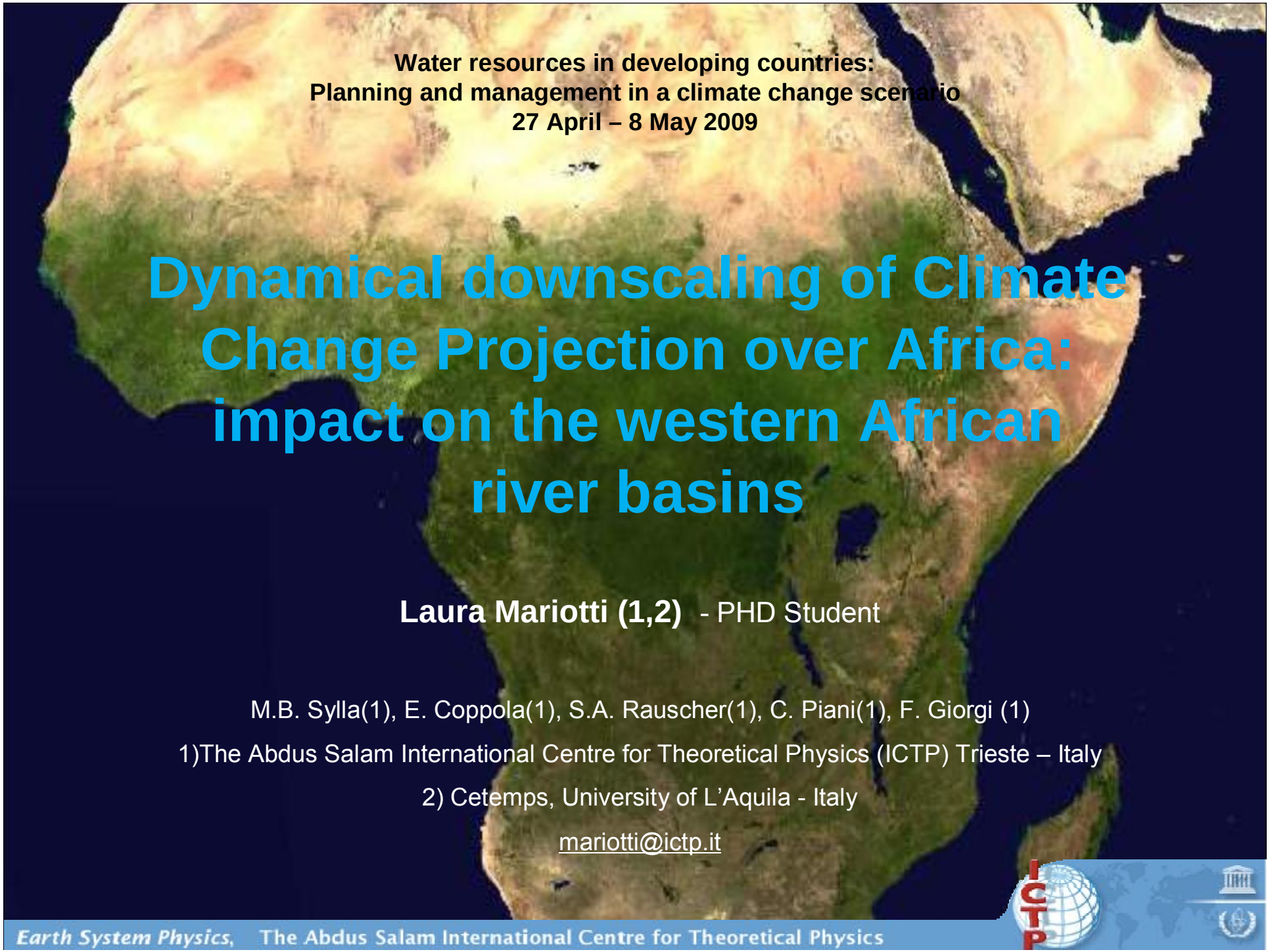


Water resources in developing countries:
Planning and management in a climate change scenario
27 April – 8 May 2009

Dynamical downscaling of Climate Change Projection over Africa: impact on the western African river basins

Laura Mariotti (1,2) - PHD Student

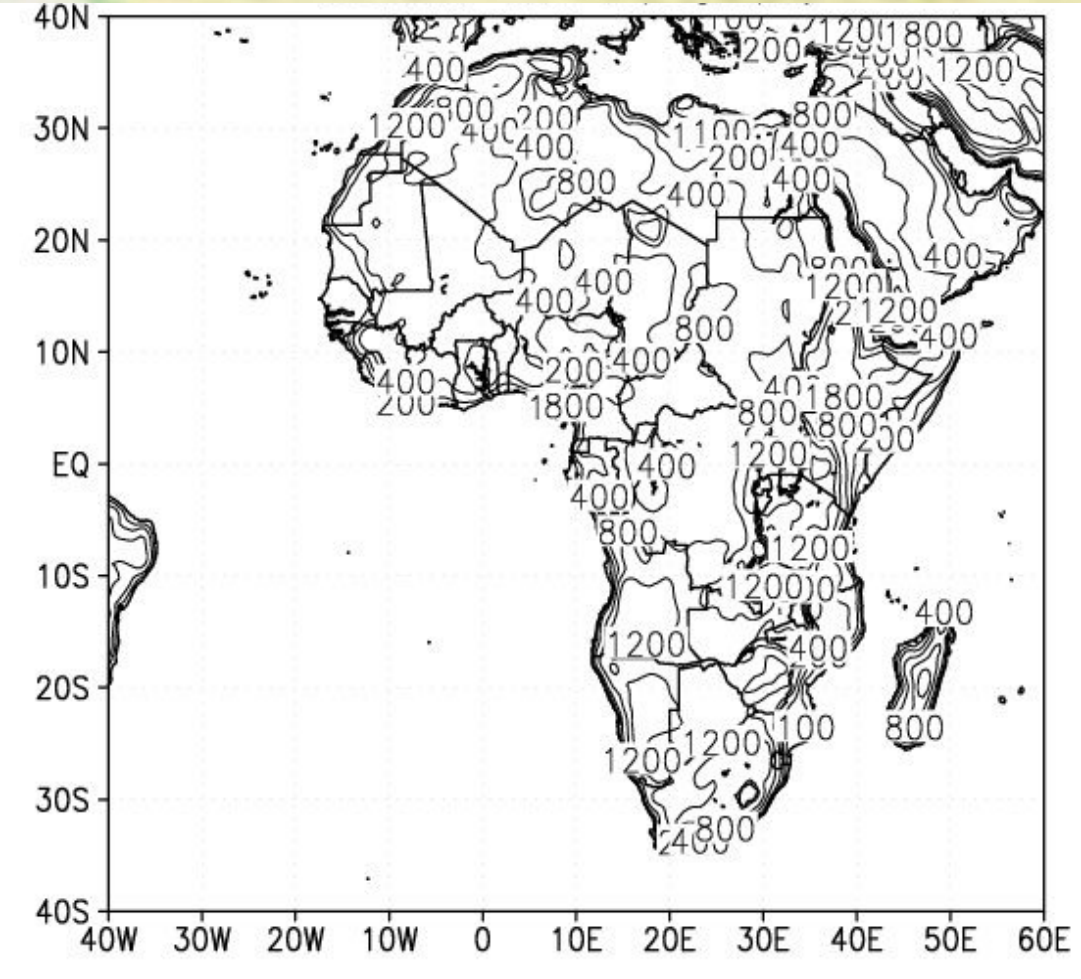
M.B. Sylla(1), E. Coppola(1), S.A. Rauscher(1), C. Piani(1), F. Giorgi (1)

1)The Abdus Salam International Centre for Theoretical Physics (ICTP) Trieste – Italy

2) Cetemps, University of L'Aquila - Italy

mariotti@ictp.it

❑ Regional Climate Model (RegCM3): Domain and Topography



spatial resolution of 50 km

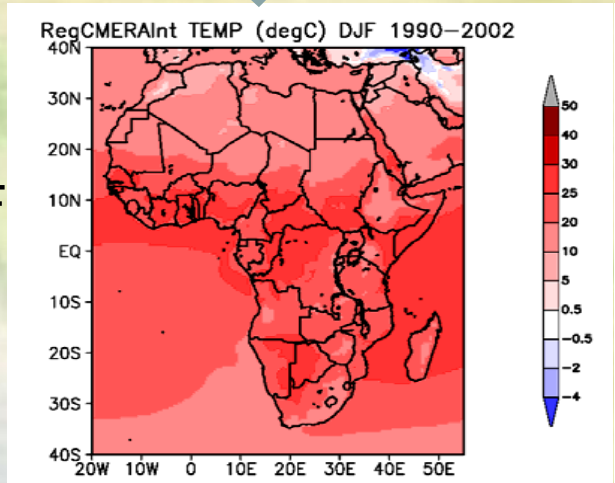
- **Control simulation using ERA-Interim as boundary conditions (1990-2007)**
- **Scenario simulations using ECHAM5-GCM A1B (1990-2100)**

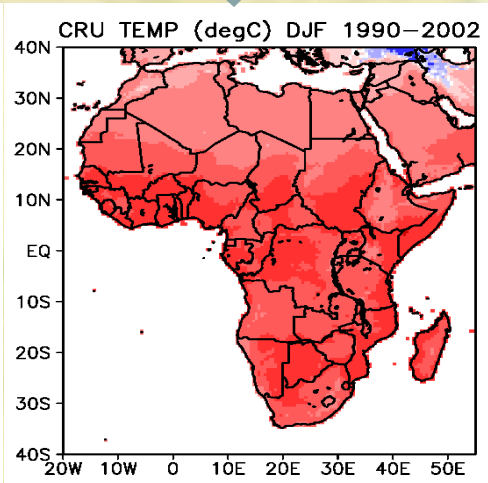
ERA-Interim RegCM3 simulations from 1990 to 2007

