



Met Office

# Understanding and predicting of local climate

## drivers over Africa using the new Met Office RCM

**Wilfran Moufouma-Okia**

Thanks to Richard Jones and José Rodriguez

4<sup>th</sup> AMMA conference, Toulouse, 2-6 July 2012



# Outline of the talk

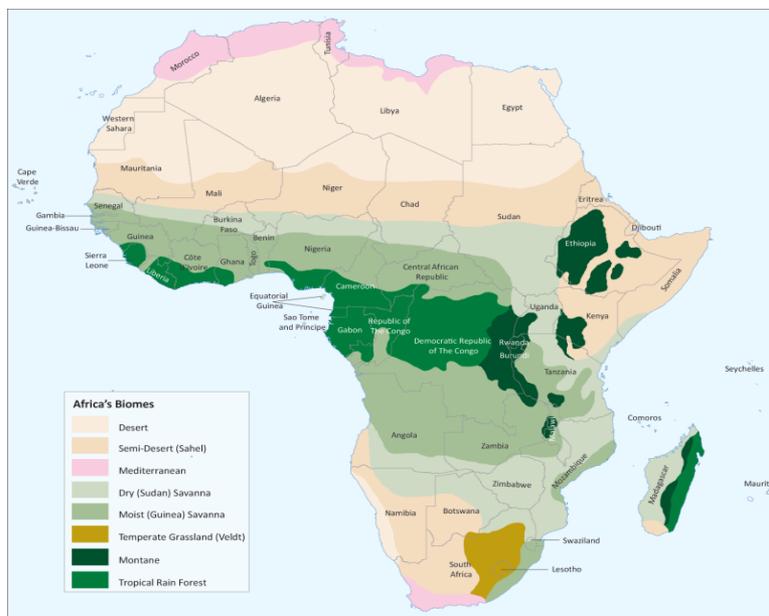
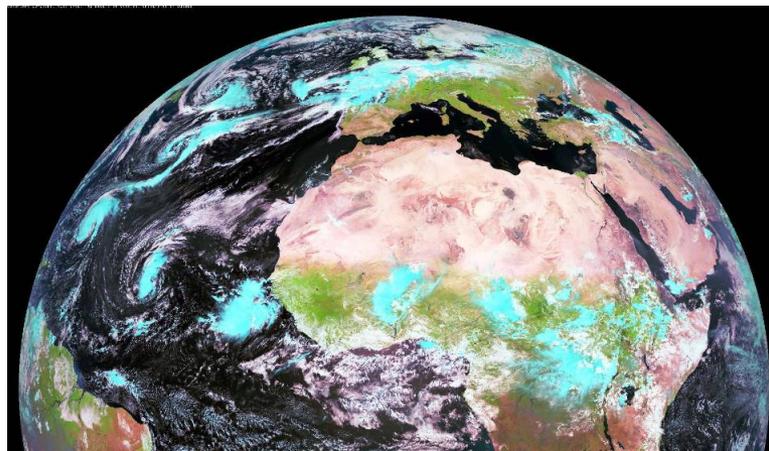
- Overview of the regional model ability
- Resolution effects on simulations
- Impact of physical processes



# Motivation

“Improved understanding and predicting of African climate drivers”

- DFID Climate Science Research Partnership (CSRP)
- Met Office “agenda” for reliable prediction across weather and climate timescales
- Complexity of climate processes and multi-scale interactions
- Land surface and physiographic features
- Poor ability of climate models in this region



# Possible sources of GCM errors

## Model resolution

### local processes:

- Land surface
- Atmosphere
- Ocean

### Remote processes:

- Teleconnections
- Atmosphere
- Ocean

- Methods to disentangle the contribution of each factor
- Develop the GA3 regional model to address part of the issue
- Initial applications:

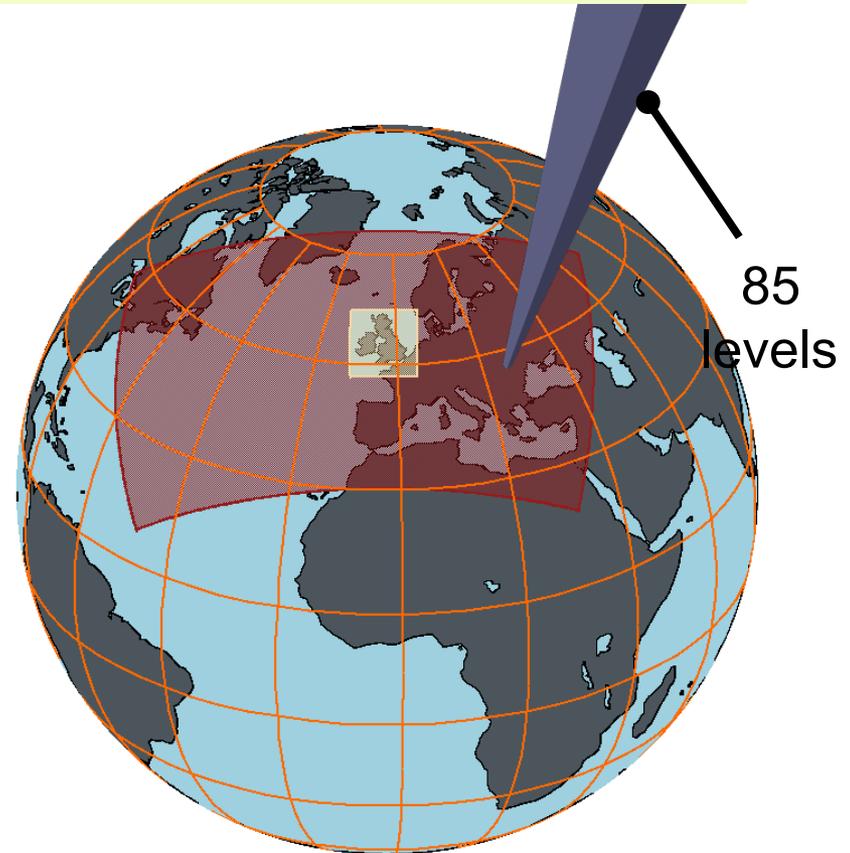
Downscaling of GLOSEA seasonal forecasts (ICPAC, Kenya)

Role of dust and seasonal inundation on the local climate

# Global Atmosphere model (GA3)

Single scientific configuration of MetUM global atmosphere to be used across all timescales:

- Atmospheric component of HadGEM3
- Choice of dynamical and physical cores
- Independent of horizontal resolution (and resolution dependent options)
- Horizontal resolutions: ~135km, ~80km, ~60km, ~40km, ~25km, ...
- 85 vertical levels (85km): 50 (troposphere) + 35 (stratosphere)
- Not restricted to global model use



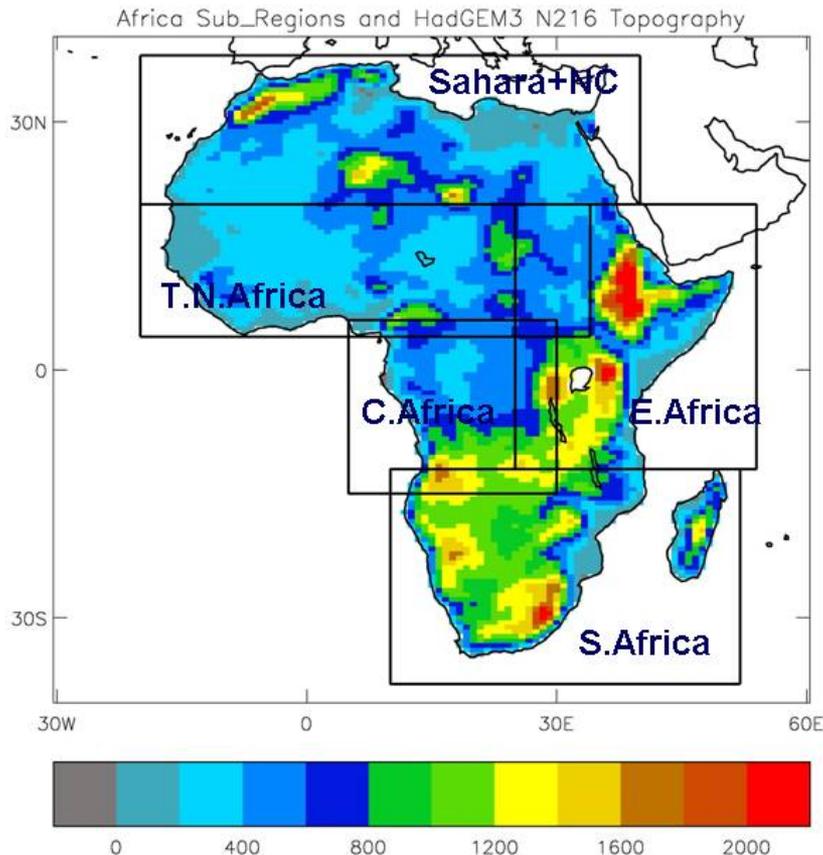
RCM and GCM with fully consistent physical formulation



