Using Climate Models to predict Precipitation at upper Blue Nile

Sherien A. Zahran

PhD, Researcher, Environment and climate change Research Institute (ECRI), National water research center
(NWRC) Ministry of Irrigation and water resources (MIWR), Cairo, Egypt,
Assistance Professor at Canadian International Collage (CIC),.
sherine_zahran@cic-cairo.com,shereinzahran@gmail.com

Abstract: The changes in the climate is clearly differs than other stress factors, where the harshness and incidence are undefined. A necessary need for complete climate change adaptation procedure through defining and consumingthe available data on effects of climatic changes.The purpose of present investigation was to elucidate the effect of climatic diversity (precipitation) in Blue Nile that was represented in 3regions; “Bahr Dar, Combolcha,Debremarcos”. The projections of Ten GCMs climate models were used in the current study. Measuring of improbability in term of sensitivity of those models seasonally and inter-annually for precipitation. Downscaled information for the IPCC-SRES A2 greenhouse gas productionssettingdemonstratingaextraordinary growth of discharges into the forthcoming were evaluated to choice a forecast that would end in the driest and wettest impending for the Blue Nile sub-basin. Intervalsequence for 1961:1990 offer a base line for climate variation scenario. The near future prediction for 2046:2065 was applied. The results shown that there is great fluctuation in precipitation among the annually models however the expectedvariationissues are restricted to the perceived in wet season comparing with dry season.

[Sherien A. Zahran,**Using Climate Models to predict Precipitation at upper Blue Nile.***Life Sci J*2019;16(1):1-9].ISSN: 1097-8135 (Print) /ISSN: 2372-613X (Online).http://www.lifesciencesite.com. 1.doi:10.7537/marslsj160118.01.

Keywords: Climate change, Blue Nile, climate model.

I. Introduction

A. Climate Variability and Change in the NileBasin

TheNile River Basin is located in wide bounds of latitude and extreme ranges of landforms. Consequently, greatly varying climatic conditions are prevailing in different parts of the Nile Basin. The spatial and temporal variability of climate, particularly precipitation, in the Nile Basin is mostly governed by the movement of the Inter Tropical Convergence Zone (ITCZ), by the El Nińo/Southern Oscillation (ENSO) and Sea Surface Temperature (SST) over the Indian and Atlantic oceans, and by the land topography (Mohamed et al., 2005). Therefore, the location of the Nile Basin and the surrounding climatic processes are imposing greater intra- and inter-annual variability to the water resources of the region. Moreover, these processes responsible for climate variability in the region are susceptible to changes due to enhanced emissions of greenhouse gases and to alterations in land use/cover. Consequently, the water resources of the Nile Basin are highly vulnerable to anthropogenic global warming.

The IPCC fourth assessment report has classified Africa as the utmostsusceptible to impacts of weather change and variability owing to manydisresses and little adaptive ability [1] (IPCC, 2007). Most General Circulation Model (GCM) estimates similarly predictbasin-wide temperature increase in the Nile Basin. The precipitation estimates of the coupled GCMs have exhibited significant variation both across the sub-basins and the models [2]. This implies that the prediction of the Nile Basin precipitation and other climatic variables by the large-scale global climate models are not reliable for impact assessment and development of adaptation strategy. The uncertainties in these major climatic variables of the region might arise from the inability of the global climate model expectations to explanation for the effect of land cover variations on the upcomingweather, and from the comparativelyreducedexemplification of major events responsible for climate variability (ITCZ, ENSO and SST) in the region [3]. These limitations of the global GCM predictions could be mitigated through application of regional climate models with relevant forcing agents and boundary conditions [4].

Different climate impact studies conducted in the Nile Basin suggest that the Basin water resources are highly vulnerable to plausible changes in temperature, precipitation and sea level. The Nile River flow from Lake Victoria might completely cease in response to temperature rise and slight decrease in precipitation around the Equatorial lakes [5]. The rainfall fluctuations over the Easter highlands could significantly effect on the main Nile flow. The water lever rise in the Mediterranean Sea would submerge the most fertile irrigation lands of the Nile Delta. Generally, climate change and variability in the Nile Basin would substantially affect both water availability and the demand for fresh water in the region.

Certainly, research proposed that small alterations in atmospheric movement are relativelypredominatein the Nile Basin, and deliveredexplanation for the detected ENSO and SOIrelationships with Eastern Nile precipitation. The physical basis for the dispute is as follows:

- The ITCZ itself shifts based on a group of causes that comprise the earth's orbiting axis, variations in the position of the sun, and the strength of radioactive forcing from the sun, [6].
- The ENSO phenomenon induces SST changes which alter the ocean circulation as well as the movement of the ITCZ thus influencing tropical climate patterns. For example, higher SSTs lead to drier conditions over many subtropical regions during El Niño, Chang and Fu, (2002).
- ENSO may play a role in triggering or pre-disposing the system for particular IOD conditions, [7]. This plays a prominent role in inter-annual variability by inducing a strong zonal gradient in tropical sea-surface temperatures,Indeed, Indian Ocean temperatures tend to begin to rise about five months following ENSO events and the strongest recent IOD episode was during the El Niño in 1997-98.

