Simulations of Future Climate of the Greater Horn of Africa using Regional Climate Model

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OUTLINE

- Brief on ICPAC
- Introduction
- RCM Description/Domain
- Comparison of GCM and RCM Output for major Rainfall Seasons
- Validation and Verification of the Model
- Future Climate Change (2070-2100)
- Summary and Conclusion

The IGAD Climate Prediction and Applications Centre (ICPAC)

- a specialized Institution of the seven IGAD countries in the Greater Horn of Africa plus Tanzania, Burundi and Rwanda (protocol signed).
- ICPAC is charged with the responsibility of:-

✓ **climate monitoring**

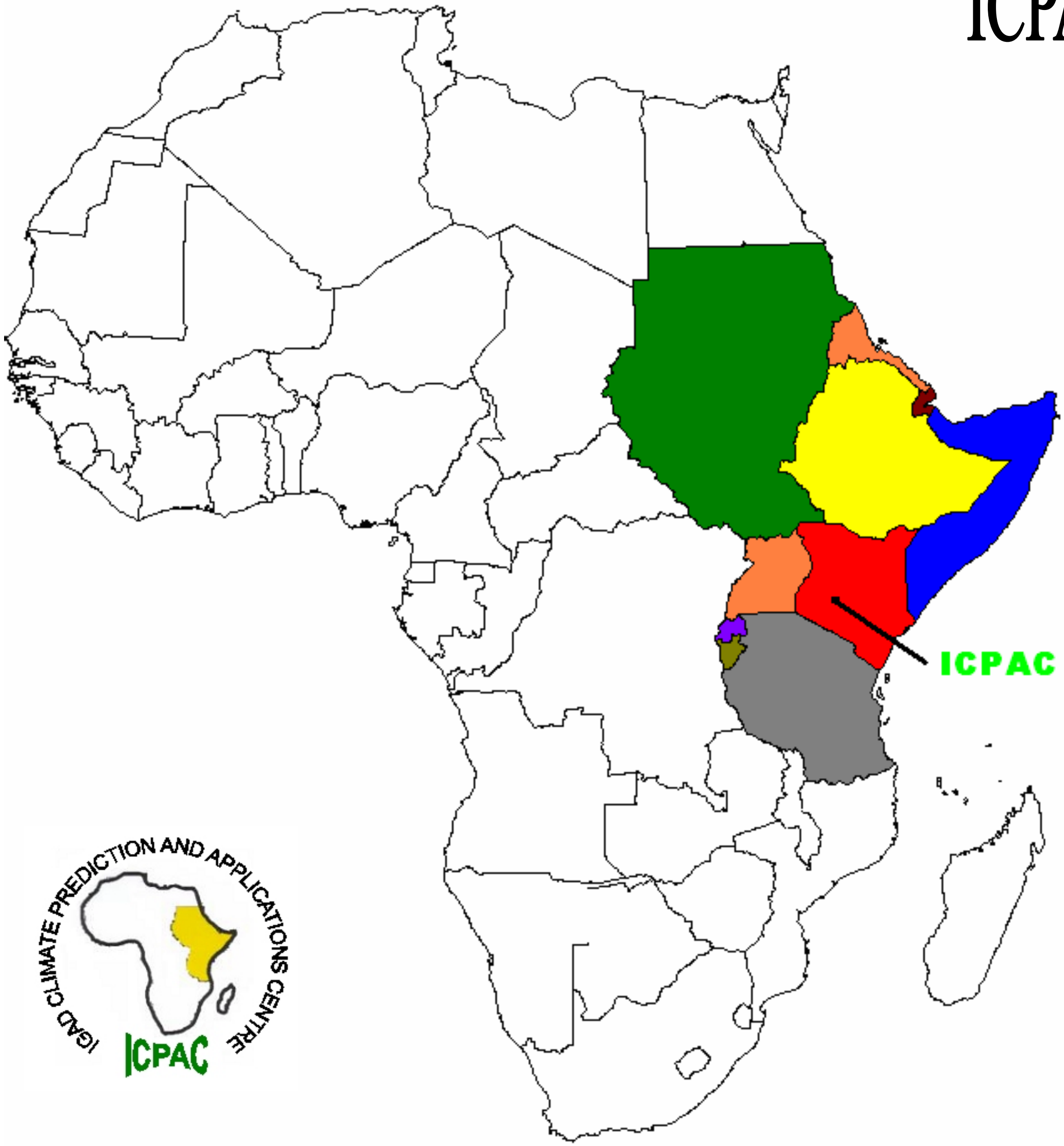
✓ **prediction**

✓ **early warning and applications**

✓ **support specific sector applications for the mitigation of the impacts of climate variability and change**

- for the reduction of climate related risks in the Member countries.

ICPAC Member Countries



Mission

Provision of timely climate early warning information and supporting specific sector applications to enable the region cope with various risks associated with extreme climate variability and change for poverty alleviation, environment management and sustainable development of the member countries.

INTRODUCTION

- Estimates of the impacts of climate change (and related adaptation measures) can be obtained from scenarios of the future climate, produced by Global Climate Models (GCMs) forced by projected Greenhouse Gas (GHG) concentrations
- Although GCMs contain all the important physical processes of the climate system, their predictions lack the detail useful at the local level because of the relatively coarse horizontal resolution (hundred kilometres)
- Regional Climate Models (RCMs) are nested with GCMs to provide the finer detail of the climate change projections by “dynamically downscaling” the meteorological information of the GCMs from the global scale to the regional scale (few tens of kilometres).

RCM DESCRIPTION

- **GCM RESOLUTION**:

  Grid boxes of 300km X 300km
- **RCM** : Hadley Centre regional climate model HadRM3P (Jones et al., 2004)

  Grid boxes of 50 km X 50 km [0.44 x 0.44 degrees]
- **VERTICAL LEVEL**:

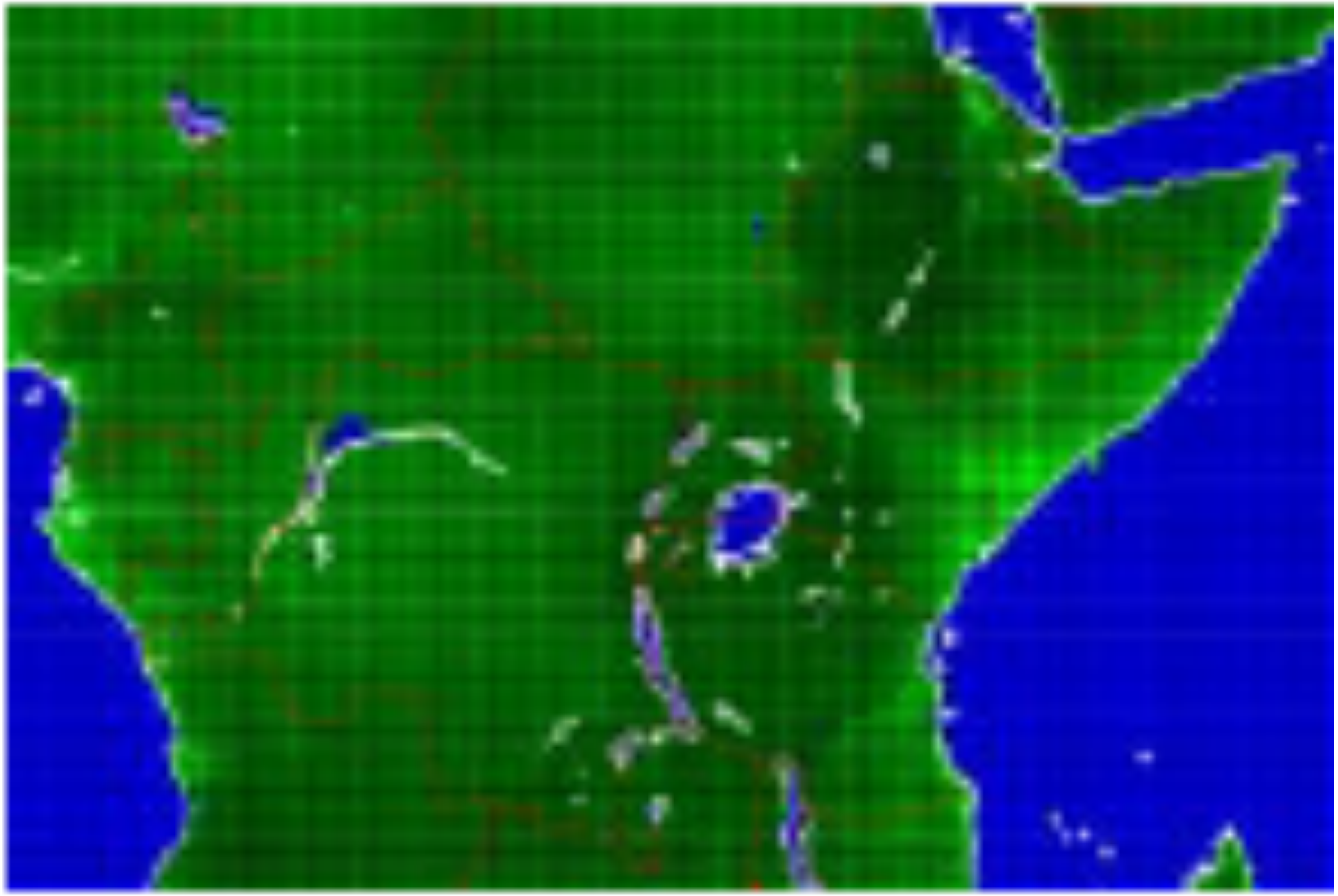
  19 levels from the ground up to 0.5 hPa (30Km)
- **LATERAL BOUNDARY CONDITIONS (LBC)**

  drivers of the simulation and are produced from the ERA40; ECHAM4; UK HadAM3P
- SRES: A1,A2, B1,B2 …

Verification datasets

- The following four datasets are used to assess the realism of HadRM3P and its consistency at large-scale with large-scale driving atmospheric conditions:
- CRU gridded monthly data at $0.5^o x 0.5^o$ horizontal resolution
- Atmospheric circulations from both ERA40 and NCEP-R2 reanalysis, respectively with 1.125x1.125 and 2.5x2.5 degree horizontal resolution.

