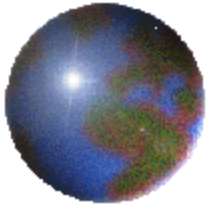
Modeling the effect of climate change on Water Resources in Southern Africa



***Ismaila Diallo[1, 2] and Lu Li[3]**

[1]Earth System Physic section, The Abdus Salam ICTP.

[2]Cheikh Anta Diop University (UCAD), Laboratoire de Physique de l'Atmosphére et de l'Océan Siméon-Fongang (LPAO-SF). Dakar-Sénégal.

[3]Department of Geosciences, University of Oslo, Norway.

***idiallo@itcp.it**

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S. Sandeep (University of Oslo)

X. Chong-Yu (University of Oslo)

Introduction

- South Africa receives about 60% of its total rainfall during the austral summer season (December-January-February, DJF) except for southwestern region and along the south coast and has large spatio-temporal variability.

- This large variability have significant effect in this region which economy relies heavily on rain-fed agriculture and hydropower, thus change in rainfall pattern due to climate change make this critical.

- It is important to provide projections of possible changes in hydrologic regimes over the region for use of impact studies.

- Towards this goal the SoCoCa project was initiated in which climate projection obtained from RCM is used as input into hydrological models in order to assess related impacts in the region

- The RCM selected for this project is RegCM4

(1) Ability of RegCM4 to reproduce the daily rainfall characteristics

How well these indices are captured over SA?

(2) The 2nd purpose of this study is to provide a model estimate of change in hydrological elements.

Large-scale hydrological model WASMOD-D

Model set up…

- ❑ **RegCM4: Giorgi et al. 2012**
- ❑ **A countunious simulation of 40 years : 1990-2029**

➢ **Grell /Fritsch and Chapell**

➢ **CAM4 0.9x1.25 deg.**

25km and 18 vertical levels

➢ **Present day and early future under RCP4.5**

Reference: *Diallo I, Giorgi F, Sandeep S, Stordal F, Guiliani G (2013) Change in daily extremes in the early future over Southern Africa using RegCM4 regional climate model". Int J. of Climatology.*

❑ Validation data

Daily precipitation → **TRMM (0.25 x 0.25°)**, **GPCP1DD (1 x 1°)** — **1998-2009**