II. . Climate Change Impact In Nile Basin

Potential impacts due to climate change are likely to be cross-cutting across all aspects of water resource management in the basin. The Nile Basin is potentially highly vulnerable to climate change with the areas of particular concern being water resources, agriculture, health, ecosystems and biodiversity, and Forestry. The longer-term impacts will include:

- Changing rainfall patterns affecting agriculture and reducing food security;
- Worsening water security and economic growth prospects;
- Shifting temperature affecting vector diseases.

A very high proportion of the basin's agriculture is rain-fed. AgriculturalProduction, comprisingadmission to food is predictable to be harshlynegotiated by climate variability and amendment. The suitable area for production of crops and sereals, the interval of cultural seasons and the rate of yielding per season and annually,principallyalongside the boundaries of semi-arid and arid regions, are predictable to decline. This would additionalbadlydistress food safety and aggravateunderfeeding.

It can be expected that many parts of the basin will face greater water stress in the future. Small reductions in rainfall could cause large declines in runoff. The problematic of water insufficiency is likely to be more critical in areas of very high population growth rates (for instance, Egypt, Uganda, Ethiopia,...) and already highrates of water resource use.

The health impacts of a quicklyaltering climate conditions are probable to be significantly undesirable. Parts of the basin are nowsusceptible to a series of climate subtledisorders like the contigeous disease in the world which calledrift valley fever, which infects mainly the livestock and transmitted to contact peoples; the other contagious disease is the cholera, which is accompanied both floods and droughts; and in addition the malaria which transmitted by insects to human beings.

Sea level rise resulting from global climate change and associated flooding to the delta areas could increase force migration of local population. Increased salinization of coastal is very likely to negatively impact water supplies for domestic and agricultural use.

Local food deliveries are in addition subjected for bad influences from changes in the climate through deficiency in the resources of fisheries particularly in the huge as result of elevation in the temperatures of water, which may be aggravated by continualsever-fishing.

To illustrate the changes that are already being experienced, extensiveinstabilities in precipitation and overflow have happenedabove the basin in modernyears. The recorded data during 20th century,revealed that the average flows during 10 years of the Blue Nile (Khartoum gauge) were ranged from 42.2 to 56.7 BCM, whereas, the average flows for the White Nile (Malakal gauge) were ranged from 25.5 to 36.9 BCM.These instabilities have been accountable for fluctuations in decade-mean, where Main Nile release of up to ± 20% which have had significantvalues for water resource utilization in Egypt and Sudan.

Study has been carried out by [7]who shown that the average yearly quantity that is released by the Blue Nile River into the Main Nile will reduce at a rate of 9.5% as a result of climatic changes, this depends on the available data concerning valuation of the effects of climataticchanges on the Blue Nile system, particularly after building of Border and Mandaya dams. Whereas, another study revealed that the expected reduction in hydropower at the main four dams along the Blue Nile River may reach 7% as a result of climatic changes, As a consequence for this reduction, the fish production may be dropped to 3% and a significant reduction (may reach -65%) in dry season low flows lengthways the lower Blue Nile River. The prospective bad impacts of climatic changes will lead to negative penalties on water accessibility for riparian societies, quality of water,biologicalprocessesand navigation. As a consequences of climatic changes, it is endorsed that processes to statement the above effects should principally involve the application of specific operating procedures at main dams lengthways the Blue Nile River, intended at comprehendingsettled trade-offs among environmental, social and economic costs and welfares, and at modifyingeffects of climatic changes.

III. Blue Nile Charactarestic

The percentage area of fishining of the Blue Nile constitutes merely 8% of the total area of Nile Basin,whereas, the Blue Nileaddsflow at Aswan Dam in Egypt about 60% of the Main Nile River. The rate of rains in the Blue Nile Basin varied according to the season and to the location, where the rains yearly fallsin Sudan averaged 400 mmm in a site close to the union with the White Nile, while it averaged 2000 mm in the Ethiopian highlands. There are a seasonal and yearly variation in the Blue Nile Basin hydrology, channel inclines and quicklycorrodingwatershedsandverysharp catchment, which accordingly lead to sever loads of sedemints. This is intensified by improper practices in the agriculture,deforestationand sever grazing. There are presently three chief hydropower systems in the Blue Nile catchment in Ethiopia viz. Fincha, Tis Abbay andBeles.