# CORDEX evaluation framework

(Nikulin et al, J. Climate 2012)

## Interior domain and assessment areas



### GA3-based RCM:

- nonhydrostatic, fully compressible, semi-implicit and semi-lagrangian
- fully consistent with GA3 physical formulation
- 50km grid-spacing hybrid height levels
- JULES land surface scheme

### Experimental design:

- domain: CORDEX (Africa)
- integration period: 1989-2008
- SST/SICE: Reynolds (daily)
- driving conditions: ERAINTERIM

### Parallel experiments

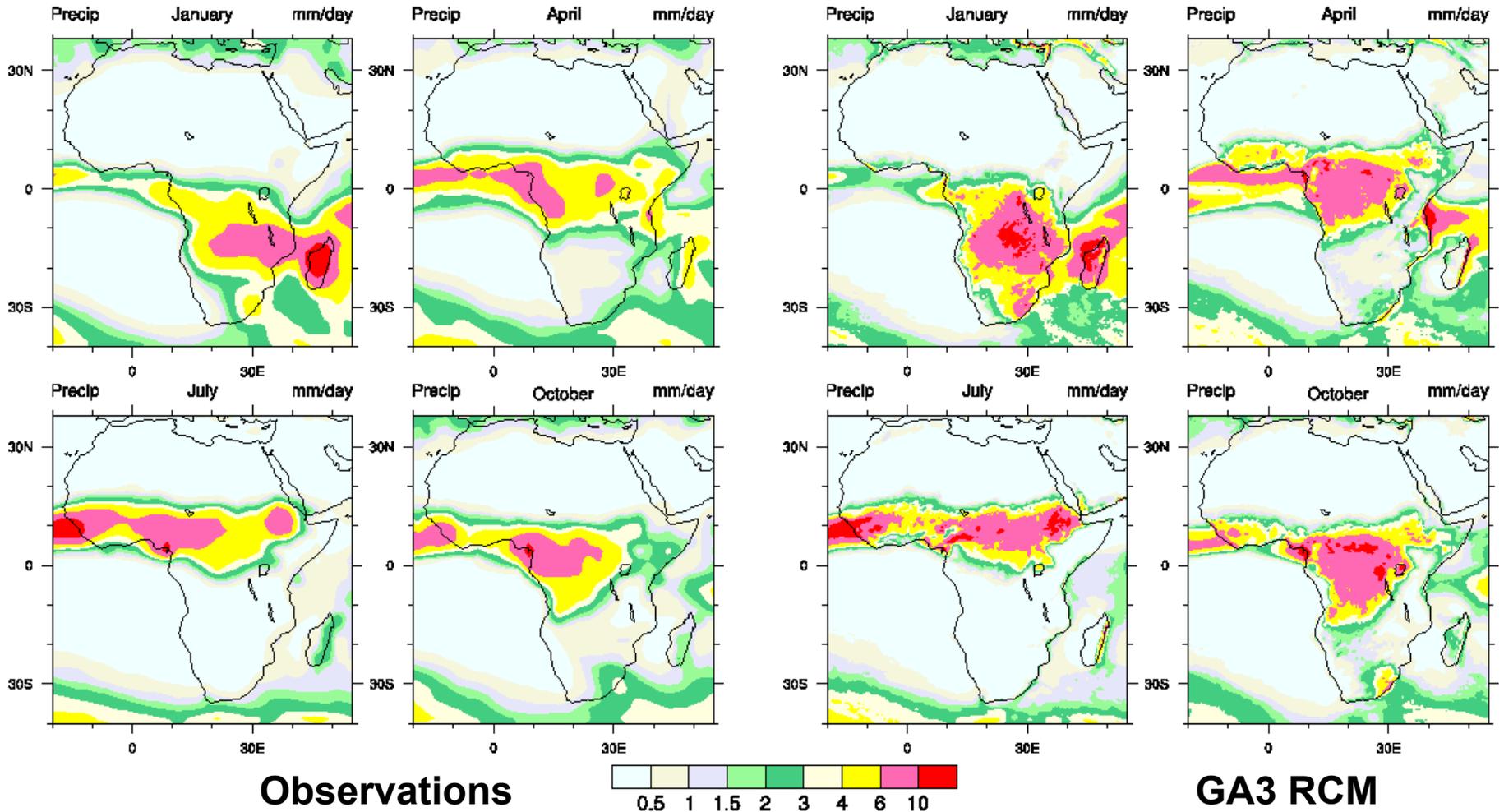
- 12km, 25km, 80km, 90km, 135km
- physics changes



# Monthly timescale

GPCP Climatology : 1990-2007

RCM50km Climatology : 1990-2007



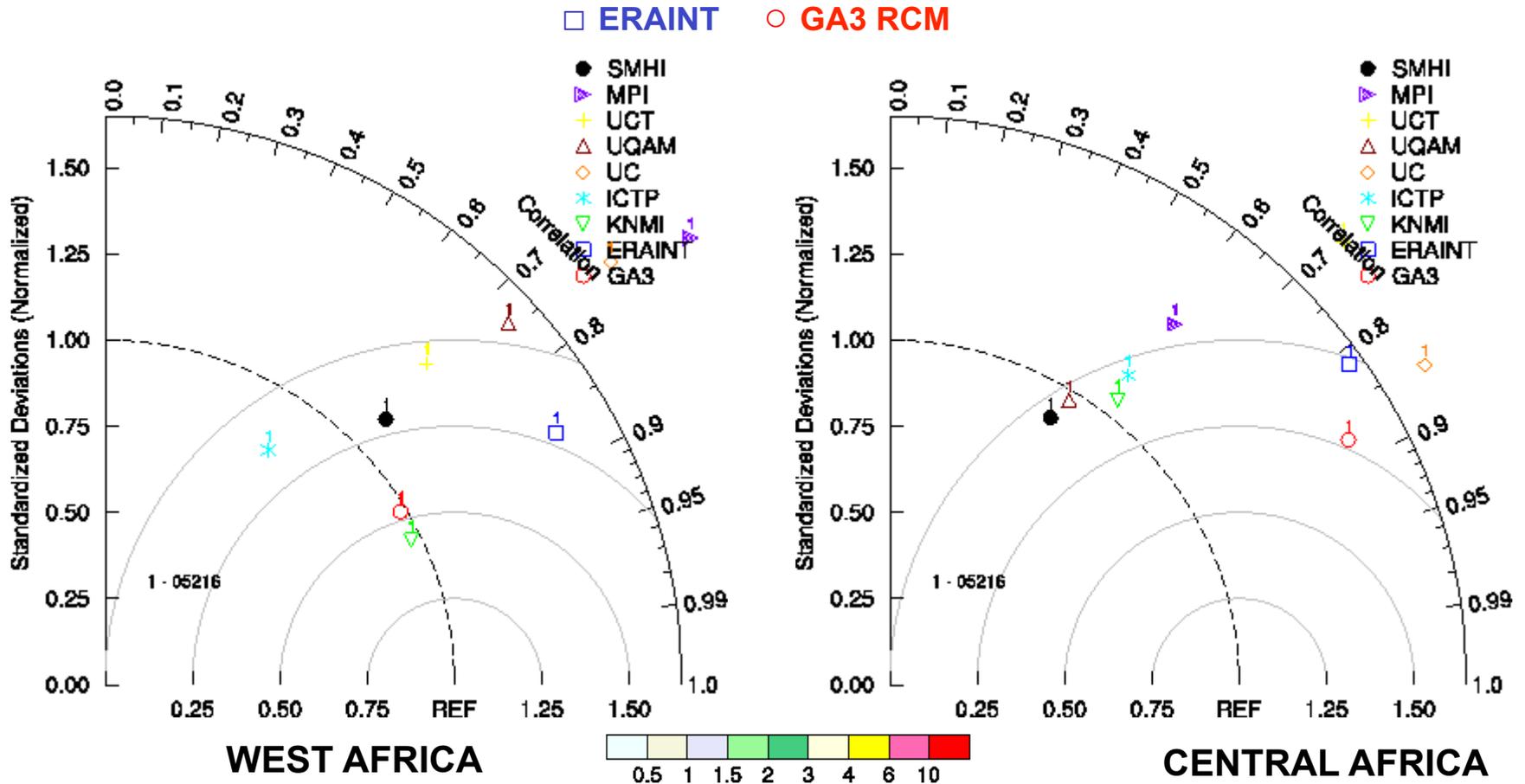
**Large wet biases in Central Africa**



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# Comparison GA3RCM vs CORDEX

