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

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OUTLINE

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• 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.
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 $0.5^\circ\times0.5^\circ$ horizontal resolution
  • Atmospheric circulations from both ERA40 and NCEP-R2 reanalysis, respectively with $1.125^\circ\times1.125^\circ$ and $2.5^\circ\times2.5^\circ$ 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
COMPARISON OF OBSERVED AND MODEL OUTPUT FOR MARCH-MAY RAINFALL SEASON
MEAN SEASONAL SURFACE TEMPERATURE

GCM

RCM

temperature_at_1-5m
Mean: 23.3666  Max: 34.6152  Min: 12.6623

temperature_at_1-5m
Mean: 236.991  Max: 305.692  Min: 203.186
(a) March – May

(b) June – August

(c) October – December

(d) December – February
ANNUAL CYCLE FOR SIMULATED AND OBSERVED MINIMUM TEMPERATURE
• 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

ECHAM4

\[ y = 0.0616x + 0.5283 \]
\[ R^2 = 0.53 \]

HadAM3P - OBSERVED

\[ y = 0.2079x + 0.4123 \]
\[ R^2 = 0.51 \]

ERA40

\[ y = 0.5292x + 0.06 \]
\[ R^2 = 0.54 \]

RCM

\[ RCM = 1.3\times\text{HadAM3P}-0.3\times\text{ECHAM4} + 0.6201 \]
\[ R^2 = 0.70 \]
(c) June-August

(d) September-December
% DIFFERENCE IN FUTURE MEAN MAM TEMPERATURE (2070-2100) AND BASELINE (1961-1990)
Future Climate Change (2070-2100)

Precipitation (mm/month)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Mean PREC IS (2070-2100)  Mean Station  Mean PREC IS (1960-1990)  Mean CRU
Seasonal land precipitation (mm/day) statistics for land points only

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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