With respect to Sudan, two large dams were constructed on the Blue Nile River contributingin supplying with enough water for the purposes of hydropowerandirrigation viz. SennarsandRoseiresdams. The mainwater in the Blue Nile Nile River in Sudan are consumed in the agriculture particularly in the purposes of irrigation. On the Chief Nile River downstream of the Blue Nile meeting, more Sudanese irrigation systems are situated upstream and downstream of Merowe Dam.Merowe Dam is situatednear to the 4 waterfallclose the city of Merowe and its main uses is for production of electricity from waterpower. Whereas, in EgyptThe High Dam at Aswan was built onthe Nile River just downstream of the Sudan/Egypt boundary is constructed mainly for the purposes of regulation of water downstream discharge essential for irrigation mandate, with control of floods control and for generating of electricity from hydropower which considered the secondary profits of the High dam.

This study trace the seasonal and inter annual variability of precipitation on three stations along the Blue Nile called “Bahr dar, Combolcha, Debremarcos for IPCC A2 emission scenario.

In climate science a number of different standardized data formats are in use. The main reason for the development of these formats were:

Efficient storage: all formats are binary rather than ASCII, some formats (e.g. GRIB) allow data to be stored using fewer bytes for each number; Efficient access: all formats are direct access. This means they are regularly structured so you can easily pick out e.g. one particular time step, or one location without the need to search from the beginning.

TABLE ILocation of Stations

Stations	Latitude	Longitude
`Bahr dar	11.6	37.4
Combolcha	11.08	39.72
Debremarcos	10.35	37.72

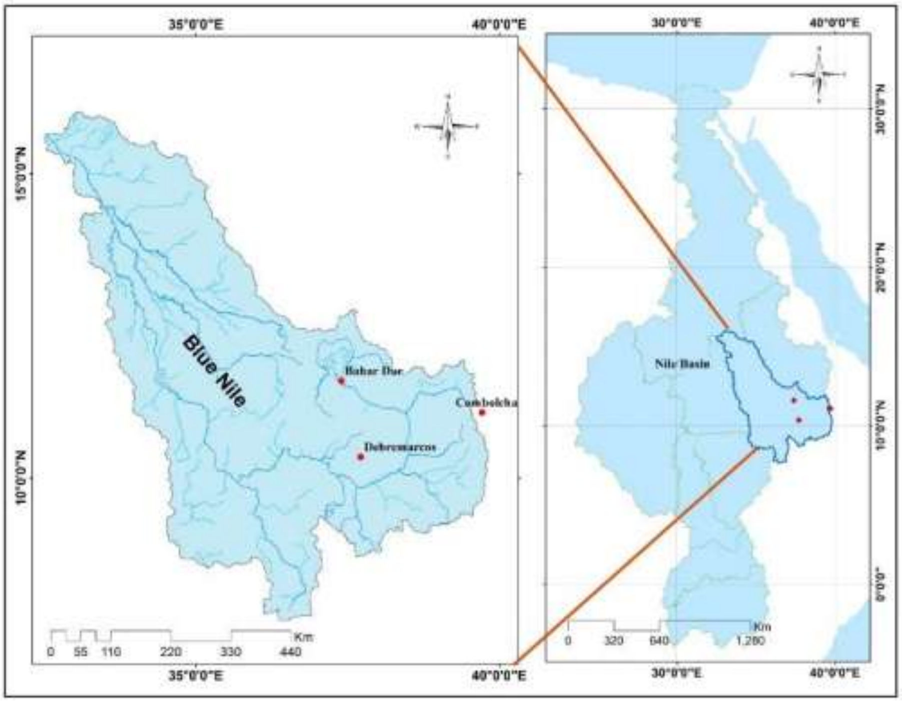


Fig. 4 Blue Nile catchment

IV. Climate Data

To make them self-descriptive: with many datasets around it makes sense that each file itself contains descriptive information on what is stored in that file, which variables, which grid (levels), which time step time period etc.

The most commonly used data formats in climate science are GRIB, NETCDF or HDF. For each of these many tools are available to manipulate such files, to view the data, or to extract the data in other formats (ascii) etc.

The IPCC AR4 (i.e. CMIP5) dataused in this study came in either GRIB (all model results) or NETCDF (the observed climate data from NAOO). The newest IPCC AR5 (CMIP5) data are much better standardized and all come in compressed NETCDF.

V.NOAA Datase

The NOAA dataset was selected for the three station of this study (Bahr dar, Combolcha, Debremarcos). The simulated data by GCMs was compared with the NOAA data set to define the climate change factor of historical data, then we can use these change factors in prediction of the climate parameters on near and far future. The resolution for this data is around 25 km *25 km.

