Downscaled Climate Change Projections for Wa District in the Savanna Zone of Ghana

Article *in* Journal of Disaster Research · July 2014

5 authors, including:

Bruce Hewitson
University of Cape Town
152 PUBLICATIONS 9,740 CITATIONS

Mark Abekoe
University of Ghana
28 PUBLICATIONS 354 CITATIONS

George Owusu
University of Ghana
13 PUBLICATIONS 48 CITATIONS

Paper:

Downscaled Climate Change Projections for Wa District in the Savanna Zone of Ghana

Emmanuel Tachie-Obeng[*1], Bruce Hewitson[*2], Edwin Akonno Gyasi[*3], Mark Kofi Abekoe[*4], and George Owusu[*3]

[*1]Environmental Protection Agency
Post Office Box M326, Accra Ghana
E-mail: etachieobeng@gmail.com
[*2]CSAG ENGEO Department, University of Cape Town, South Africa
[*3]Department of Geography and Resources, University of Ghana, Ghana
[*4]Department of Soil Science, University of Ghana, Ghana
[Received March 26, 2014; accepted July 20, 2014]

The possibility of future climate change in Ghana has received much attention due to repeated droughts and floods over the last decades. The savanna zone which is described as the food basket of Ghana is highly susceptible to climate change impact. Scenarios from 20-year time slices of the near future – 2046-2065 – and the far future – 2081-2100 – climate change meant to help guide policy remain a challenge. Empirical downscaling performed at the local-scale of Wa District in the savanna zone of Ghana under the IPCC A2 SRES emissions scenario showed evidence of probable climate change with mean annual temperatures expected to increase over an estimated range of 1.5°C to 2.3°C in the near future, with number of cool nights becoming less frequent, especially during the Harmattan[1] period. The dry season is expected to be warmer than the wet season, with high inter-annual variations projected in both maximum (T_{max}) and minimum (T_{min}) temperatures. Given an average of 1 day of $T_{max} >$ 40°C per month in the control period of 1961-2000, the number of hot days is expected to increase to 12 by 2046-2065. An increase in total rainfall is projected with possible shifts in distribution toward the end of the year, with a slight increase in rainfall during the dry season and an increase of rainfall at the onset and toward the end of the wet season. However, a decrease in June rainfall is projected in the wet season. The objective of this paper is to improve the understanding of future climate as a guide to local level medium-term development plans of effective adaptation options for Wa district in the savanna zone of Ghana.

Keywords: climate-projected climate scenario, Ghana, rainfall, temperature

1. Introduction

The possibility of future climate change in Ghana has received much attention due to increasing drought and flood events in the last four decades. Ghana and most other African countries where livelihoods depend on climate [1] may suffer with projected climate change [2], hence there is a need to examine possible future climate scenarios as a basis for effectively planning and direction to policy in the context of projected climate change.

According to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), global surface temperature change for the end of the 21st century is highly likely to exceed 2°C for representative concentration pathways RCP6.0 and RCP8.5 [3]. In Ghana, monthly temperatures have been increasing in the range of 0.1°C to 0.7°C per decade since the end of the 1970s [4], but rainfall projections are fraught with difficulties. In West Africa, especially between 0°N and 15°N, which includes Ghana, different models output show conflicting projections with no reliable conclusion drawn [4]. Recent research by Giannini et al. [5] indicated that the 21st century will have increased annual rainfall in West Africa. Again, current scientific evidence shows that climate change will continue into the future regardless of the effectiveness of mitigation [4]. Rain-fed agriculture is the main food production source in Ghana, so food availability and sustainability are restricted by rainfall amount and distribution, making the need for reliable rainfall projections for Ghana highly relevant.

Initial climate change scenarios in Ghana conducted by the Environmental Protection Agency (EPA) and the Ghana Meteorological Agency (GMet), driven by Model for the Assessment of Greenhouse-GasInduced Climate Change (MAGICC) under IPCC A1[2] SRES, projected an increase in mean daily temperature between 2.5°C and 3.2°C, while annual rainfall totals were projected to decrease between 9% and 27% throughout ecological zones by 2100 [6].

Global Circulation Models (GCMs)[3] are currently the tools most commonly used for climate projection. Due to

1. Harmattan is a dry and dusty West African trade wind which blows from the Sahara into the Gulf of Guinea between the end of November and middle of March (dry season). The temperature can be as low as 3°C.

2. The A1 scenario represents very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies.

3. A mathematical model of the general circulation of a planetary atmosphere or ocean and based on the Navier-Stokes equations on a rotating sphere with thermodynamic terms for various energy sources.

their rough resolution, typically 300 × 300 km in the tropics, they cannot be used for projecting the local changes in scale required to assess impact and adaptation measures [7-9]. Investigations into short-term variations in projected rainfall in many parts of Ghana were based on GCMs output without downscaling to suitable local scale [10-13]. Forecast types that rely mainly on the El-Nino Southern Oscillation (ENSO) phenomenon or local seasurface temperatures (SSTs) are only valid on a monthly or seasonal scale, thus also requiring longrange forecasting. The current use of empirical downscaling models has contributed significantly to predicting future climate based on localscale weather. According to Hewitson and Crane [8], empirical downscaling is one means of circumventing the problem of scale mismatch because it derives local climate response to largescale atmospheric states using more appropriate GCM attributes as required by impact assessment and adaptation. Downscaling thus plays a pivotal role and remains a keystone also in the tropics for simulating projected local-scale climate change. This research focuses on the production of projected local-scale future climate change scenarios through downscaling.