❑ Climate indices

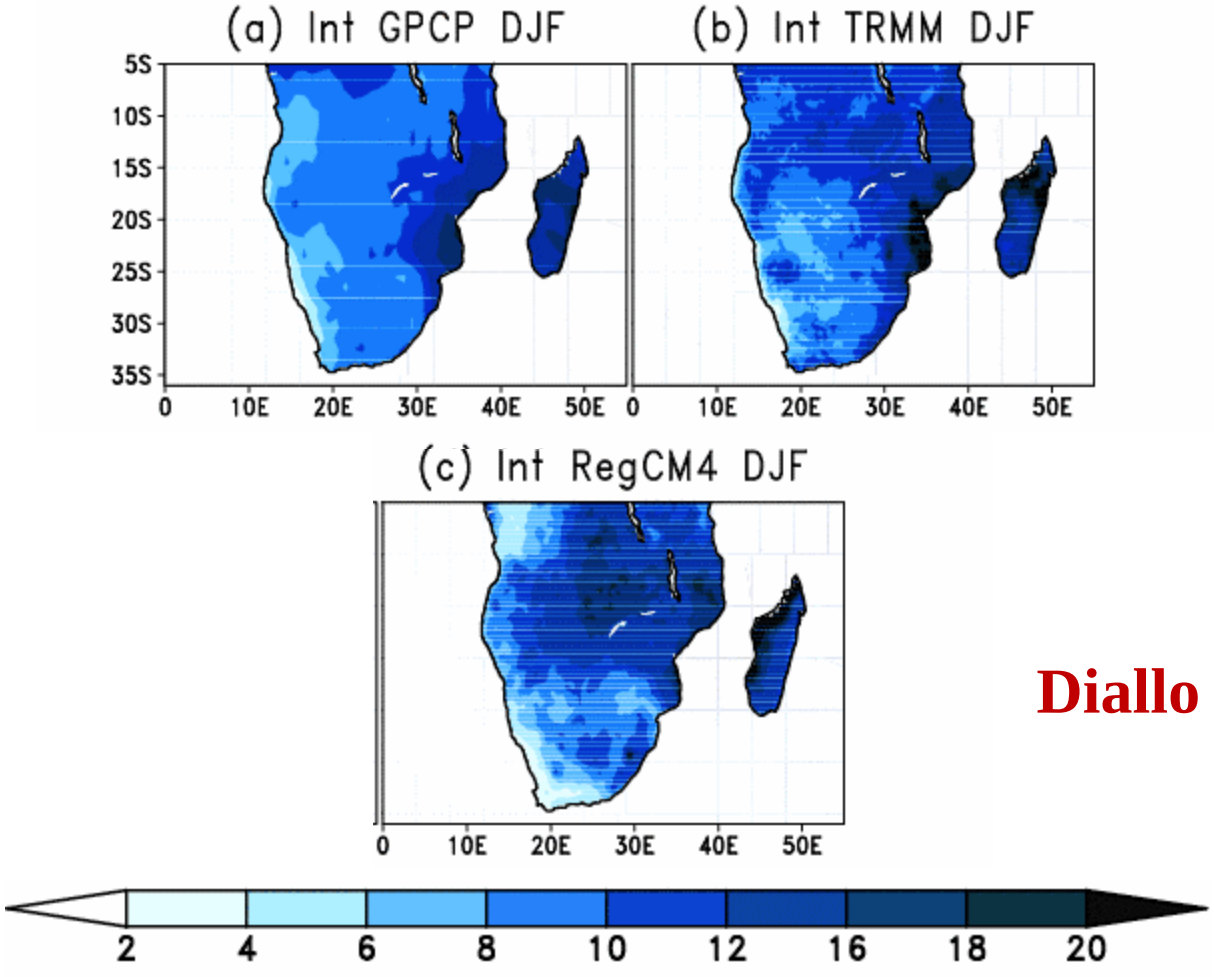
CDD: days < 1mm/day

CWD: days R>=1 mm/day

Frequency: Number of days with RR>1mm

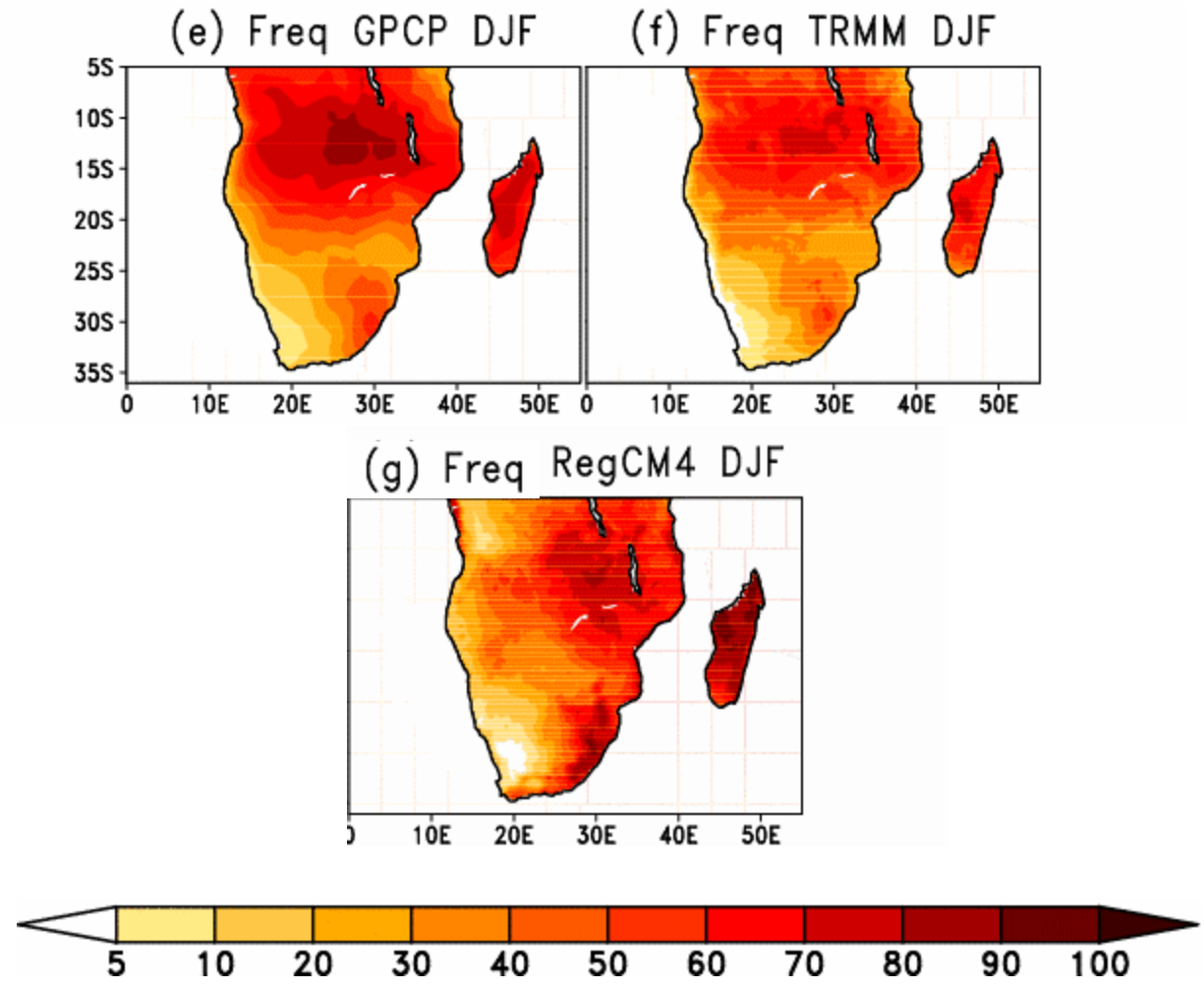
Intensity: mean RR amount during wet days