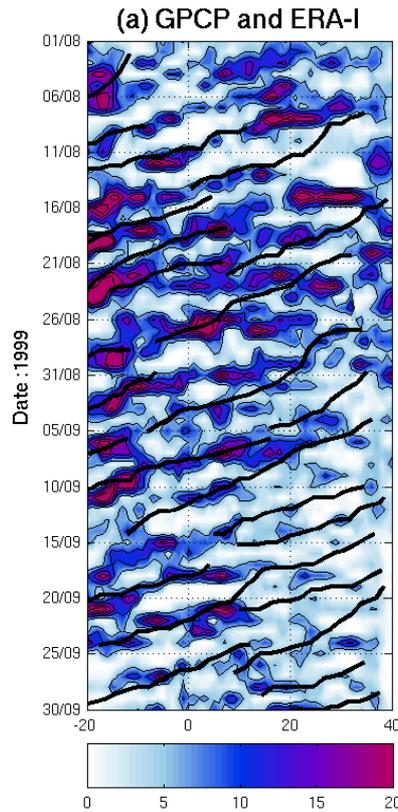
Annual rainfall (1990-2007)



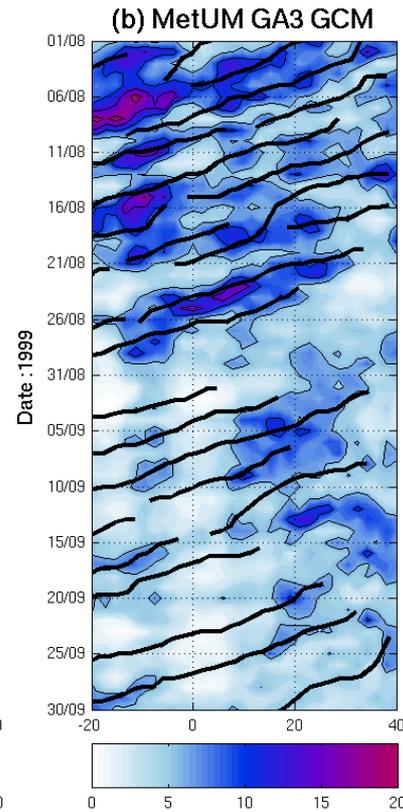
Good agreement with the best RCMs and improvement over ERAINTERIM

# Westward propagating wave structures

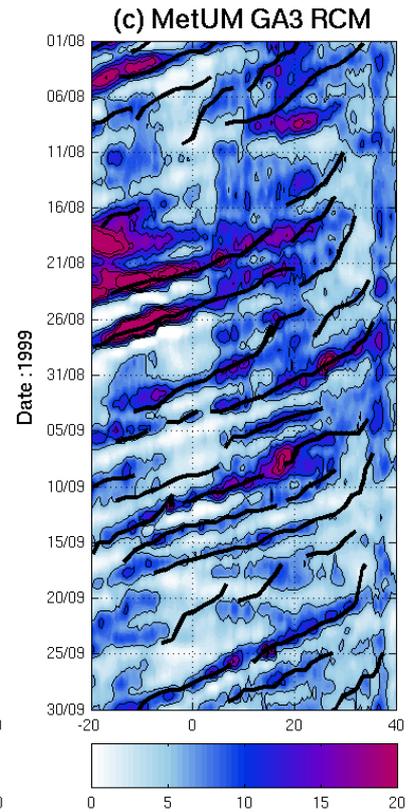
**GA3 RCM captures westward propagating AEWs and their coupling with precipitation**