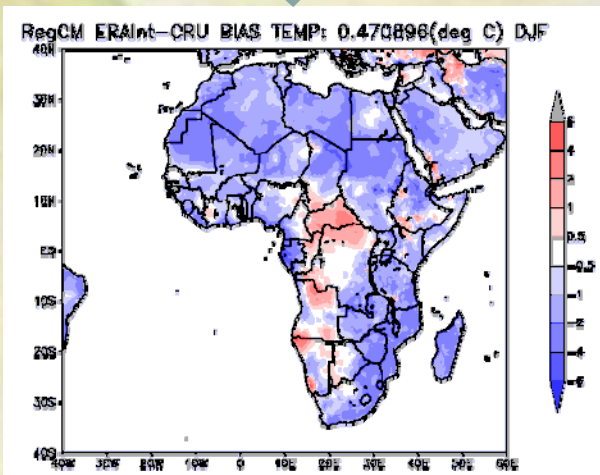
❑ Temperature Climatology

RegCM | CRU | RegCM-CRU

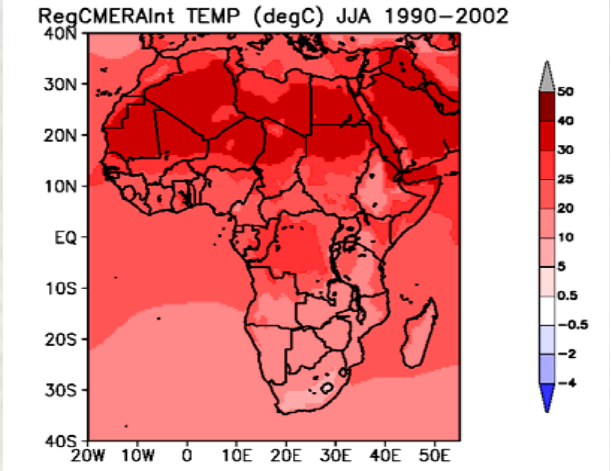
DJF

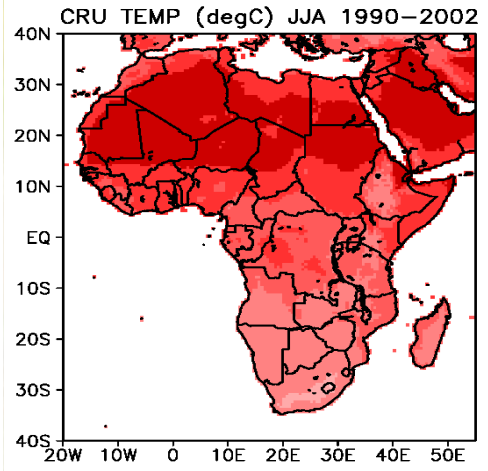


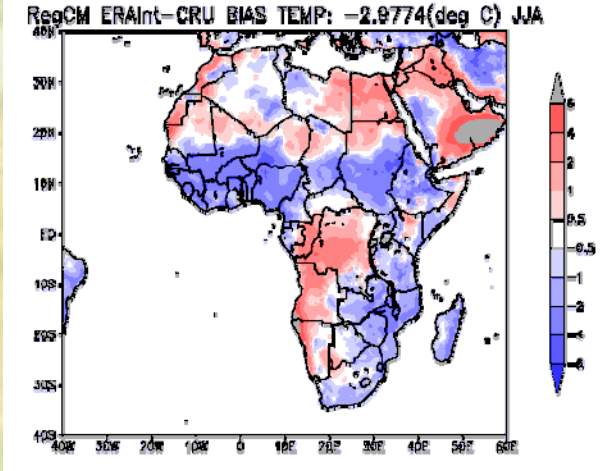




JJA



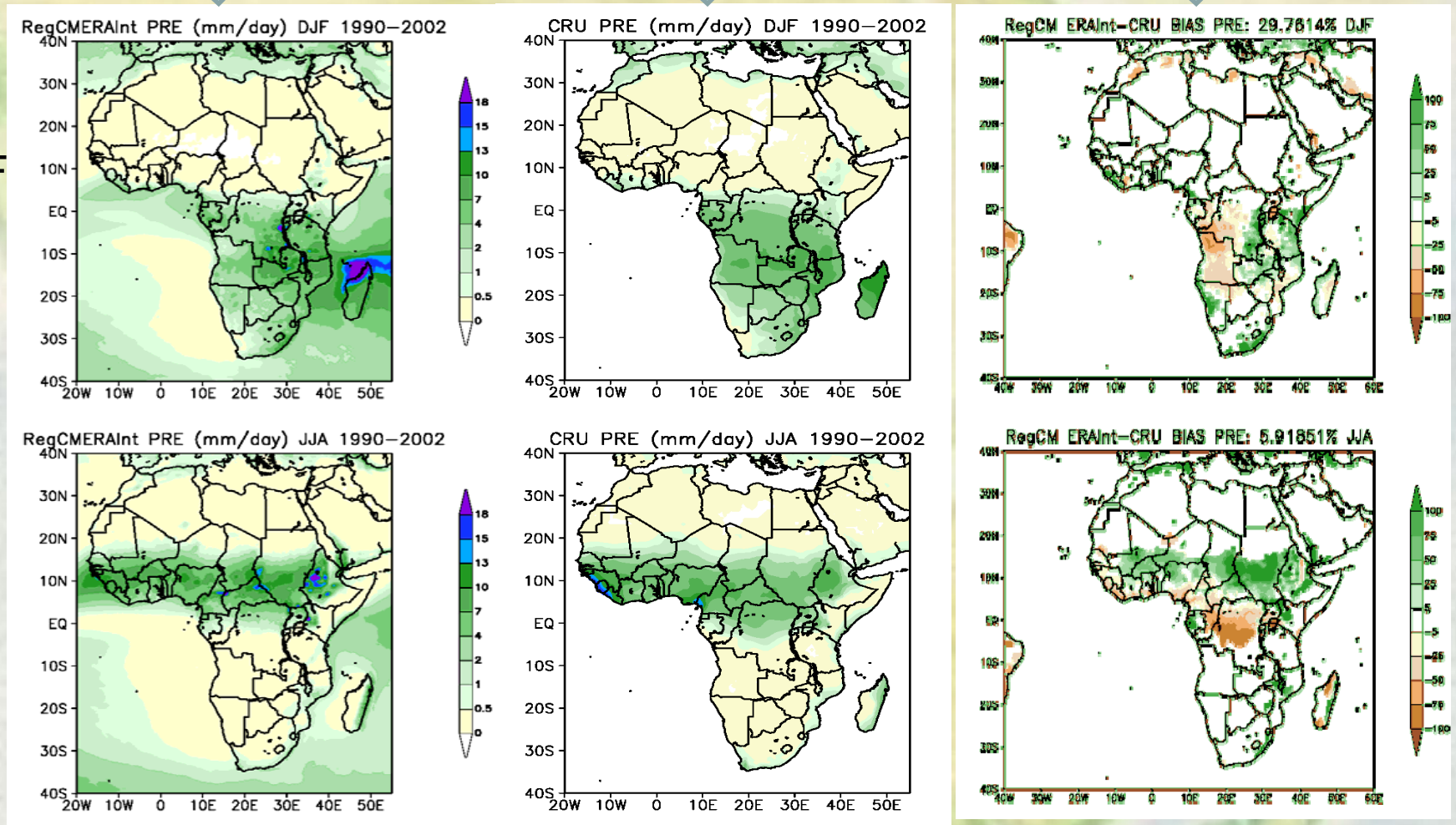




❑ Precipitation Climatology

RegCM | CRU | RegCM-CRU

DJF



JJA

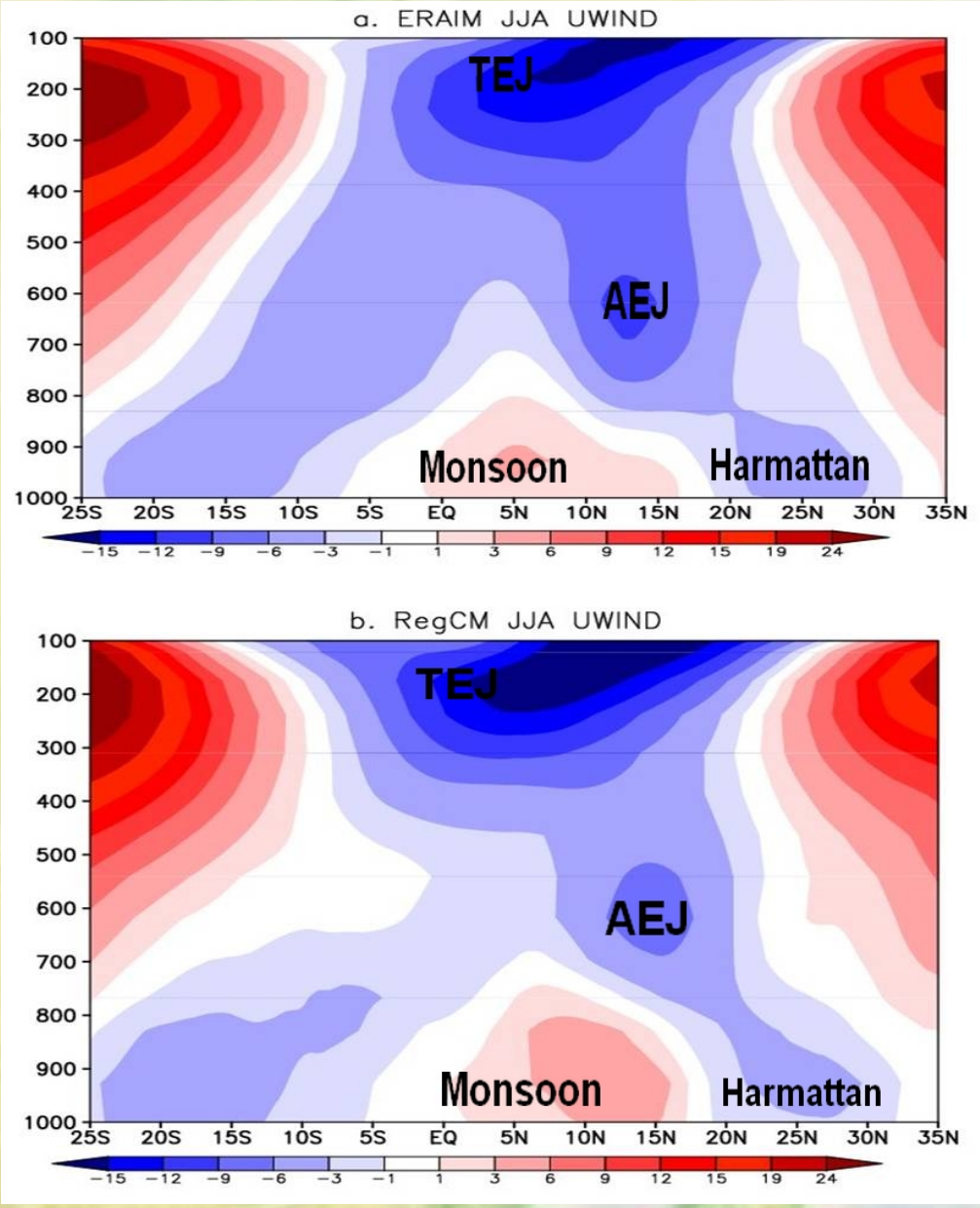
❑ Mean Zonal Wind (5°W and 30°E): North Africa Boreal Summer (JJA)

❖ ERA-Interim

(AEJ=African Easterly Jet)
(TEJ=Tropical Easterly Jet)

❖ RegCM3

✓Features, Position and Height Captured
✓Stronger Monsoon Flow
✓ Weaker AEJ
✓ Larger TEJ Core



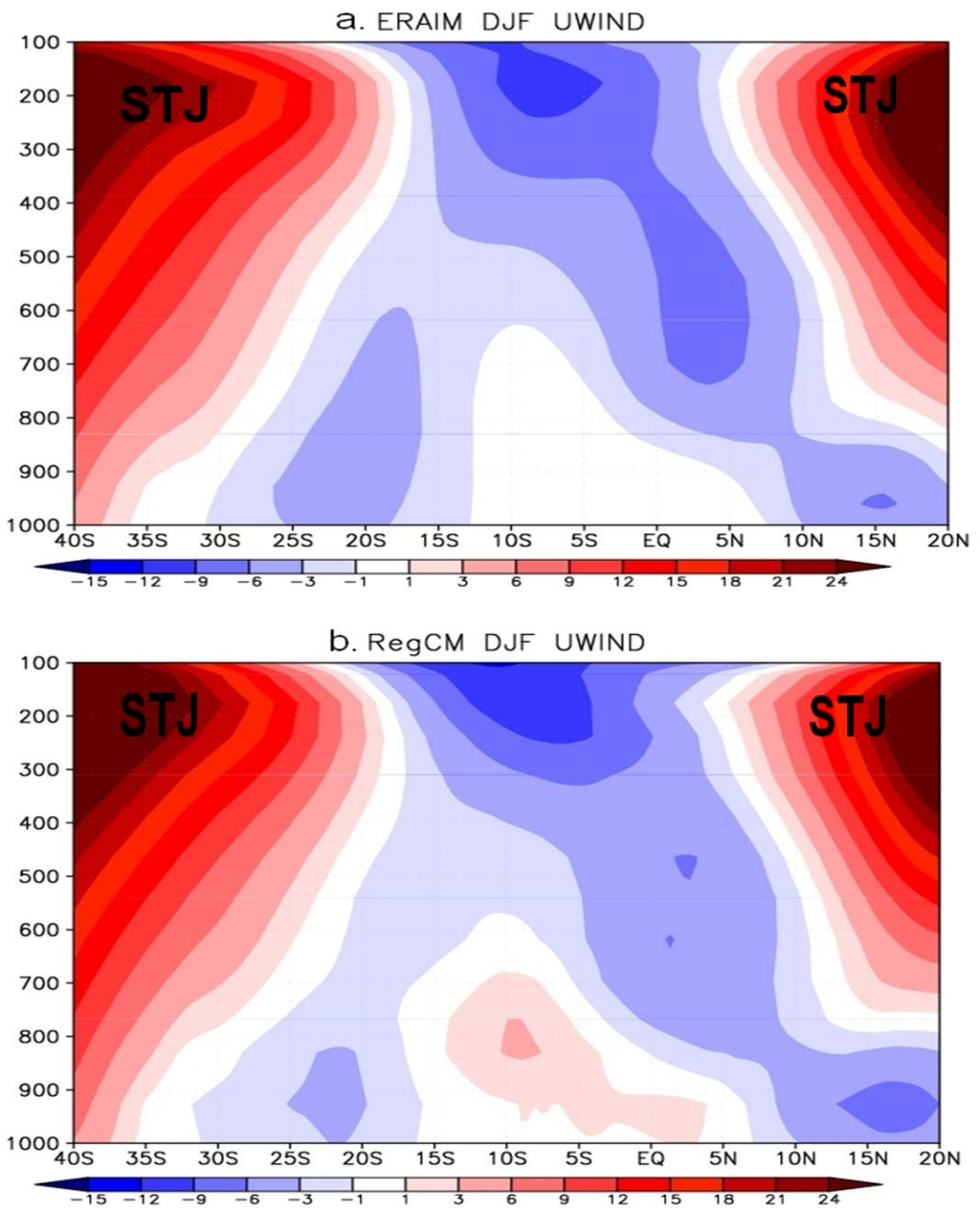
❑ Mean Zonal Wind: South Africa Austral Summer (DJF)

❖ ERA-Interim

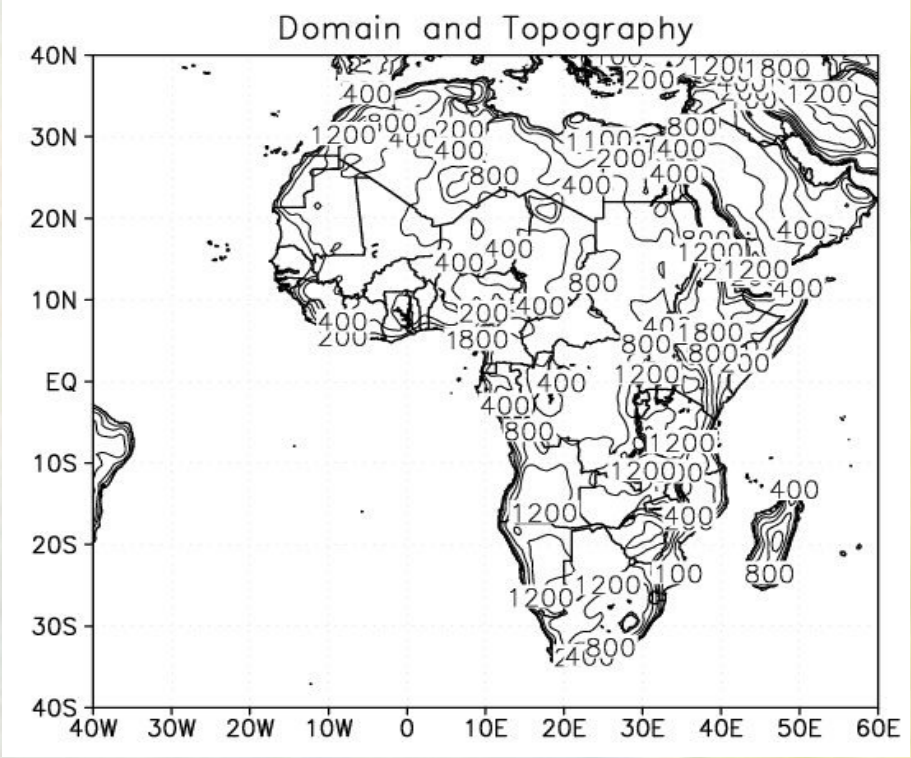
(STJ=Subtropical Jet Stream)

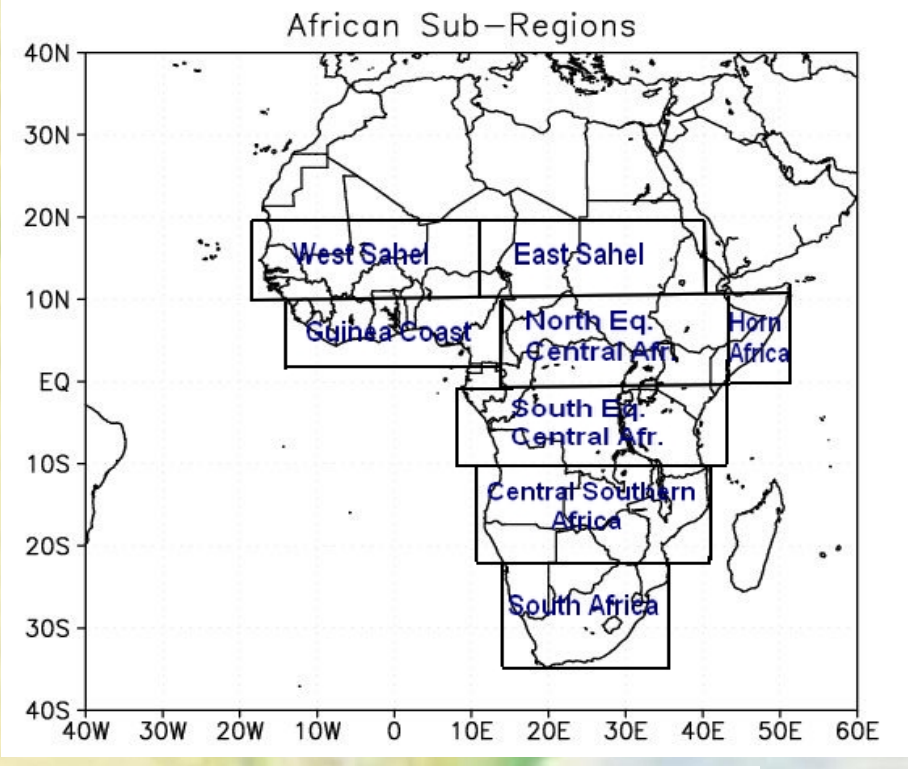
❖ RegCM3

✓ STJ Captured: Strength, Position and Extent
✓ Weaker Mid-level Easterlies



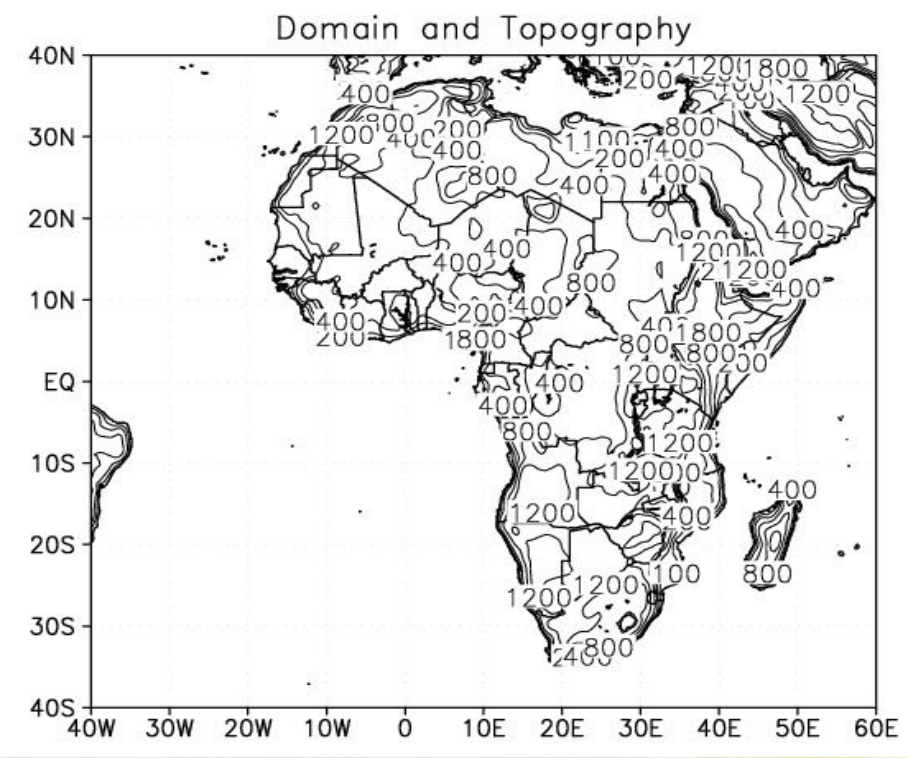
❑ Domain, Topography, Subregions and Data