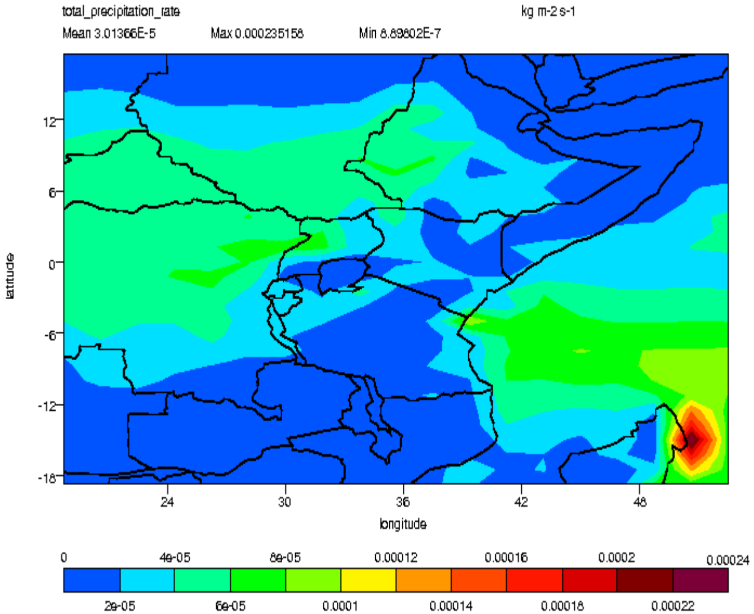
Non-CORDEX Domain



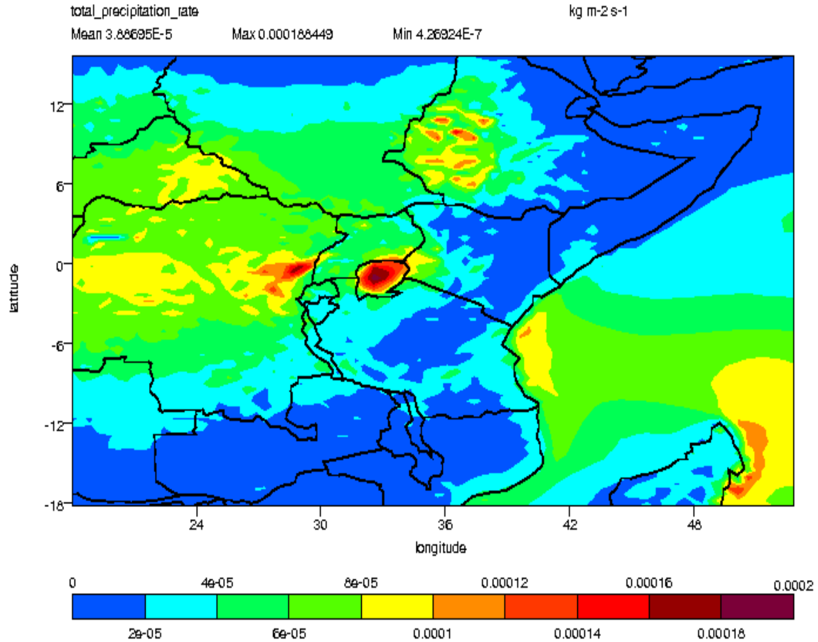
Validation and Verification of the Model

- GCM vis à vis RCM
- Rainfall and Temperature Climatology [1960 – 1990] comparison model and observed
- Annual cycles
- Winds circulation patterns

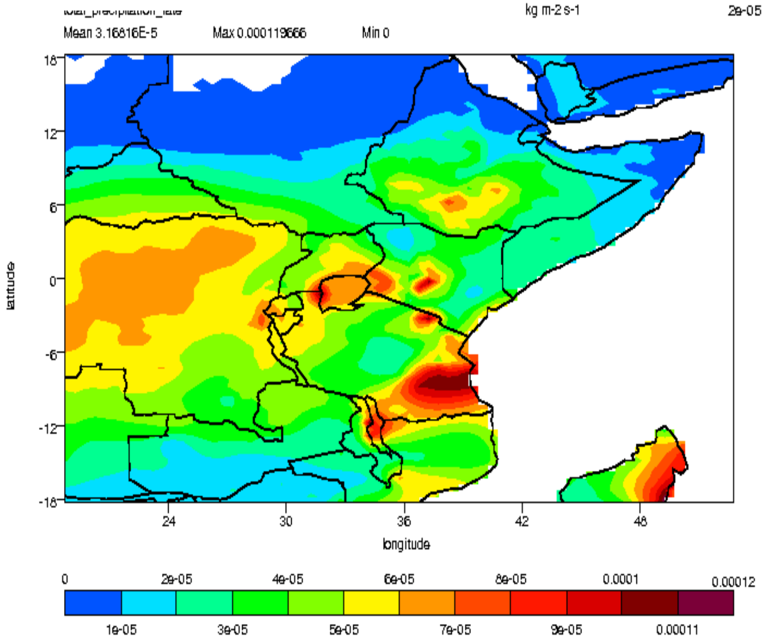
GCM Mean Rainfall (1961-1990) Climatology