DJF: Intensity

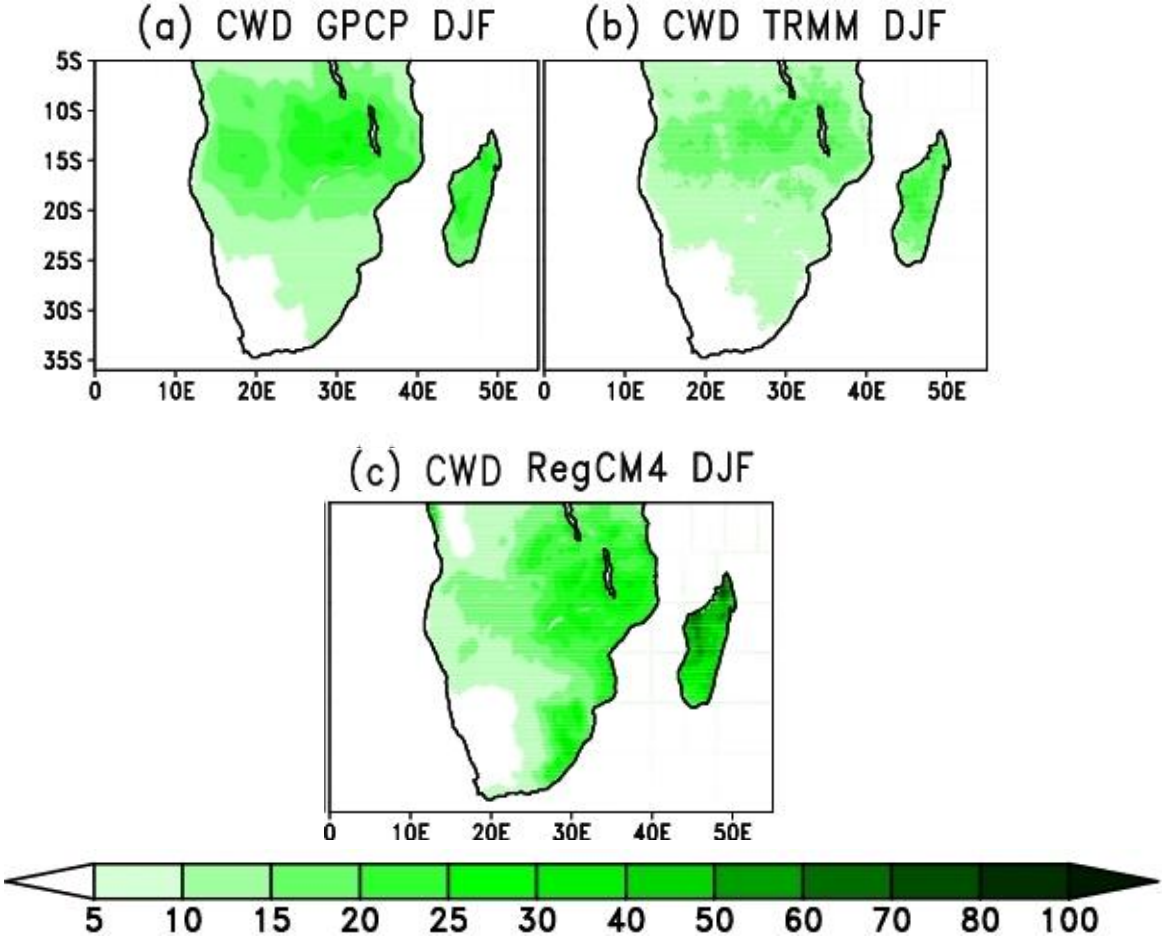


Diallo et al. (2013)

