

**Climate Change Scenario Simulations over  
Eritrea by Using a Fine Resolution Limited  
Area Climate Model:  
Temperature and Moisture Sensitivity**

by

**Asmerom Fissehatsion Beraki**

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# Climate Change Scenario Simulations over Eritrea by Using a Fine Resolution Limited Area Climate Model: Temperature and Moisture Sensitivity

*Asmerom Fissehatsion Beraki*

Promoter: Prof. C.J. de W. Rautenbach  
Department: Department of Geography, Geoinformatics and Meteorology  
Faculty: Faculty of Natural and Agricultural Sciences  
University: University of Pretoria  
Degree: Master of Science

## Summary

The climate of the eastern section of the Sahelian latitude, especially over the Eritrean subdomain, is often associated with long drought episodes from which the atmospheric mechanisms are poorly understood. In an effort to improve our knowledge of weather and climate systems over this region, the PRECIS Regional Climate Model (RCM) from the United Kingdom (UK) was obtained and implemented. Such a climate model that is based upon the physical laws of nature has the ability to simulate regional-scale atmospheric patterns, and therefore, may significantly contribute to our understanding of local atmospheric processes. In this dissertation the assessment of past regional climate trends from both observations and model simulations, and the simulation of scenarios for possible future climate change were regarded as important. To investigate this, the PRECIS RCM was first nested over the Eritrean domain into the “atmosphere only” HadAM3H global General Circulation Model (GCM) and forced at its lateral boundaries by a 30-year present-day (1961-1990) integration of the same global model. Secondly, the PRECIS RCM was constrained at its lateral boundary by the “fully coupled” HadCM3 GCM (for Sea Surface Temperatures (SSTs) and sea-ice) and its improved atmospheric component (HadAM3H GCM). The latter simulations provided boundary conditions for the A2 and B2 future emission scenarios (Special Report on Emission Scenarios (SRES)) to simulate a 20-year (2070-2090) projection of future climate. These experiments allowed for verification of both spatial and temporal present-day climate simulations, as well as possible future climate trends as simulated by the PRECIS RCM over the Eritrean domain, with specific emphasis on temperature and moisture related variables.

The study indicates that PRECIS RCM climate simulations are mostly in harmony with observed spatial patterns. This skill may be attributed to the full representation of the climatic system (land surface, sea, ice, atmosphere and atmospheric chemistry such as sulphur and greenhouse gasses) in the model configuration. However, when comparing PRECIS RCM results with the much coarser resolution ( $2.5^{\circ} \times 2.5^{\circ}$ ) National Centre for Environmental Prediction (NCEP) reanalysis data, obvious differences do occur. These differences are not necessarily the result of poor model performance, but may be attributed to more detailed simulations over the finer RCM grid ( $0.44^{\circ} \times 0.44^{\circ}$ ).

Future climate scenario simulation with the PRECIS RCM over Eritrea produce increased surface temperature in both the A2 and B2 SRES scenario integrations, relative to the present climatology. This temperature increase also appears in the driving GCM (HadCM3) as well as in other GCM results from the Inter Governmental Panel for Climate Change (IPCC) initiative. There are, however, mixed signals in rainfall projections. According to PRECIS RCM results, rainfall is expected to increase in most of the Eritrean region.

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## **LIST OF SYMBOLS**

$E$	:	RMS difference
$\bar{E}$	:	Bias
$E'$	:	Pattern RMS difference
$f_n$	:	Model variable
$N$	:	Discrete points (in time and/or space)
$R$	:	Correlation coefficient
$r_n$	:	Observed variable
$\alpha$	:	Positive constant
$\sigma$	:	Vertical (sigma) coordinate
$\sigma_f, \sigma_r$	:	standard deviation (for model and observed fields)

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## **LIST OF ABBREVIATIONS**

AGCM	Atmospheric General Circulation model
AOGCM	Atmosphere-Ocean General Circulation model
BMO	United Kingdom Meteorological Office
CCSR/NIES99	Japanese Centre for climate system Research fully coupled GCM
CGCM1/CCCma	Canadian Centre for Climate modelling and analysis
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia).
CSIRO-Mk2b	CSIRO fully coupled GCM
ECHAM4	German Climate Research Centre fully coupled GCM
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño Southern Oscillation
EROS	National Center for Earth Resources Observation and Science
GCM	Global Climate Model
GFDL	Geophysical Fluid Dynamics Laboratory
GFDL99-R30	GFDL fully coupled GCM
GISS	Goddard Institute for Space Studies
HadAM3H	The Hadley Centre Atmosphere only GCM
HadCM3	The Hadley Centre Fully Coupled GCM
HadISST	Hadley Centre Observed Sea Surface Temperature
HadRM3	The Hadley Centre Regional Climate Model
IPCC	Intergovernmental Panel for Climate Change
ITCZ	Intertropical Convergence Zone
LAM	Limited Area Atmospheric Model
MLWE	Ministry of Land, Water and Environment
MM5	Regional Climate Model of Pennsylvania State University (PSU) – National Centre for Atmospheric Research (NCAR) version 5
NCEP	National Centre for Environmental Prediction
NCM	Nested Climate Model
NWP	Numerical Weather Prediction
RCM	Regional Climate Model
PRECIS	Providing Regional Climates and Impacts Studies
SRES	Special Report on Emission Scenarios
SST	Sea Surface Temperature
UKMO	UK Met Office
UNFCCC	The United Nations Framework Convention on Climate Change.
WRD	Water Resources Department