**ERAINT**



**GA3 GCM**

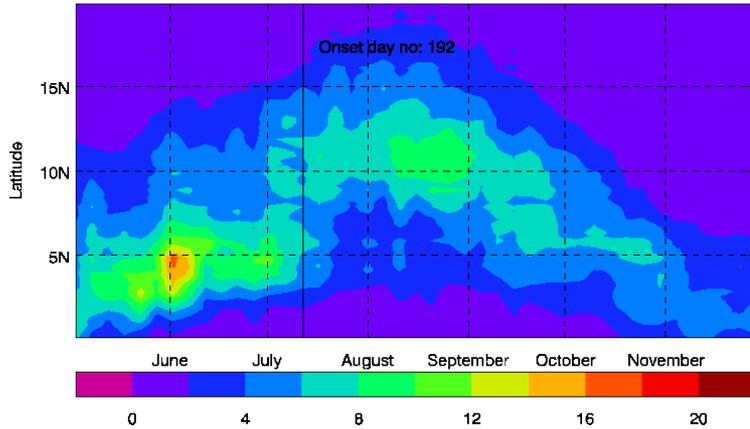


**GA3 RCM**

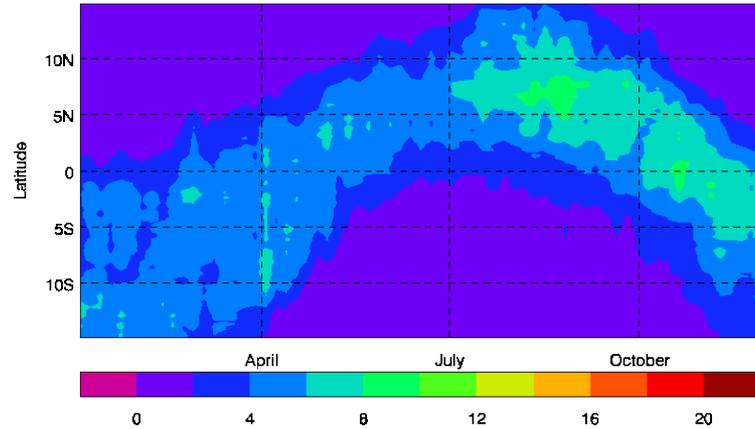


# Intraseasonal timescale: Time-latitude evolution of daily rainfall

Daily rainfall TRMM (0N-20N,-10W-10E) in 1998-2006

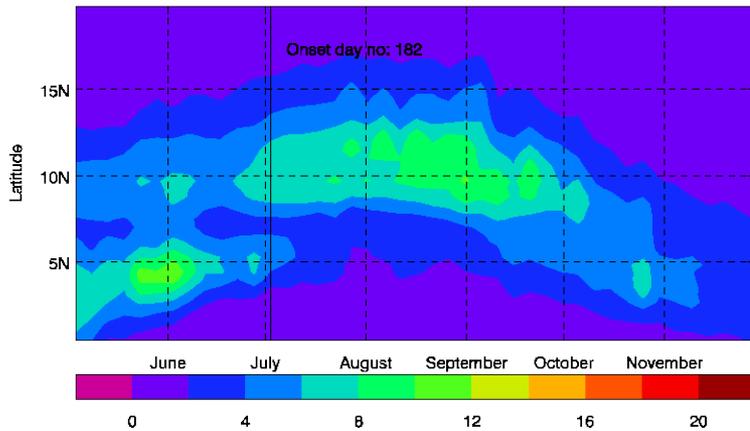


Daily rainfall TRMM (-15N-15N,10W-30E) in 1998-2007  
Onset day no: 2

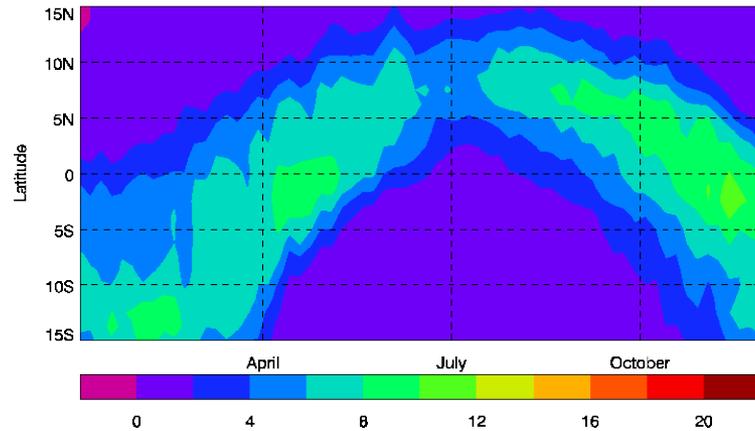


**TRMM**

Daily rainfall R50km (0N-20N,-10W-10E) in 1998-2006



Daily rainfall N96L85 (-15N-15N,10W-30E) in 1998-2007  
Onset day no: 10



**GA3RCM**

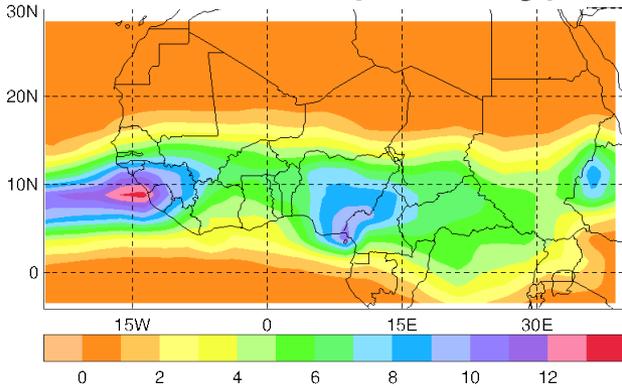
Time →

**West Africa**

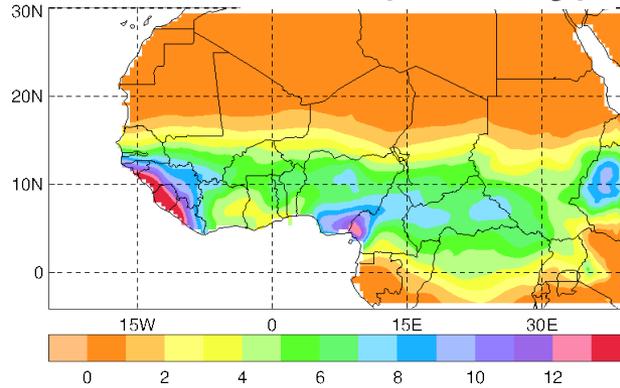
**Central Africa**

# Benefit of high spatial resolution

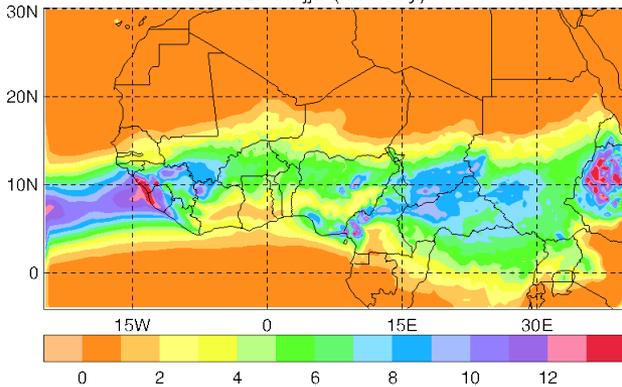
JJA GPCP (mm/day)



CRU (mm/day)

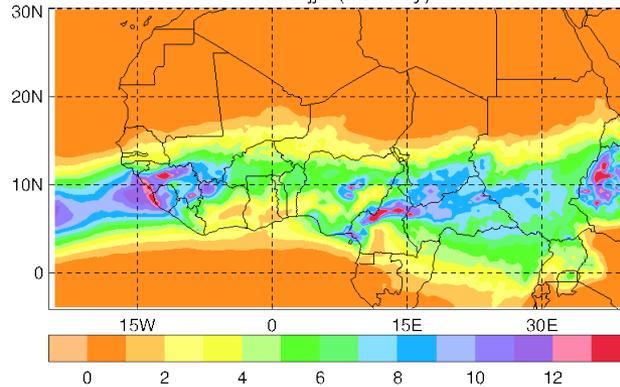


25km jja (mm/day)



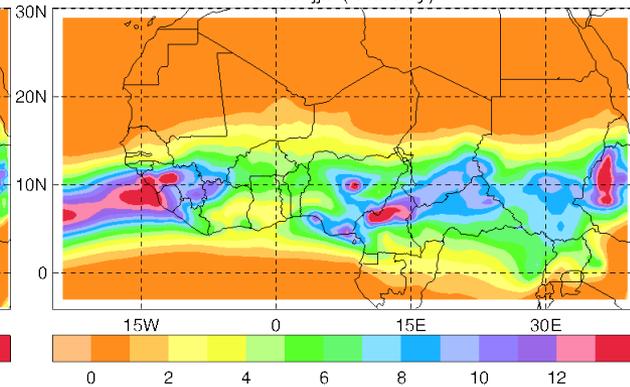
25km RCM

50km jja (mm/day)



50km RCM

90km jja (mm/day)

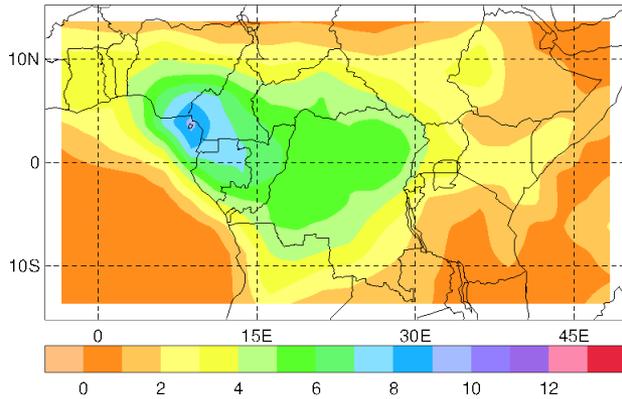


90km RCM

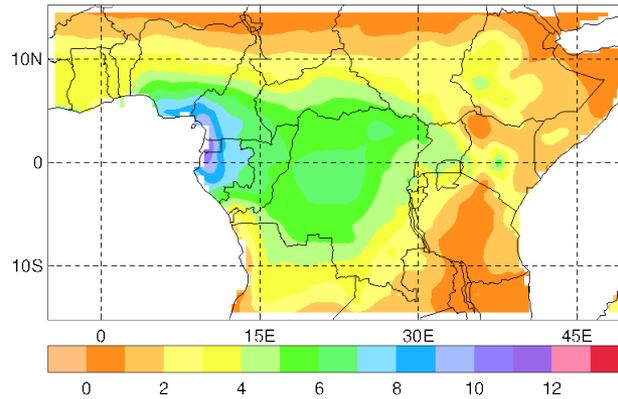
Precipitation biases are reduced with increased spatial resolution

# Benefit of high spatial resolution

**SON GPCP (mm/day)**

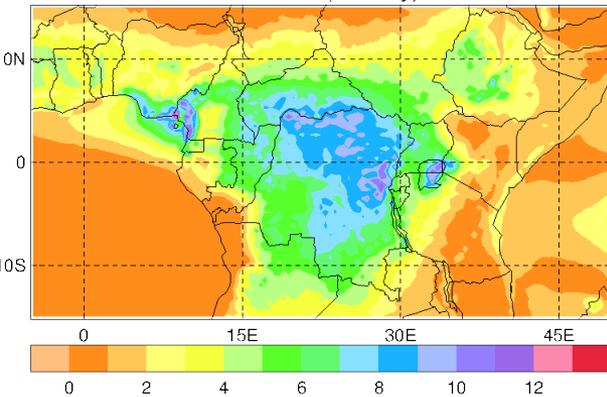


**CRU (mm/day)**



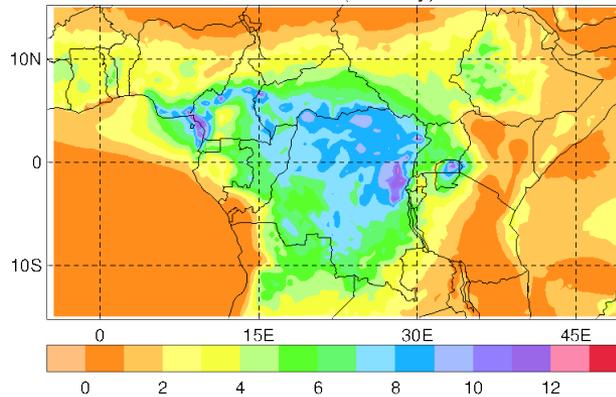
**Key precipitation errors persist with increased spatial resolution over Central Africa**