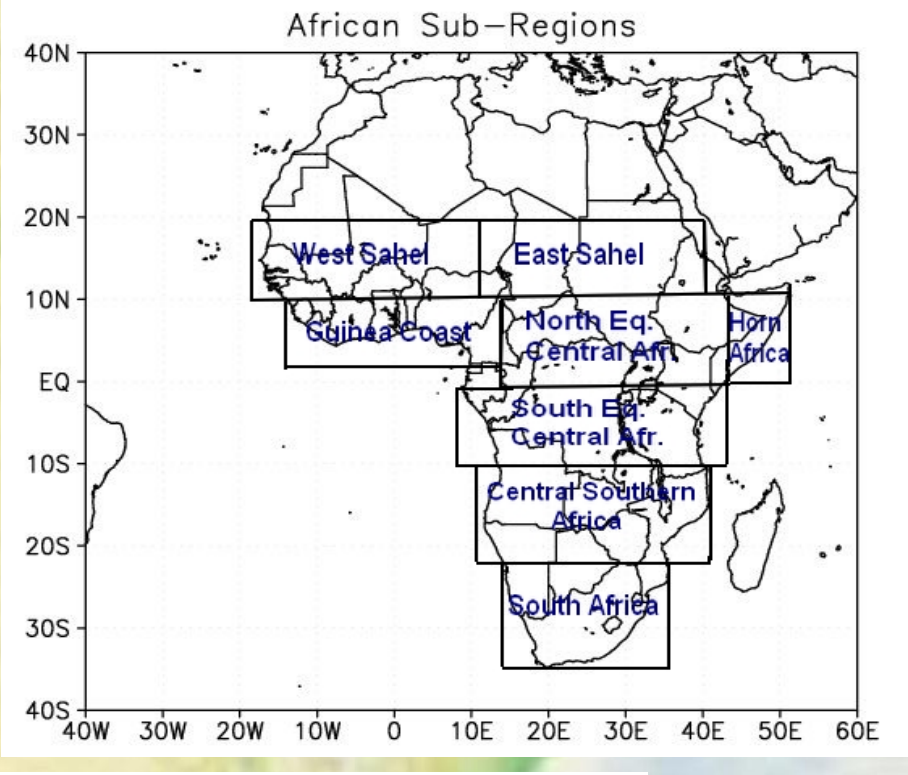




Data	RegCM3	ERAIM	GPCP	CRU	FEWS
Period	1989-2005	1989-2005	1989-2005	1989-2002	2001-2005

❑ Rainy Seasons



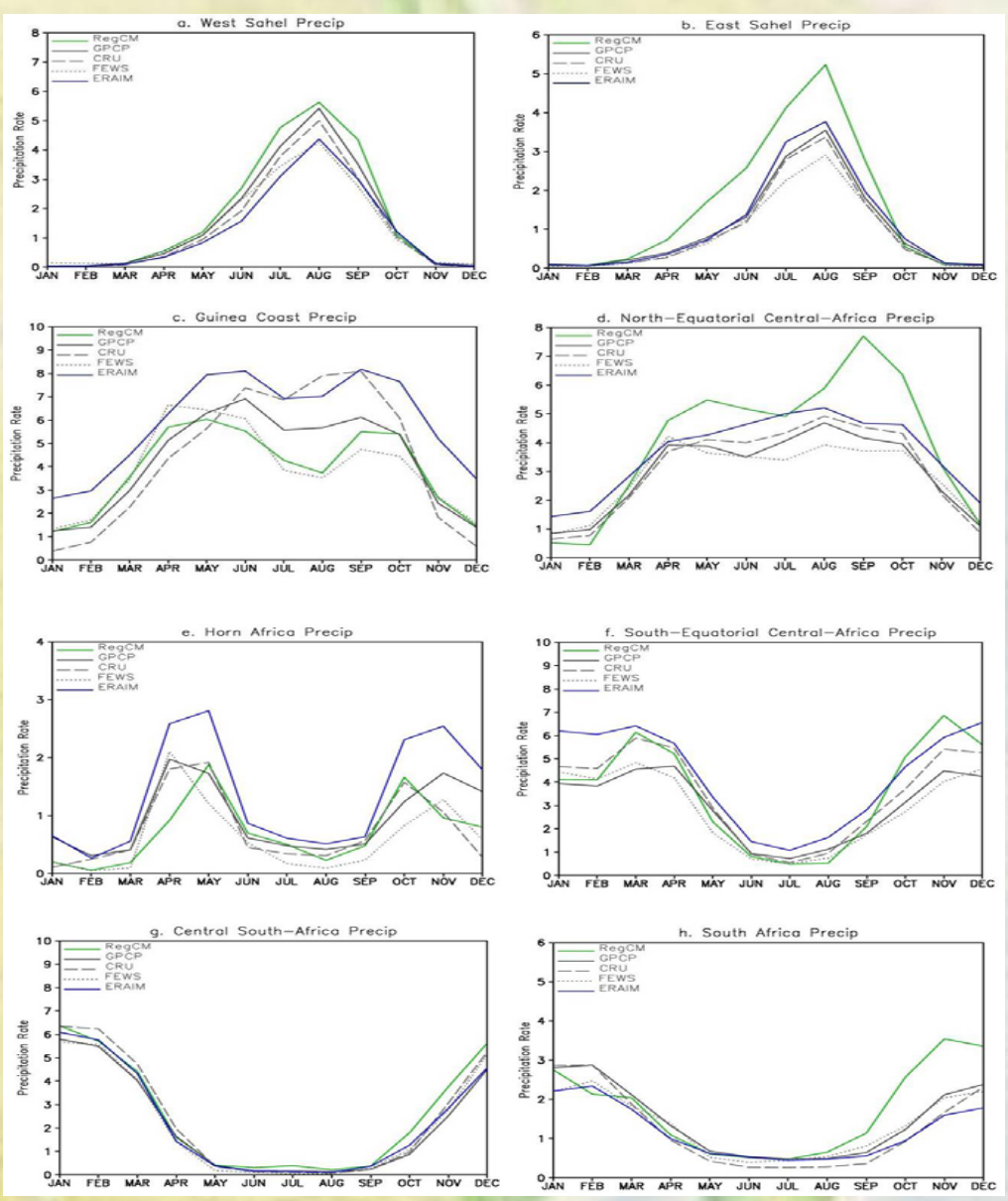


Sub-regions	WSA	ESA	GCO	NEC	SEC	HOA	CSA	SOA
1st Rainy Season	JAS	JAS	MJJ	AMJ	FMA	MAM	DJF	DJF
2nd Rainy Season			ASO	ASO	NDJ	SON		

❑ Mean Annual Cycle over Homogeneous Climate Subregions

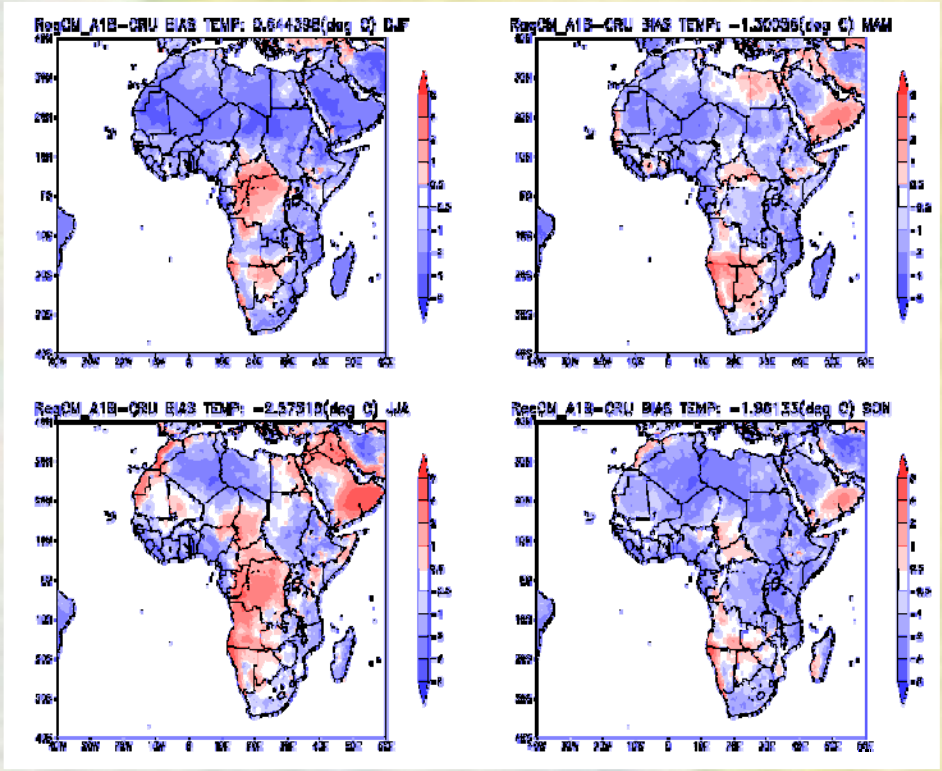
❖ Semi-Arid Subregions:
✓ West Sahel: JAS
✓ East Sahel: JAS
✓ Central South Africa: DJF
✓ South Africa: DJF

❖ Equatorial Subregions:
✓ Guinea Coast:
MJJ and ASO
✓ North Eq. Central Africa:
AMJ and ASO
✓ South Eq. Central Africa:
FMA and NDJ
✓ Horn of Africa:
MAM and SON