The objective of this paper is to downscale future climate change to station-scale level as the foundation for realistic climate-change impact prediction and adaptation strategies. The downscaling technique employed here was developed by the Climate Systems Analysis Group (CSAG) based on A2 emission scenarios from the IPCC Special Report on Emissions Scenarios (SRES) applicable to local weather. The study quantified and analysed projected temperature and rainfall in Wa district for the near future (NF) 2046-2065 and far future (FF) 2081-2100 and evaluated them by comparing simulated output to existing temperature and rainfall datasets from 1961 to 2000 as discussed in secsion 2.3 below.

2. Data and Study Area

2.1. Meteorological Data

Long-term daily rainfall and temperature datasets from 1961-2000 were obtained for Wa from the Ghana Meteorological Agency (GMet) (**Fig. 1**). The climate record was 85% complete (valid values) considering all missing data. Variables of *u* and *v* were referenced as wind components also as discussed in section 2.3.

Daily rainfall and maximum and minimum temperatures were used to derive projected climate scenarios. All such data are shown and discussed in sections 2.2 and 2.3 below. Apart from the local weather dataset, the National Centre for Atmospheric Research (NCAR) Reanalysis 2 Project (NCEP) was accessed via their website[4]. The local weather dataset, together with the NCEP reanalysis data, were used for simulating future climate scenarios. Datasets were collected for weather stations with World Meteorological Organization identity (WMO ID) and study site weather codes.

4. See http:/www.cdc.noaa.gov

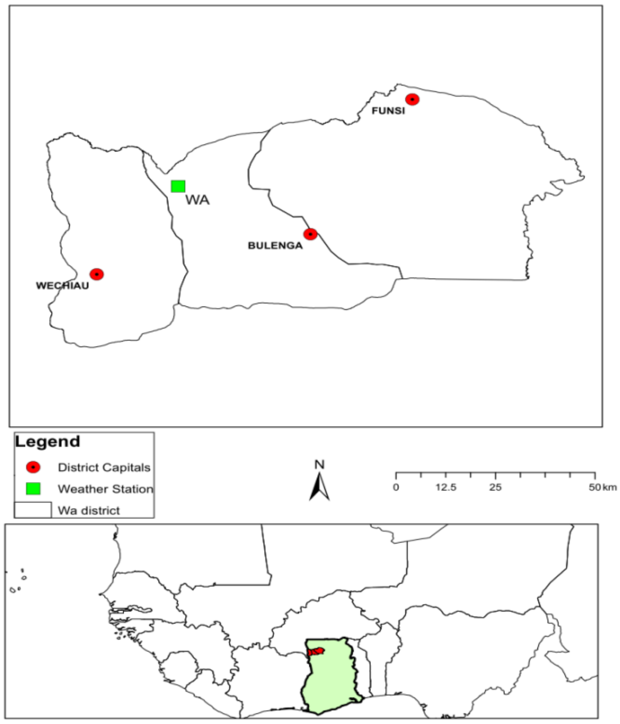

Fig. 1. Wa (red) in Ghana (light green).

2.2. General Circulation Model Data

Apart from long-term daily weather observations, output from GCMs were also used to generate future climate scenarios at the study sites. GCM data were obtained from World Climate Research Programme (WCRP) phase 3 of the Coupled Model Intercomparison Project (CMIP3) Multimodel Database. Nine GCM models (**Table 1**) were used and simulation data was examined for two time periods – a control period for the present climate – 1961-2000 – and a future period where simulating greenhouse gas concentrations is based on the A2 emission scenario[5] from the IPCC SRES. Two 20-year NF – 2046-2065 – and FF – 2081-2100 – time slices were used.

2.3. Projected Future Climate Change

Climate scenarios were projected based on a statistical downscaling technique called the self-organizing map (SOM)[6] downscaling developed by the CSAG of the University of Cape Town, South Africa.

The technique downscaled daily weather – rainfall, minimum and maximum temperature – over Wa weather station using general circulation models (GCMs) on the regional scale. SOMs were used to characterize atmospheric status in a localized domain surrounding each target location with 6-hourly NCEP reanalysis data from

5. The A2 scenario represents very heterogeneous with continuously increasing population and regionally oriented economic growth that is more fragmented and slower in terms of technological development, social and political structures and income distribution.
6. Self-organizing map (SOM) is a data description and visualization tool that extracts and displays the major features of the multidimensional data distribution function.