RCM Mean Rainfall (1961-1990) Climatology



COMPARISSON OF OBSERVED AND MODEL OUTPUT FOR MARCH-MAY RAINFALL SEASON

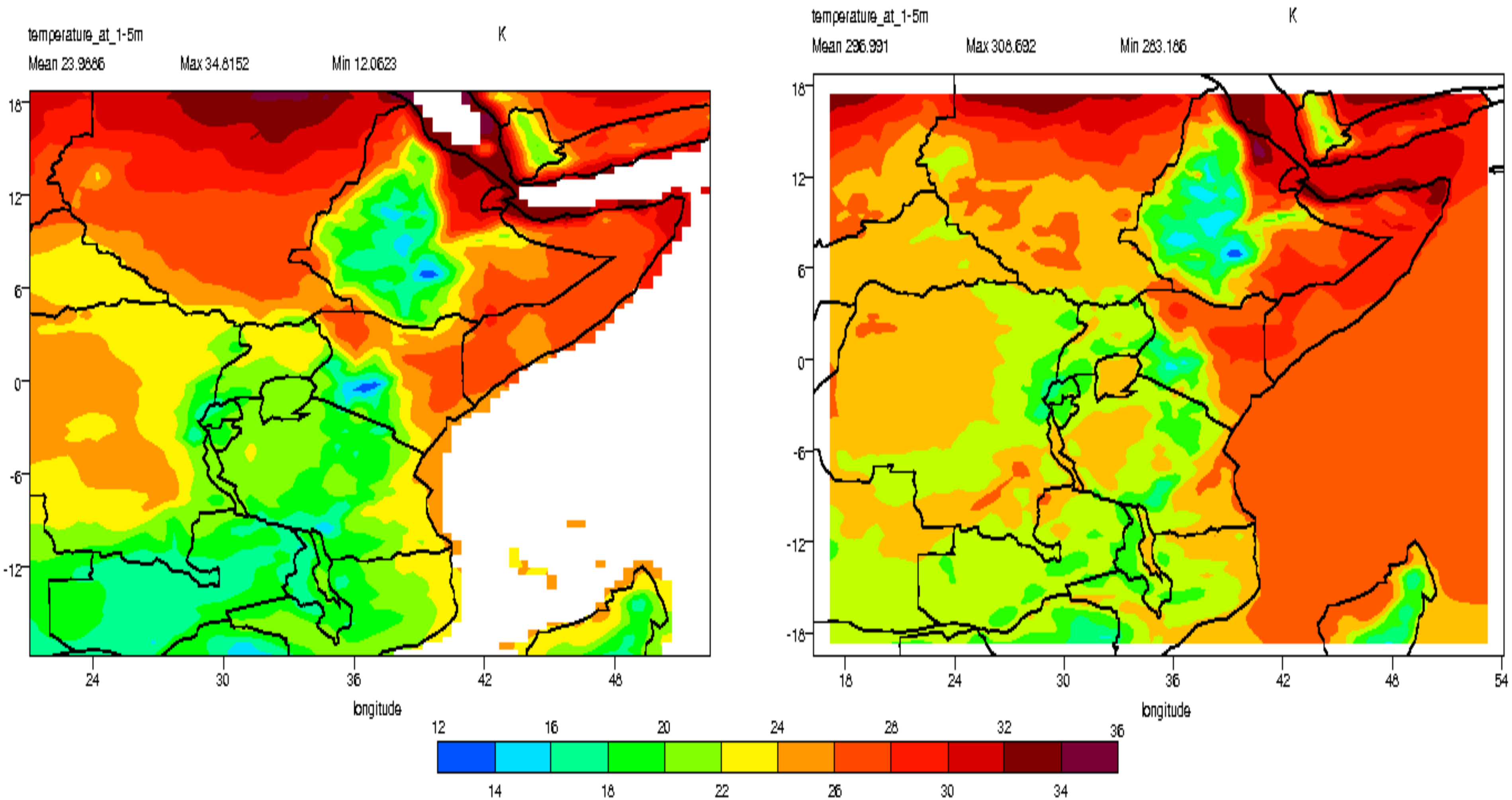


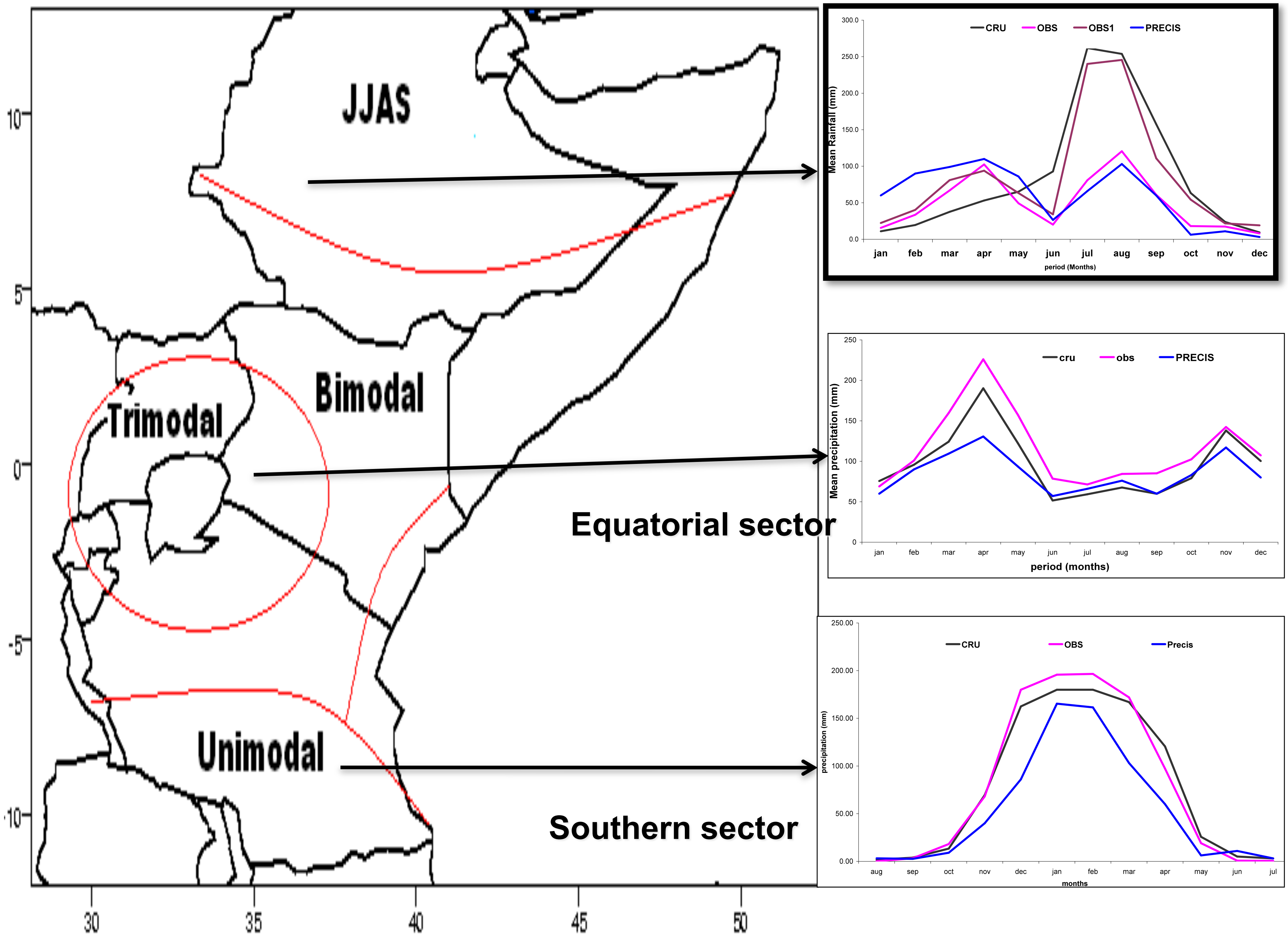
CRU Mean Rainfall (1961-1990) Climatology

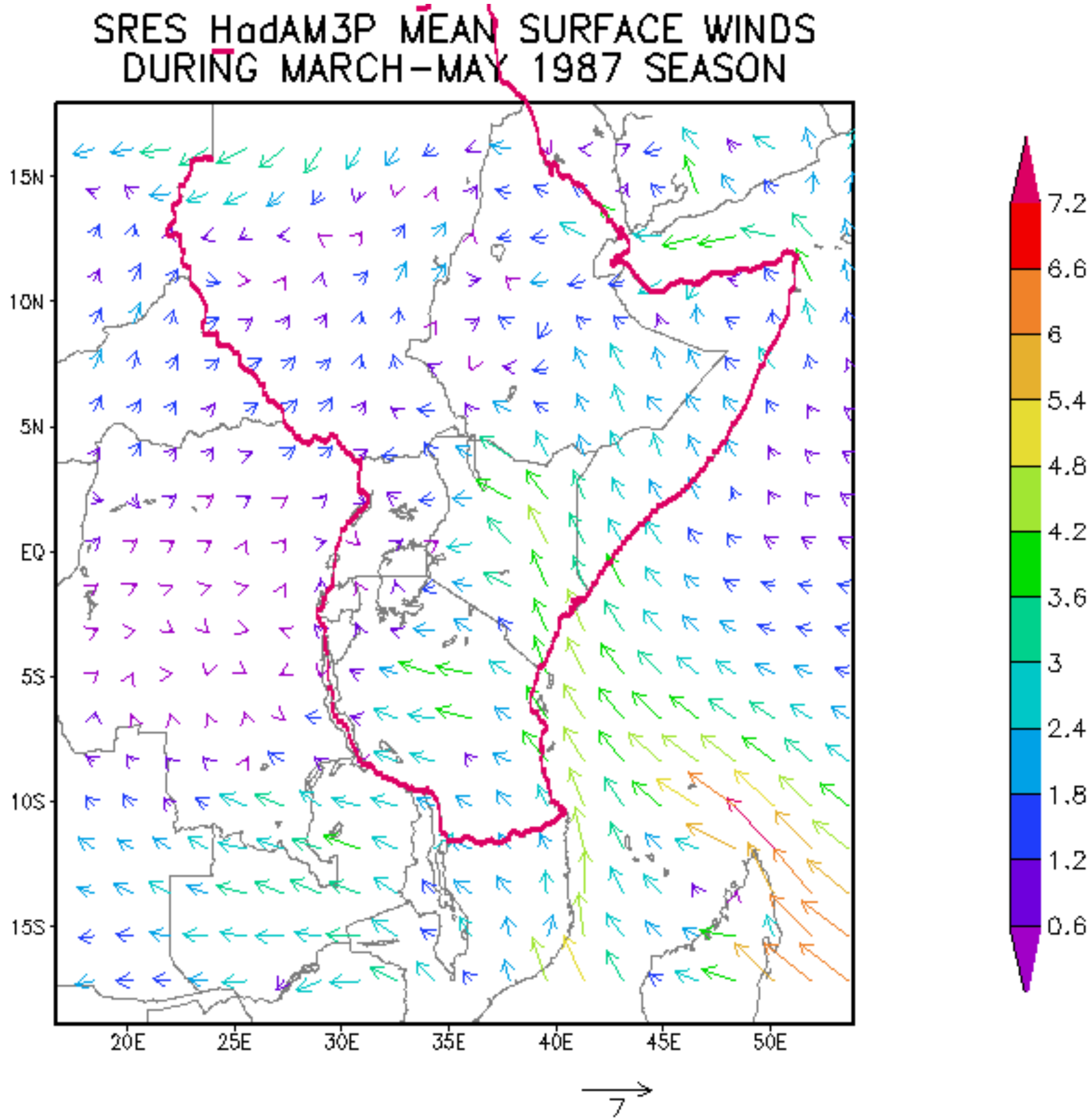
MEAN SEASONAL SURFACE TEMPERATURE

GCM

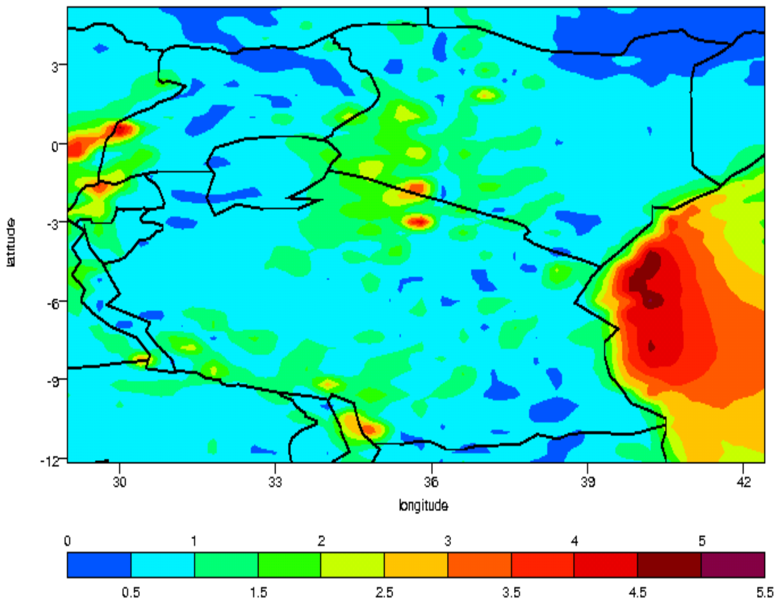
RCM



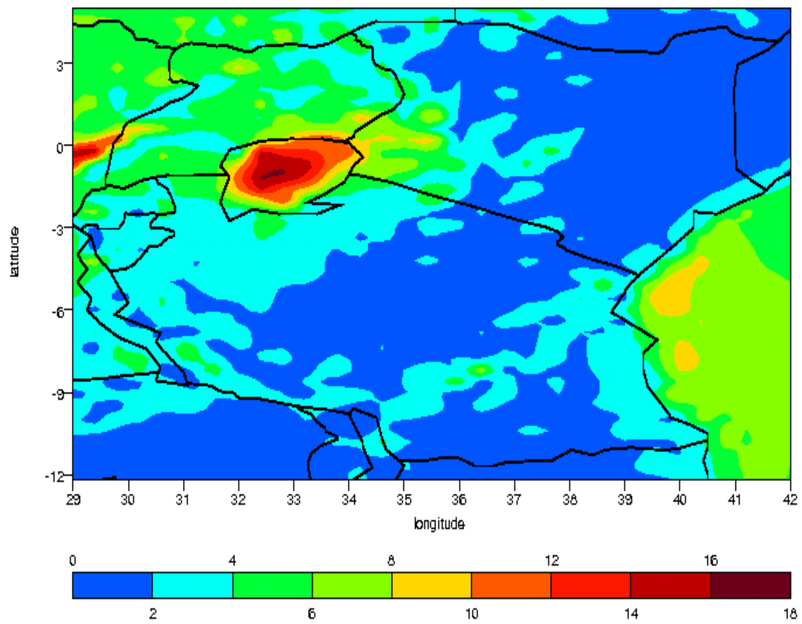

JJAS
Bimodal
Trimodal
Unimodal
Equatorial sector
Southern sector
10
5
0
-5
-10
30
35
40
45
50
CRU
OBS
OBS1
PRECIS
Mean Rainfall (mm)
period (Months)
jan feb mar apr may jun jul aug sep oct nov dec
cru
obs
PRECIS
Mean precipitation (mm)
period (months)
CRU
OBS
Precis
precipitation (mm)
months
aug sep oct nov dec jan feb mar apr may jun jul



