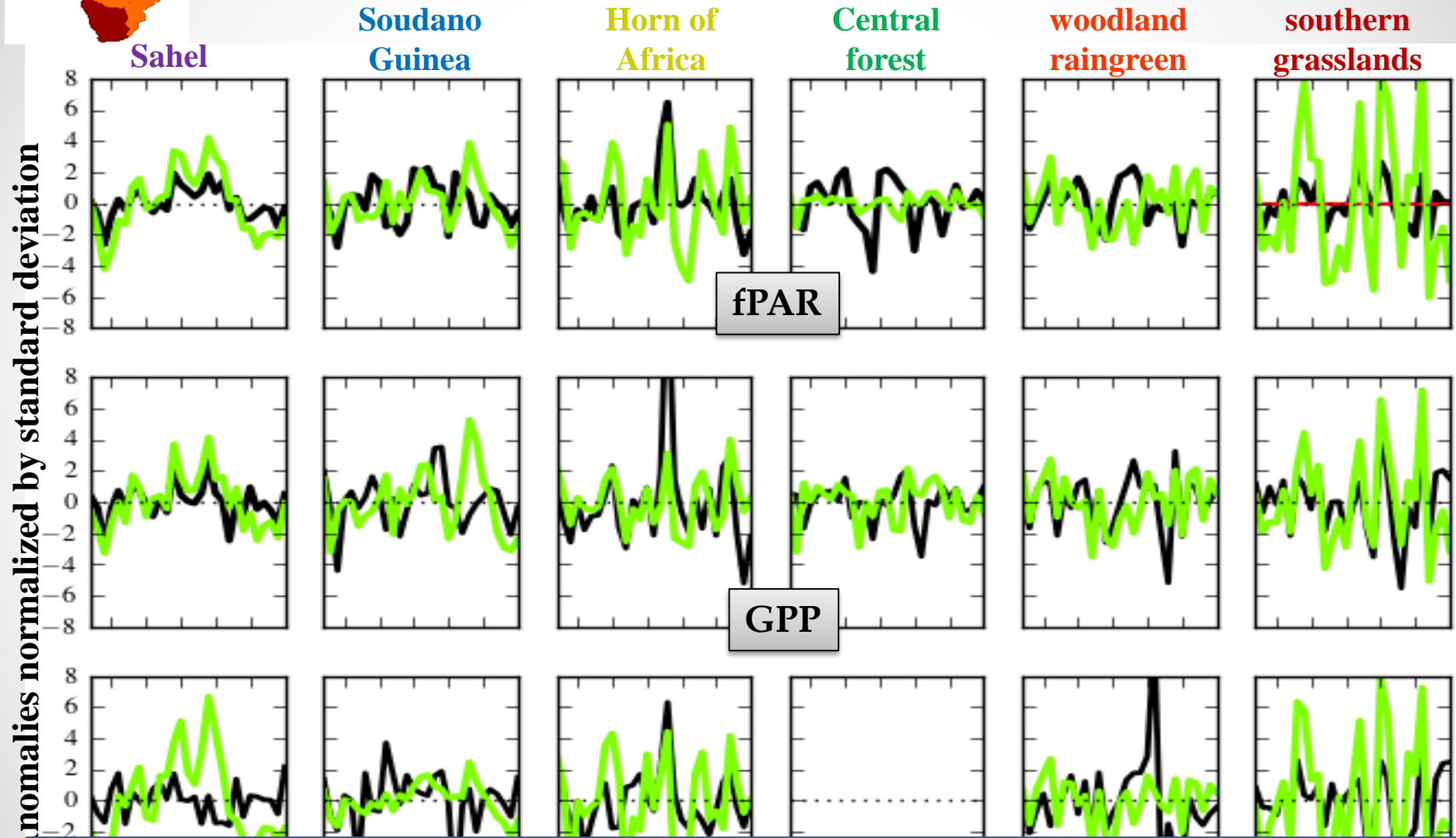
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