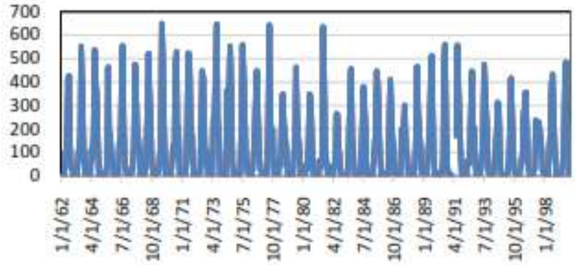


Fig. 5 Monthly precipitation (mm) at BAHAR DAR during1962: 1999

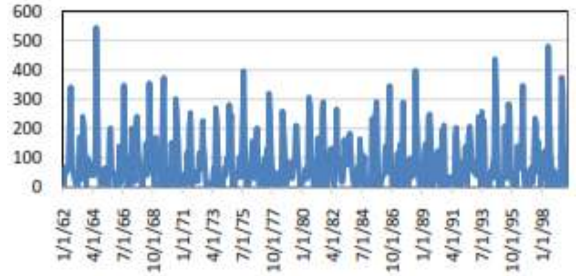


Fig. 6 Monthly precipitation (mm) at COMBOLCHA during 1962: 1999

VI. Climate Change Emission Scenarios (IPCC Scenarios Story Line)

The Intergovernmental Panel on Climate Change (IPCC) constructed a special report on emission scenarios (SRES) to explore future developments in the global environment with special reference to the production of greenhouse gases and aerosol precursor emissions. The SRES defined four scenarios describing the relationships between the forces driving greenhouse gas and aerosol emissions and their evolution during the 21st century for large world regions, labeled A1, A2, B1, and B2. Each scenario represents different demographic, social, economic, technological, and environmental developments that diverge in increasingly irreversible ways. Scenario families contain individual scenarios with common themes. The six families of scenarios discussed in the IPCC's Fourth Assessment Report (AR4) are A1FI, A1B, A1T, A2, B1, and B2. Results from Atmosphere-Ocean Circulation Models (AOGCMs) showed that the expected temperature change (Table III) at 2090-2099 relative to 1980-1999 as computed for all scenario families.

According to the computed results, it can be noticed that B1 scenario has the least estimated increase in temperature over the year 2090-2099 since it is the most ecologically friendly scenario; it is characterized by decline in population, introduction of clean technologies, and economic and social stability. While scenarios A1T, B2 and A1Bgave similar estimates of an average increase of 2.8 degree in temperature. On the other hand scenario A1FI gave the highest estimate of temperature change of 4 degrees Celsius, since the scenario is of a more integrated world with rapid economic growth with emphasis on fossil-fuels.

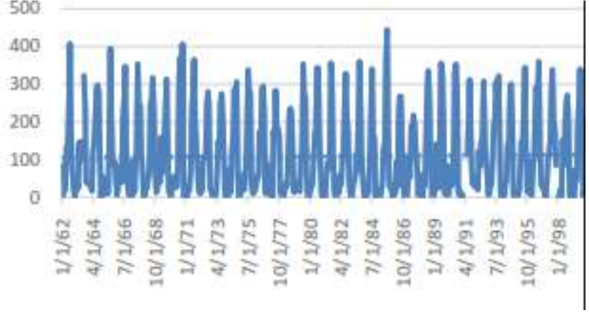


Fig.7 Monthly precipitation (mm) at Debremarcos during 1962: 1999

Table II. Temperature Changes Predictions by AOGCMS for all SRES Emission Scenario Families for the Years 2090-2099 Relative to 1980-1999 (Wigely 2008)

Case	Temp. change 0C	
	Best Estimate	Likely Range
Constant Year 2000	0.6	0.-0.9
-B1 Scenario	1.8	1.1-2.9
A1T Scenario	2.4	1.4-3.8
B2 Scenario	2.4	1.4-3.8
A1B Scneraio	2.8	1.7-4.4
A2 Scenario	3.4	2.0-5.4
A1FI Scenario	4	2.4-6.4

VII. Global Climate Models Assessment

Climate change data obtained for the stations on Blue Nile from the Climate Change Systems Analysis Group (CSAG) at the University of Cape Town. The modeling approach that was use to investigate a climate change scenario for the Blue Nile throw 3 stations (Bahr dar, Combolcha, Debremarcos) is discussed in more detail as fallowing:

Data produced by CSAGuses Global Climate Models (mathematical models of the general circulation of a planetary atmosphere) to generate the large scale climatic state, and statistical downscaling to produce finer resolution climate change information that take into account the regional/local physiographic factors.In this process historical climatic records are used to train a statistical downscaling of ten of the CMIP3 archived Global Climate Models. Table (III) illustrate Models that simulated the IPCC scenarios whenever The 10 models that have been used in this study are:

CGCM3.1 (T47), CNRM-CM3, CSIRO MK3.5, GFDL CM2.0, GFDL CM2.1, GISS ER, IPSL CM4, ECHO G, ECHAM5 / MPI OM and MRI CGCM 2.3.

As with all downscaling methods it is important to verify that the method being used is able to reproduce the observed climate at the station scale. This is usually done by driving the downscaling method using a climate re-analysis circulation dataset such as National Center for environment protection (NCEP)“http://www.ncep.noaa.gov/”.Theresultant downscaled time series can be compared to an observed time series to determine the performance of the method for a location. This downscaled time series (known as the control time series) is statistically similar to the historical time series.