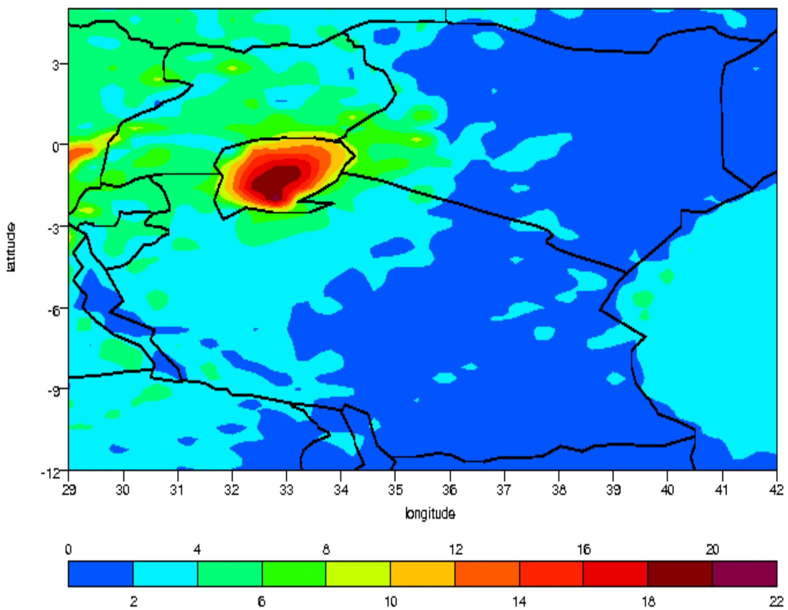
SRES HadAM3P MEAN SURFACE WINDS
DURING MARCH-MAY 1987 SEASON
15N
10N
5N
EQ
5S
10S
15S
20E
25E
30E
35E
40E
45E
50E
7
7.2
6.6
6
5.4
4.8
4.2
3.6
3
2.4
1.8
1.2
0.6



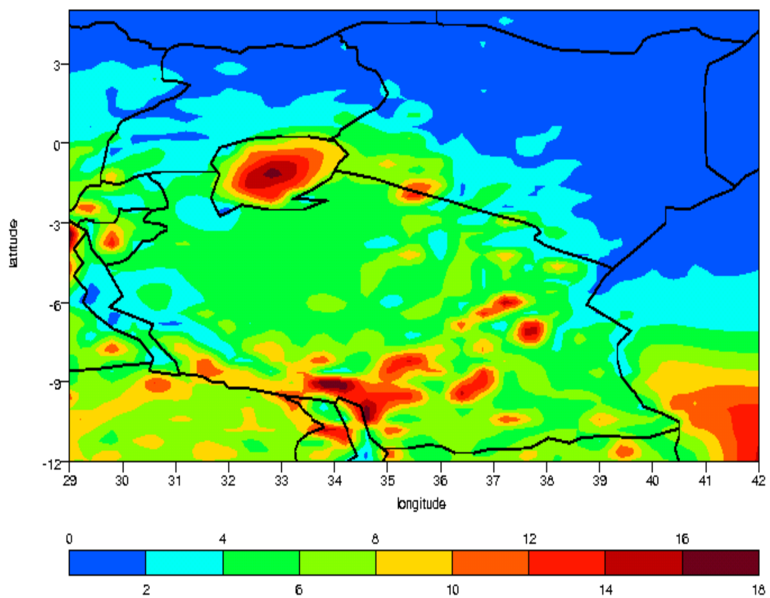
(a) March – May



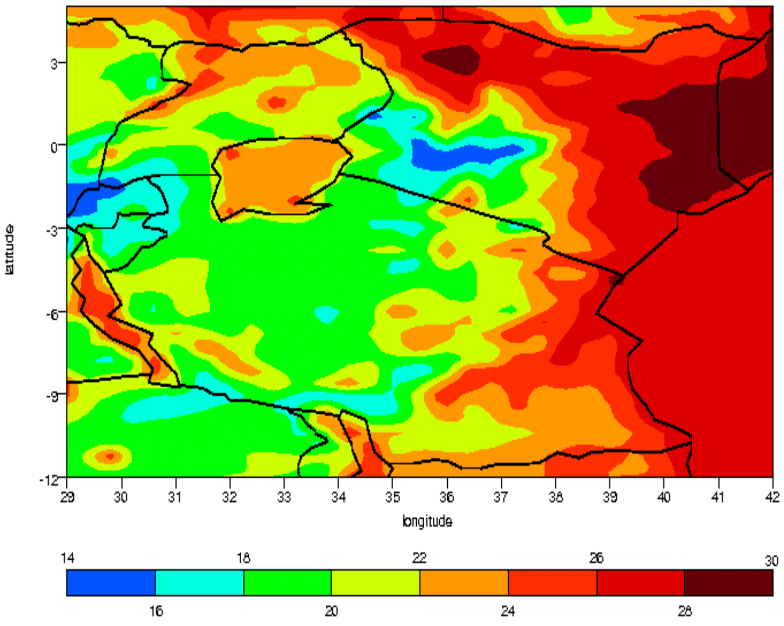
(b) June - August



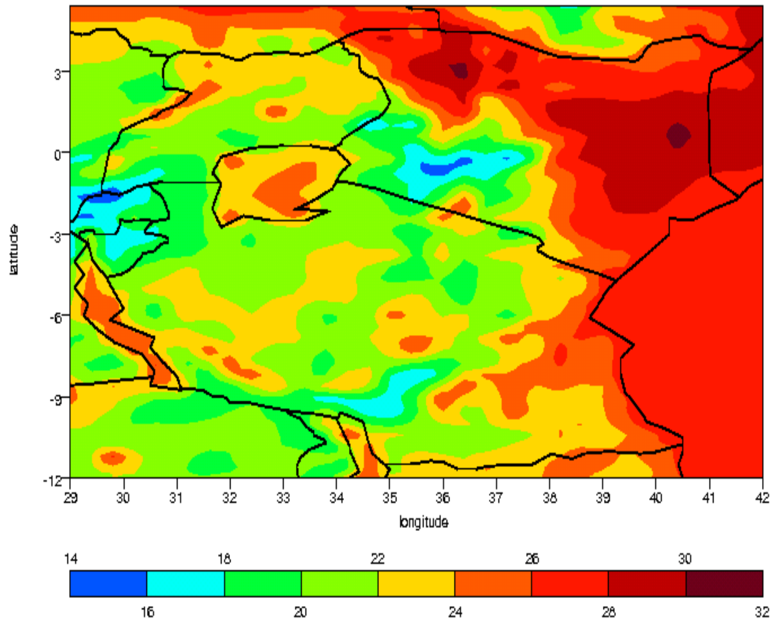
(c) October – December



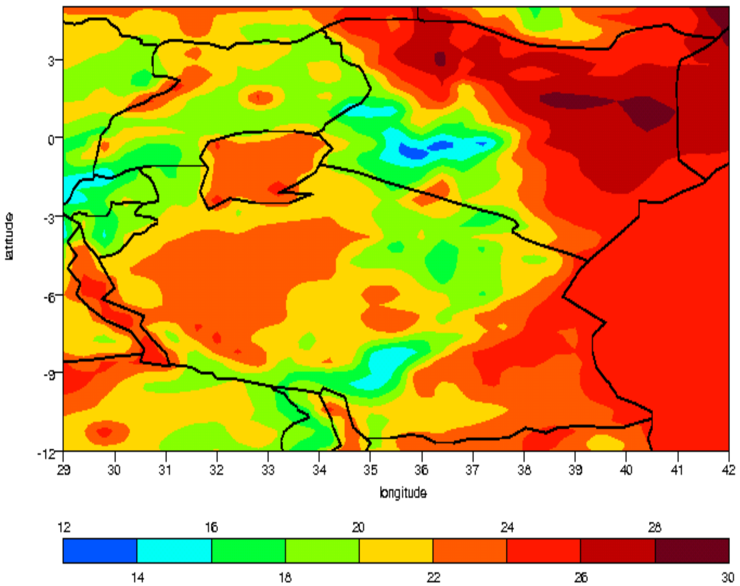
(d) December - February



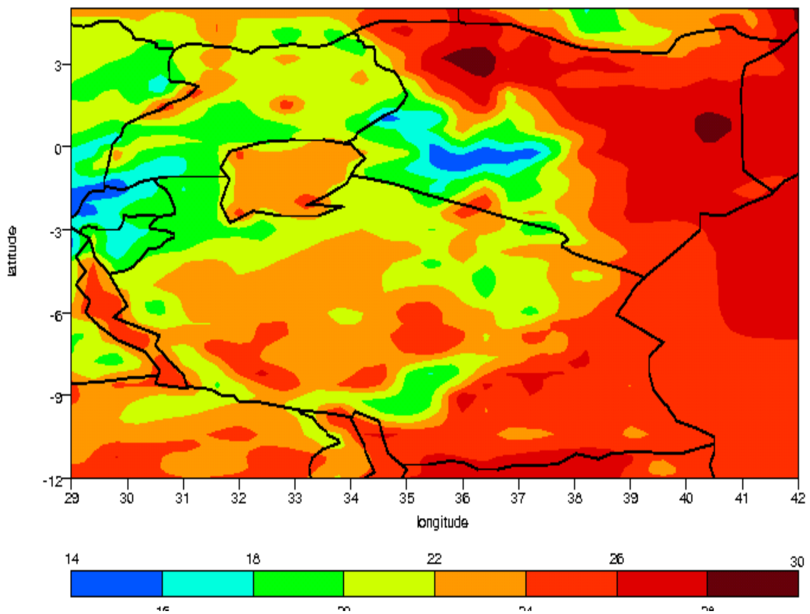
(a) December-February (DJF)



(b) March-May (MAM)