**25km son (mm/day)**



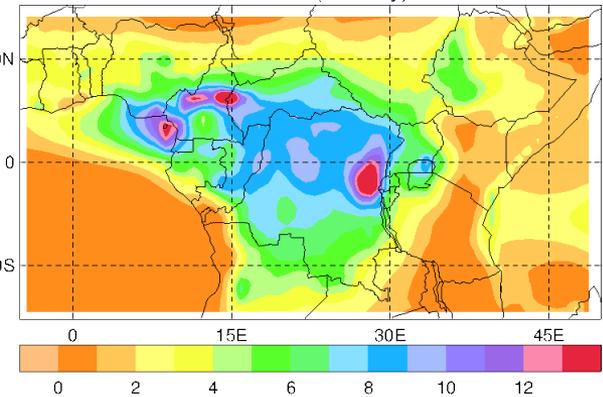
**25km RCM**

**50km son (mm/day)**



**50km RCM**

**90km son (mm/day)**

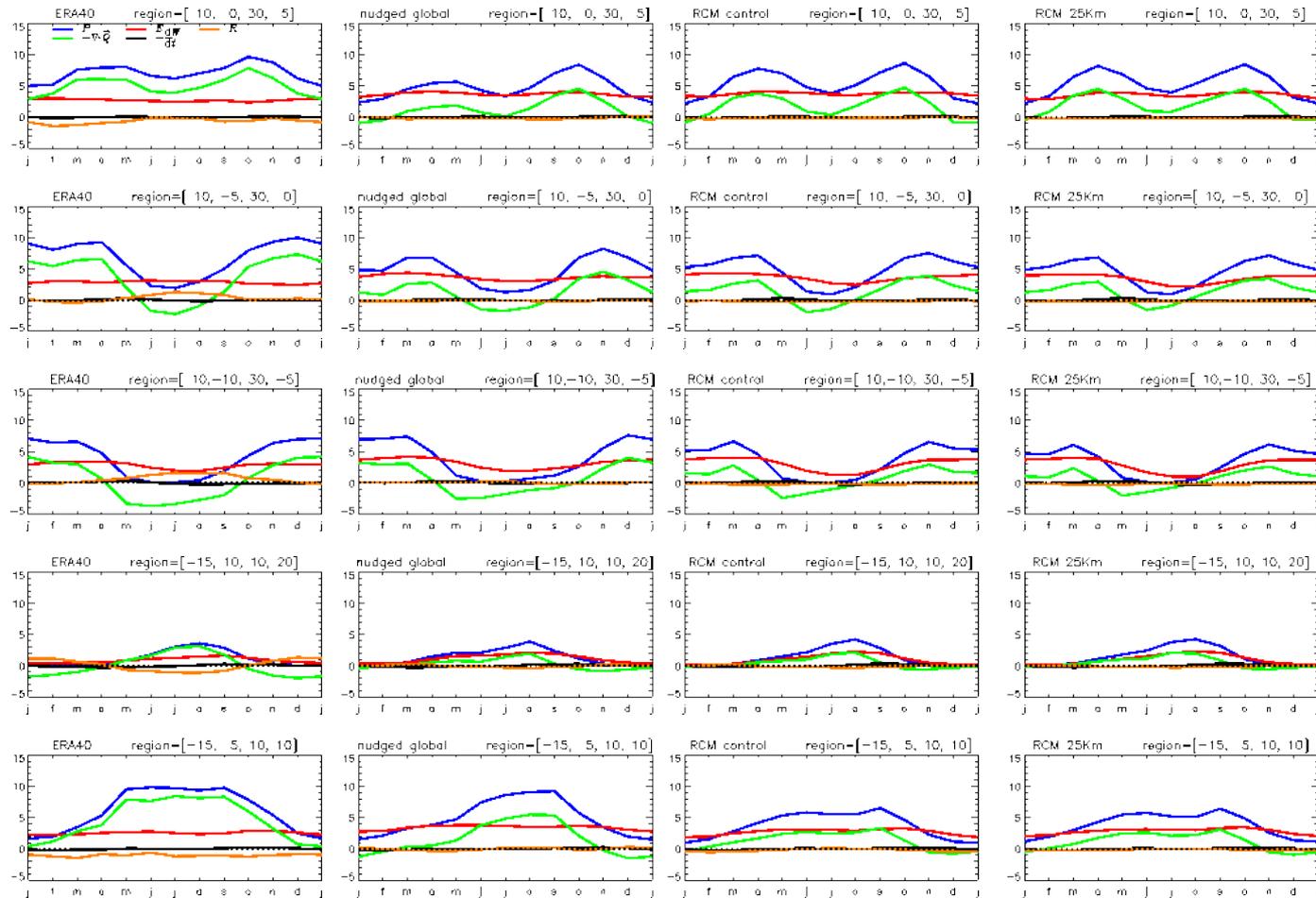


**90km RCM**

# Atmospheric water budget and recycling

## Deficit of moisture convergence in Central Africa

- Precipitation
- Evaporation
- Moisture convergence
- Water content
- residual



Cameroon

Congo

Angola

Sahel

Guinea coast

ERA40

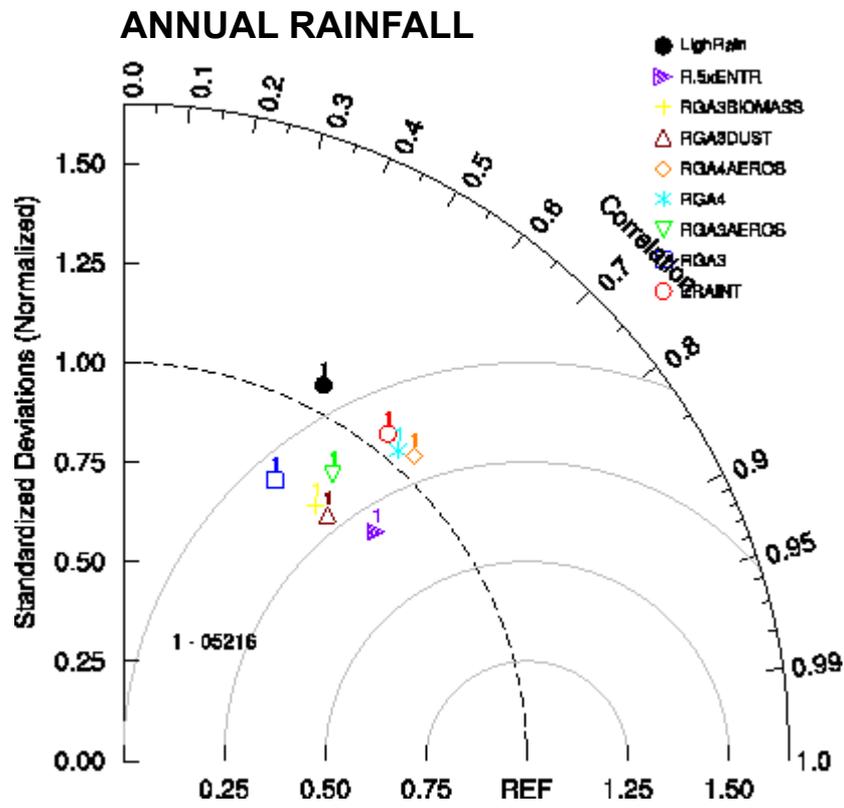
Nudged GCM  
~135km

50km RCM

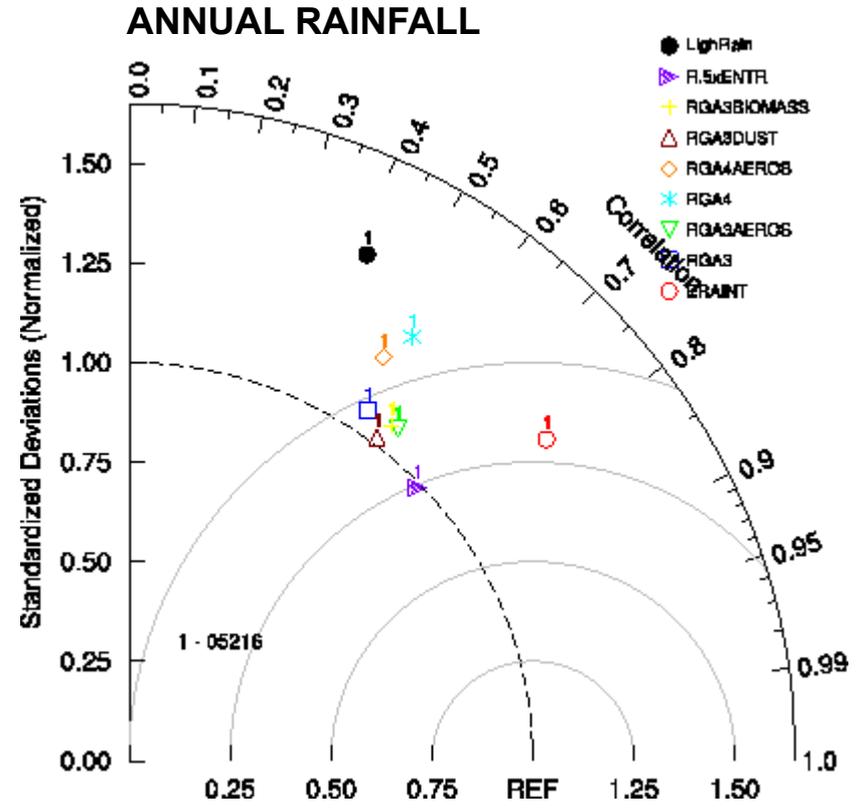
25km RCM

# Impact of physics changes

Improvements come mostly from increase of entrainment, aerosols, and mineral dust changes