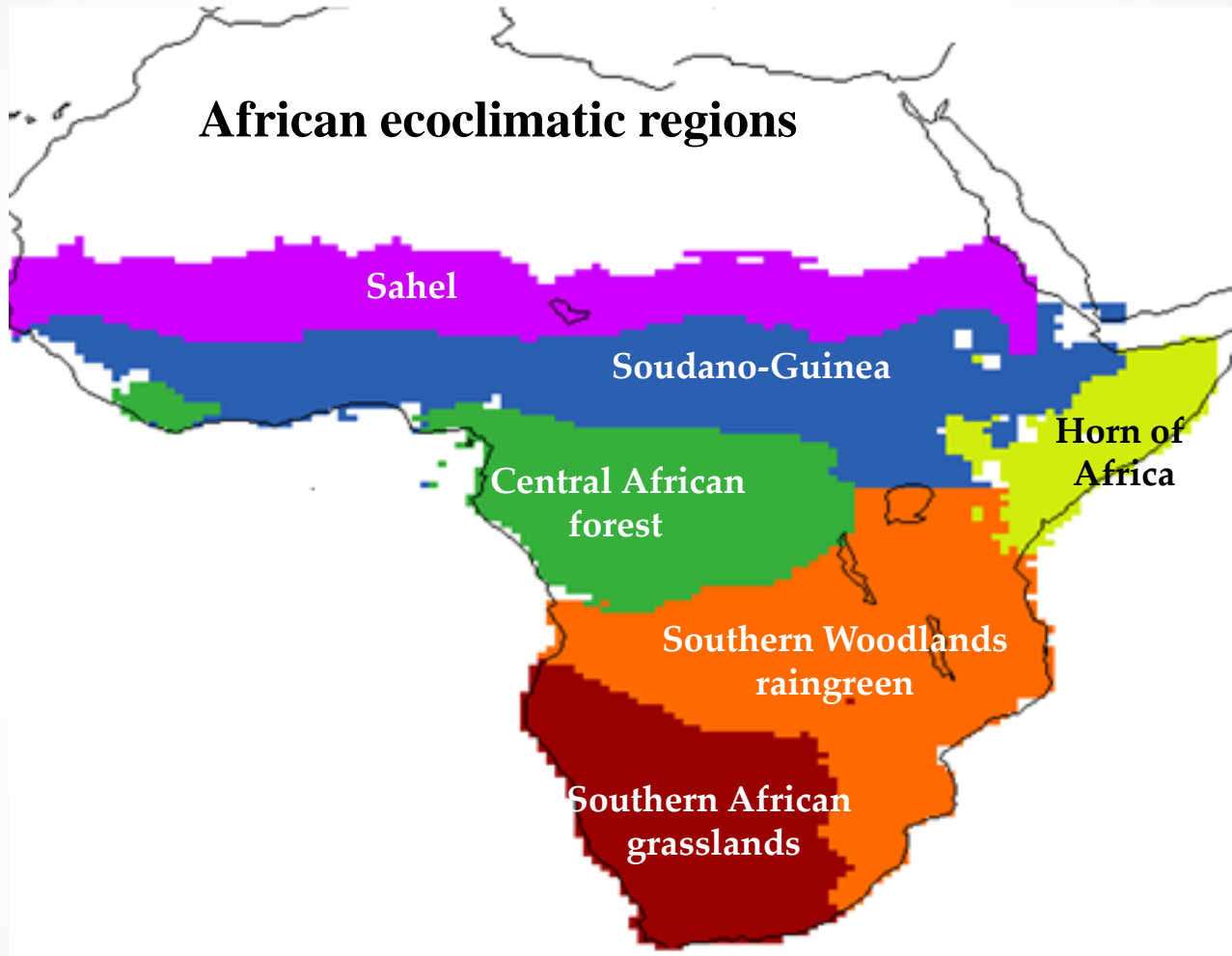
African ecoclimatic regions