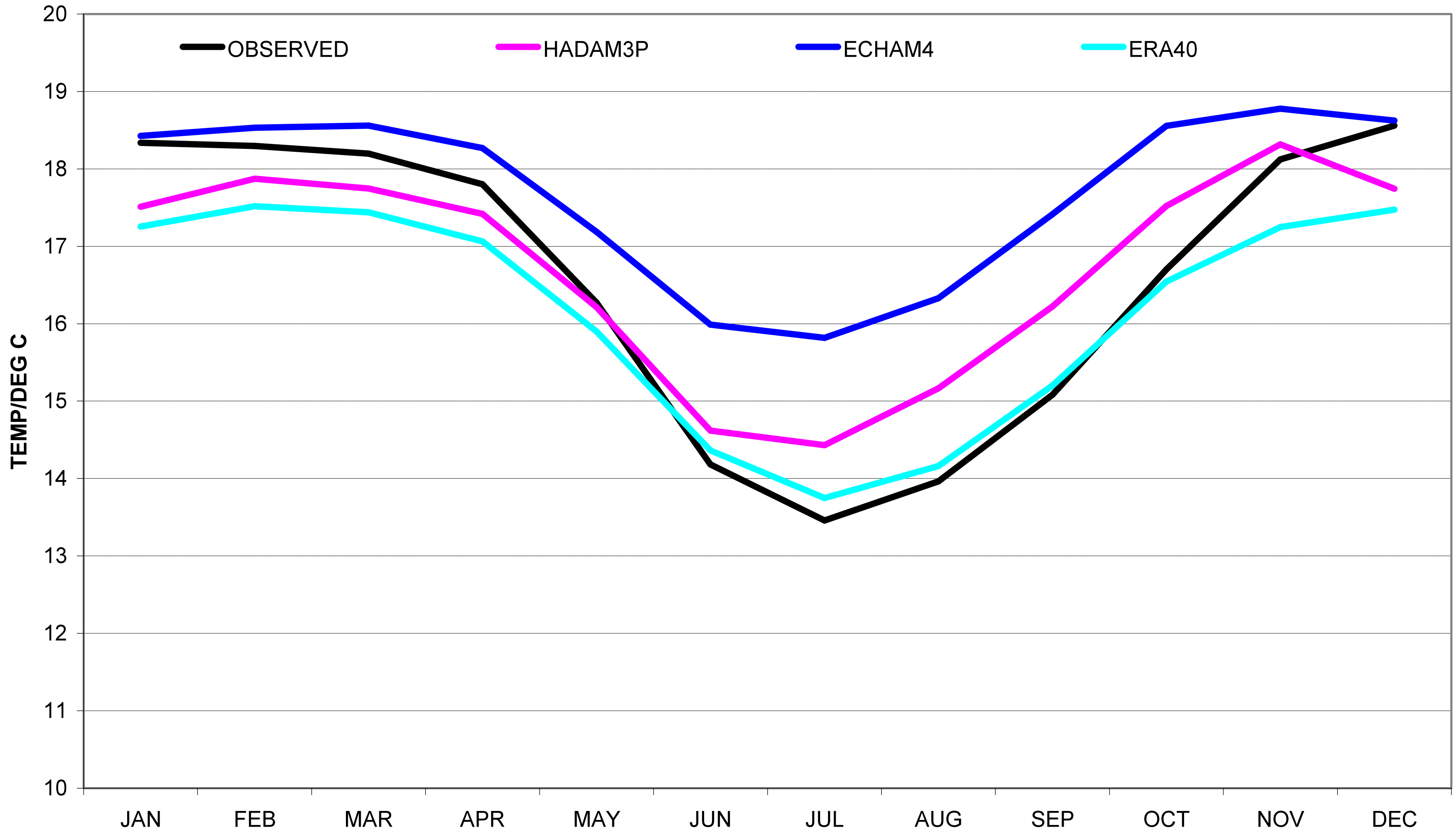


(c) June – August (JJA)



(d) October – December (OND)

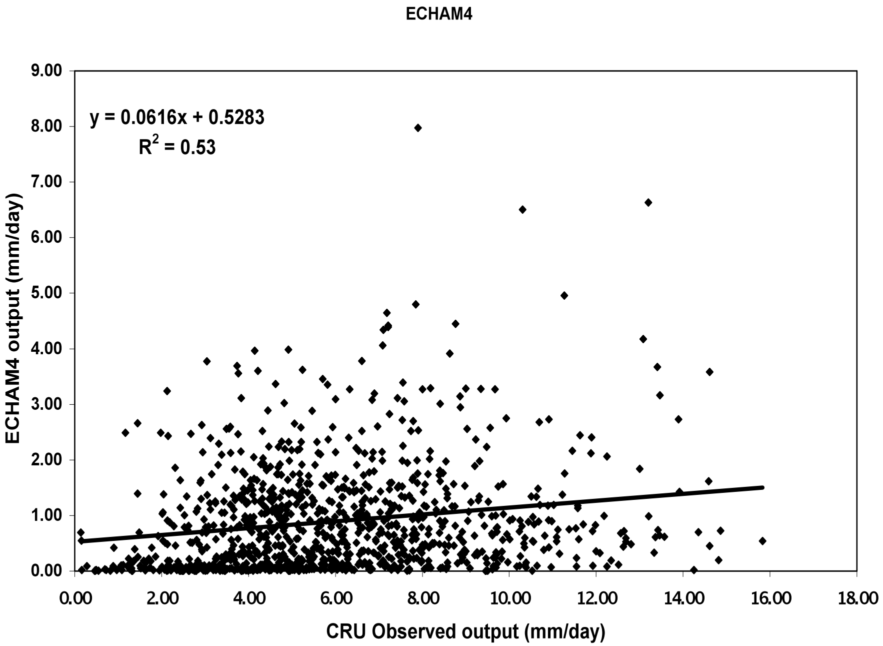
ANNUAL CYCLE FOR SIMULATED AND OBSERVED MINIMUM TEMPERATURE

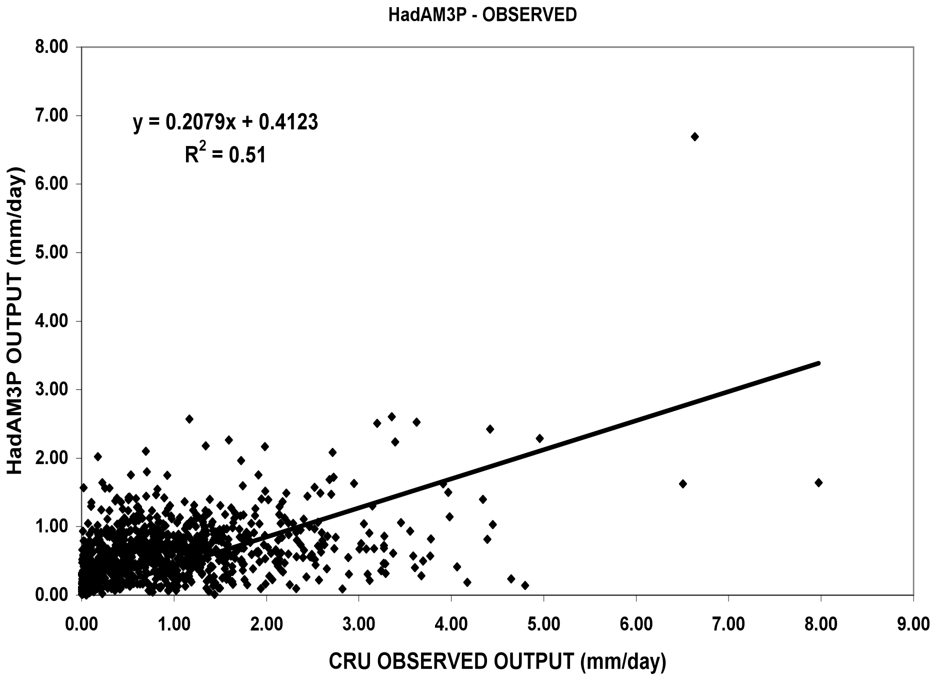


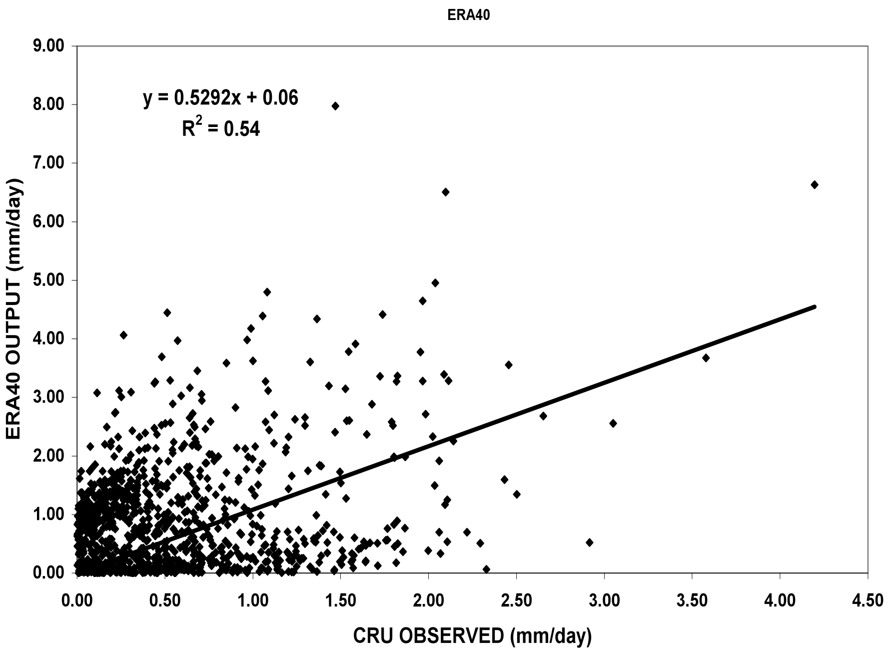
NOTE

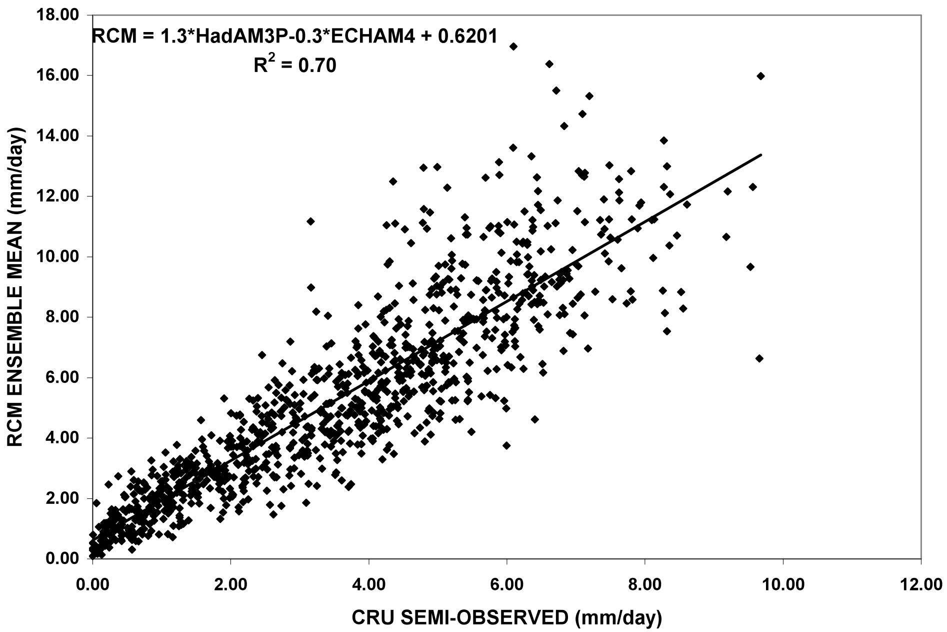
- GCM does not capture well the correct spatial distribution of rainfall over the region particularly over the Lake Victoria region, coastal strip and eastern highlands
- Annual cycles for both precipitation and temperature are captured fairly well
- Cyclones are captured by both the GCM and RCM models
- Unlike rainfall, mean surface temperature is homogeneous hence captured by both the GCM and RCM
- Winds patterns confirm moisture advection from the ocean to the region in a wet seasons