**WEST AFRICA**



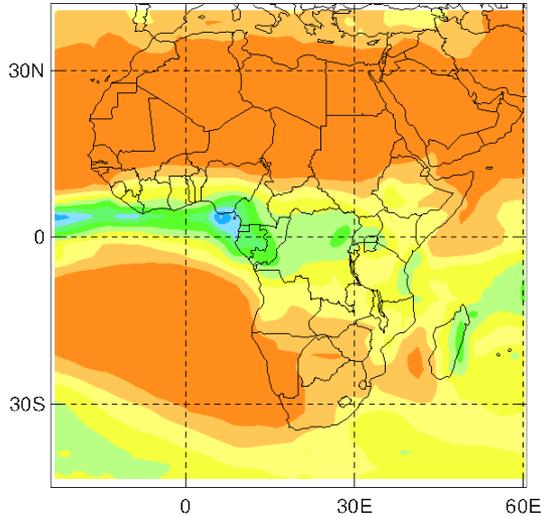
**CENTRAL AFRICA**

□ CONTROL ○ ERAINT ▼ ENTRAINMENT △ DUST ▼ AEROSOLS + BIOMASS \* GA4 RCM ◇ GA4 RCM+ AEROSOLS

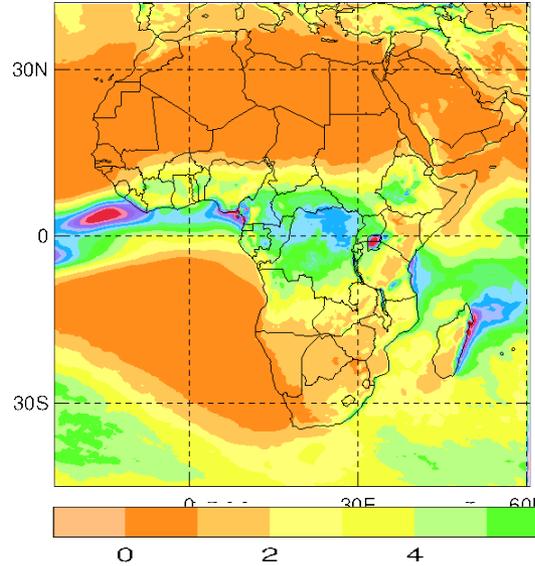
# What is the added value of RCM?

First 25km GA3 RCM nested within the N216 GA3 GCM (1995-2007)

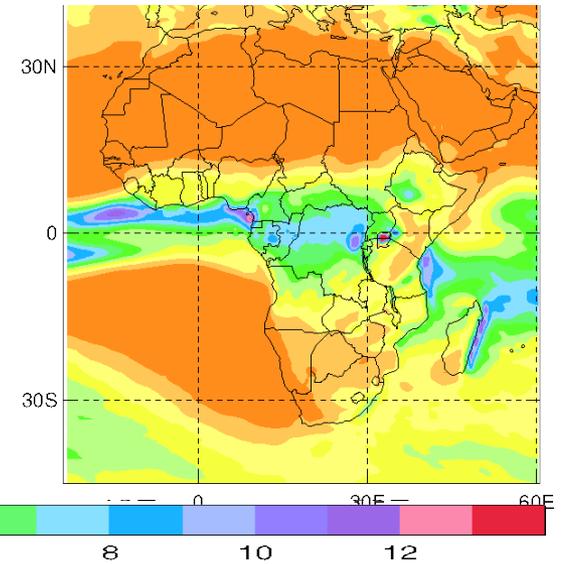
**MAM GPCP (mm/day)**



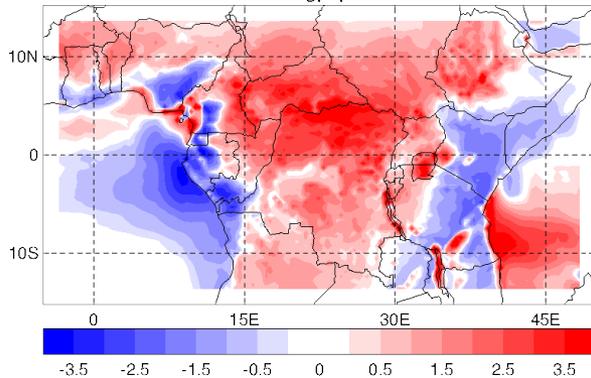
**MAM nested 25km RCM**



**N216 driving GCM (~100km)**

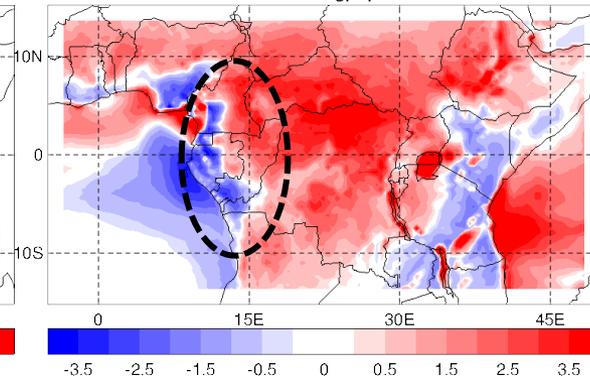


25km - gpcp mam



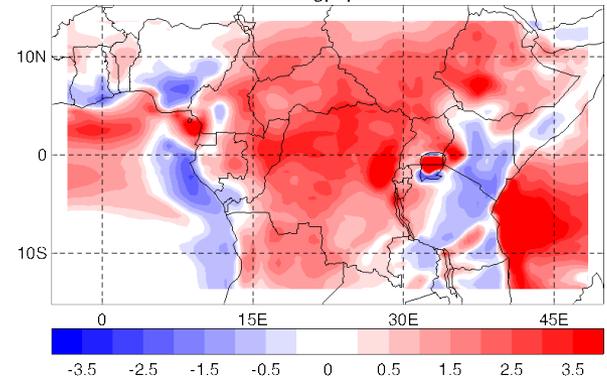
**ERAINT driven RCM25km**

RCM25km - gpcp mam



**RCM25km**

N216 - gpcp mam



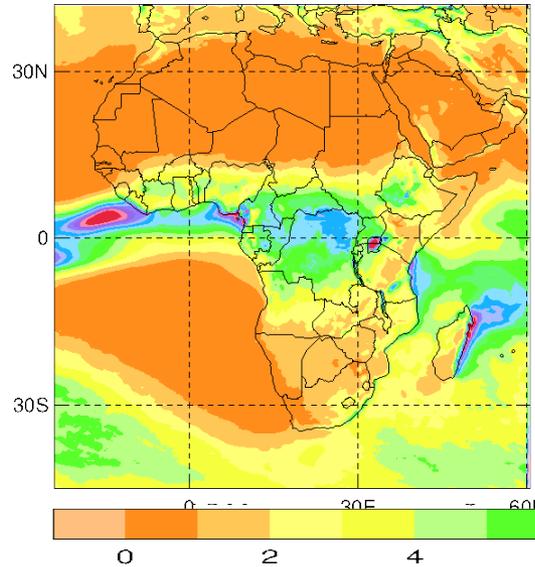
**N216 GCM (~100km)**

# What is the added value of RCM?

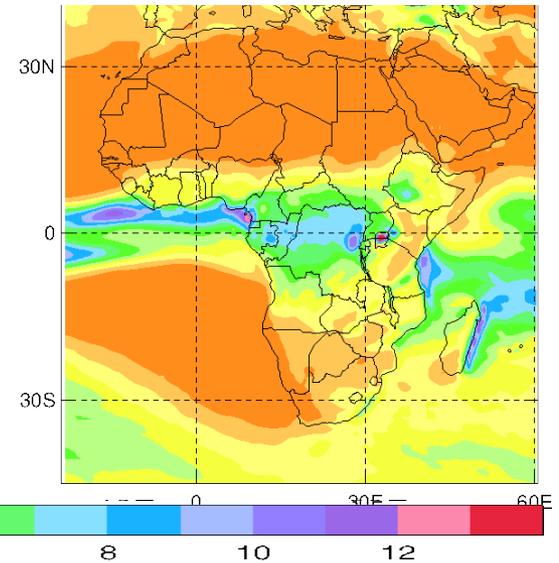
First 25km GA3 RCM nested within the N216 GA3 GCM (1995-2007)

Large-scale consistency between GA3 driving N216/ GCM and nested 25km/RCM, and similarity between model rainfall biases

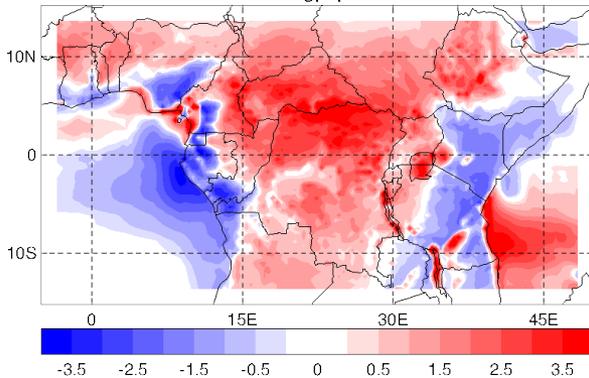
MAM nested 25km RCM



N216 driving GCM (~100km)