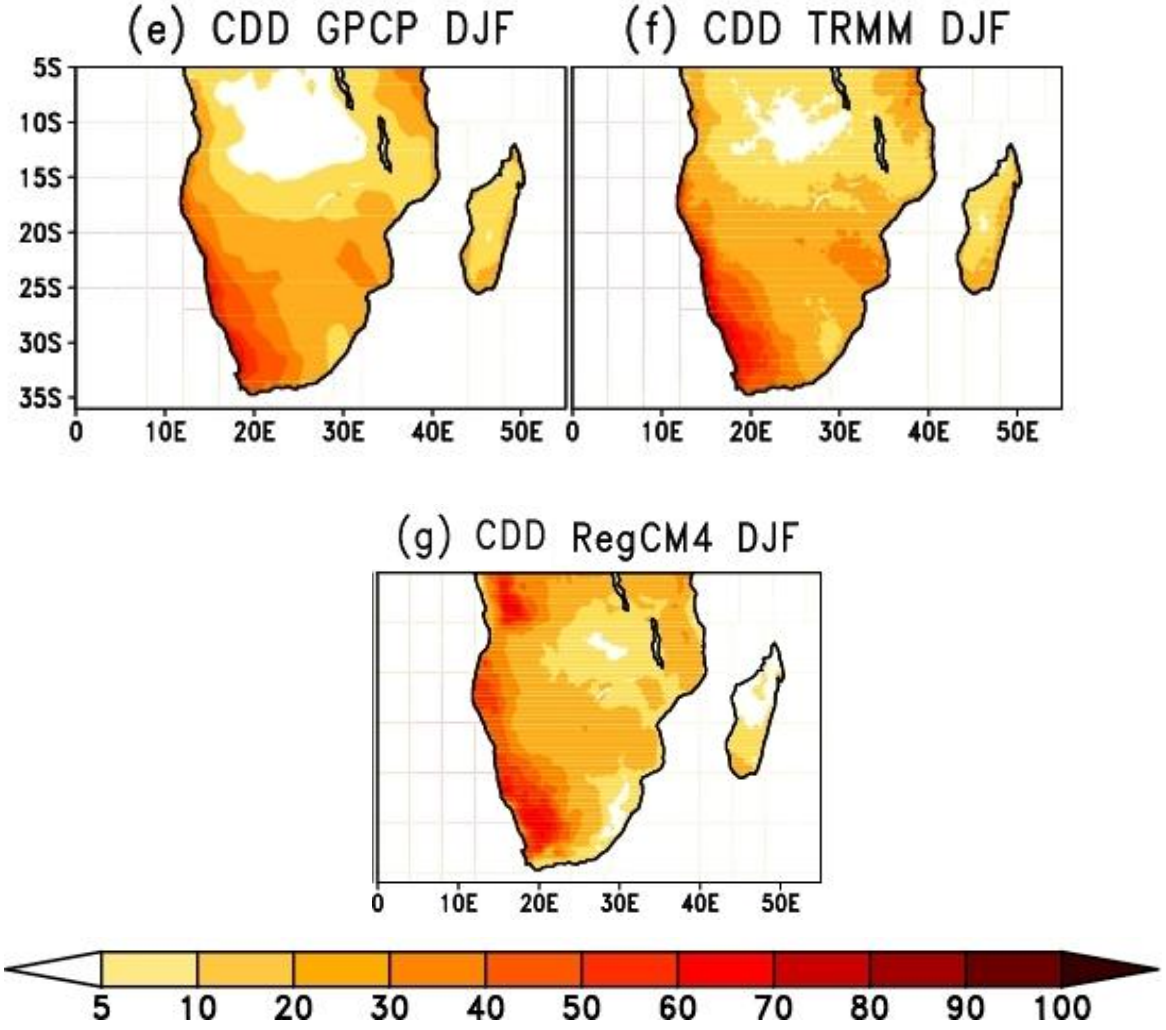
❑ DJF: Frequency



❑ DJF: CWD


(a) CWD GPCP DJF
(b) CWD TRMM DJF
(c) CWD RegCM4 DJF
5S
10S
15S
20S
25S
30S
35S
0
10E
20E
30E
40E
50E
5
10
15
20
25
30
40
50
60
70
80
100

❑ DJF: CDD


(e) CDD GPCP DJF
(f) CDD TRMM DJF
(g) CDD RegCM4 DJF
5S
10S
15S
20S
25S
30S
35S
0
10E
20E
30E
40E
50E
5
10
20
30
40
50
60
70
80
90
100

…..Summary

- **RegCM4 captures fairly well the mean spatial distribution of rainfall and temperature as well as the mean circulation features over SA.**

- **RegCM4 reproduces the daily rainfall characteristic distribution.**

- **RegCM4 output will be used to drive our hydrological model over SA .**

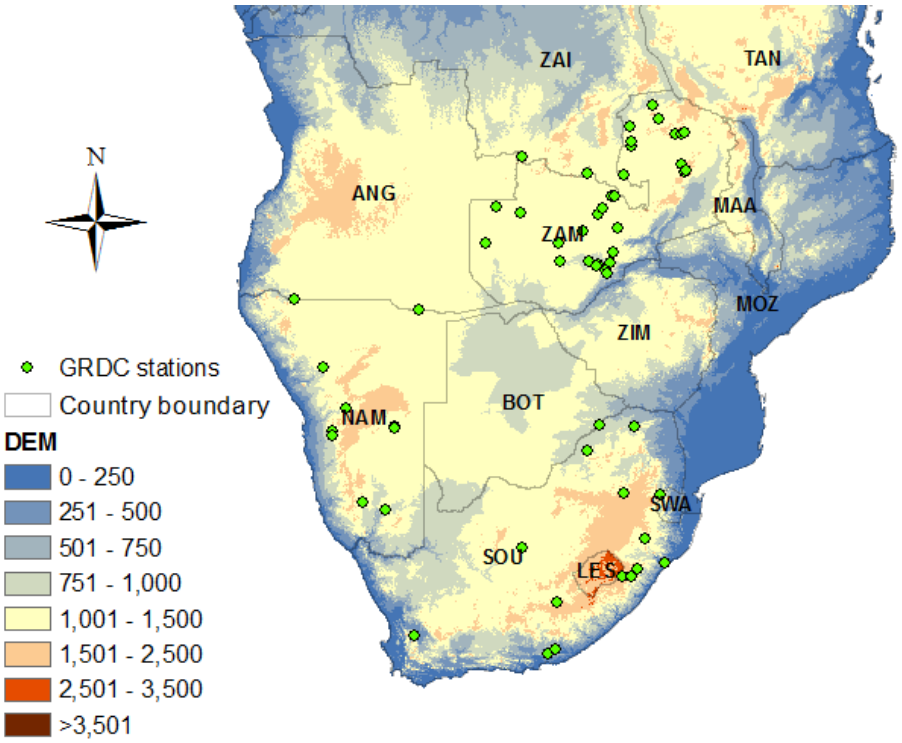
❑ Large-scale Hydrological model: WASMOD-D