Model Verification

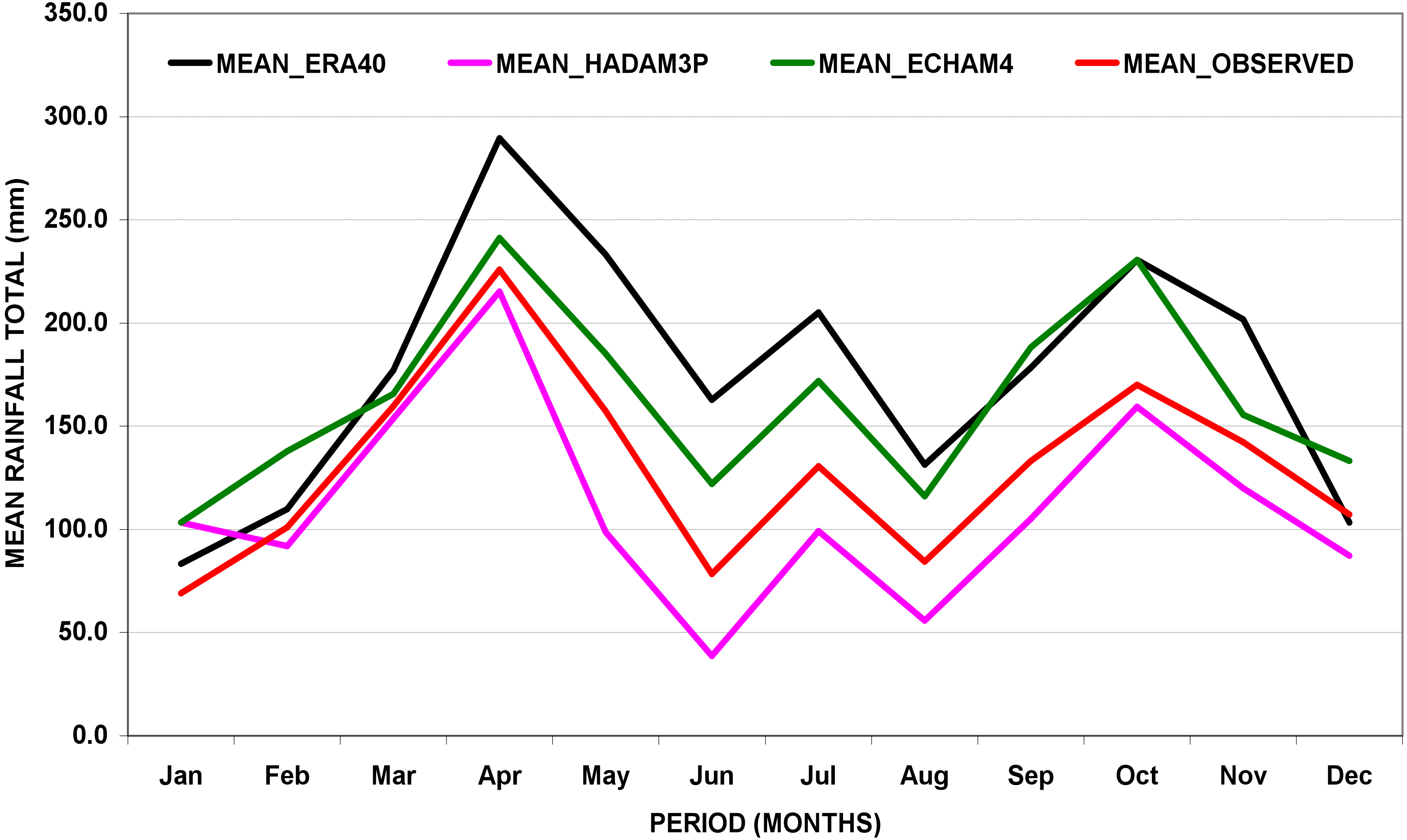




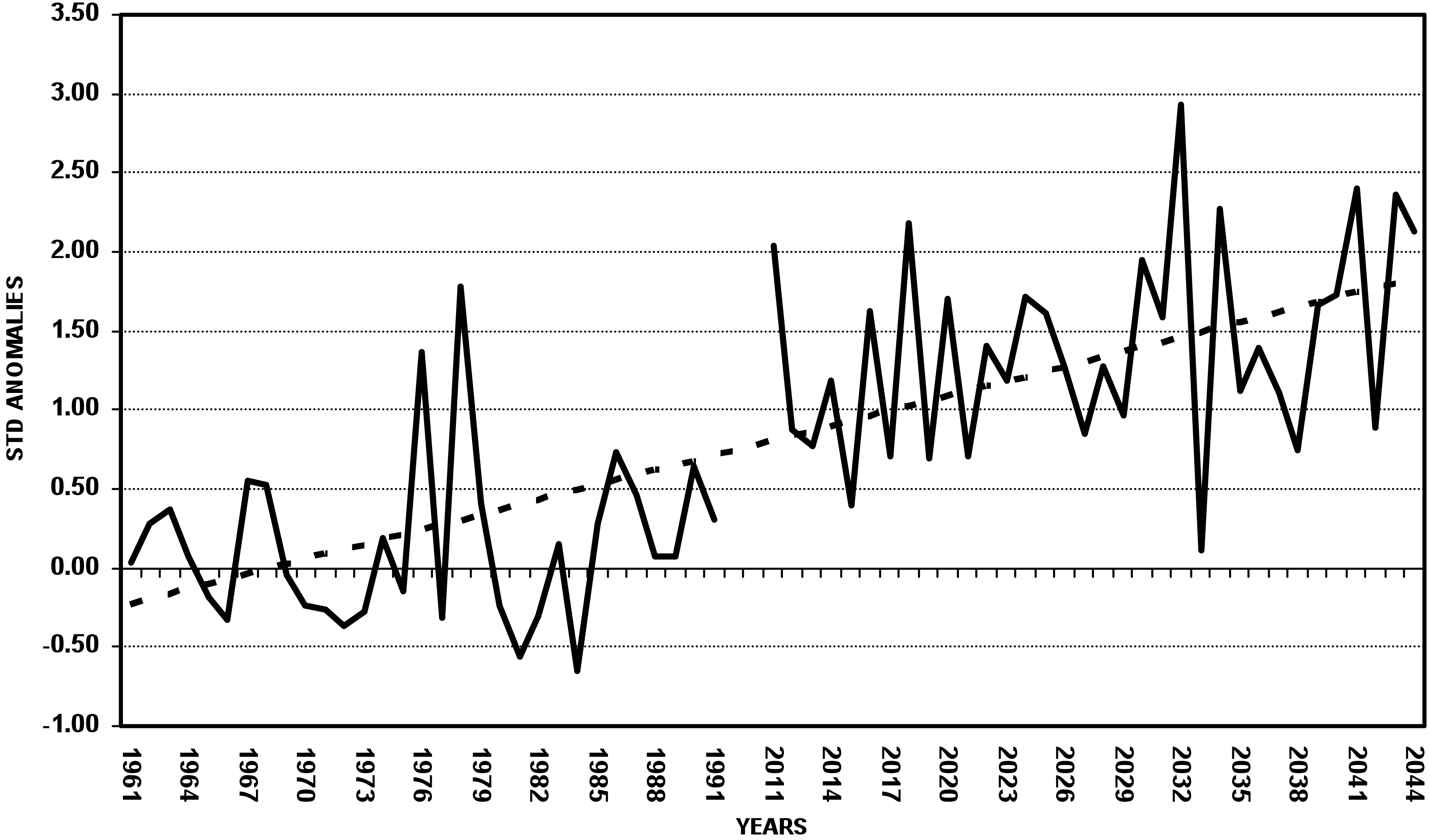


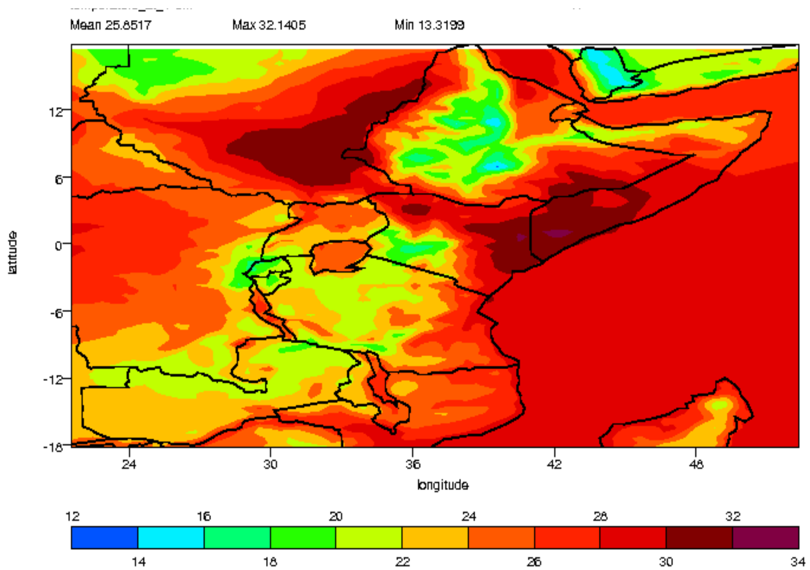


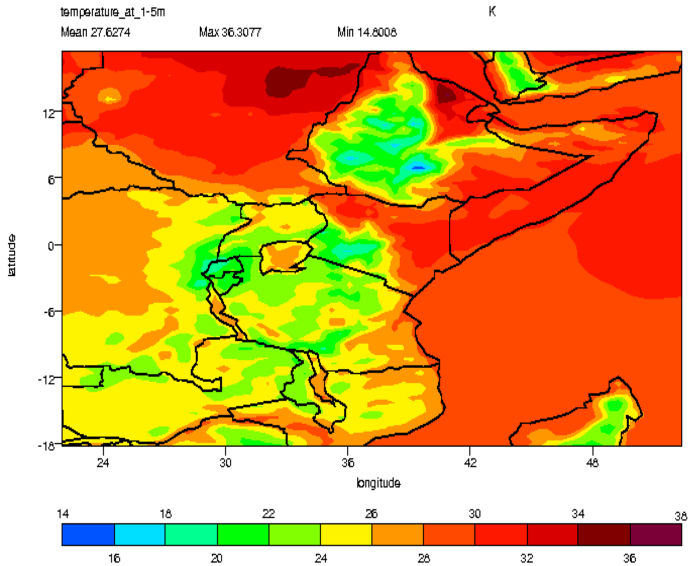
Annual cycles of various RCM models



PROJECTED MEAN SEASONAL SURFACE TEMPERATURE

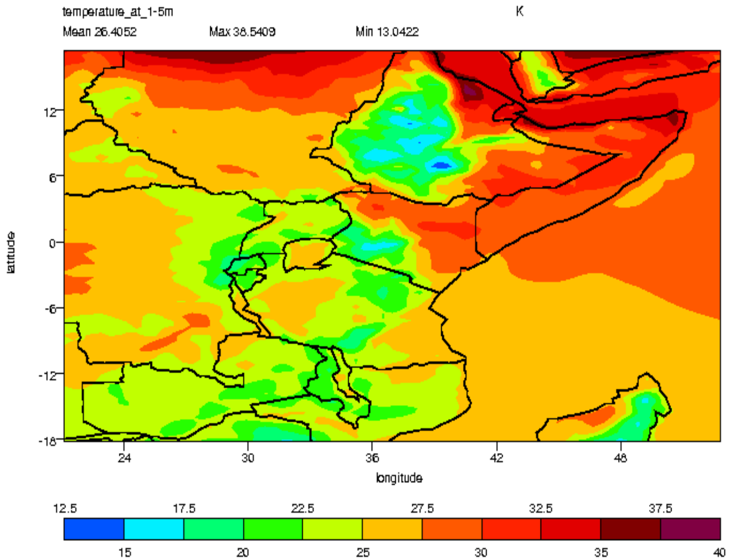




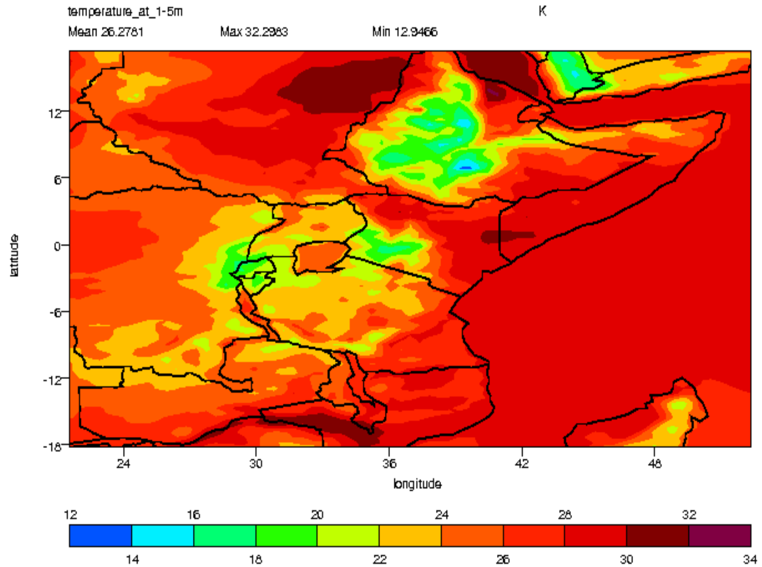


MEAN JJA TEMPERATURE (2070) HADAMP3 A2

MEAN OND TEMPERATURE (2070) HADAMP3 A2

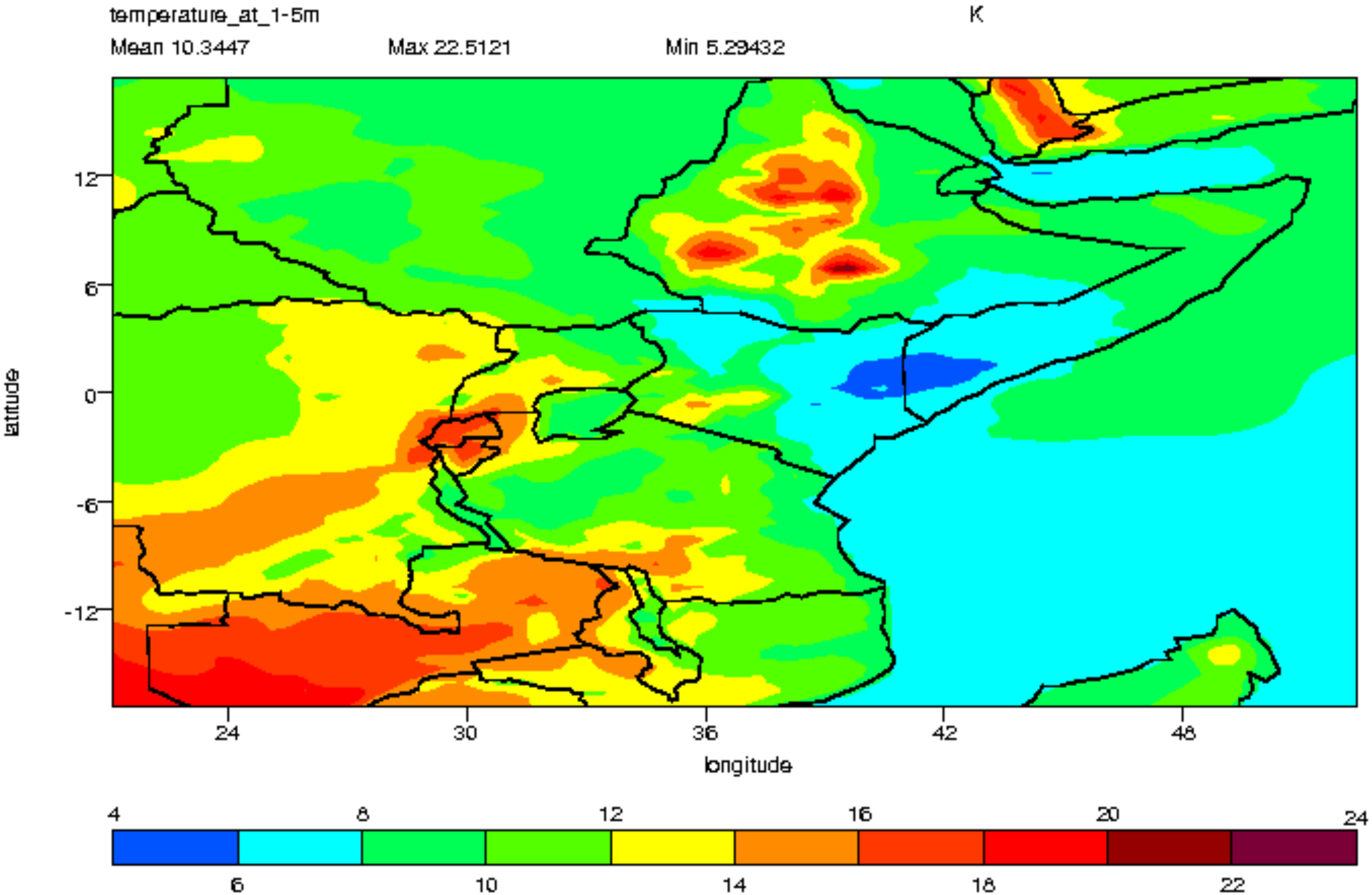


(c) June-August

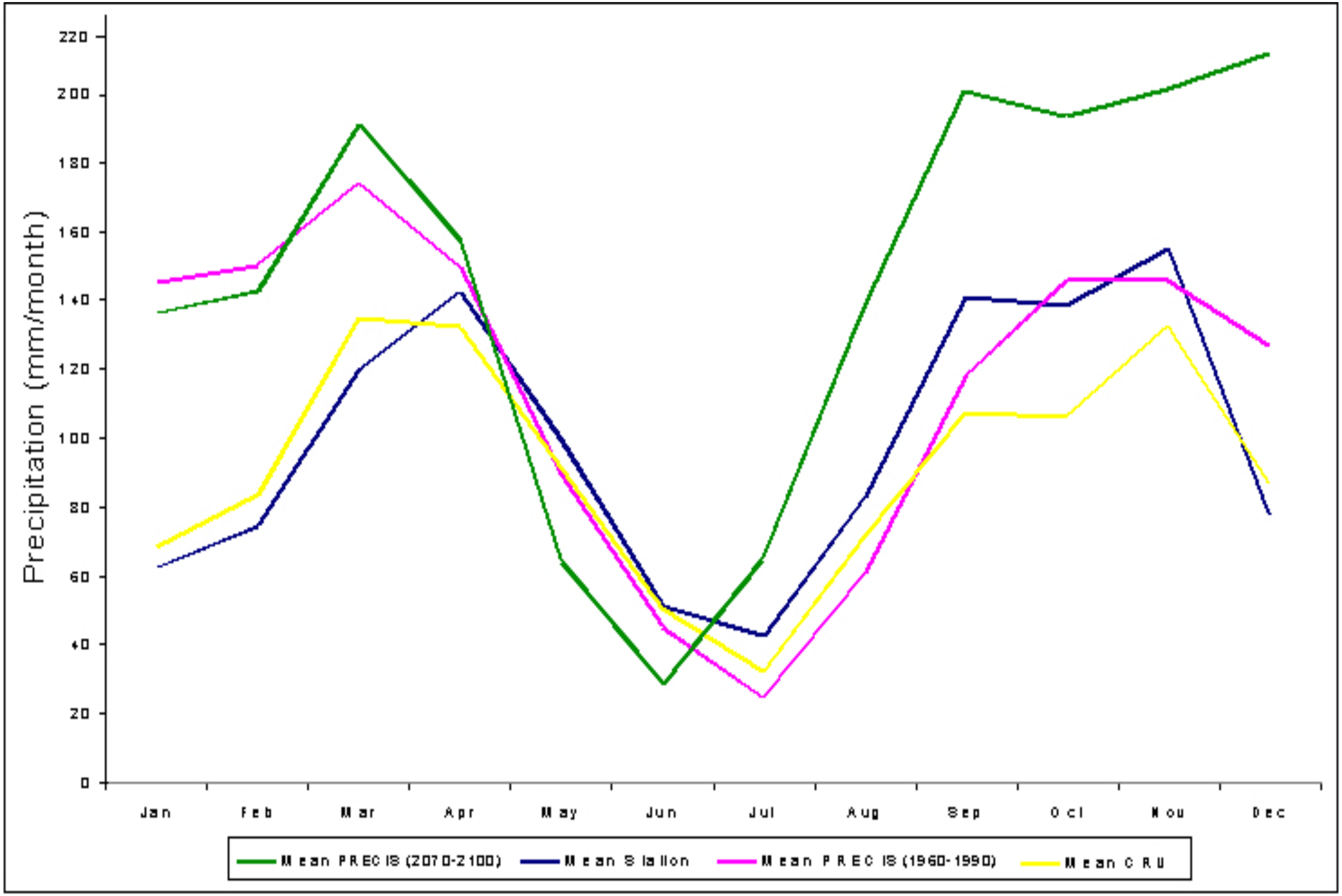


(d) September-December

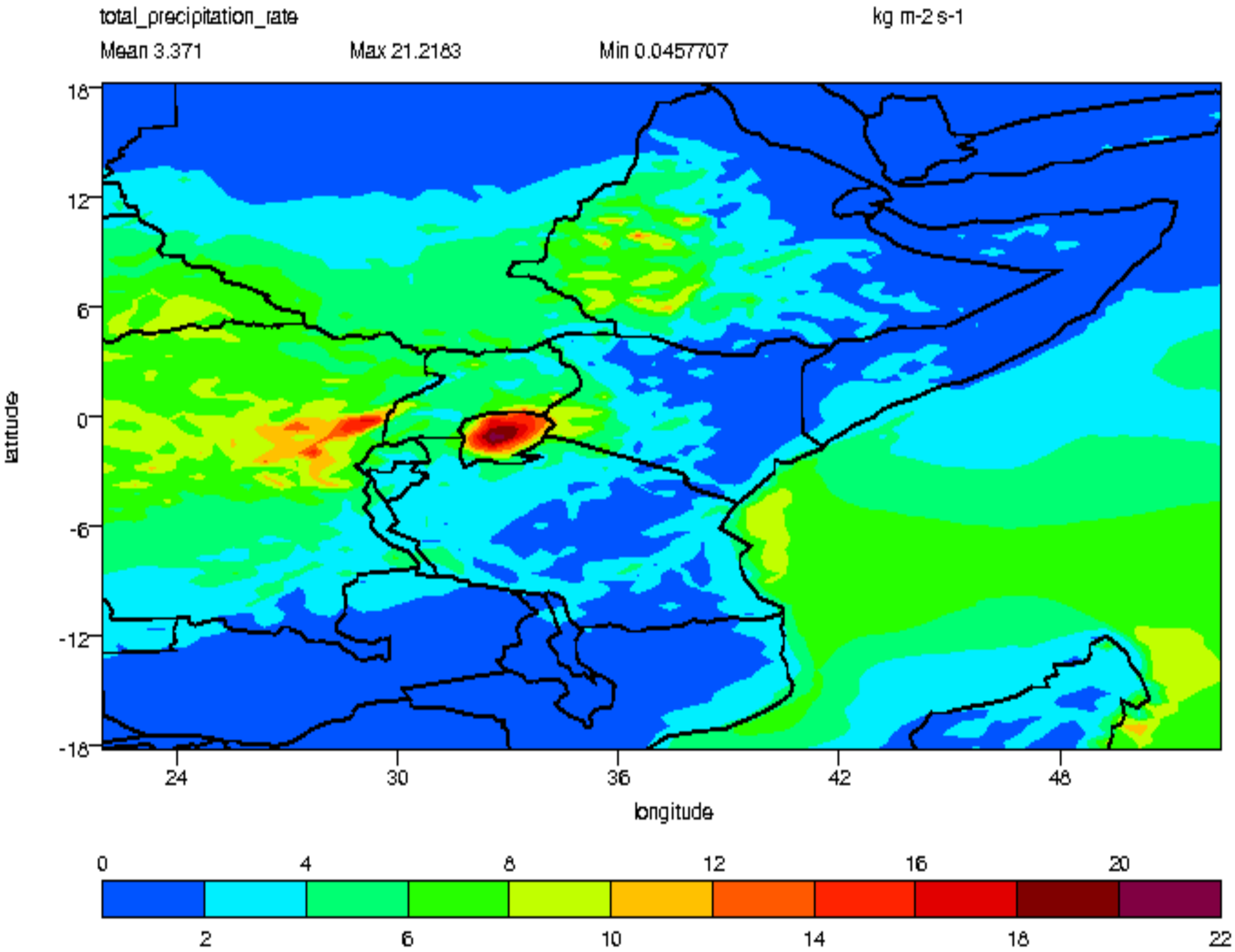
% DIFFERENCE IN FUTURE MEAN MAM TEMPERATURE (2070-2100) AND BASELINE (1961-1990)