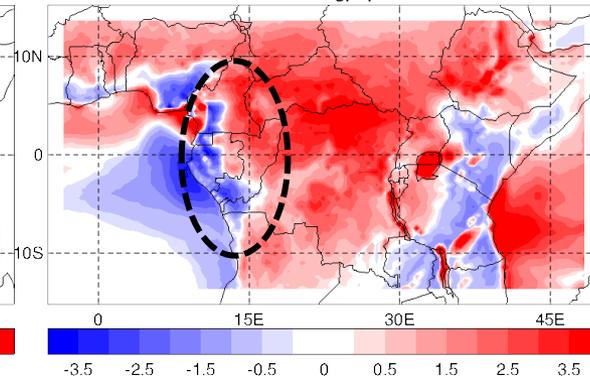


25km - gpcp mam



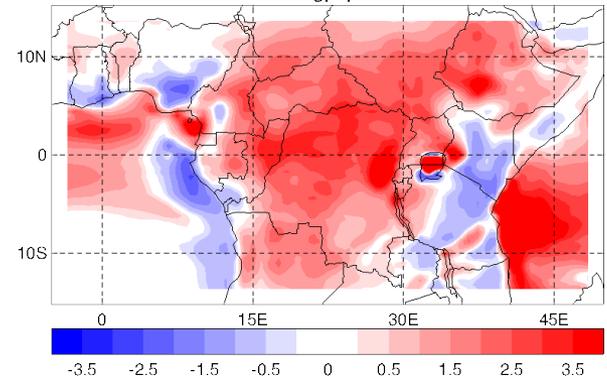
ERAINT driven RCM25km

RCM25km - gpcp mam



RCM25km

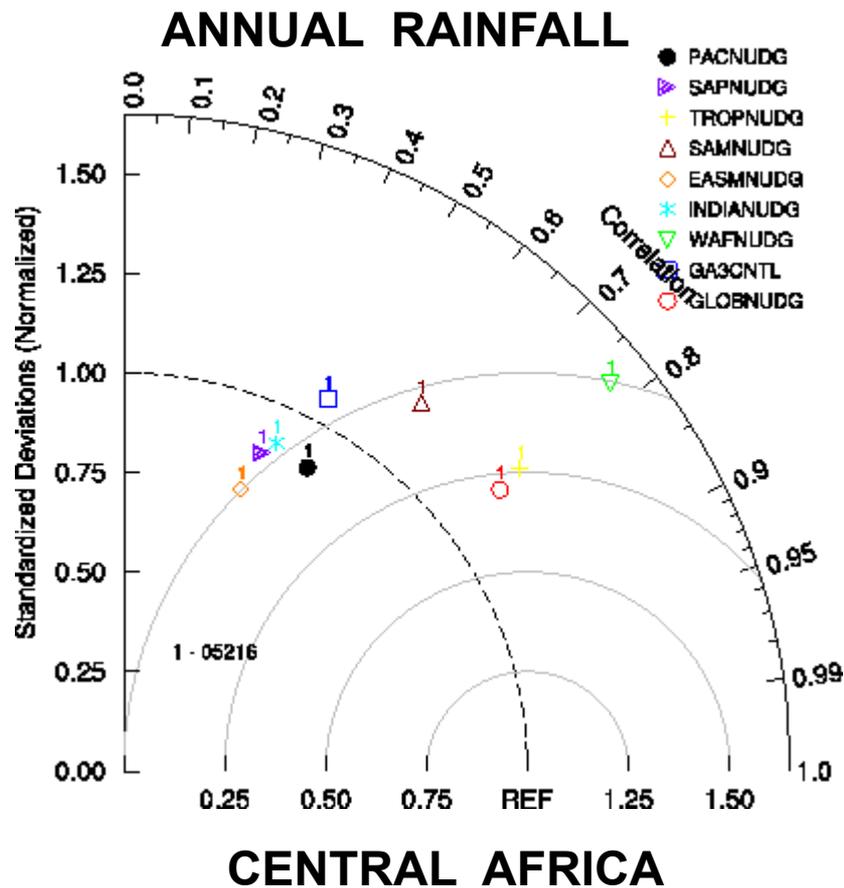
N216 - gpcp mam



N216 GCM (~100km)

# Role of processes from remote regions

Use of the grid-point nudging approach within GA3 where only U,V, and  $\Theta$  are nudged



**GA3 GCM rainfall errors over Central Africa respond to circulation anomalies in other tropical subregions, including Tropical Pacific and India monsoon areas**