Three primary data sets were utilized, comprising time series of monthly mean values for precipitation.Downscaled data for the SRES A2 greenhouse gas emissions scenarios representing a high growth and moderate growth of emissions into the future were assessed to select a scenario that would result in the driest future for the Blue Nile sub-basin.The future 2045-2065, SRES A2 scenario was selected.

VIII. Quantitative Evaluation of Uncertainties

The output from current major GCMs cannot be directly used in hydrological model due to large biases between GCMs output and ground observations without downscaling, many downscaling methods to predict more precise climate and hydrological variables from large-scale GCM output have been proposed.Uncertainties in the projected climate change mainly arise from (1) the formulation and accuracy of the GCMs itself, (2) the magnitude of anthropogenic impacts, and (3) the temporal and special impact of natural variations internal to the climate system. The GCMs uncertainty can be attributed to the structural set-up (e.g. choice of the grid resolution and climate processes) and variability in the internal parameterizations within a sub-grid scales. The anthropogenic uncertainty is a scenario uncertainly in evolution of socio-economic and human activities. As mentioned above, to account for the coarse GCMs output and scenario uncertainties, the multi GCMs and multi scenario ensemble simulations are recommended for a better assessment of climate change impacts. The third uncertainty usually arises from the differences in initial conditions used in the GCMs. When we assessing regional hydrological impact, we should consider another uncertainty arise from the choice of downscaling method. Generally, there are two types of downscaling measures: dynamical downscaling and statistical downscaling. Different downscaling method with different initial and boundary conditions will produce different results. In this study statistical downscaling was used for prediction the variation of precipitation in Blue Nile catchment at selected stations. Whatever for reducing the uncertainty for model projection, The change factors between the average monthly precipitation of observed and predicted model simulation for near future (2046:2065) have been calculated as shown in the following tables and Figs:

Table III. Models that Simulated the IPCC Scenarios

#	GCM Model	Descriptions
1	MPI ECHAM 5	ECHAM5/MPI-OM, Max Planck institute, for metrology, Germany
2	CSIRO MK 3.5	CSIRO, Atmospheric research Australia
3	CGCMA -CGCM 3.1	CGCMA CGCM 3.1(T47), Canadian Center For Climate Modelling&Analysis, Canada
4	GISS model ER	GISS, NASA/ Gadder institute for space shuttle, USA
5	CNRM CM3	CNRM, Mateo France, France
6	MIUB ECHO G	ECHO G, Metrological institute of the university of Bonn, Metrological Research institute of KMA, And Model and Data group, Germany/Korea
7	GFDL CM 2.0	GFDL CM2.0, US Dept. of Commerce/NOAAA/Geophysical Fluid Dynamics Laboratory, USA
8	GFDL CM 2.1	GFDL CM2.1, US Dept. of Commerce/NOAAA/Geophysical Fluid Dynamics Laboratory, USA
9	MRI CGCM 3.2a	MRI-CGCM2.3., Metrological Research institute, Japan
10	IPSL CM4	IPSL-CM4, Institute pierre Simon Laplace, France

Table (IV-1) Monthly change factors for 10 GCM models at baher dare

Month	CSIRO mk3.5	CCCMA CGCM 3.1	GISS model ER)	CNRM CM3	MPI ECHAM 5
Jan.	1.0617	0.1553	0.3754	0.9328	1.7090
Feb.	1.1130	0.7355	0.8193	1.2421	0.6458
March	0.8426	0.6760	0.8510	0.9849	1.2158
April	1.5249	0.7099	0.8040	0.9721	1.1256
May	1.0860	0.7643	1.1240	0.7933	1.1724
June	0.7408	0.9648	1.0407	0.9051	0.9922
July	0.9854	0.9880	1.1275	1.0154	1.0009
Aug.	1.0627	0.9571	0.9782	0.8840	0.9338
SEP.	1.1724	0.9299	0.8475	1.1085	0.9084
Oct.	0.9889	0.9644	1.0831	1.0054	1.1670
Nov.	1.5318	1.4985	1.6884	1.6607	1.3480
Dec.	0.6790	0.4497	1.9702	0.7402	0.9750
Avg.	1.0658	0.8161	1.0591	1.0204	1.0995

Table (iv-2) monthly change factors for 10 GCM models at baher dare

Month	MIUB ECHO G	GFDL CM 2.0)	GFDL CM 2.1	MRI CGCM 3.2a	IPSL CM4
Jan.	1.1761	0.9055	1.0818	0.4625	0.7162
Feb.	0.2454	1.2825	1.1562	0.6680	0.7747
March	1.2472	0.7621	0.8952	0.6565	2.5078
April	0.9619	0.8218	0.9076	0.7842	0.8885
May	0.9794	1.0980	0.9717	1.1298	0.8074
June	1.1056	1.0633	0.9215	1.0391	1.0951
July	1.0895	1.0514	1.0660	1.1347	0.8756
Aug.	1.1427	0.9918	1.0077	1.0289	1.0773
SEP.	1.4005	1.0574	1.1951	1.1459	1.0578
Oct.	1.2799	1.0788	1.0396	1.1043	1.0638
Nov.	0.9652	1.4481	1.2899	1.2034	1.0985
Dec.	0.6704	0.3756	1.3406	2.4464	1.2500
Avg.	1.0220	0.9947	1.0727	1.0670	1.1010

