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

by

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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°x2.5°) 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° x 0.44°).

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 Intergovernmental 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
\[ \hat{E} \] : 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
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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