○ **The water and snow balance modelling system at the macro scale (WASMOD-D, Gong et al. 2012, Li et al. 2013) developed and based on WASMOD (Xu 2002) was used in this study.**

○ **Input data are: daily precipitation, temperature and potential evapo-transpiration.**

○ **WASMOD-D calculates snow accumulation and melt and actual evapo-transpiration, and separates runoff into fast flow and slow flow.**

○ **The regional parameter and the water balance component for Southern Africa are simulated based on calibration of 22 basins over Southern Africa.**

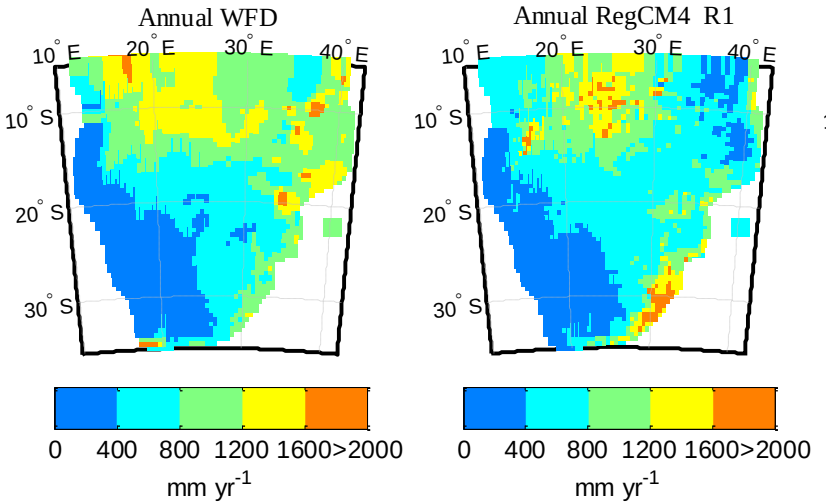


The 0.5 X 0.5 daily rainfall in WFD (Weedon et al. 2011) is used as 'observed' forcing data for 1990-2001.

Reference:

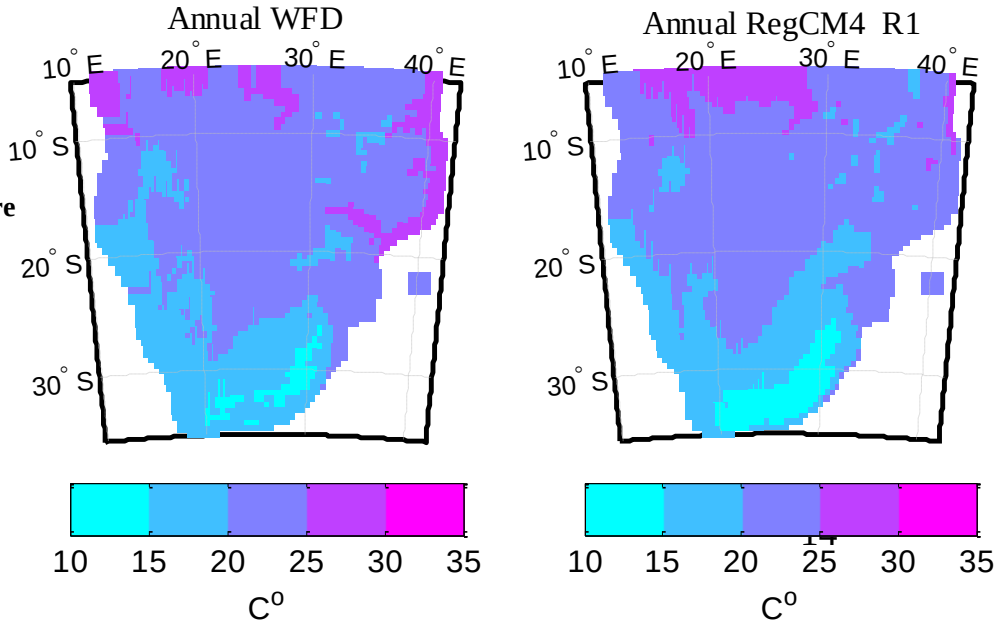
Li L, Diallo I, Xu C-Y, Stordal F, Giorgi F (2013) Hydrological projections under climate change by RegCM4 over South Africa using large-scale hydrological model. Hydrology Research.