Table v average change factors for 10 GCM climate models ipcc- sres-a2 at bahardar

Month	Average changefactors/10 GCM models
January	0.8576
Feb.	0.8683
March	1.0639
April	0.9501
May	0.9926
June	0.9868
July	1.0335
Aug.	1.0064
SEP.	1.0823
Oct.	1.0775
Nov.	1.3732
Dec.	1.0897

Table (Vi-1) Monthly Change Factors For 10 GCM Models At Combolcha

Month	CSIRO mk3.5	CCCMA CGCM 3.1	GISS model ER)	CNRM CM3	MPI ECHAM 5
January	1.074	0.735	0.871	1.205	0.891
Feb.	0.968	1.257	0.987	0.759	1.013
March	0.928	0.735	1.015	0.796	0.866
April	1.009	0.793	0.984	1.148	1.225
May	0.868	0.981	0.942	1.409	0.994
June	1.013	0.735	0.871	0.865	0.541
July	0.958	1.145	0.996	0.812	0.856
Aug.	0.901	0.754	0.883	0.818	1.073
SEP.	0.980	0.687	1.026	0.891	1.325
Oct.	1.072	1.014	1.138	1.183	1.094
Nov.	1.202	1.253	1.194	1.689	1.390
Dec.	0.687	1.111	1.075	1.052	1.566
Avg.	0.972	0.933	0.999	1.052	1.070

Table (Vi-2) Monthly Change Factors For 10 GCM Models At Combolcha

Month	MIUB ECHO G	GFDL CM 2.0)	GFDL CM 2.1	MRI CGCM 3.2a	IPSL CM4
Jan.	0.772	1.048	0.874	0.929	0.810
Feb.	0.565	1.329	1.240	1.069	0.797
March	1.240	0.877	0.907	0.973	0.934
April	1.145	1.006	0.889	0.988	1.056
May	1.064	0.969	0.959	1.016	0.970
June	1.157	0.837	0.883	0.934	0.884
July	0.906	1.091	0.951	1.134	0.786
Aug.	1.123	0.806	0.905	1.029	0.922
SEP.	1.411	1.054	1.085	1.161	1.208
Oct.	1.107	1.082	1.131	1.022	1.091
Nov.	1.038	1.033	1.227	1.092	1.275
Dec.	0.866	1.055	0.995	0.973	1.287
Avg.	1.033	1.016	1.004	1.027	1.002

Table (vii) average change factors for 10 GCM climate models ipcc- sres-a2at combolcha

Month	Average changefactors/10 GCM models
January	0.921
Feb.	0.998
March	0.927
April	1.024
May	1.017
June	0.872
July	0.964
Aug.	0.922
SEP.	1.083
Oct.	1.093
Nov.	1.239
Dec.	1.067

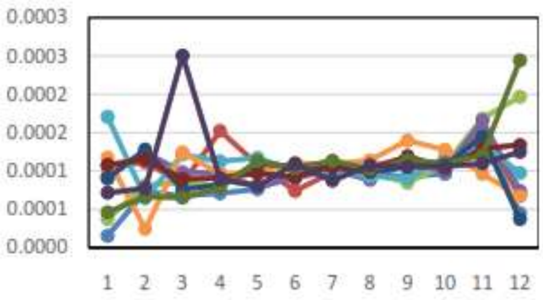


Fig. 8 Monthly Change Factors for 10 GCM models at BAHAR DAR

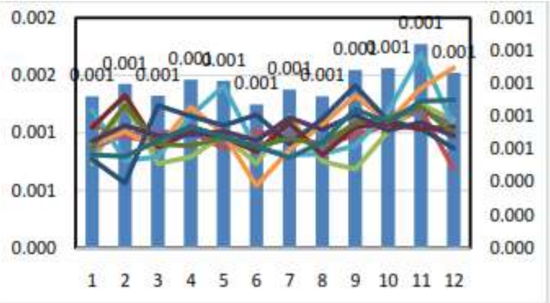


Fig.9 Monthly Change Factors for 10 GCM models at COMBOLCHA

Table (viii-1) monthly change factors for 10 GCM models at debremarcos

Month	CSIRO mk3.5	CCCMA CGCM 3.1	GISS model ER)	CNRM CM3	MPI ECHAM 5
Jan.	0.88	0.83	0.97	1.68	1.04
Feb.	1.10	1.00	1.06	0.74	1.16
March	0.93	0.94	0.97	1.15	0.91
April	0.81	0.73	1.09	1.04	1.22
May	0.88	1.04	0.90	1.24	1.03
June	0.94	1.01	0.92	1.05	0.77
July	1.02	1.11	1.10	0.99	0.93
Aug.	1.01	0.93	0.96	0.89	0.98
SEP.	1.02	0.83	1.02	0.93	1.08
Oct.	1.05	1.03	1.04	1.50	1.06
Nov.	1.32	1.20	0.91	2.25	1.26
Dec.	0.94	1.20	1.04	1.22	0.94
Avg.	0.88	0.83	0.97	1.68	1.04

