Climate Change Impact on Variability of Rainfall Intensity in Upper Blue Nile Basin, Ethiopia

Lakemariam Yohannes WORKU, E-mail: mistrelake@yahoo.com, Mobile: +251-931-500444
Arba Minch University, Arba Minch, Ethiopia

Second NASA-GHA workshop on Seasonal Prediction Hydro-Climatic Extremes in Greater Horn of Africa (GHA)
28-29 July 2015, Addis Ababa Ethiopia

Abstract

Extreme rainfall events are major problems in Ethiopia with the resulting floods that usually could cause significant damage to agriculture, ecology, infrastructure, disruption to human activities, loss of property, loss of lives and disease outbreak. The aim of this study focuses on investigating the future climate change impact on variability of rainfall intensity-duration-frequency in Upper Blue Nile basin. Precipitations data from two Global Climate Models (GCMs) have been used in the study are HadCM3 and CGCM3. The study indicates there will be likely increase of precipitation extremes over the Blue Nile basin due to the changing climate. This study should be interpreted with caution as the GCM model outputs in this part of the world have huge uncertainty.

Introduction

- Ethiopia has been engaged in developing hydropower energy in order to combat climate change and to create an efficient energy supply for sustainable development.
- Flooding, due to extreme heavy rainfall, may cause damage to hydrological structures.

Figure-1: Flood in Dire Dawa, Ethiopia 2006 (Courtesy: BBC)

Objectives

- Investigation of historical characteristics of Intensity-Duration-Frequency (IDF) of rainfall in Abbay (Upper Blue Nile) basin
- Develop a relationship of IDF curve for projected rainfall using disaggregation model
- Investigation of future characteristics of rainfall Intensity-Duration-Frequency (IDF) based on future climate change scenario

Methods

- Thirty (30) year daily meteorological rainfall data from 1961 to 1990 for twelve station was collected
- Downscaling of HadCM3A2 and CGCM3A2 from global scale to basin level using SDSM
- Rainfall Frequency analysis
- Quantile estimation for each station with different return period
- Applying stochastic disaggregation model to change daily maximum rainfall to sub-daily
- Developing IDF curve for historical and future data set
- Investigate the change in rainfall intensity

Personal Background

My name is Lakemariam Yohannes WORKU; I have B.Sc. in Meteorology Science from Arba Minch University and M.Sc. In Water Resource Engineering (Engineering Hydrology) from Bahir Dar University, Ethiopia. My Research interests focus on Climate Change, Weather Related Risks, Water Resource, Sustainable Development, Renewable Energy (especially Hydropower development, green economy) in relation to climate change and related fields.