Sahel

Soudano-Guinea

Horn of Africa

Central African forest

Southern Woodlands raingreen

Southern African grasslands
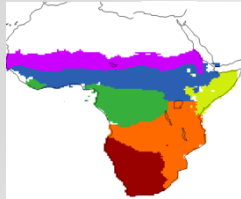
Inter-annual fPAR, GPP and SM

Inter-annual fPAR, GPP and SM

GPP and soil moisture inter-annual variabilities are the largest in savannah dominated regions (Sahel, Horn of Africa and southern African grasslands).
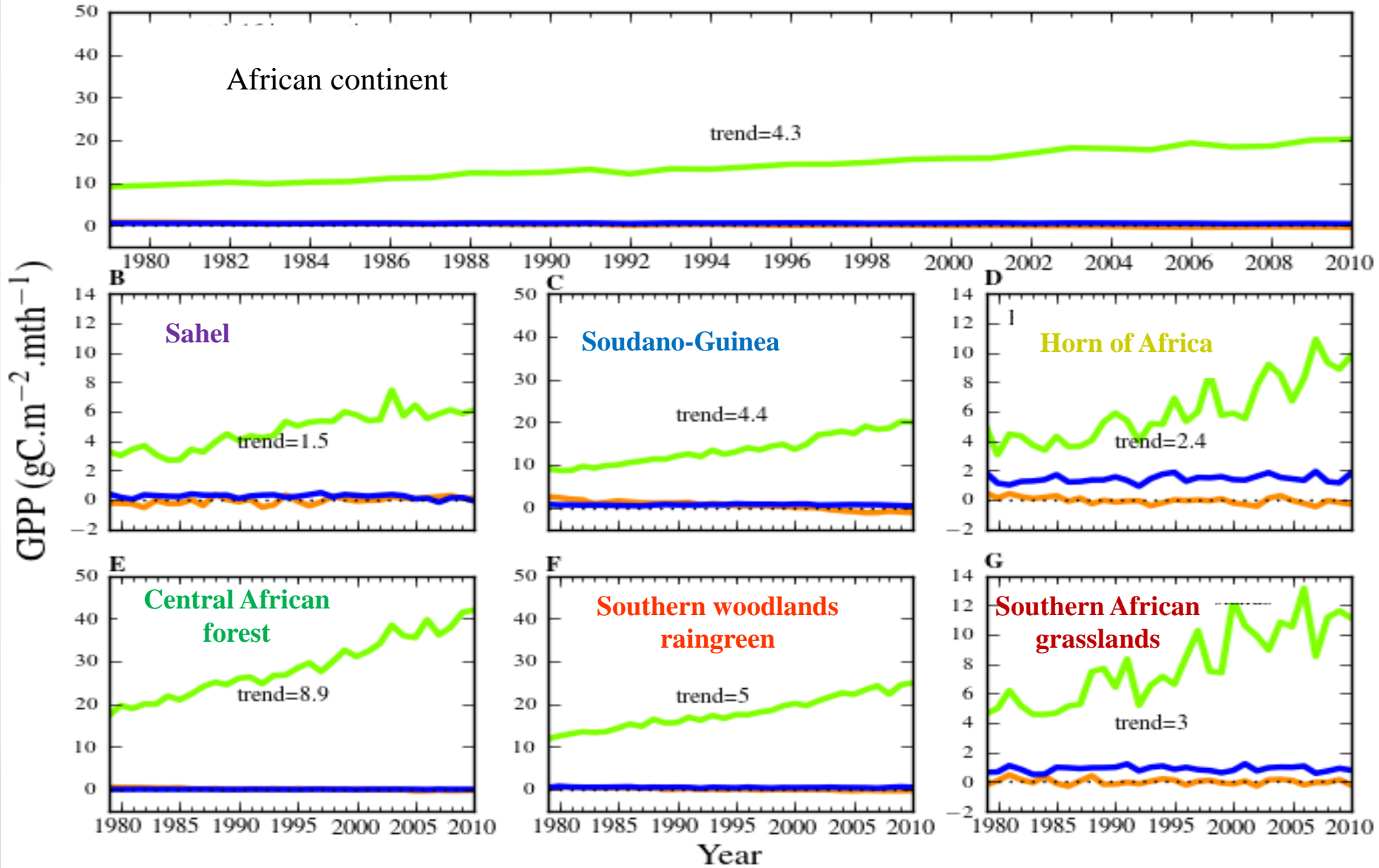
Inter-annual GPP and CO2 effect