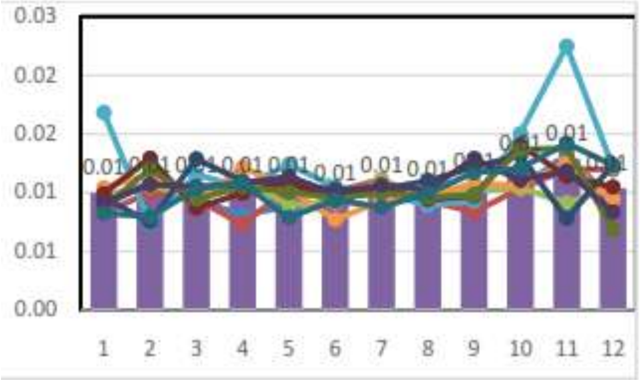


Fig. 10 Monthly Change Factors for 10 GCM models at Debremarcos

Table (VIII-2)Monthly Change Factors for 10 GCM Models AT Debremarcos

Month	MIUB ECHO G	GFDL CM 2.0)	GFDL CM 2.1	MRI CGCM 3.2a	IPSL CM4
January	0.96	0.99	0.87	0.91	0.82
Feb.	0.75	1.29	1.20	1.07	0.79
March	1.29	0.87	0.94	1.05	1.03
April	1.10	1.00	1.05	1.08	1.08
May	1.07	1.09	1.00	1.14	0.79
June	1.03	0.94	0.95	0.99	0.94
July	1.03	1.02	1.00	1.06	0.88
Aug.	1.10	0.94	0.96	1.02	0.99
SEP.	1.22	0.97	0.98	1.29	1.17
Oct.	1.32	1.40	1.37	1.11	1.21
Nov.	0.78	1.14	1.38	1.18	1.42
Dec.	1.23	1.05	0.69	0.84	1.23
Avg.	0.96	0.99	0.87	0.91	0.82

Table IXAverageChange Factors for 10 GCMs Climate Models IPCC- SRES-A2 at Debremarcos

Month	Average change factors/10 GCM models
January	1.00
Feb.	1.02
March	1.01
April	1.02
May	1.02
June	0.95
July	1.01
Aug.	0.98
SEP.	1.05
Oct.	1.21
Nov.	1.28
Dec.	1.04

IX. Result and Discussions

One of the most significant impact of climate change is likely to be on hydrological system and hence on river flow and regional water resources. The Blue Nile contributes almost 60% of the Main Nile River flow at Aswan High Dam in Egypt. Mean annual rainfall in the Blue Nile Basin varies between less than 400 mm in Sudan close to the confluence with the White Nile to more than 2000 mm in the Ethiopian highlands. The projection of the climate models for precipitation presents significant seasonal variability than inter annual. The result for the projection of the 10 models indicate that there are less agreement between model and wide range between the result has been measured as shown in Figs. (11)-(13) for Bahr dar, Combolcha, Debremarcos respectively.

At Bahar Dar, the models projections illustrate that there are big difference in precipitation on low season. The change factors vary between 0.155 for (CCCMA-CGCM 3.1) to 1.7 for (MPI-ECHAM 5). But in height season there are almost agreement between the projections ranged between (0.98) for CSIRO mk 3.5 to 1.27 for MIUB ECHO G as shown in table (V) and Fig. (VIII)

At monthly bases, the projections of the models present high agreement in wet months than dry ones in Fig. (8) and Table (IV), at Bahar dare the variation for monthly change factor was between 2.5 for IPSL CM4 at March to 0.15 for CCCMA CGCM 3.1 at January. Otherwise, for wet months the changes were between 0.79 at May for CNRM CM3 to 1.19 for GFDL CM 2.1 at Sep.