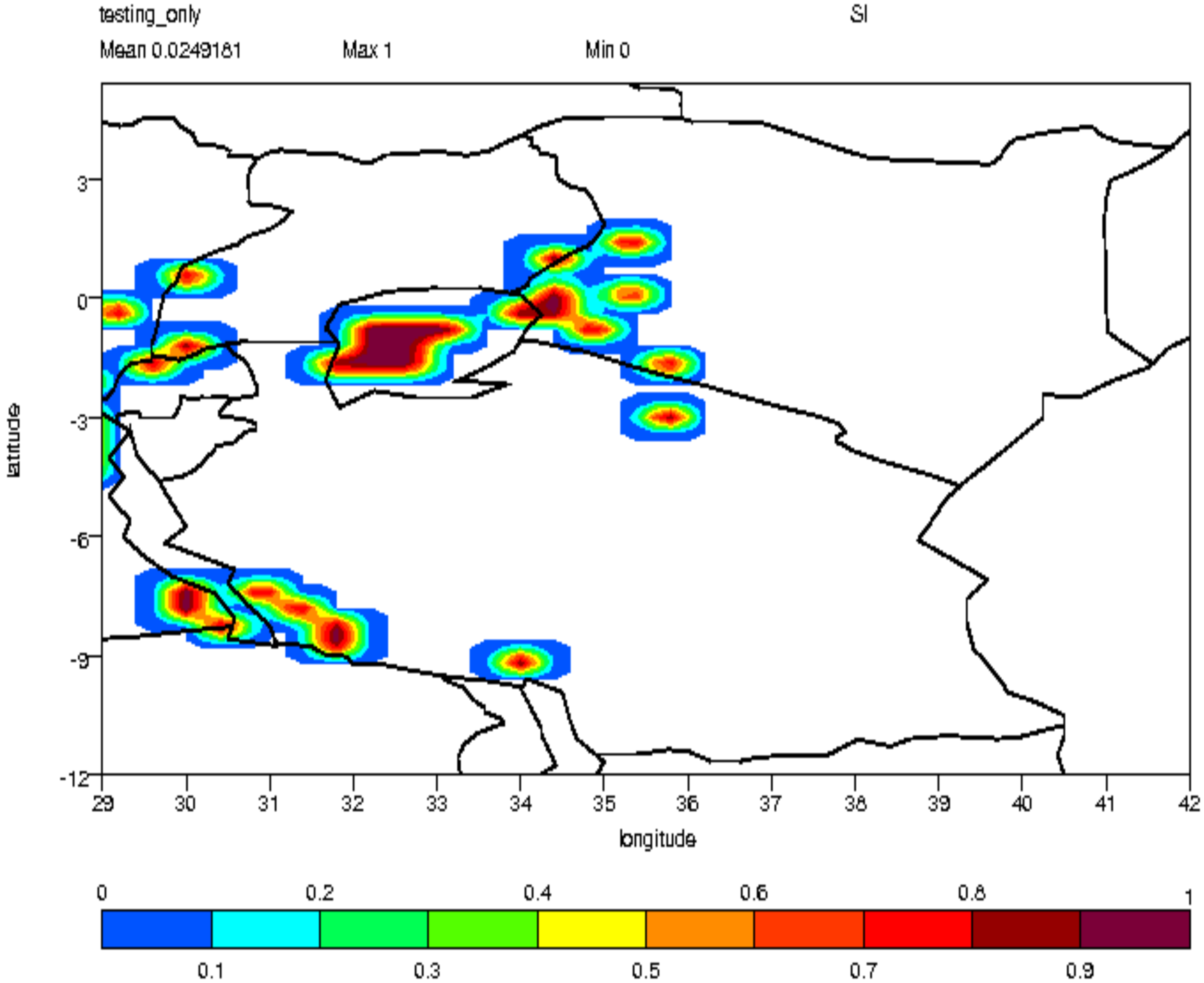
Future Climate Change (2070-2100)



MEAN MAM 2070-2100 (HADMP3 A2)



MODEL BIAS FOR MAM SEASONAL RAINFALL



Seasonal land precipitation (mm/day) statistics for land points only

	DJF	MAM	JJA	OND
Mean: **OBS**	**1.33**	**4.52**	**2.11**	**3.01**
GCM	**1.29**	**3.99**	**2.01**	**2.79**
RCM	**1.43**	**4.12**	**2.19**	**2.98**
Spatial standard deviation:				
OBS	**1.57**	**2.45**	**0.82**	**1.64**
GCM	**2.02**	**3.54**	**0.54**	**2.21**
RCM	**1.42**	**2.37**	**0.67**	**1.57**
RMS error:				
GCM	**1.53**	**3.01**	**0.57**	**1.77**
RCM	**1.36**	**1.87**	**0.33**	**1.01**
Spatial correlations:				
RCM-OBS LS	**0.67**	**0.81**	**0.78**	**0.87**
GCM-OBS LS	**0.64**	**0.70**	**0.72**	**0.82**
RCM-GCM LS	**0.69**	**0.87**	**0.92**	**0.93**
RCM-OBS MS	**0.35**	**0.40**	**0.45**	**0.48**
GCM-OBS MS	**0.26**	**0.35**	**0.24**	**0.40**
RCM-GCM MS	**0.27**	**0.33**	**-0.21**	**0.36**

SUMMARY AND CONCLUSION

- **Slight shift in timing of peak seasons**
- **Higher average temperatures in all seasons and areas (especially in the north) [3.5 °C increase]**
- **HadRM3P RCM when driven by the reanalysis captures reasonably the basic feature of the climate over the GHA regions, including the intense low-level inflow of moisture to the continent and associated rainfall annual cycles**.

THANK YOU