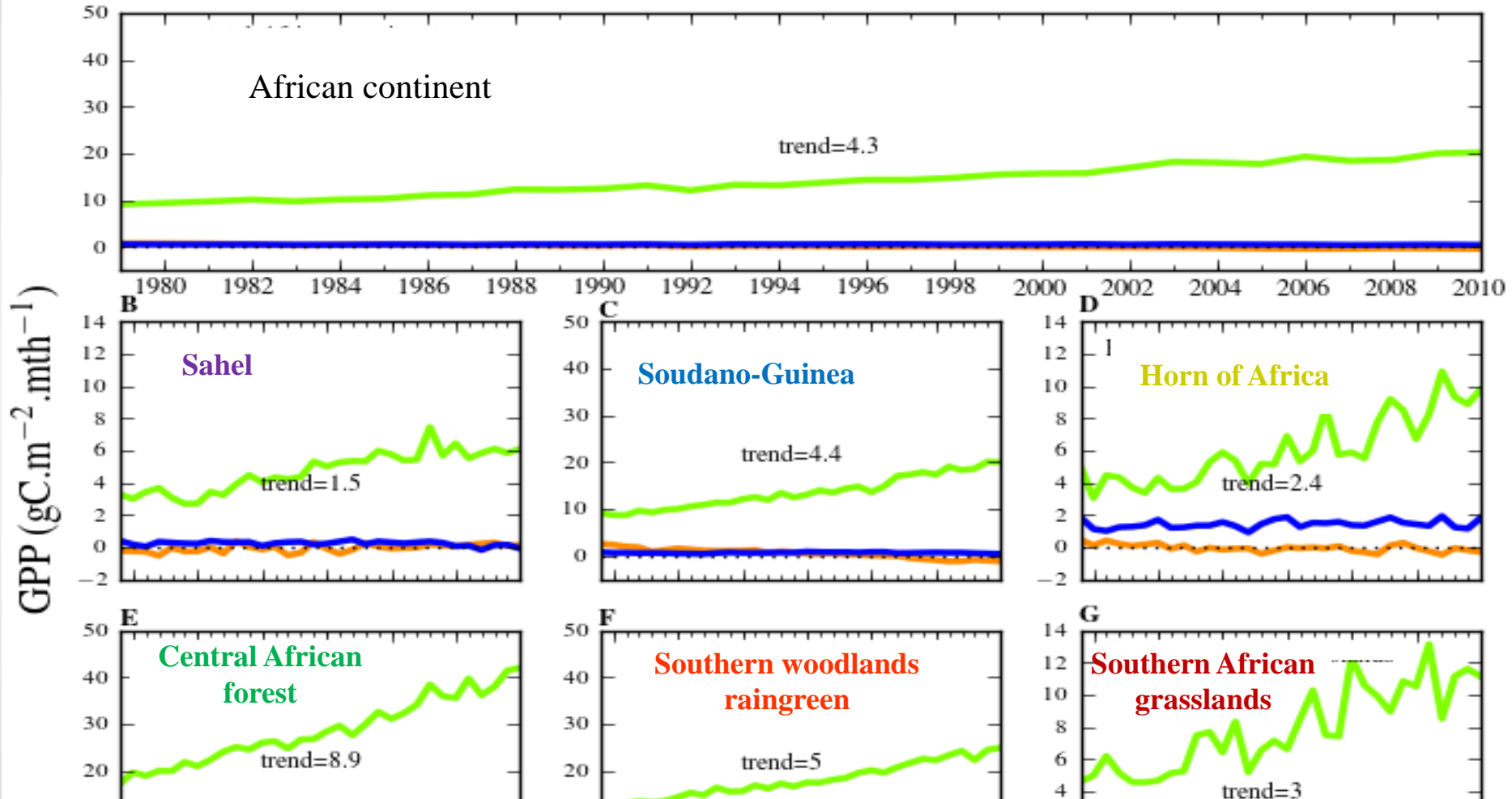Legend: GPP due to CO2 — GPP due to LUC — GPP due to irrigation