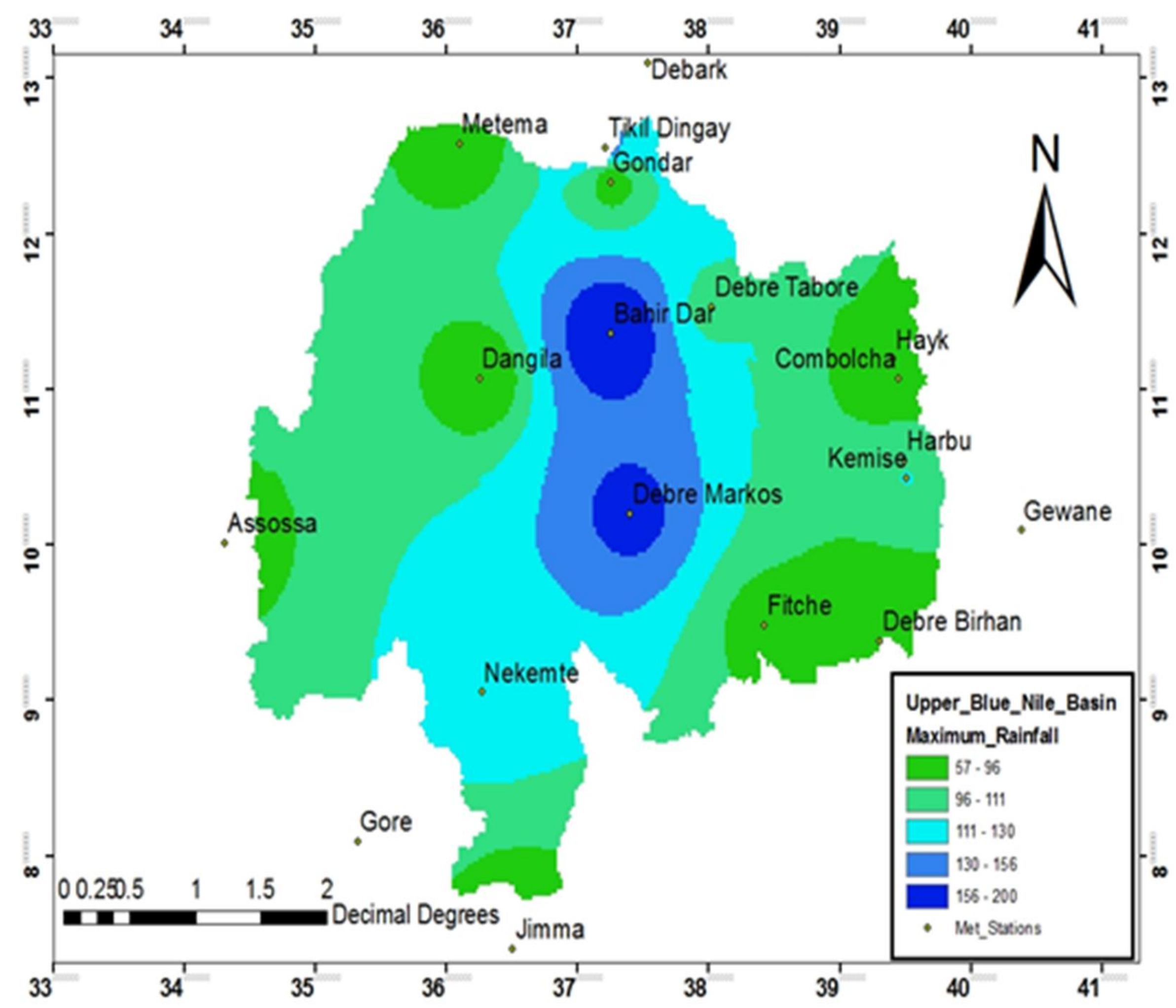

Figure-2: Extreme rainfall in Upper Blue Nile Basin

Results

- Parent distributions are Generalized Logistic (GLOG), Generalized Extreme Value (GEV) and Gamma & Pearson III (P3).
- The two GCMs (HadCM3 and CGCM3) result shows that rainfall intensity will have an increasing trend for most of stations in Upper Blue Nile basin in the future except for a couple of stations will have a decreasing intensity.
- Rainfall intensity for both HadCM3 and CGCM3 in most parts of the basin will have an increasing trend in the future with 1% to 26% for HadCM3 and 12% to 61% for CGCM3
- But there will be decreasing intensity for HadCM3 prediction in Debre Birhan (2020s), Debre Markos (2080s) and Gondar (all period) 3 to 38% and for CGCM3 prediction Hayk (2020s) and Gondar (all period) 11 to 34%.

Stations	% Change for HadCM3			% Change for CGCM3		
	2020s	2050s	2080s	2020s	2050s	2080s
Assossa	13.26	12.23	15.92	19.18	19.13	20.00
Bahir Dar	25.89	21.45	19.47	18.56	19.14	11.76
Combolcha	8.13	8.64	11.82	30.43	32.02	60.87
Dangila	6.16	6.70	7.14	17.86	21.43	23.99
Debre Birhan	-2.90	3.23	6.93	18.29	26.39	38.19
Debre Markos	18.95	18.69	-24.82	21.23	26.40	27.37
Debre Tabore	10.53	11.11	11.11	15.93	23.97	29.73
Fitche	-37.35	-36.75	-37.35	49.75	26.48	27.71
Gondar	3.76	3.77	3.05	-11.87	-15.14	-13.00
Gore	18.40	19.85	18.43	26.30	26.80	32.73
Hayk	0.26	5.07	2.65	-34.12	34.22	21.07
Nekemte	13.83	13.30	17.02	20.31	25.89	33.54