Precipitation and Temperature: WFD vs RegCM4



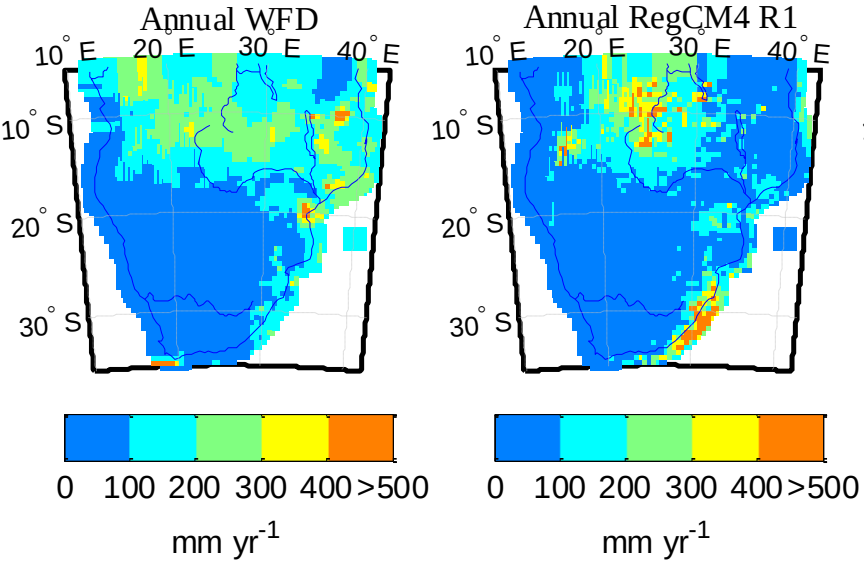
Precipitation

Temperature

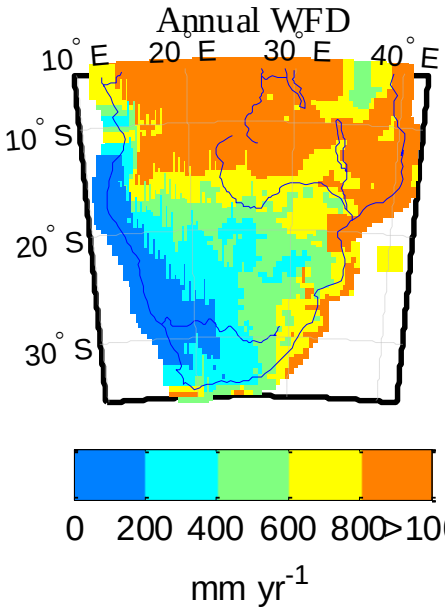


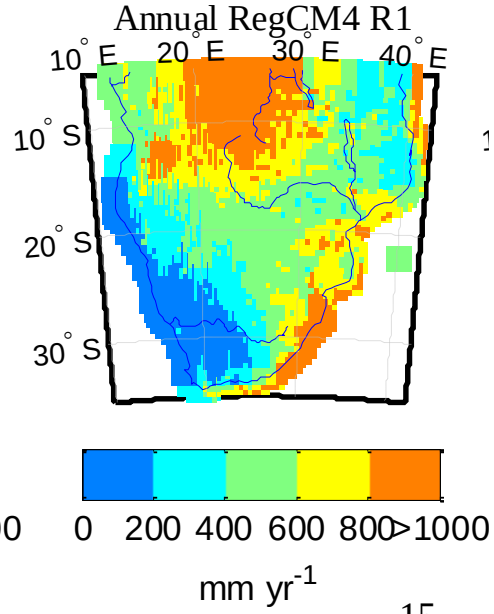
Li et al (2013)