African continent, trend=4.3

B — Sahel, trend=1.5
C — Soudano-Guinea, trend=4.4
D — Horn of Africa, trend=2.4
E — Central African forest, trend=8.9
F — Southern woodlands raingreen, trend=5
G — Southern African grasslands, trend=3
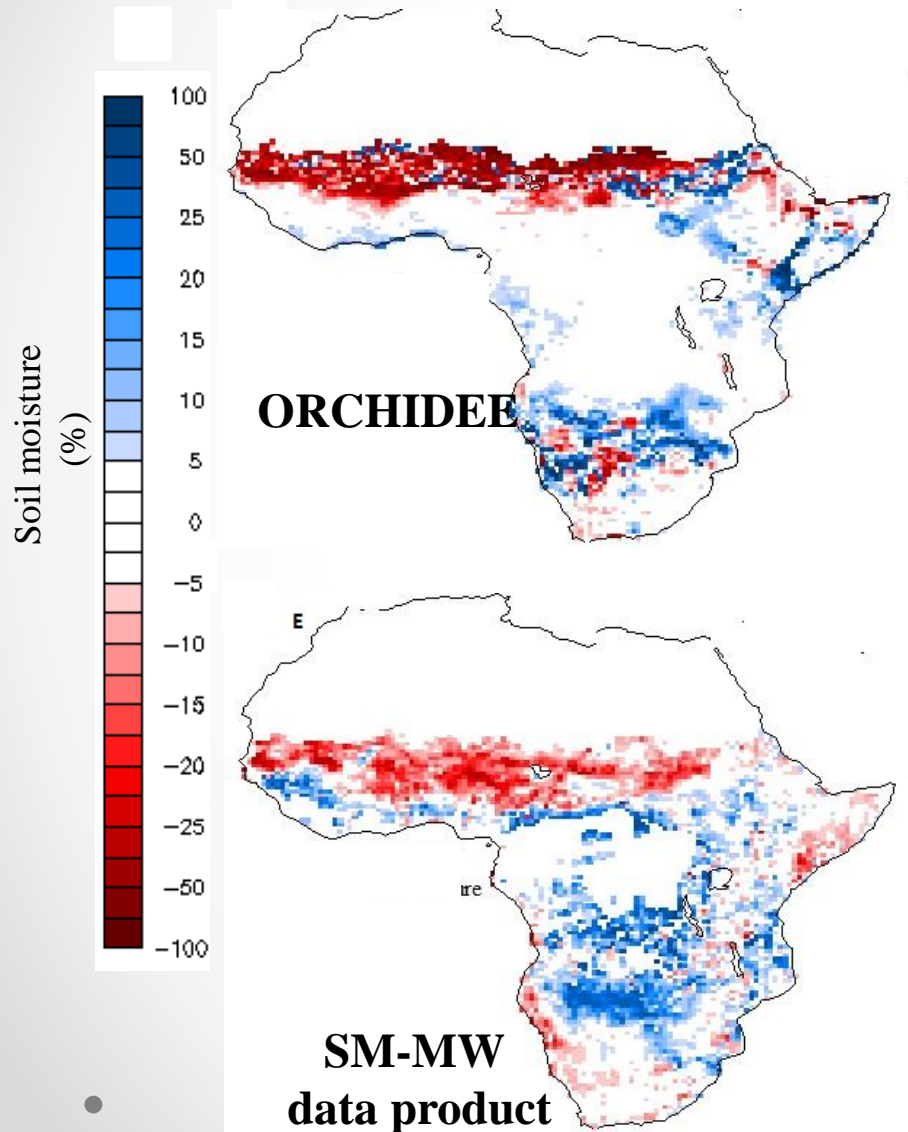
GPP (gC.m^{-2}.mth^{-1})