Table-1: Extreme rainfall changes between observed and projected data

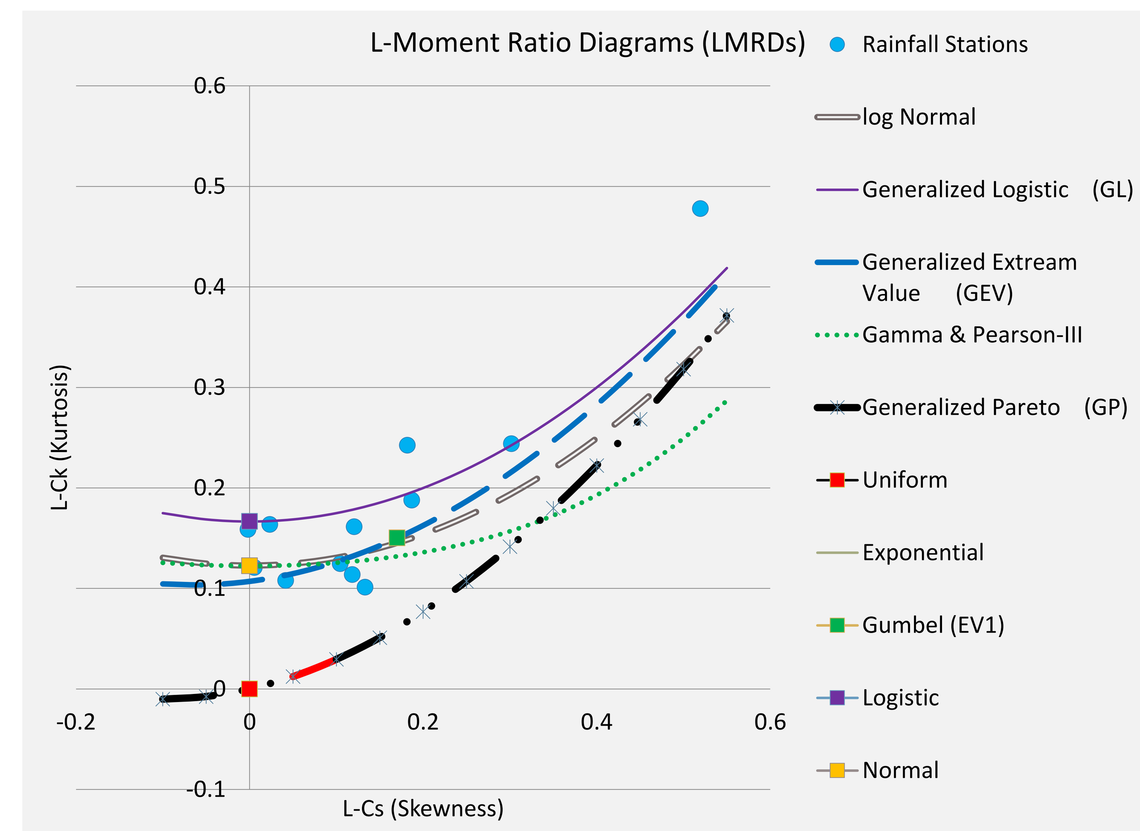

Figure-3: L-MRDs rainfall frequency analysis parent distribution chart

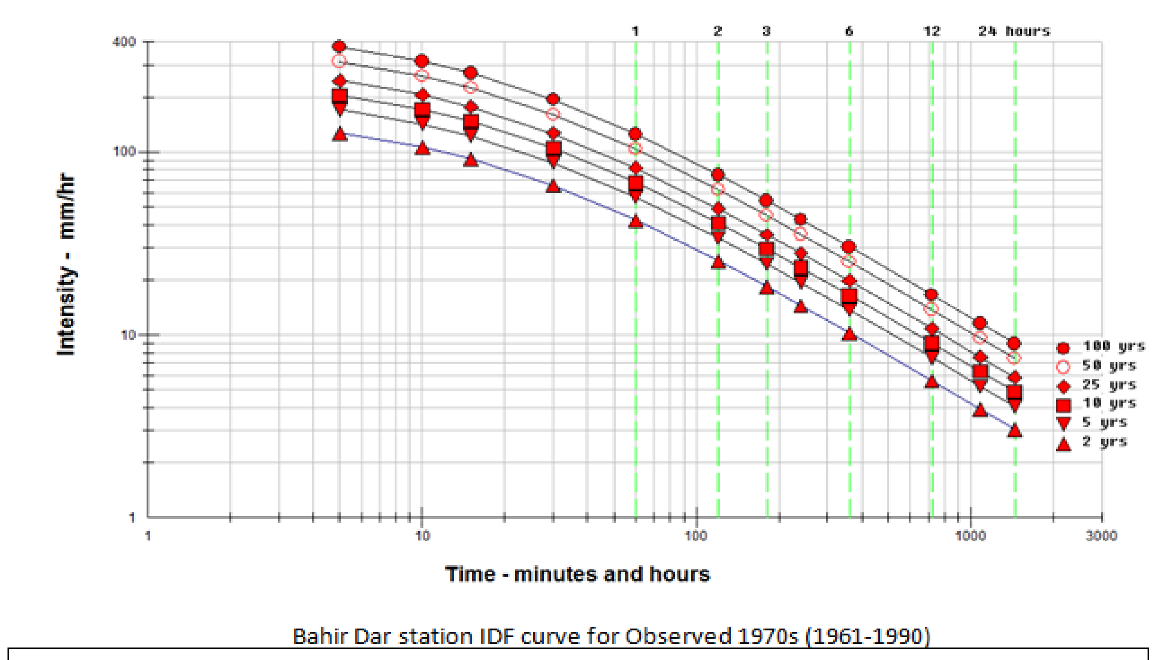

Figure-4: Rainfall IDF curve of Bahir Dar station for Observed 1970s(1961-1990)