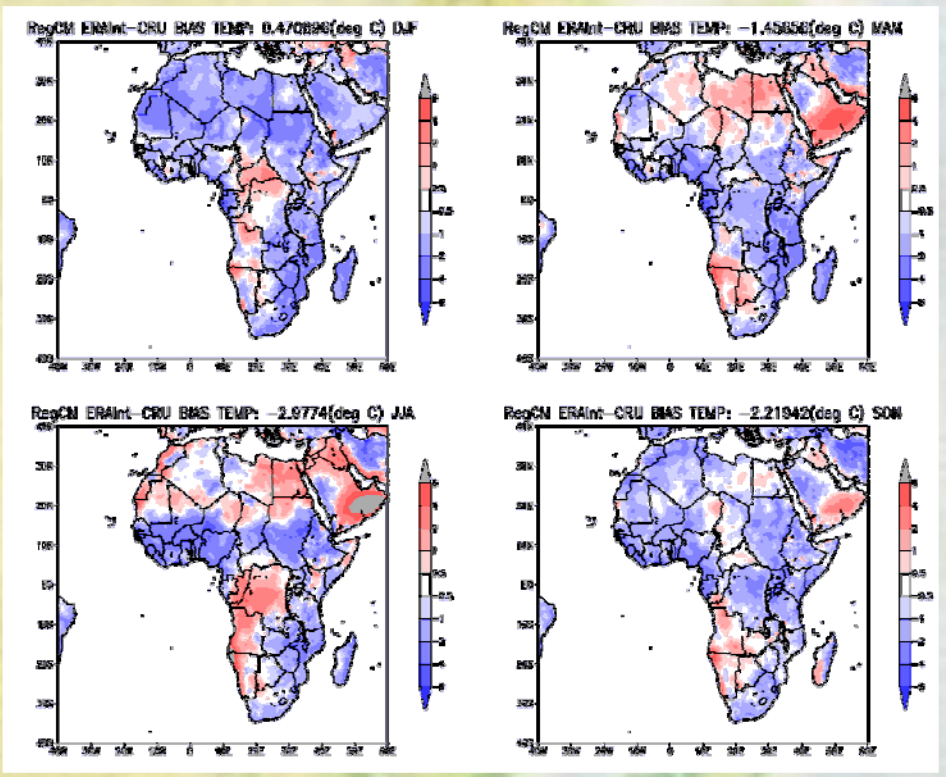


RegCM3 A1B simulations from 1990 to 2100

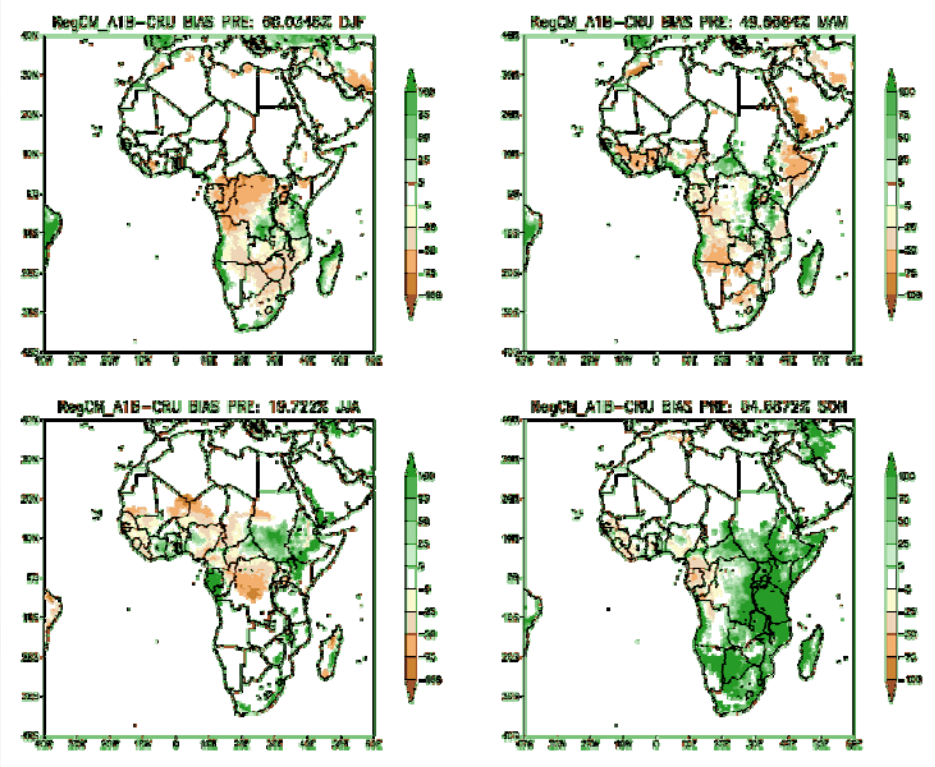
A1B scenario simulations 1990-2002



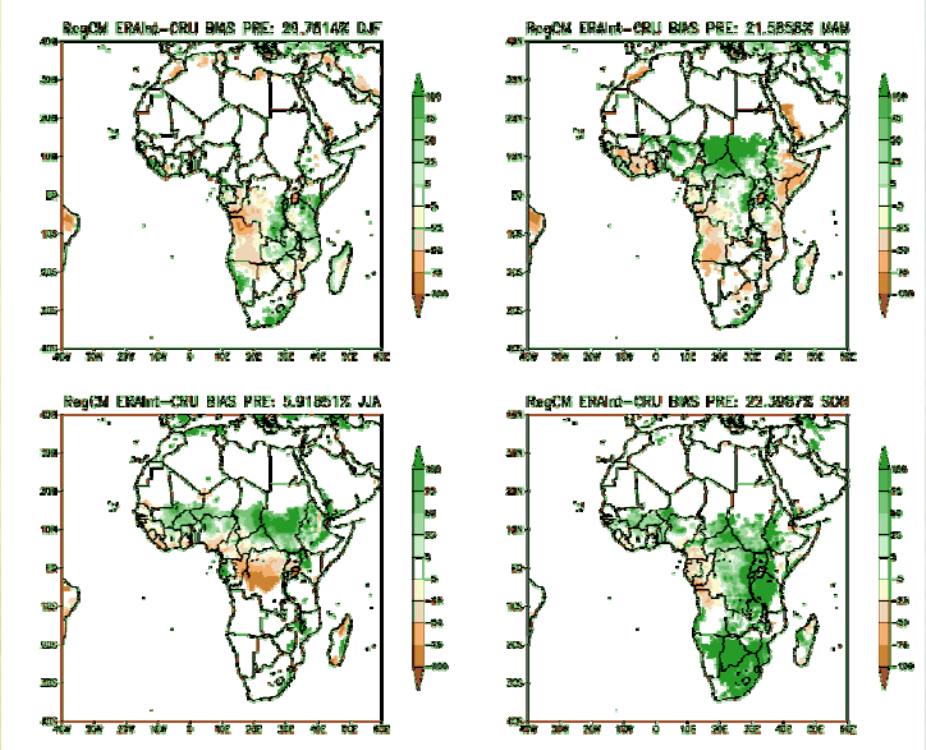
ERA-interim simulations 1990-2002



A1B scenario simulations 1990-2002



ERA-interim simulations 1990-2002



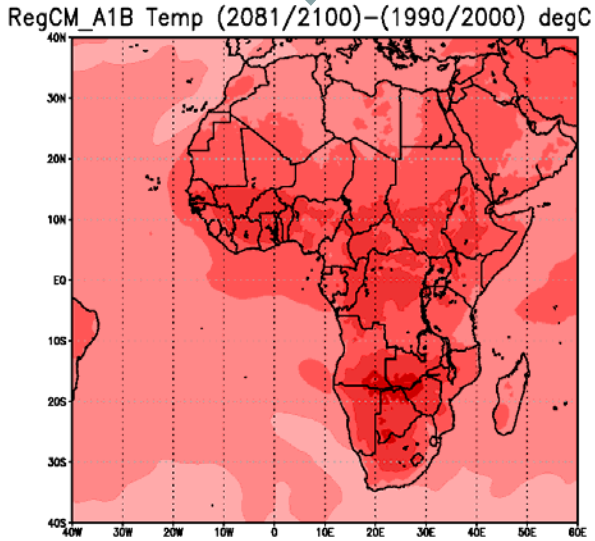
❑ Temperature Change

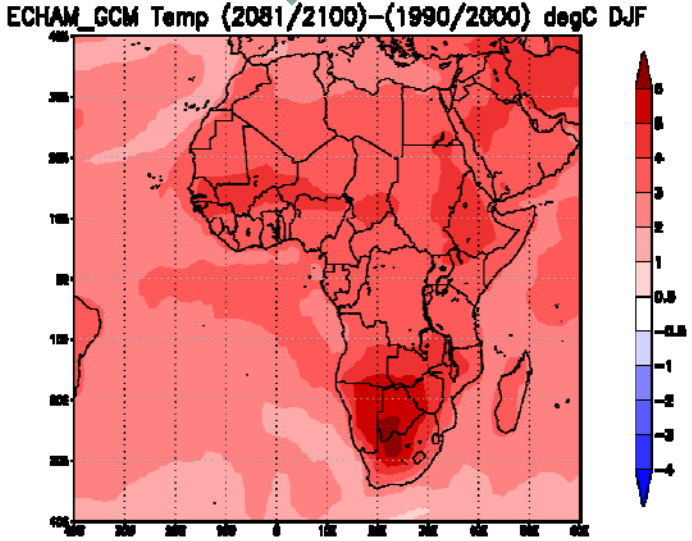
RegCM

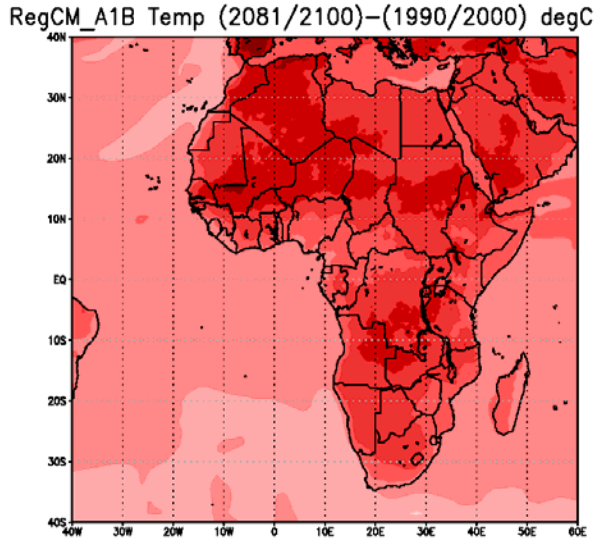
ECHAM GCM

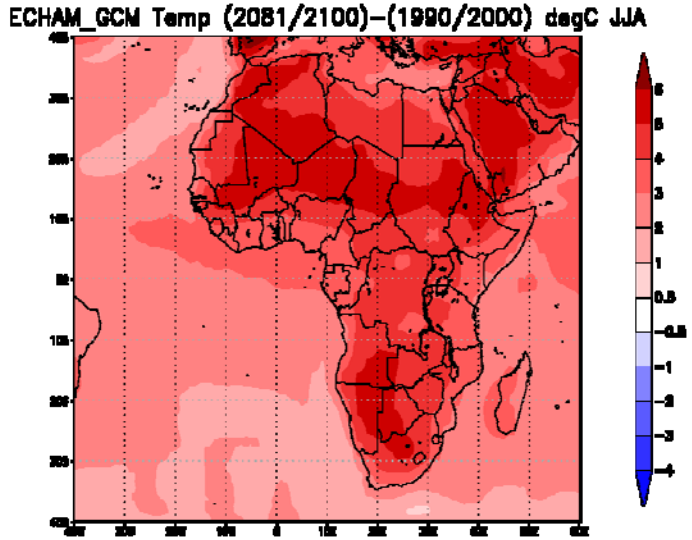
DJF

JJA









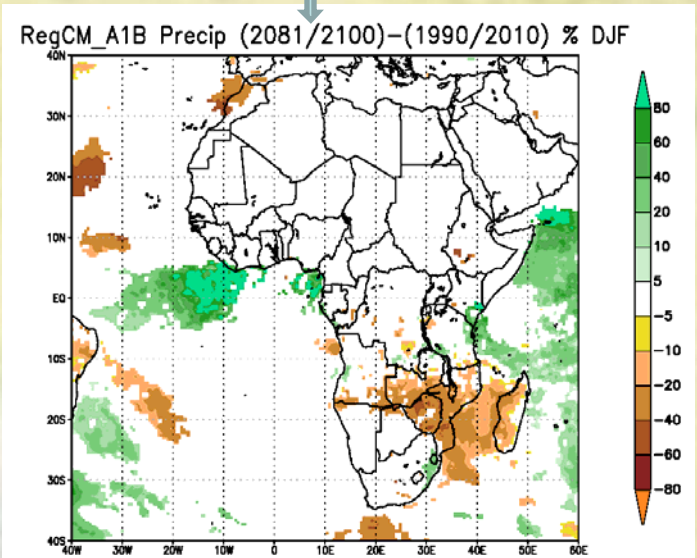
❑ Precipitation Change

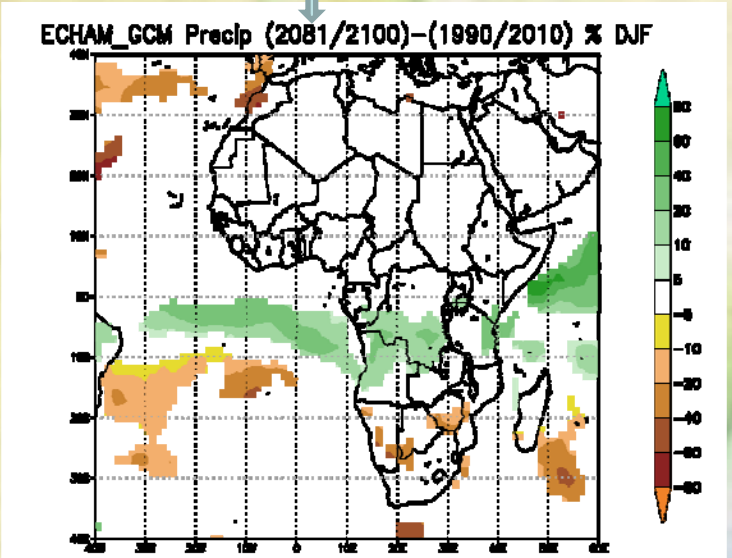
RegCM

ECHAM GCM

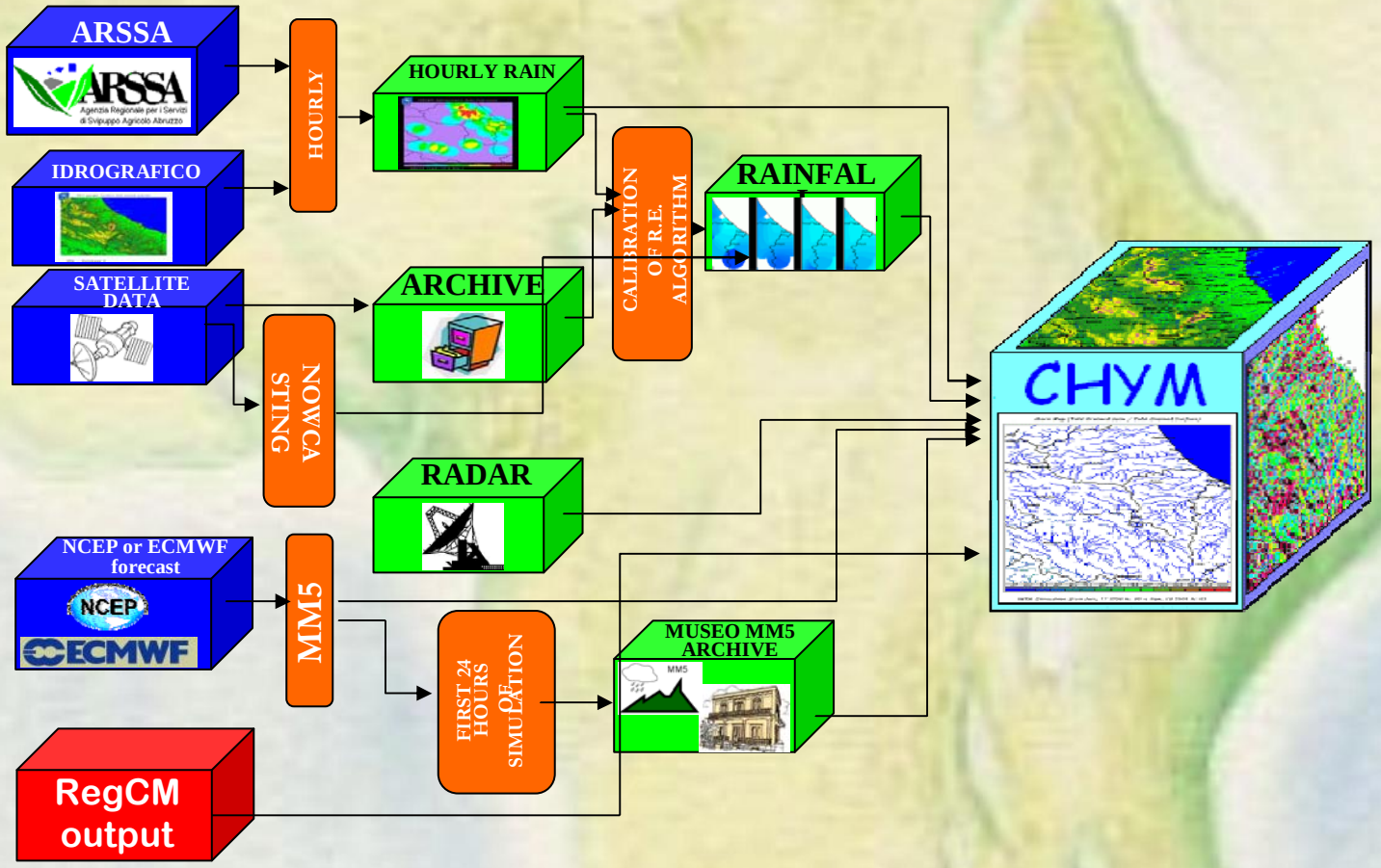
DJF

JJA





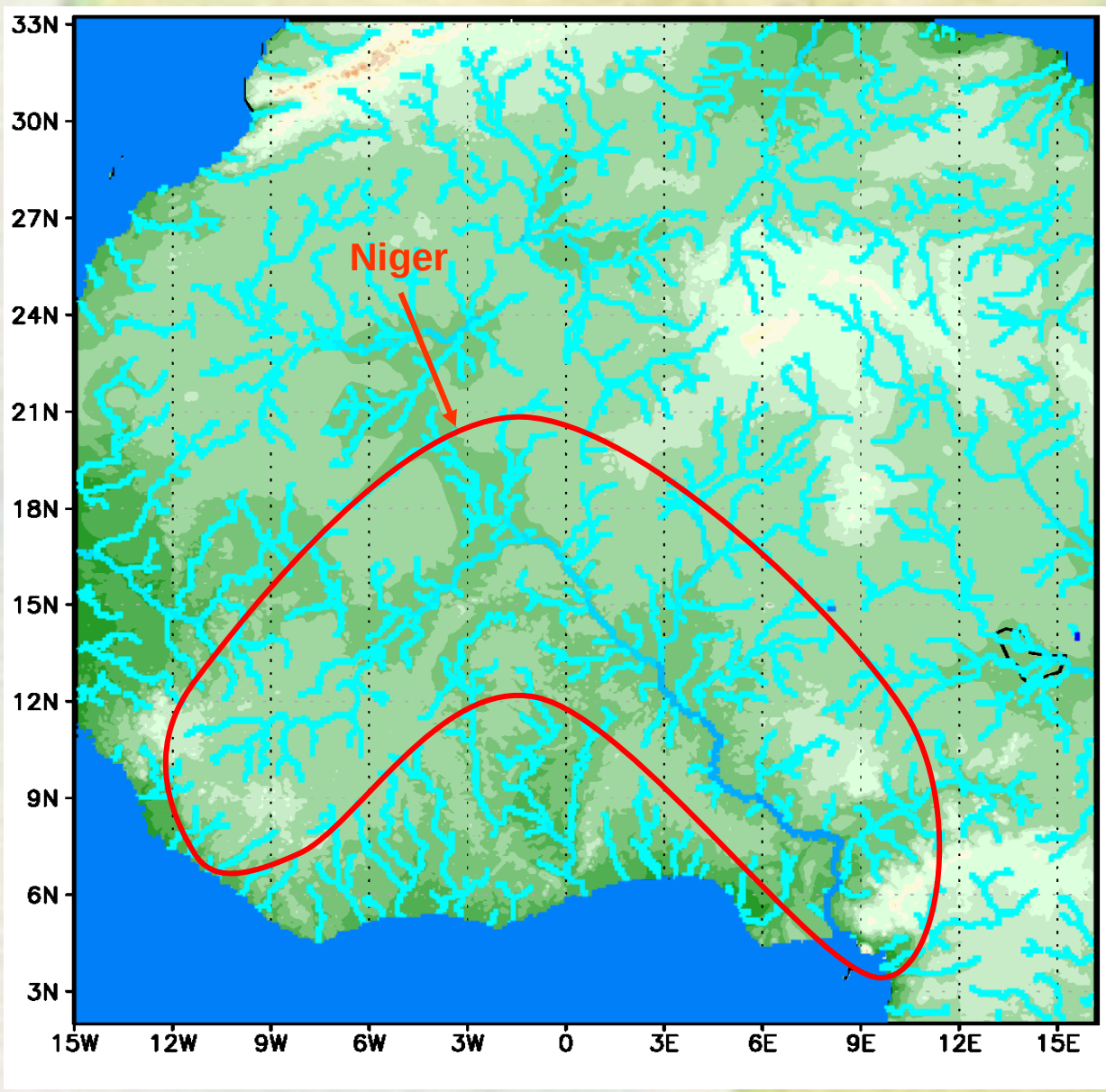
CETEMPS Hydrological Model



CHYM is a distributed grid-based hydrological model designed to acquire rainfall input from different heterogeneous sources for operating purposes.

- the model runs in each geographical domain and with any resolution up to the DEM resolution;