Year

Inter-annual GPP and CO2 effect

L'augmentation du CO2 atmosphérique entraîne une augmentation assez linéaire de la GPP sur tous les écosystèmes africains
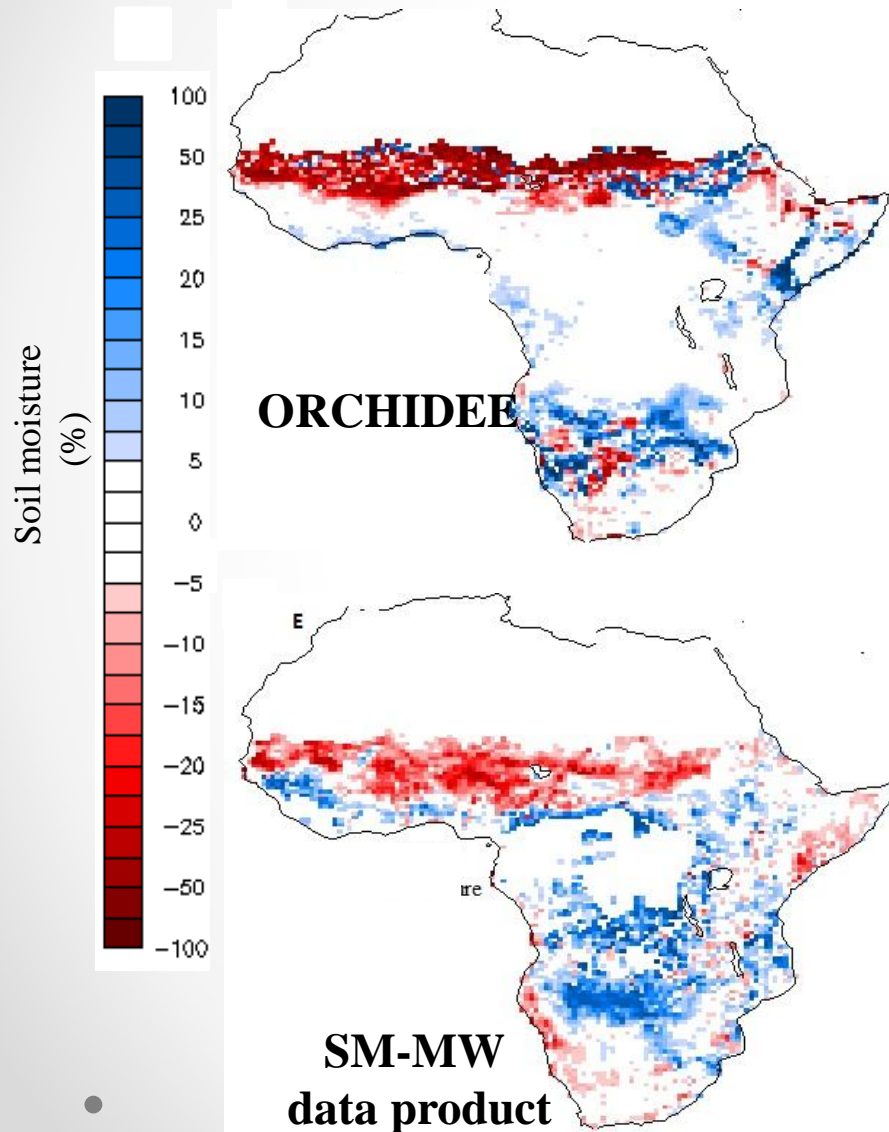
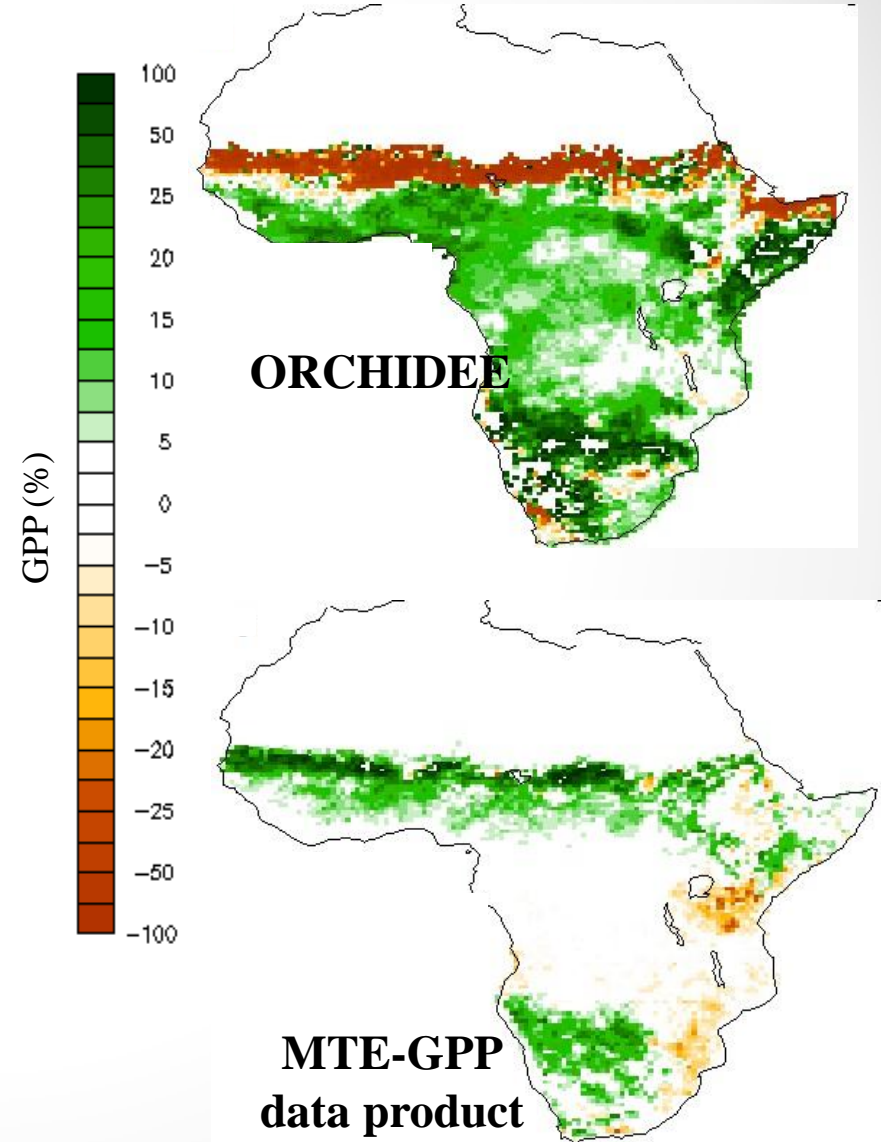# decadal change (2000-2010 minus 1980-1990)