For Bahar Dare the model CNRM CM3 and GFDL CM 2.0 are considered as a rainy models and model IPSL CM4is considered as driest one as shown in Fig. (11)

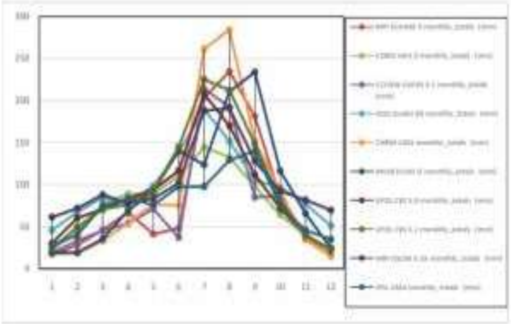


Fig.12 Variation of Monthly precipitation for 10 GCMs climate models prediction at COMBOLCHA During 2046-2065

Regarding to the Combolcha, the average monthly change factors shown moderat agreement between the models ‘ projection, its maximum was 1.239 at November and theminimum was 0.872 at June as shown in Fig. (9) and table (VI). But for monthly basis, the variation in change factors were between the variations so big which represent 0.687 at Dec. for CSIRO mk3.5 modelto 1.689 at November for CNRM CM3 model.

For Combolcha the model CNRM CM3 and MIUB ECHO are considered as a rainy models with different peaks and model IPSL CM4 is considered as driest one as shown in Fig. (12) At Debremarcos, The result for Average change factors for 10 GCMs Climate models under IPCC- SRES-A2 shown that the predicted precipitation values closed to the observed at high rainy season and decreased with 10:20% at dry seasons.

At monthly basis there are a big variability between model projection for change factor specially at January 1.6 for CNRM CM3 and 0.82 for IPSL CM4 and November 2.25 forCNRM CM3 and 0.78 for MIUB ECHO Gbut there are partially consensus between the model projection at the months of July and August.

For Debremarcos the model MRI CGCM 3.2ais considered as a rainy one and model IPSL CM4is considered as driest one as shown in Fig.13.

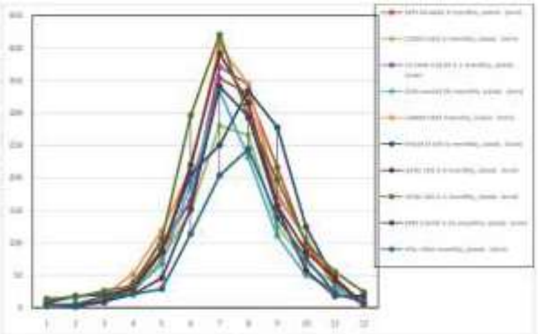
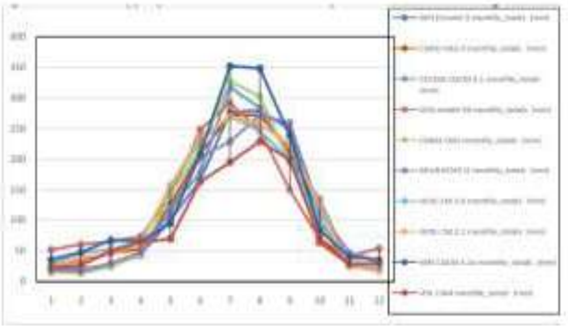


Fig.11 Variation of Monthly precipitation for 10 GCMs climate models prediction at Baher Dare During 2046-2065

12/15/2018



X. Conclusions and recommendation

In this research, the projections of the 10 climate models for precipitation at Blue Nile were presented. The seasonal variability was significant than inter annual variability. The 10 models projections illustrate that there are big difference in precipitation on low season, meanwhile in height season there are almost agreement between the projections for all locations. The result for the projections of the 10 models indicate that there are less agreement between model but ,at monthly bases, the projections of the models present high agreement in wet months than dry ones.

So, It should be noted that, the output from current major GCMs cannot be directly used in hydrological model due to large bias between GCMs output and ground observations without using downscaling.

References

[1] Mohamed, Y.A., van den Hurk, J.J.M., Savenije, H.H.G. and Bastiaanssen, W.G.M., 2005. Hydro climatology of the Nile: results from a regional climate model. Hydro. Earth Syst. Sci. Discuss., 2, 319-364.

[2] IPCC, 2007. Working Group II Fourth Assessment Report: Impacts, Adaptation and Vulnerability. Available online at www.ipcc-wg2.org

[3] Conway, D. and Hulme M., 1996. The impacts of climate variability and future climate change in the Nile Basin on water resources in Egypt. Int. J. Water Resource. Devt., 12(3), 277-296.

[4] Hulme M., Doherty, R., Ngara, T., New, M. and Lister, D., 2001. Africa Climate Change: 1900-2100. Climate Res., 17, 145-168.

[5] Strzepek, K.M., Yates, D.N. and Quosy, D.E.D.E., 1996. Vulnerability assessment of water resources in Egypt to climate change in the Nile Basin. Climate Res., 6, 89-95.

[6] Collino, T., Black, E., Grimes, D.I.F. and Slingo, J.M., 2002. Seasonal forecasting of the Ethiopian summer rains. Int. J. Climatology, 24, 1345-1358.

[7] Allen, M.R. and Ingram, W.J., 2001. Constraints on future changes in climate and hydrologic cycle. Nature, 419, 224-232.