❑ Evaporation and runoff: WFD vs RegCM4



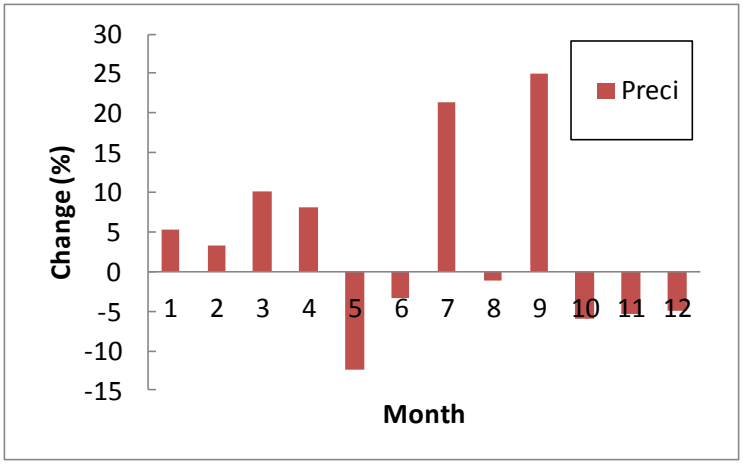
runoff

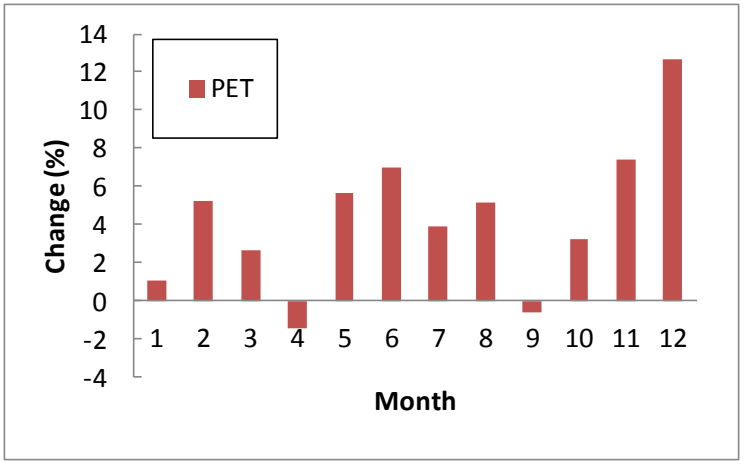


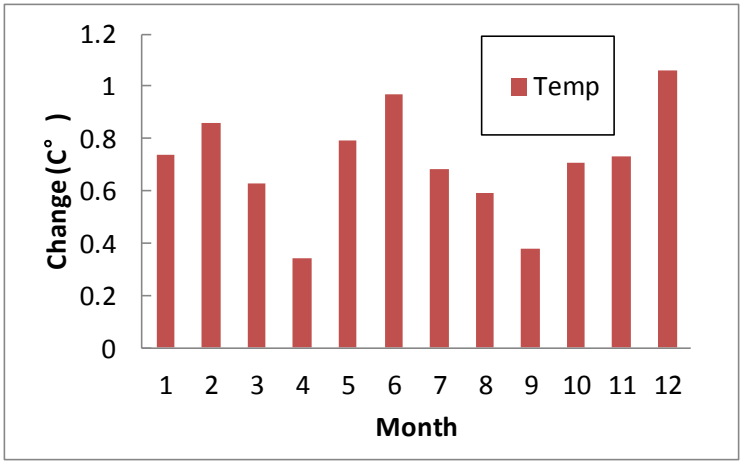


evaporation

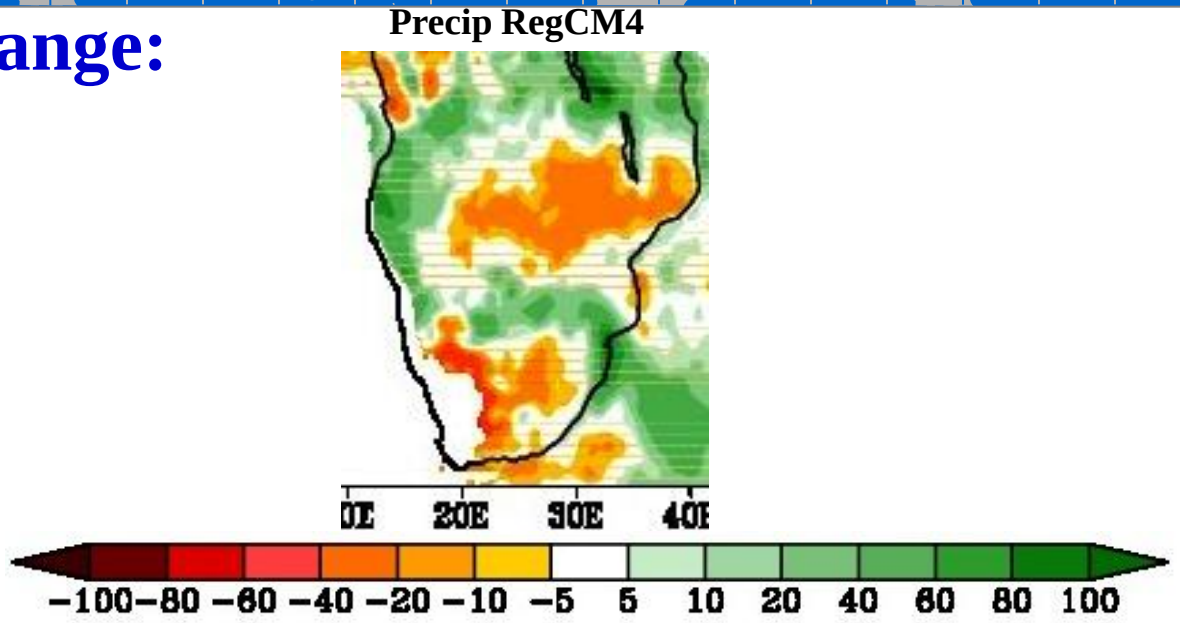
❑ Mean monthly change (2010-2029 vs 1990-2009)

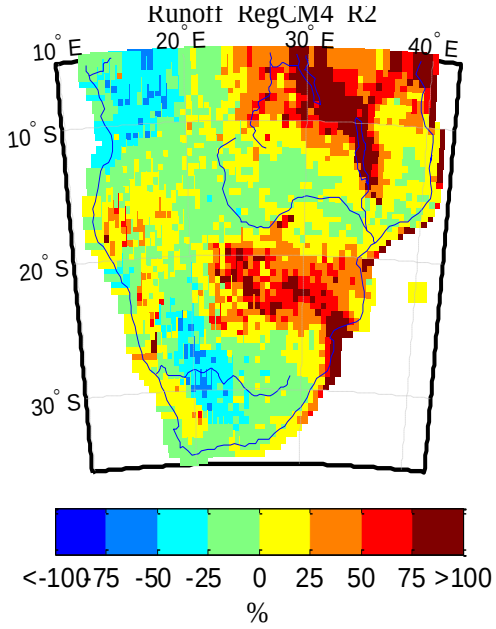


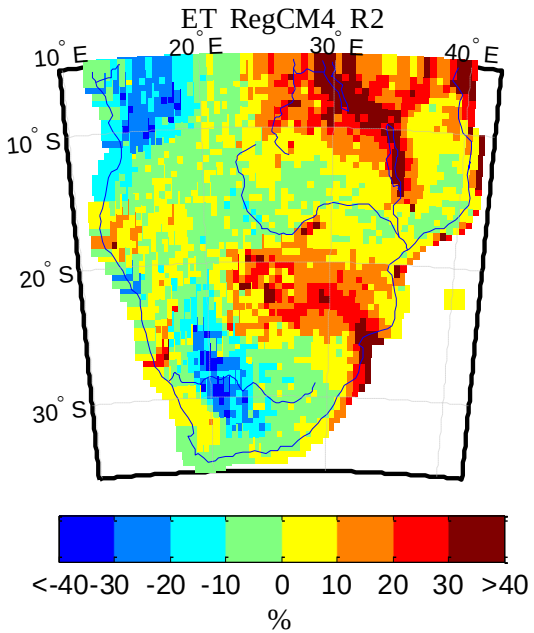




❑Annual Change:







Climate change versus climate variability

The climate change versus climate variability is estimated by signal-to-noise ratio (SN).