Soil moisture

decadal change (2000-2010 minus 1980-1990)

Soil moisture

GPP

ORCHIDEE

ORCHIDEE

SM-MW
data product

MTE-GPP
data product

Résumé

Are African GPP and SM increasing or decreasing over the past 30 years at regional to continental scale, and why?

✓ Both, simulated GPP and data product (MTE-GPP) increase steadily over Africa.

✓ Both modeled Soil Moisture and data product (SM-MW) show a decrease over the Sahel and the Soudano-Guinea regions.

✓ 50% of the GPP increase in ORCHIDEE can be attributed to the CO_2 increase.

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Résumé

What are the African eco-climatic regions that have the largest inter-annual variability and what are the underlying climatic drivers?

✓ The savannahs-dominated regions show the largest inter-annual variability in GPP and soil moisture in both modeled and data product.

✓ ORCHIDEE model is over-sensitive to inter-annual rainfall forcing (r=0.80 correlation between ORCHIDEE GPP and rainfall against r=0.34 for data product

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Résumé

Did land-use changes affect the inter-annual and decadal response of GPP over the last 30 years?

- ✓ Moderate role of land use change in the simulated GPP trend, probably underestimated in the datasets.

- ✓ Sahel: more sensitive to land use change than to CO2 in the sahelian water use efficiency

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Merci de votre attention

No one trusts a model except the man who wrote it; everyone trusts an observation except the man who made it (Harlow Shapley)

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