**Best results come from the Global and Tropical nudging**



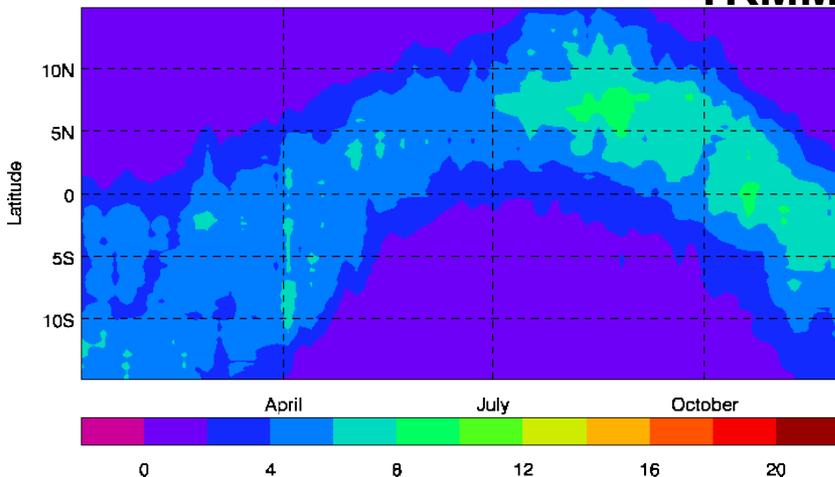
# Remote processes vs resolution

Use of the grid-point nudging approach where only U,V, and  $\Theta$  are nudged

Daily rainfall TRMM (-15N-15N,10W-30E) in 1998-2007

Onset day no: 2

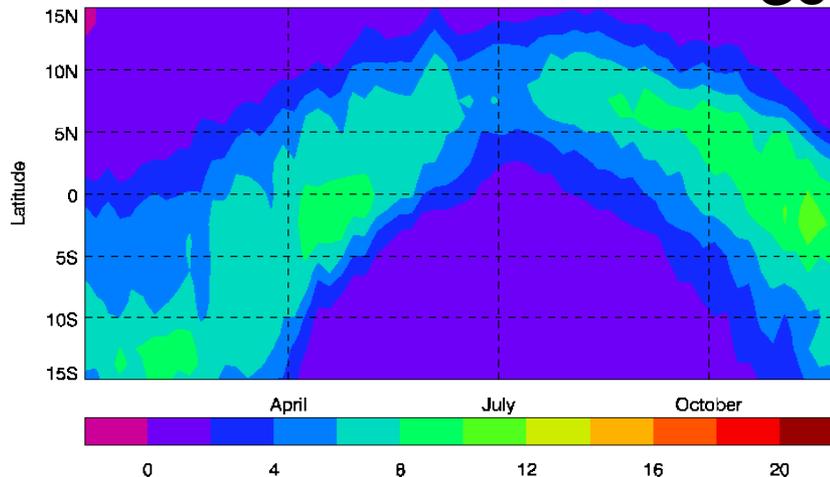
**TRMM**



Daily rainfall N96L85 (-15N-15N,10W-30E) in 1998-2007

Onset day no: 10

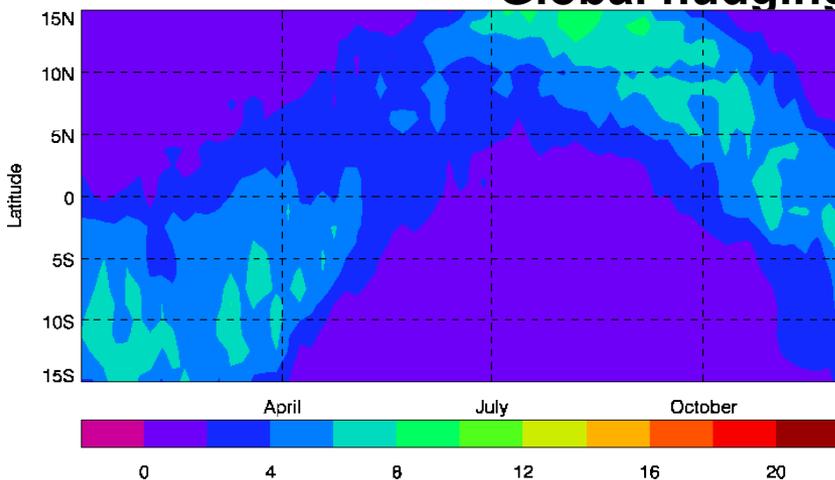
**GCM**



Daily rainfall GLOBL63 (-15N-15N,10W-30E) in 1998-2007

Onset day no: 2

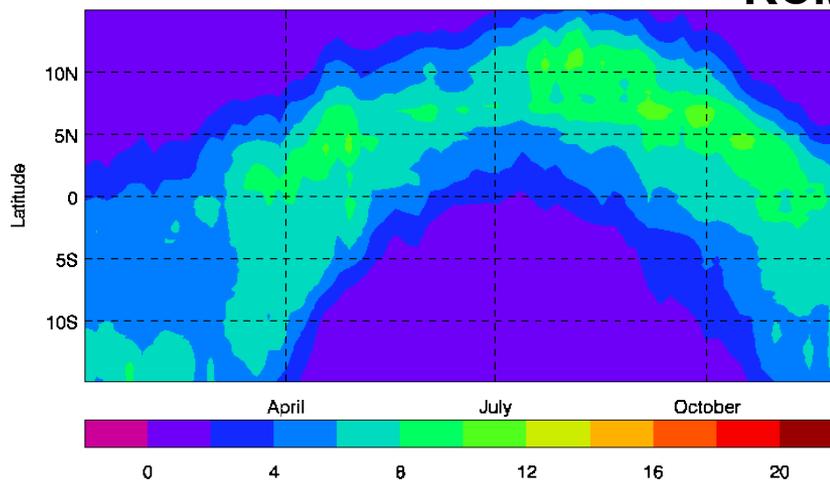
**Global nudging**



Daily rainfall R25km (-15N-15N,10W-30E) in 1998-2007

Onset day no: 2

**RCM25km**





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# Summary

- GA3 RCM captures reasonably well the basic features of the African climate and agrees well with the best of the CORDEX RCMs.
- Central Africa remain the most challenging subregion to simulate with the model exhibiting wet biases, deficit in moisture convergence and enhanced local recycling of rainfall.
- Enhancing the spatial resolution help reducing model biases, but few errors persist across the model spatial resolutions, suggesting issues rooted within the physical formulations or missing processes.
- Physics changes impacting on GA3 RCM skills include increase of entrainment rate, aerosols, mineral dust, and biomass burning.
- Added value of the RCM is investigated through nesting of the 25km GA3 RCM into ~100km GA3 GCM, ensuring full physical consistency between components of the downscaling system.
- Use of seamless global and regional prediction systems can help to understand the local versus remote drivers of the African climate.



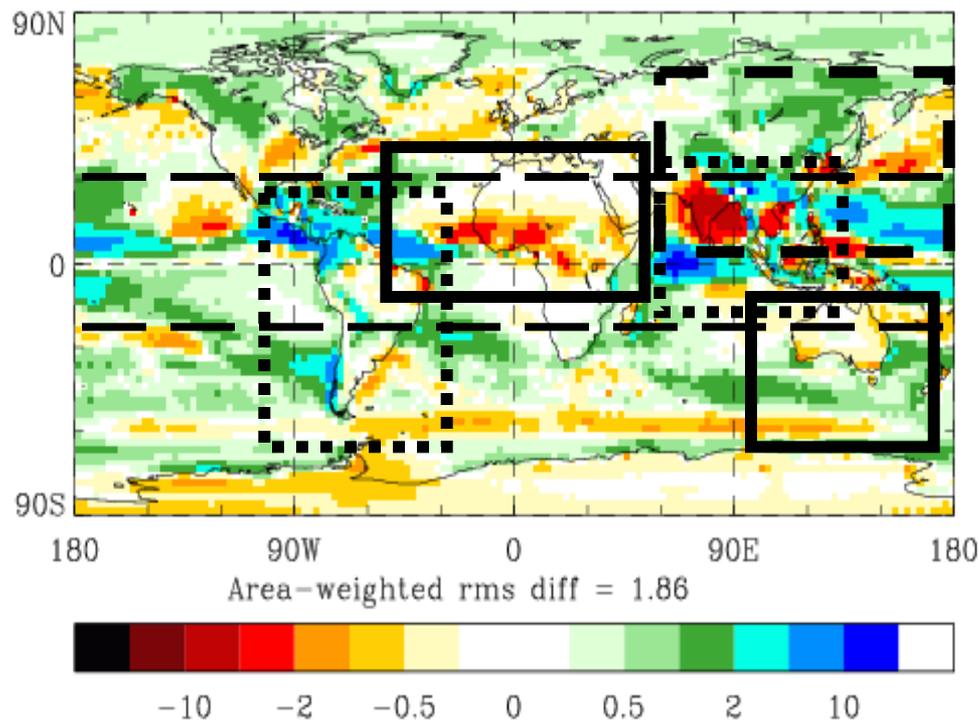
**Thank you very much!**

**Any questions?**

**Regions:**

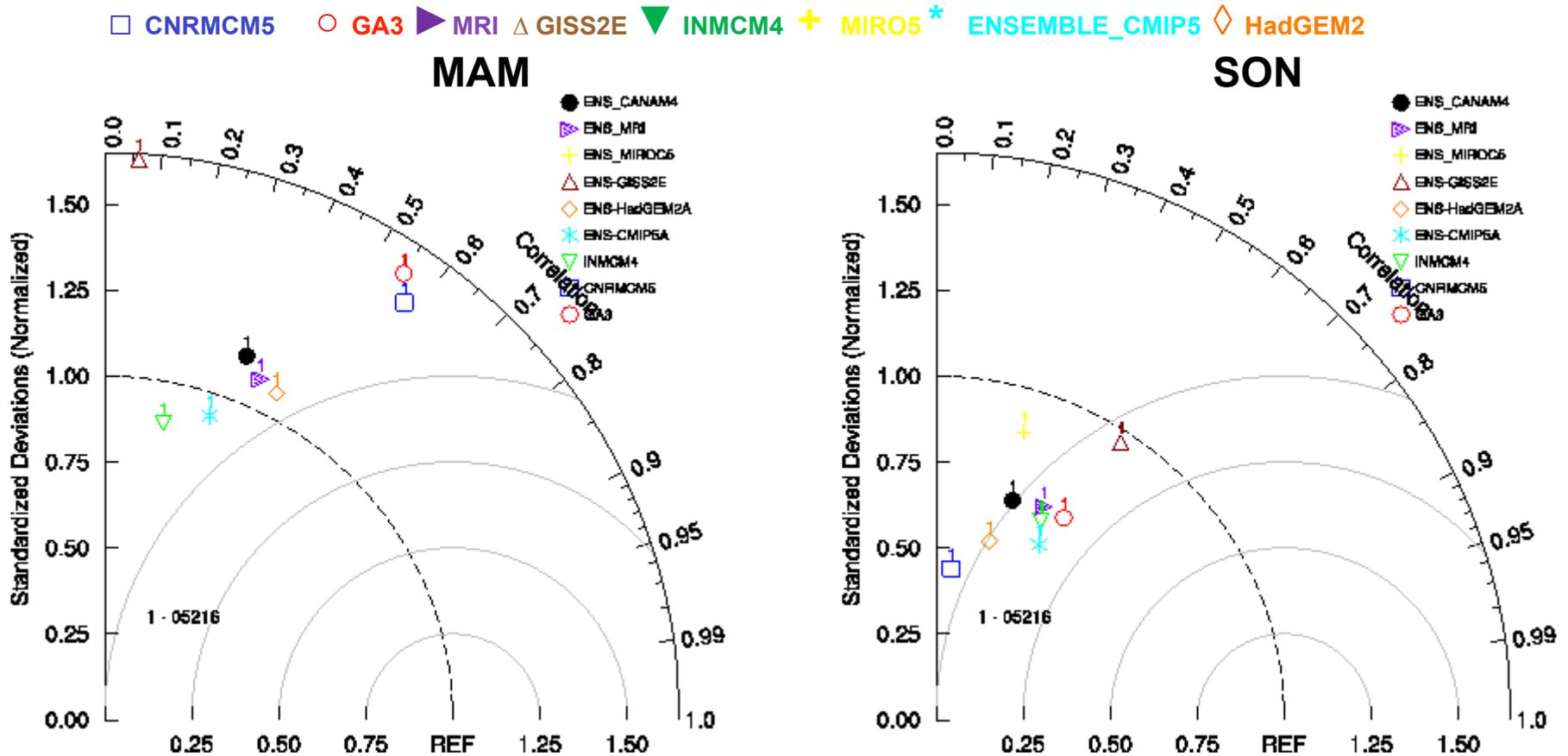
- Tropics [30S-30N; 0-360E]
- West Africa [10S-40N;40W-60E]
- Central Africa [40S-40N;10E-60E]
- West + East Asia [10S-40N;60E-150E]
- East Asia [10N-70N;60E-180E]
- Tropical pacific [30S-30N;120E-300E]
- Australia [60S-10N;90-180E]
- South America [64S-20N;270E-340E]
- North America [20N-70N;230E-310E]

Areas used for regional nudging





# Comparison GA3 vs CMIP5/AMIP



Models have issue with rainfall variability in autumn over Central Africa