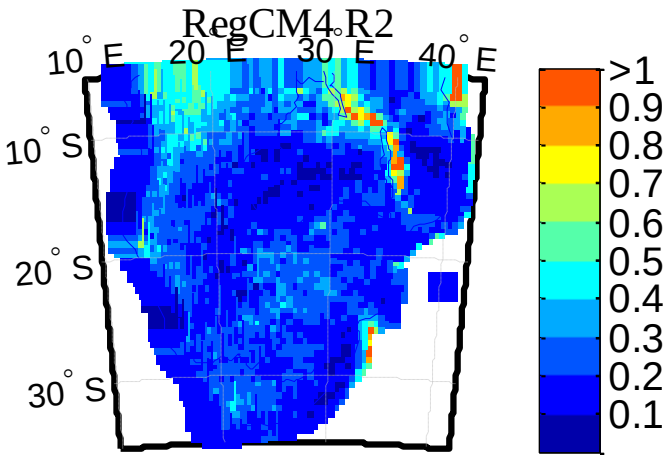
$$SN = \frac{|X_{fut} - X_{pres}|}{\delta}$$

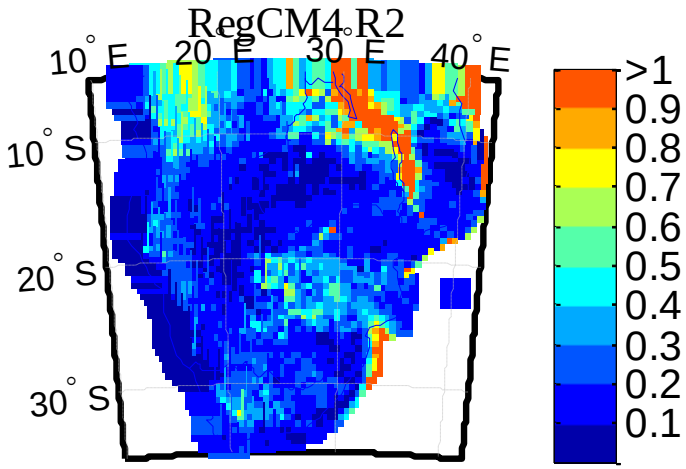
- **Where X_{fut} and X_{pres} represent the mean monthly values of variable for the near future (2010-2029) and present (1990-2009) time slices, respectively.**

- **while δ is the standard deviation of monthly values of this variable for the present**

SN > 1 suggests a climate change signal which can clearly be distinguished from variability.

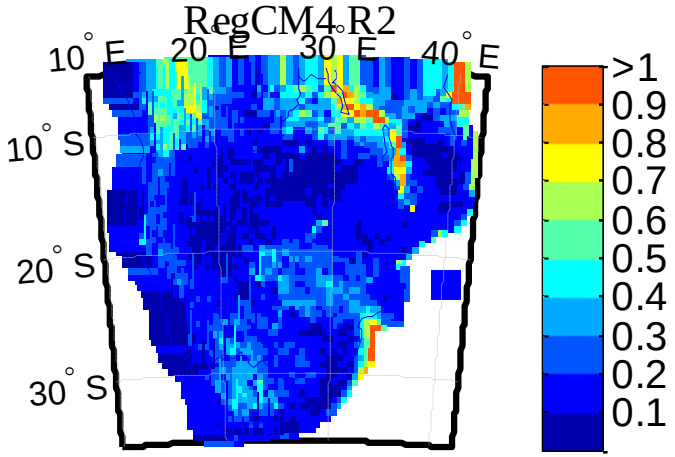
Precipitation





runoff

evaporation



Larger SN ratio over Lake Malawi and Tanganyika

Conclusions

- **RegCM4 captures the daily rainfall characteristics fairly well although the model overestimates the rainfall frequency over high topography.**

- **Similar distributions of precipitation are estimated from WFD and RegCM4.**

- **Although RegCM4 slightly underestimates the annual evaporation in humid areas, RegCM4 did a quite good job in simulation of temperature and hydrological components compared to the WFD in the historical period.**

- **Temperature and potential evapotranspiration increase over continental Southern Africa for the near future (2010-2029), especially the eastward of 25° E from RegCM4.**

……..Conclusions

- **An increase in runoff and actual evaporation over coastal area of Namibia and Malawian region and decrease across the driest region in a wide area encompassing Kalahari Desert, Namibia and Angola had been found in the near future in RegCM4.**

- **The stronger climate change signals are found over the humid tropic area (north of Angola and south of Dem Rep of Congo) in precipitation as well as in evaporation and runoff. The strong signals were also found in runoff and actual evaporation over Malawian region by RegCM4.**

THANKS FOR YOUR ATTENTION !!!