- it can be coupled with the several regional models (for example: the MM5 meteorological model and with RegCM regional climate model).

CHyM



spatial resolution of 9.5km

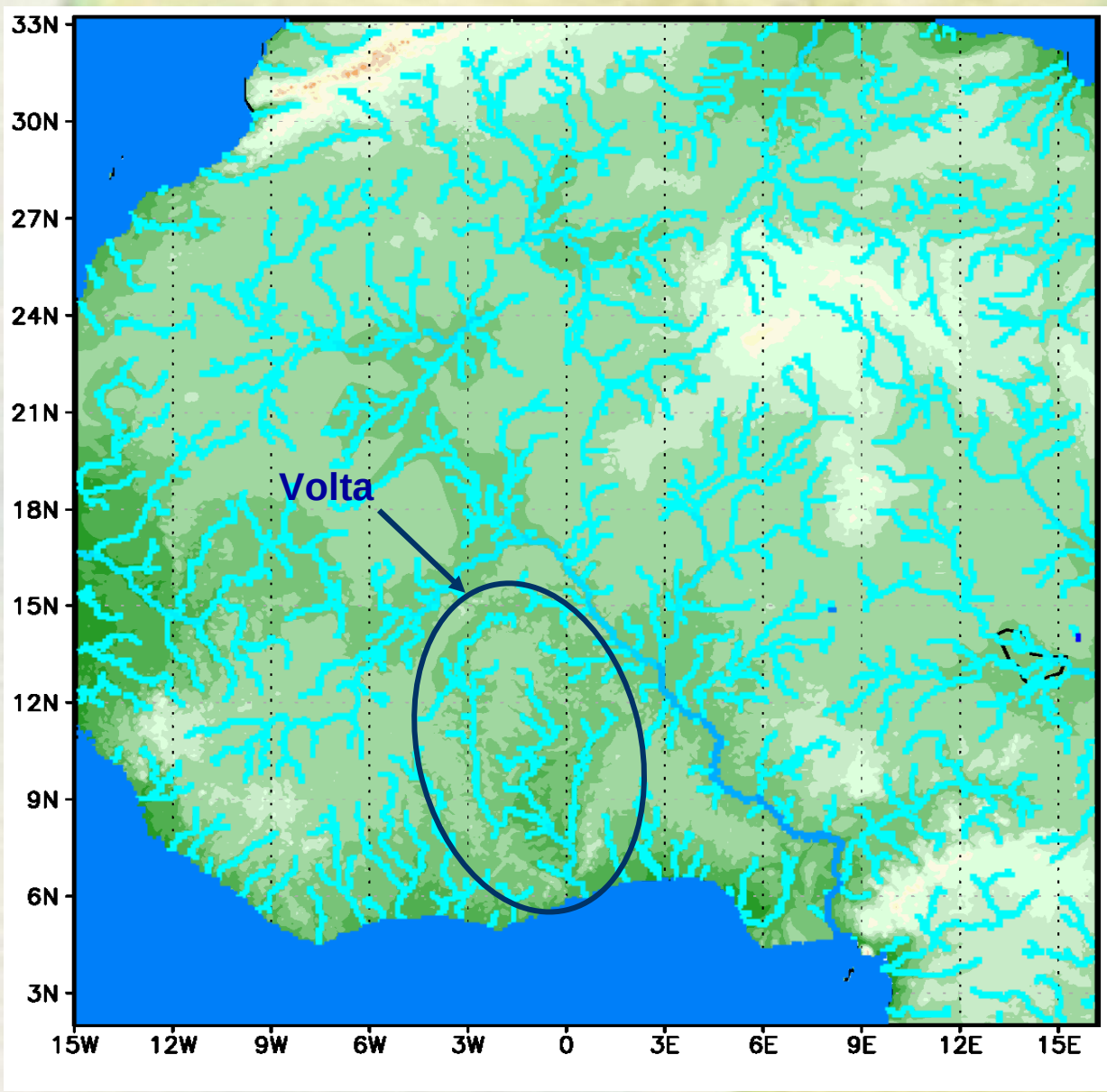
Niger:

- Length 4180 km
- 5 States (Guinea, Mali, Niger, Benin, Nigeria)

Volta:

- Length 1600 km
- 3 States(Burkina Faso, Ghana, Ivory Coast)

CHyM



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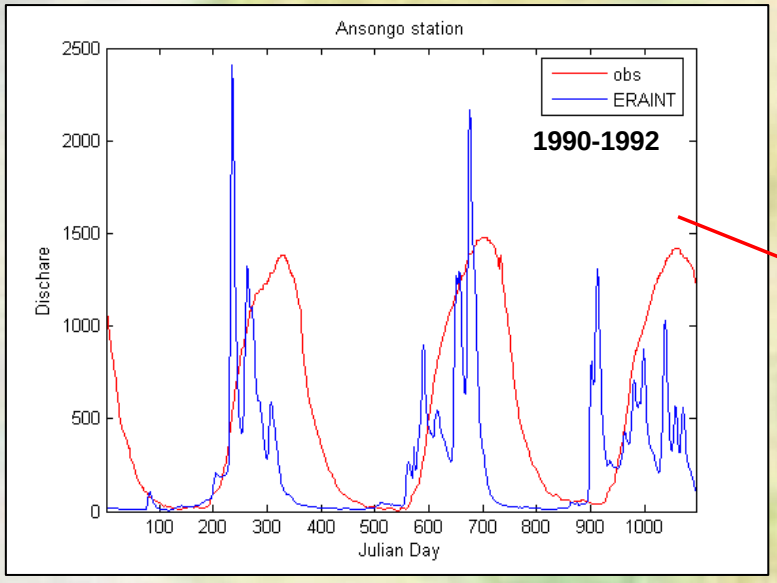
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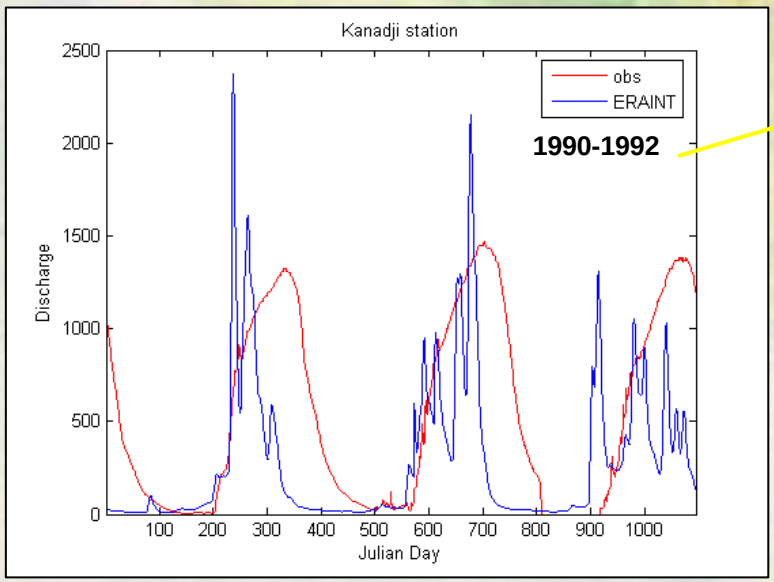
Kanadji station
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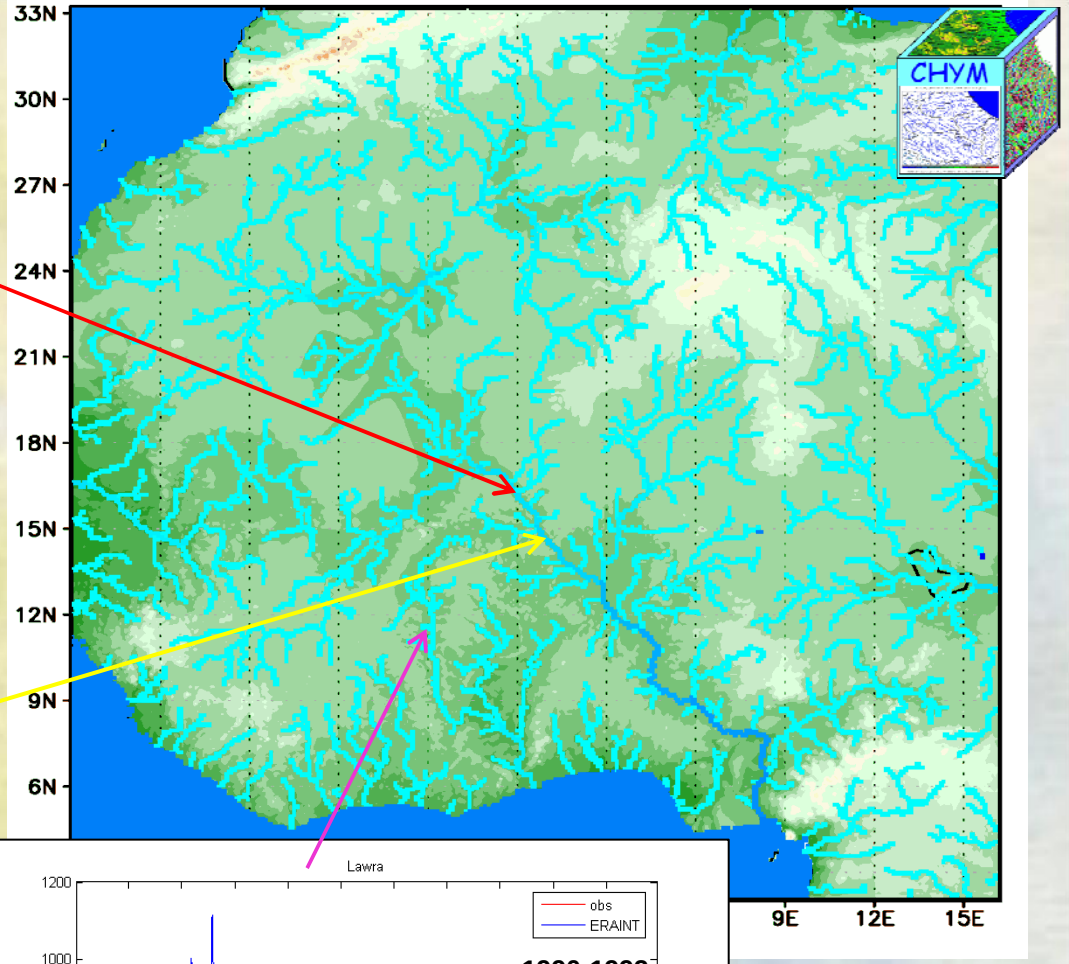
1990-1992
Discharge
Julian Day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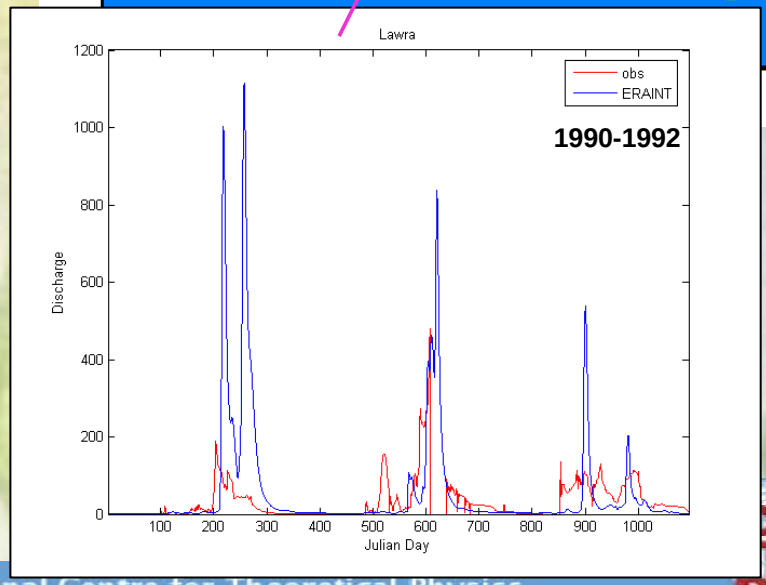
CHYM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1990-1992
Discharge
Julian Day

Thank you
for your attention

Conclusions

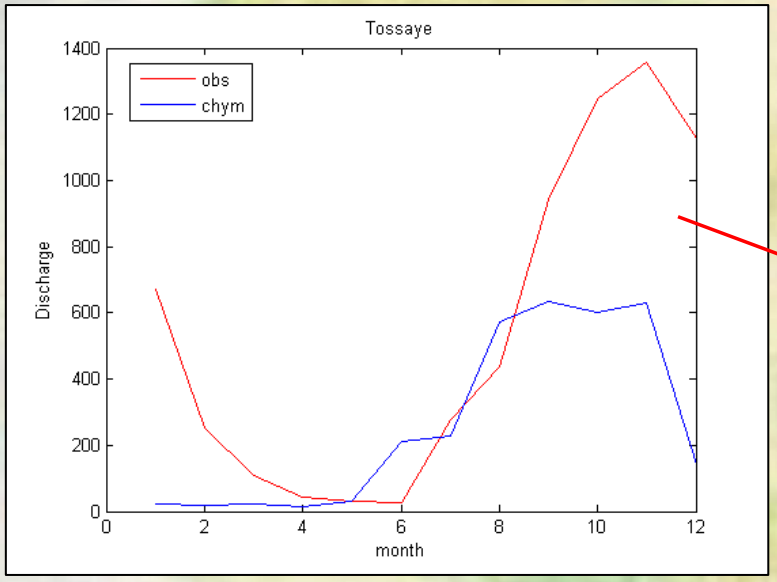
Two sets of simulations were conducted over the entire African domain at 50 km resolution.