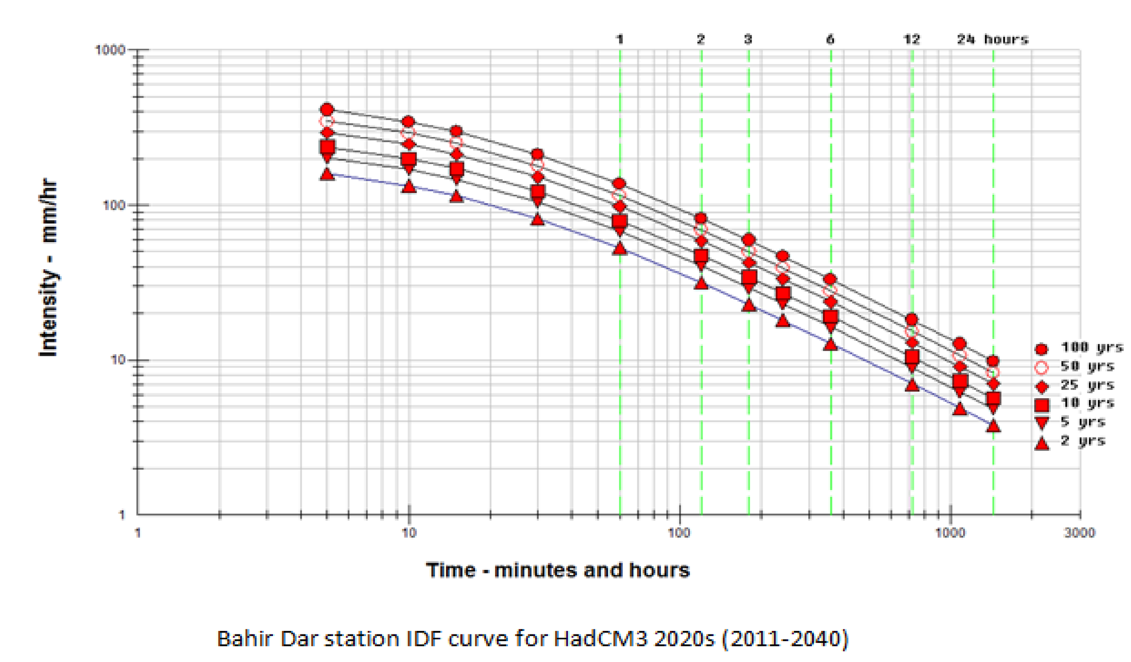

Figure-5: Rainfall IDF curve of Bahir Dar station for HadCM3 2020s(2011-2040)

Conclusions

- Annual downscaled daily maximum rainfall of Bahir Dar, Debre Markos, Gondar, and Nekemte stations shows decreasing trend for GCMs and Debre Birhan for HadCM3. However, the other stations annual maximum rainfall has an increasing trend for both GCMs
- Extreme rainfall will very likely increase in the future scenario within the basin
- Rainfall Intensity will increase for both GCMs in the future
- Hydrological structures should be designed by considering a very likely increment of rainfall intensity
- However, the result should be taken with caution as future global climate model results are with high uncertainty in tropics part of the world

Acknowledgement

Special thanks to Blue Nile Water Institute (Bahir Dar University) and Ethiopian Meteorological Society (EtMS) for their generous financial support to this research work

Reference

• ABDO, K., FISEHA, B., RIENTJES, T., GIESKE, A. & HAILE, A. 2009. Assessment of climate change impacts on the hydrology of Gilgel Abay catchment in Lake Tana basin, Ethiopia. *Hydrological Processes,* 23, 3661-3669.
• AWULACHEW, S. B., MCCARTNEY, M., STEENHUIS, T. S. & AHMED, A. A. 2008. *A review of hydrology, sediment and water resource use in the Blue Nile Basin*, Download full text free.
• CONWAY, D., BROOKS, N., BRIFFA, K. & MERRIN, P. 1998. Historical climatology and dendroclimatology in the Blue Nile River basin, northern Ethiopia. *Variabilité Des Ressources en Eau en Afrique Au Vingtième Siècle*, 243.
• HAMED, K. & RAO, A. R. 2010. *Flood frequency analysis*, CRC press.
• IPCC 2007. *Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC*, Cambridge University Press.
•SINE, A. & AYALEW, S. 2004. IDENTIFICATION AND DELINEATION OF HYDROLOGICAL HOMOGENEOUS REGIONS-THE CASE OF BLUE NILE RIVER BASIN.
• WILBY, R. & DAWSON, C. 2007. A decision support tool for the assessment of regional climate change impacts *SDSM 4.2.* UK: Environment Agency of England and Wales.