- For the control simulation, the ERA-Interim boundary conditions were used.

- For the A1B emission scenario simulation, the ECHAM5 GCM were employed used as boundary conditions.

- The control simulation performs quite well in terms of temperature and precipitation during the seventeen years of validation. The model is able to capture fairly well the main zonal circulations influencing the African continent (the monsoon flow, the African Easterly Jet, the Tropical Easterly Jet and Subtropical Jet Stream).

- The scenario simulation shows a warming up to 5 degrees for the period 2081-2100 compared to present day everywhere on the continent and for all seasons, it shows a negative precipitation change in spring and summer in the Sahel region and also in winter in South Africa.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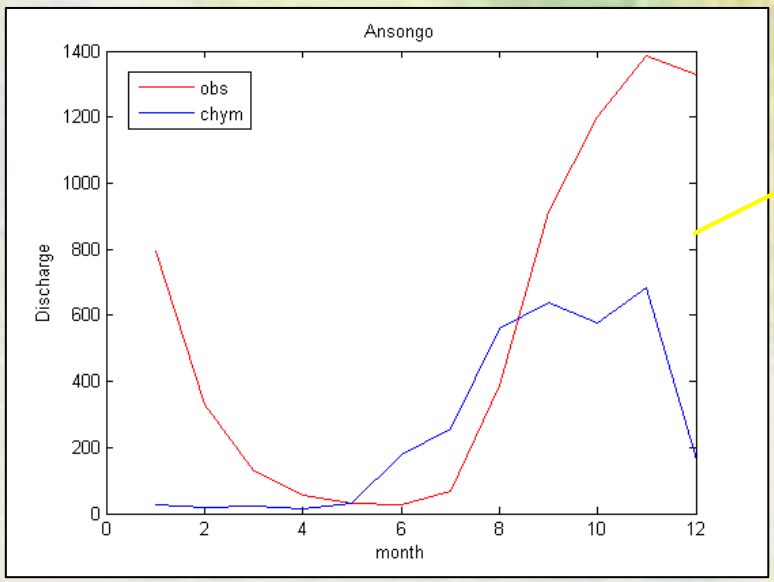
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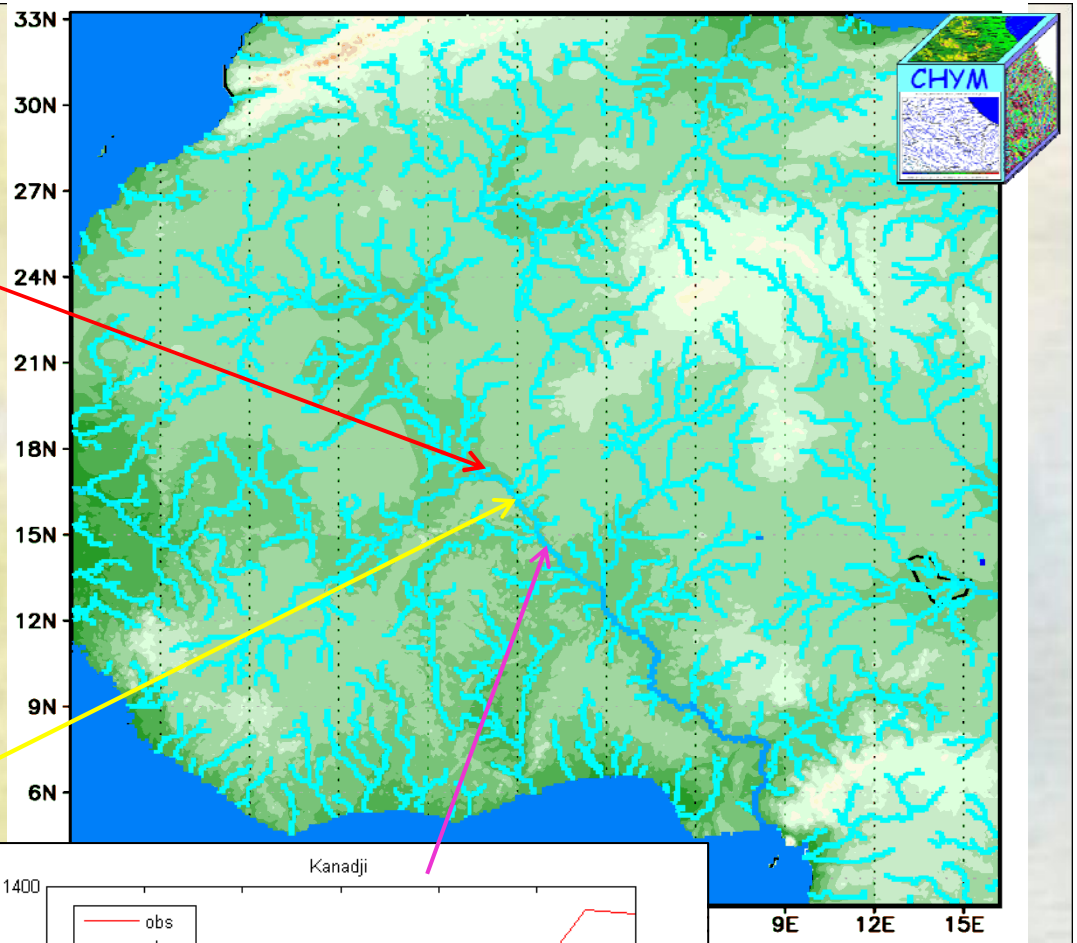
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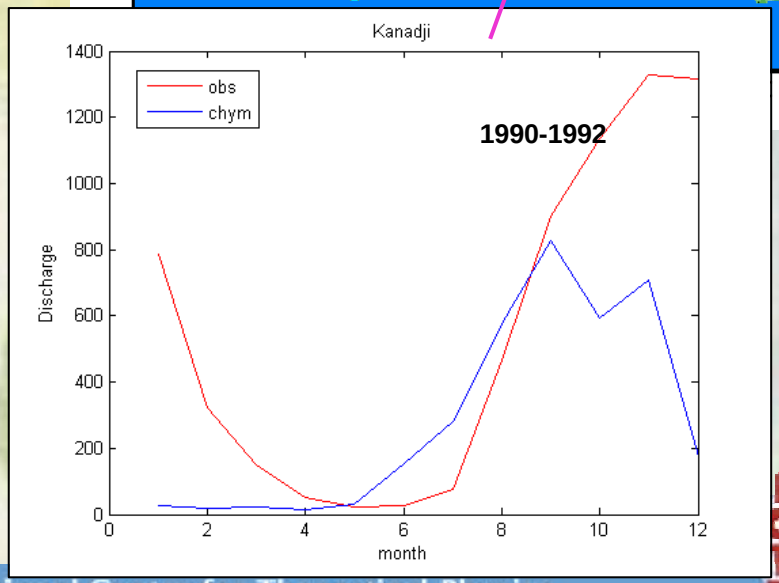
CHYM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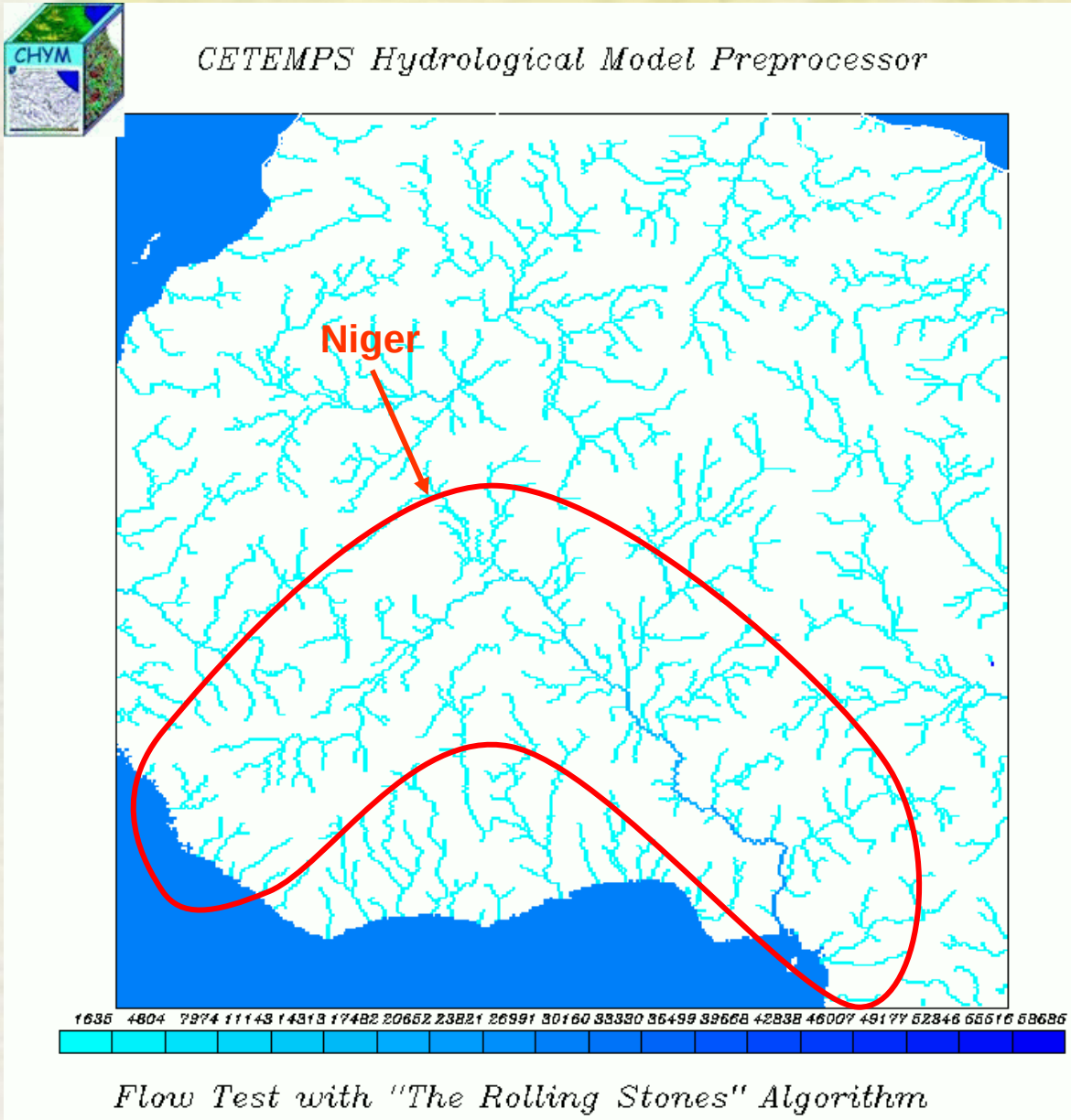
CHyM



spatial resolution of 9.5km

Niger:

- Length 4180 km
- 5 States (Guinea, Mali, Niger, Benin, Nigeria)

Volta:

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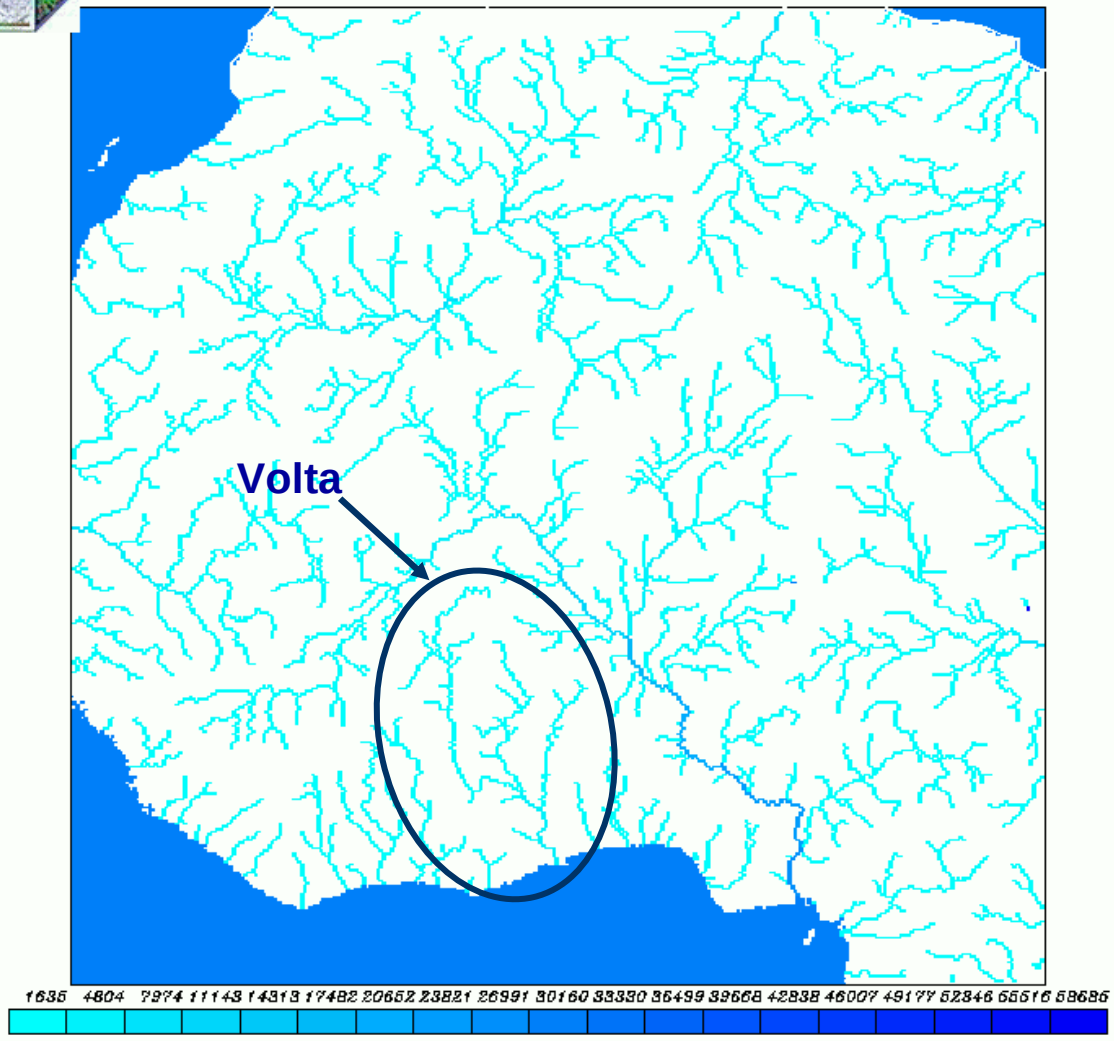
- 3 States(Burkina Faso, Ghana, Ivory Coast)

CHyM

CETEMPS Hydrological Model Preprocessor



Flow Test with "The Rolling Stones" Algorithm

spatial resolution of 9.5km

Niger:

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Volta:

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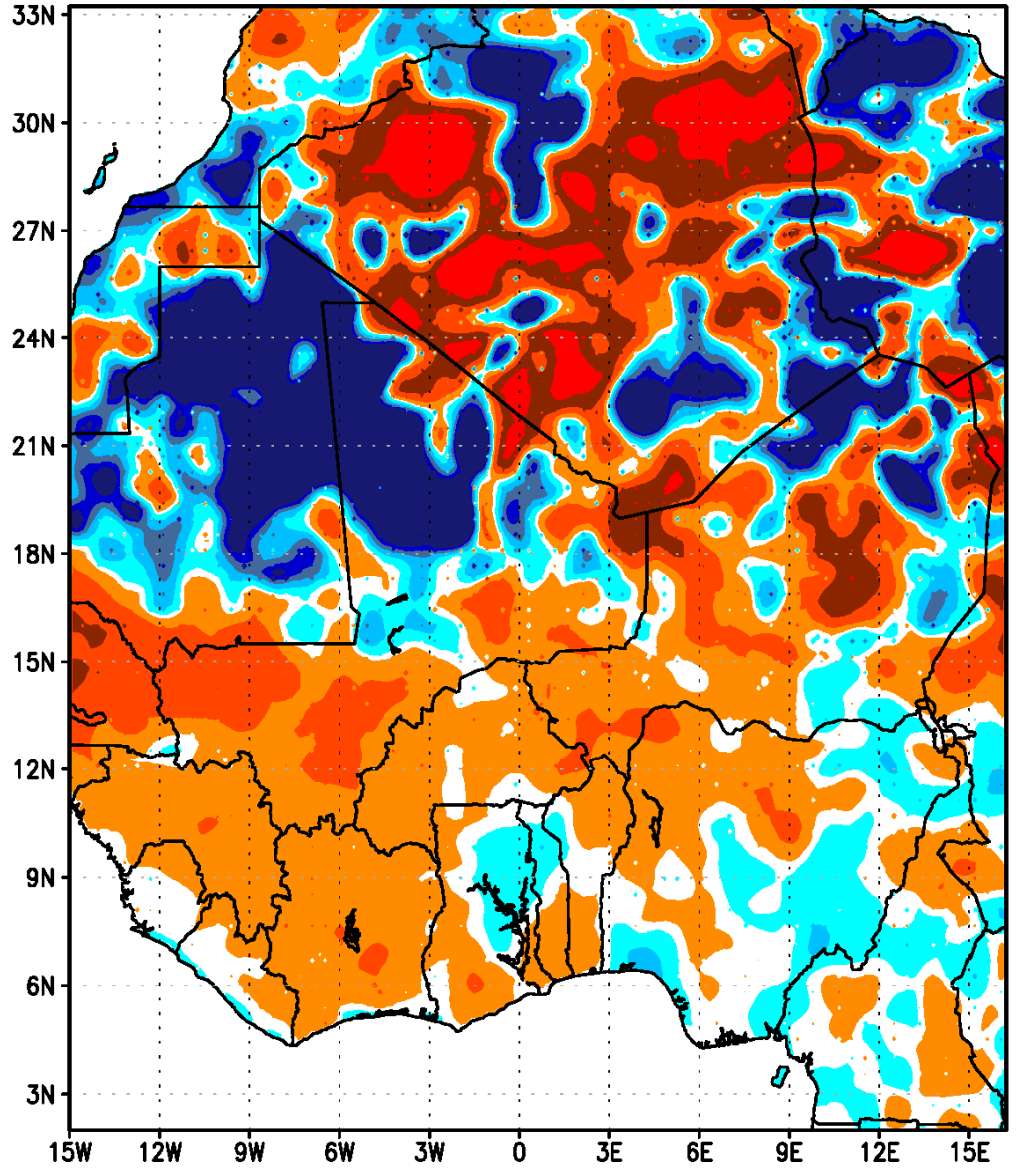
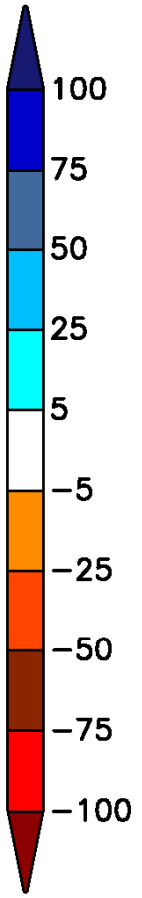
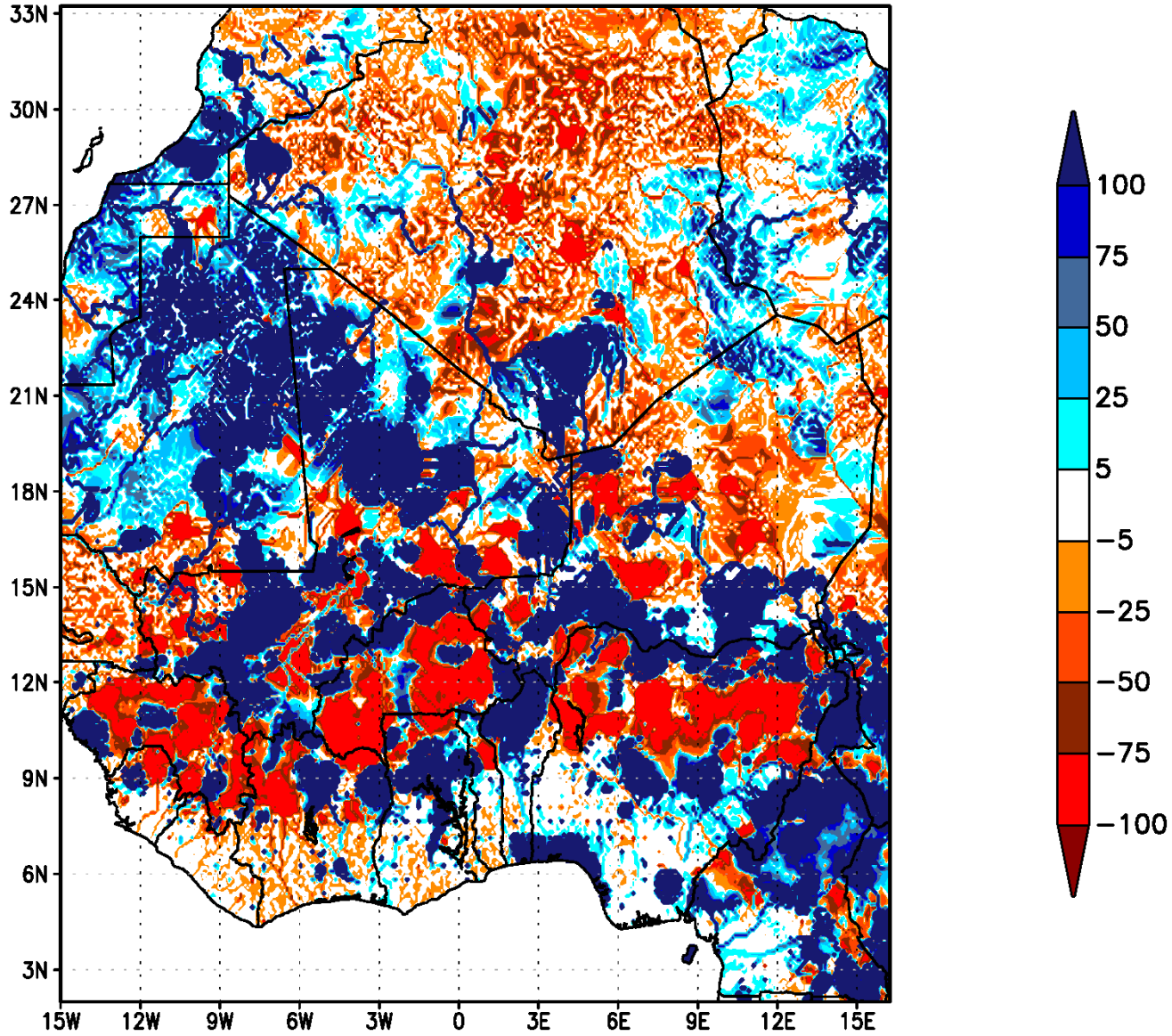
MJJAS precipitation change (2080/2082)−(1990/1992)

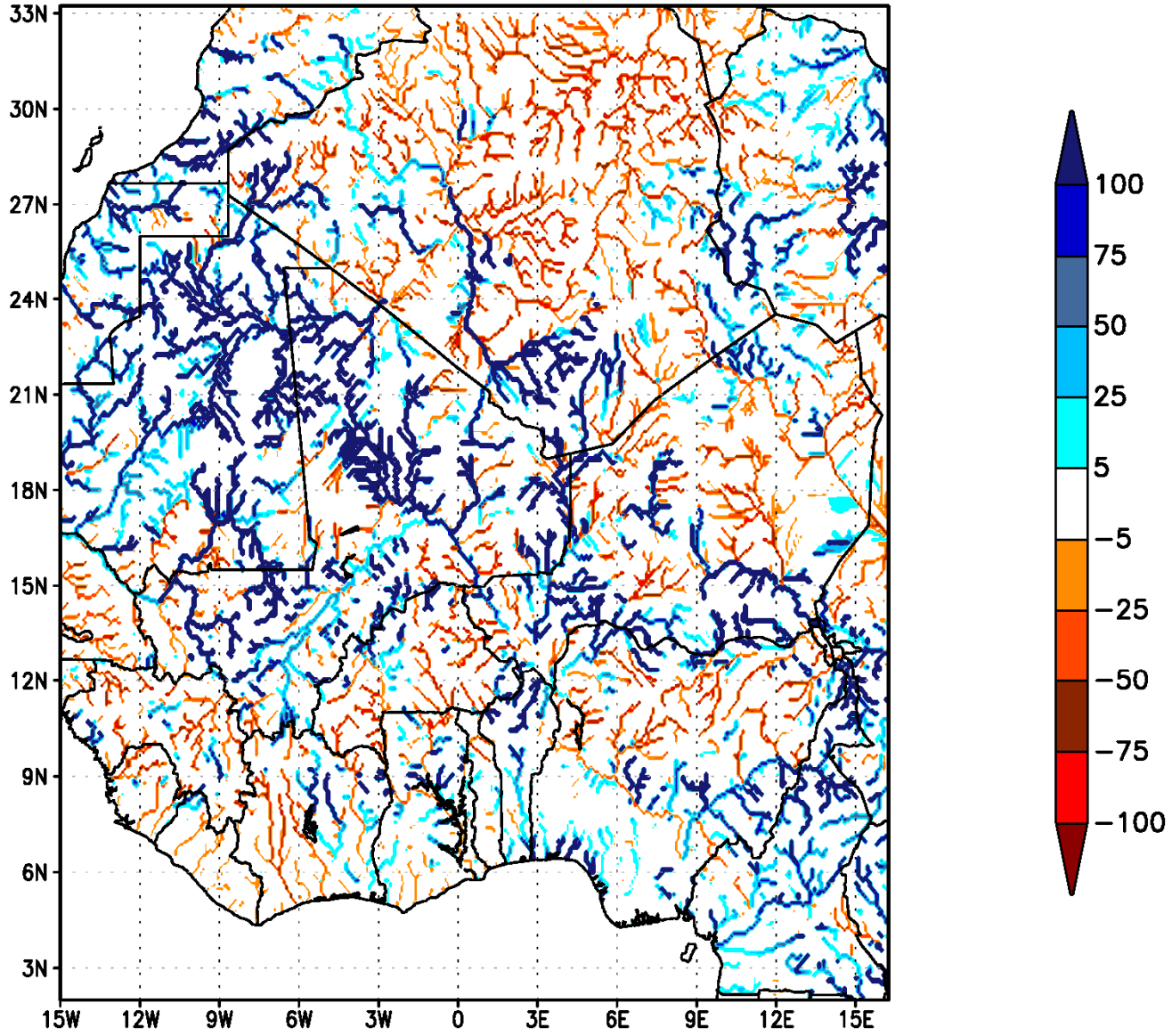




MJJAS runoff change (2080/2082)−(1990/1992)



MJJAS runoff change (2080/2082)−(1990/1992)

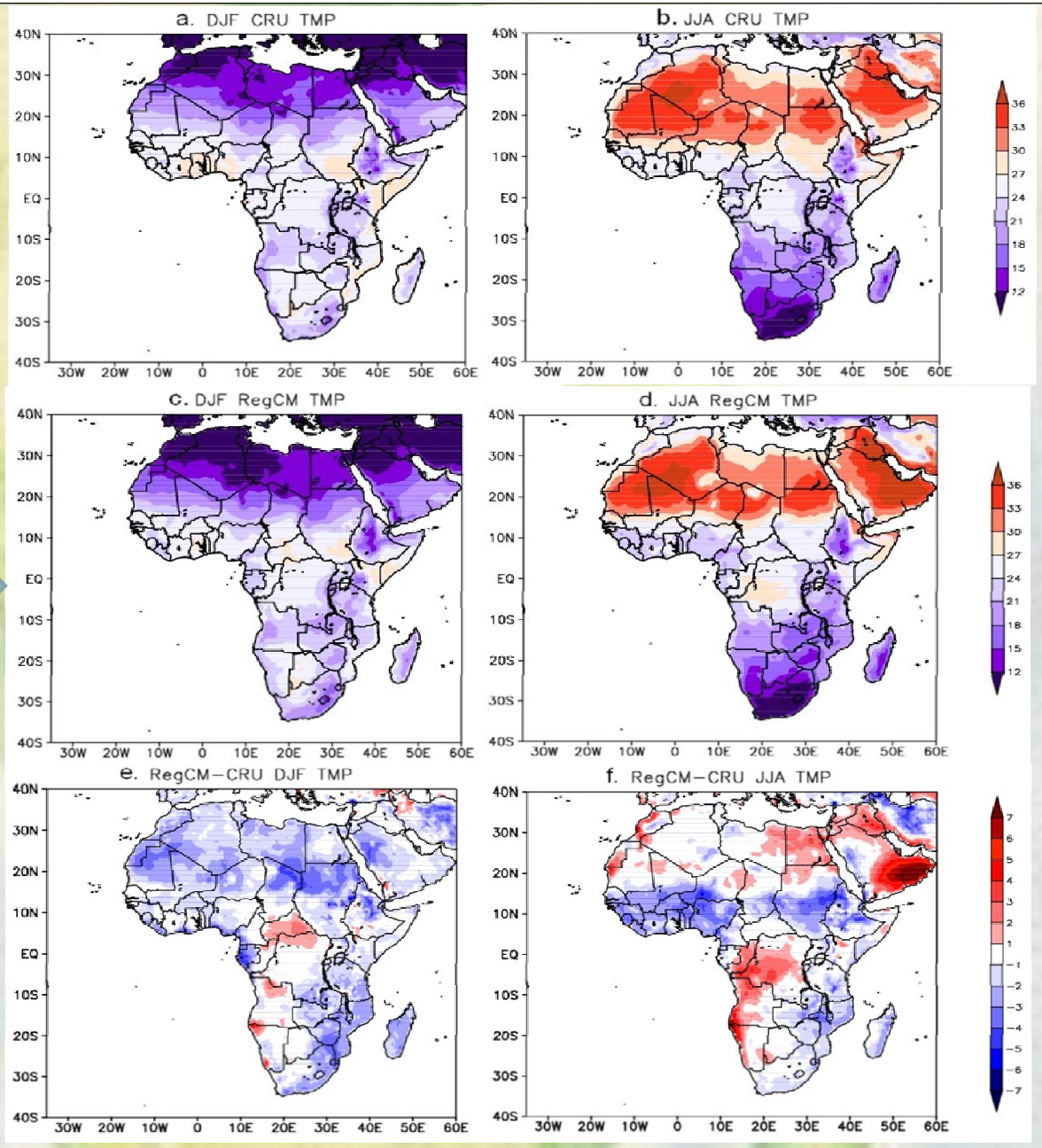


❑ Temperature Climatology

❖ CRU

❖ RegCM3

❖ RegCM3 minus CRU



❑ Precipitation Climatology

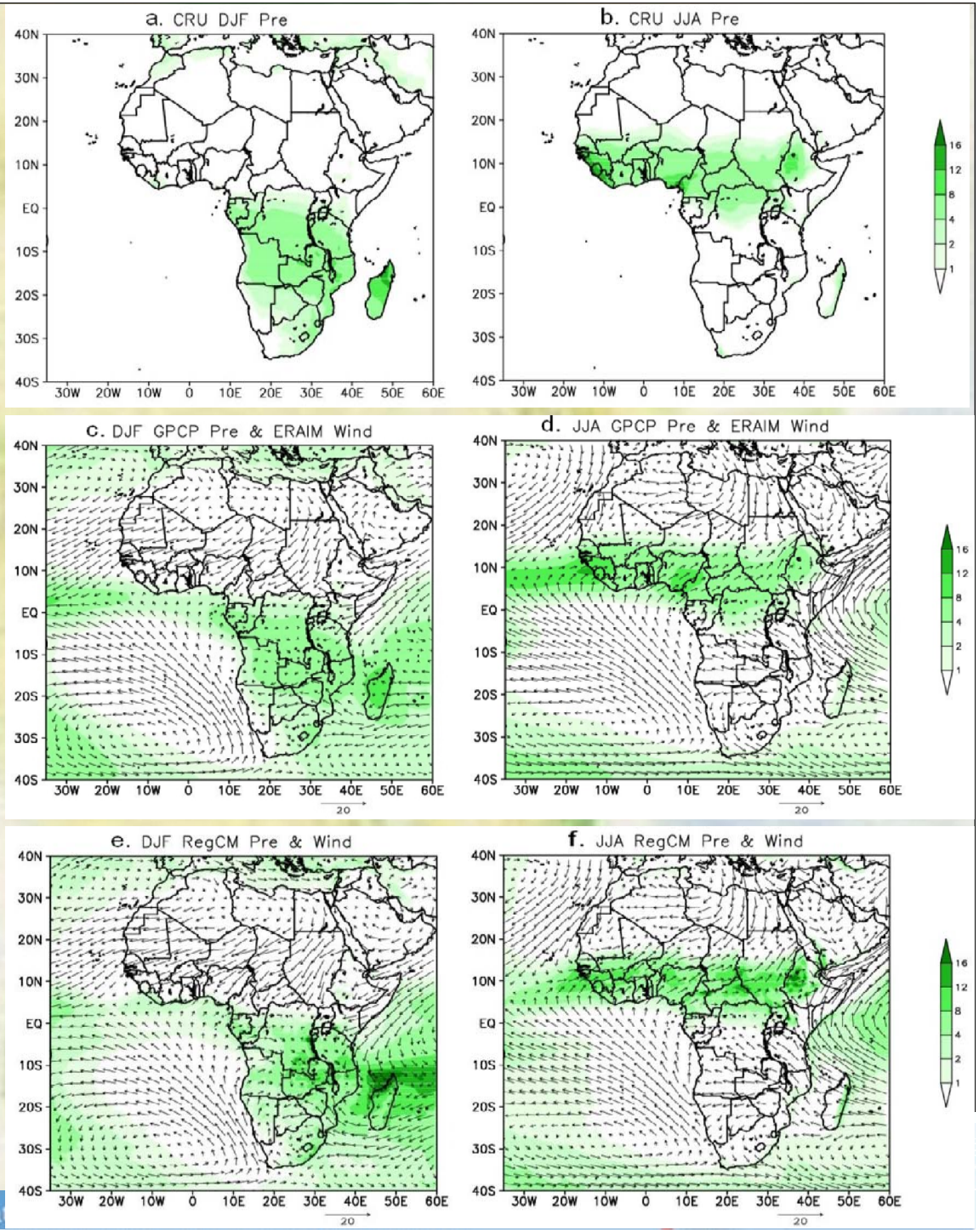
❖ CRU

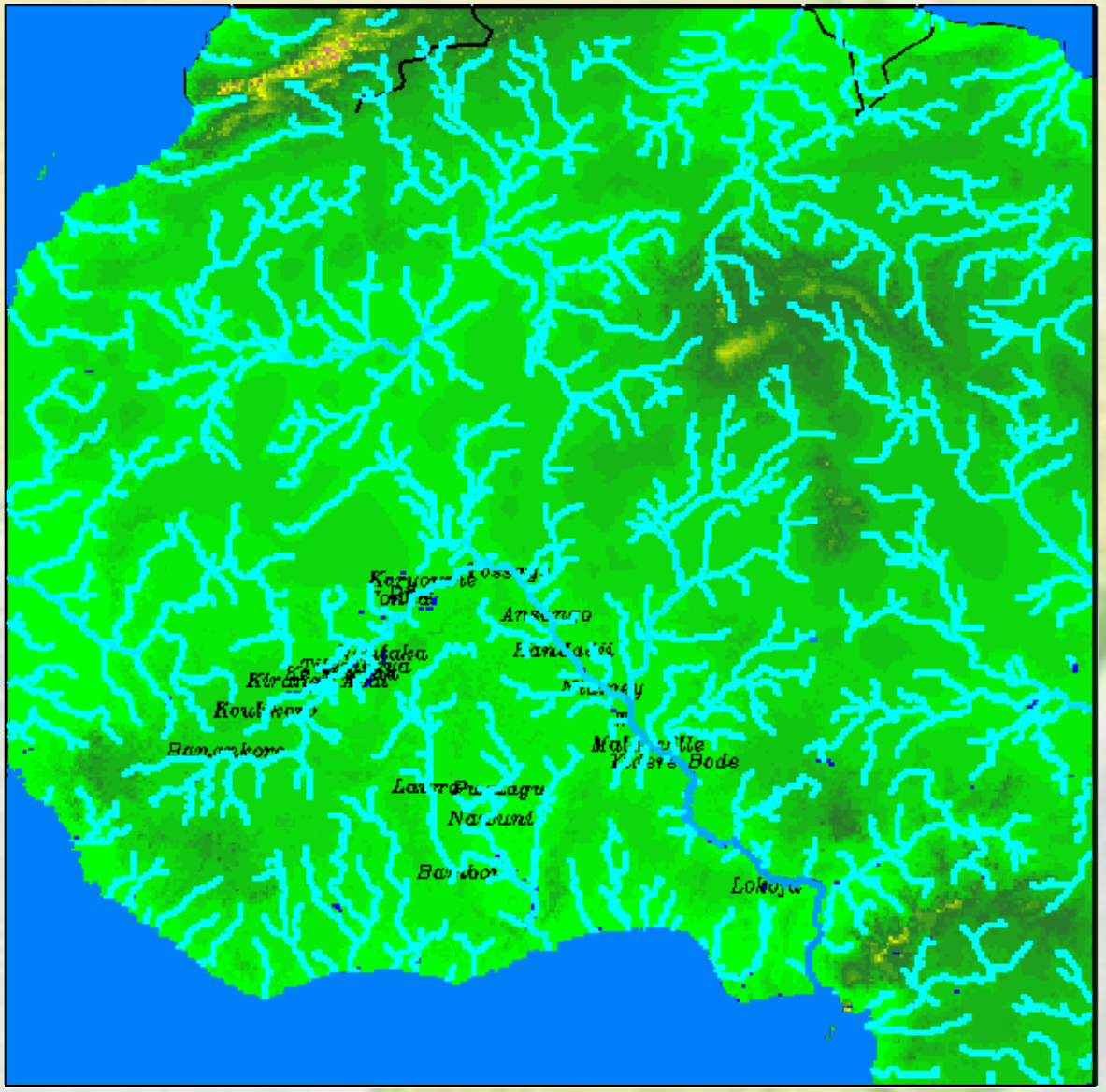
❖GPCP

✓ Discrepancies between Observed Climatologies: Maxima over Ethiopia Highlands in CRU not found in GPCP

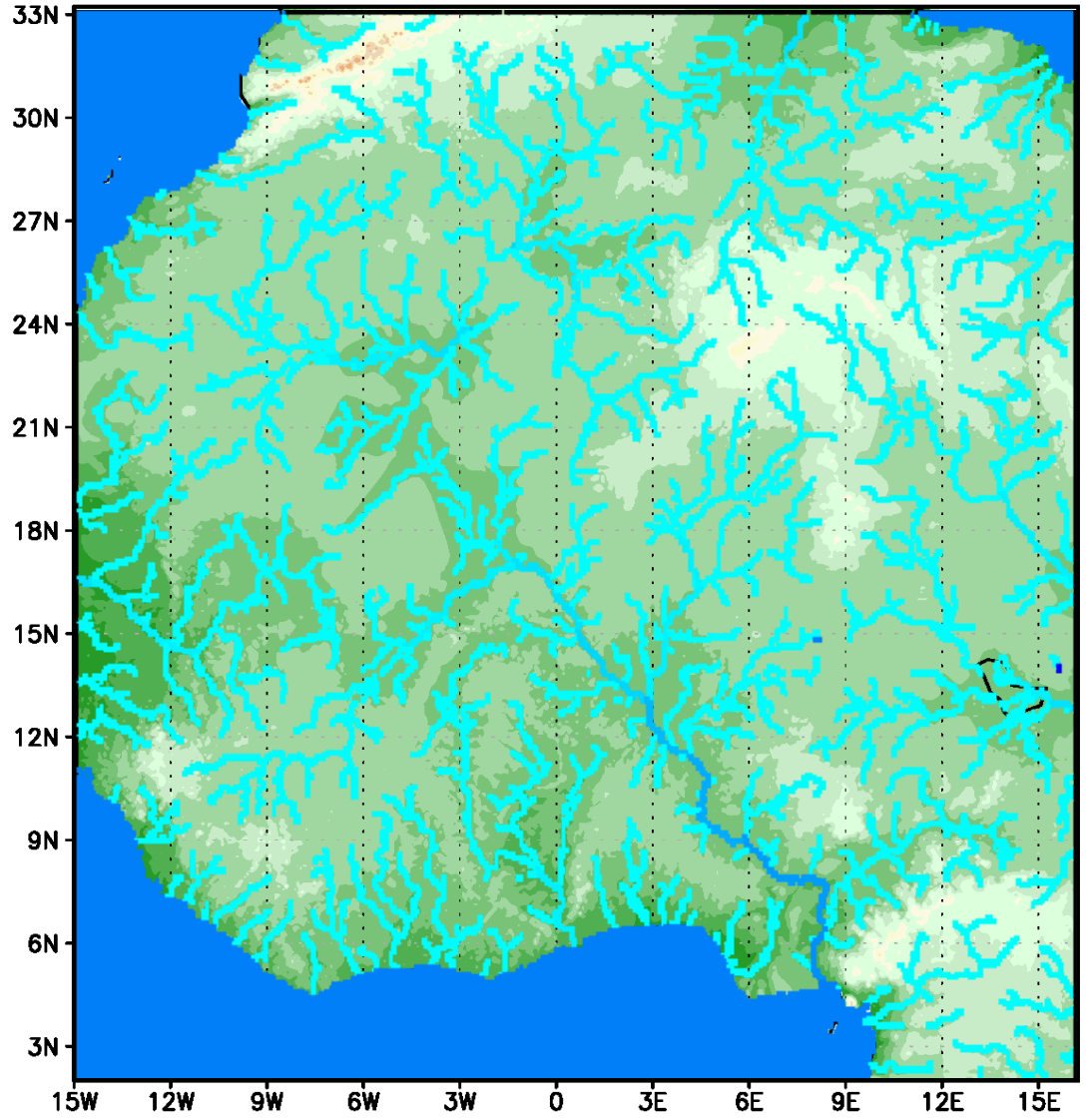
❖ RegCM3

✓Additional Peaks over Complex Terrains not found in Observation





CHyM DEM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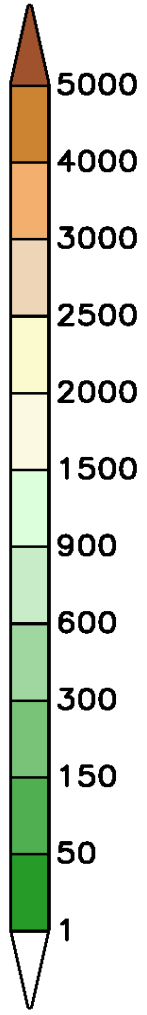
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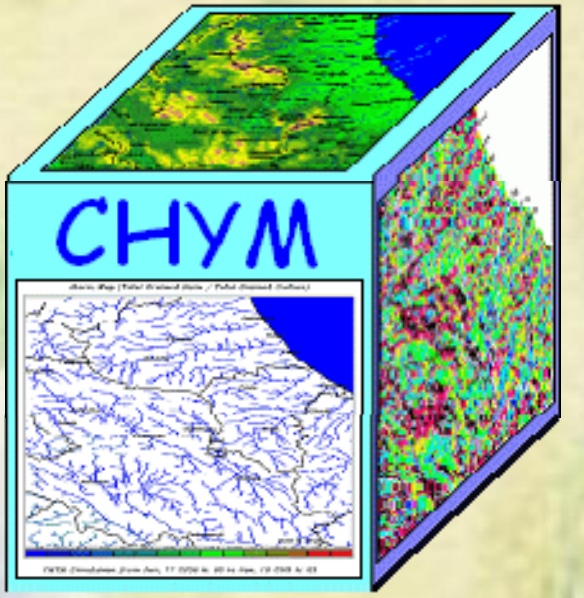
CETEMPS Hydrological Model



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"Cellular automata algorithms for drainage network extraction and rainfall data assimilation"
Hydrological Science Journal, June 2007. Vol. 52.