WATER RESOURCES AND CLIMATE CHANGE IMPACTS IN ARAB REGION

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ABSTRACT

*Observed warming over several decades has been linked to changes in large scale hydrological cycle such as increasing atmospheric water vapor content; changing precipitation patterns, intensity and extremes. Over the 20th century; precipitation has mostly decreased over Arab region. The Arab region is a diversified region in terms of its climate change impacts and threats and also in terms of country classifications (least developed, middle income and high income). With this diversification in mind, the common need across all countries is the knowledge on how to adapt to the different climate change challenges. Global Circulation Models (GCM) output described in the 2007 IPCC Fourth Assessment Report (SRES scenarios) was used in this research to indicate the different scenarios of future climate in the Arab region. The resolution of these GCM models is 111km * 111 kilometers. For estimation of impact assessments at a national and regional level; Regional climate model (RCM) (PRECIS) was used where its resolution is 50 km * 50 km. PRECIS model was used with forced HADCM3 (GCM) model to predict the different climate parameters such as rainfall and temperature in the Arab Region for the period from year 2000 to year 2100. Two scenarios were used for this purpose; namely A1B and A1. The results of PRECIS indicate that the rainfall will increase slightly in most of Arab countries and will reach up to 100 mm/year in the year 2100. The results show also that there will be an increase in temperature by 3.7 C^0 in average by the end of year 2100 which will cause Sea Level Rise with an average value equals 0.59 m. This Sea Level Rise will create many vulnerable areas along the north coast on the Mediterranean Sea.*

Keywords: Climate change, Arab Region, Sea Level Rise.

1 INTRODUCTION

Over the past 30 years, climate disasters have affected 50 million people in the Arab world, costing about $12 billion directly and many multiples of that indirectly (World Bank, 2012). Recent trends suggest that dry regions are becoming drier and flash floods have become more frequent. The year 2012 was globally the warmest since records began in the late 1800s, with 19 countries setting new national temperature highs. Five of these were Arab countries, including Kuwait, which set a new record at 52.6 °c in 2010, only to be followed by 53.5 °c in 2011 (World Bank, 2012). This research aims at discovering the climate change effects on the Arab region using GCM and RCM models.

2 METHODOLOGY

To investigate the impacts of climate change on temperature, precipitation, and sea level rise in the Arab region, the following data were collected and the following steps were done.

2.1 Meteorological data

Meteorological data in 30 stations cover all Egypt and 50 stations cover Arab region were collected. The location of Arab region is shown in “Fig. 1”. These data include minimum temperature, maximum temperature and rainfall intensity on daily basis.

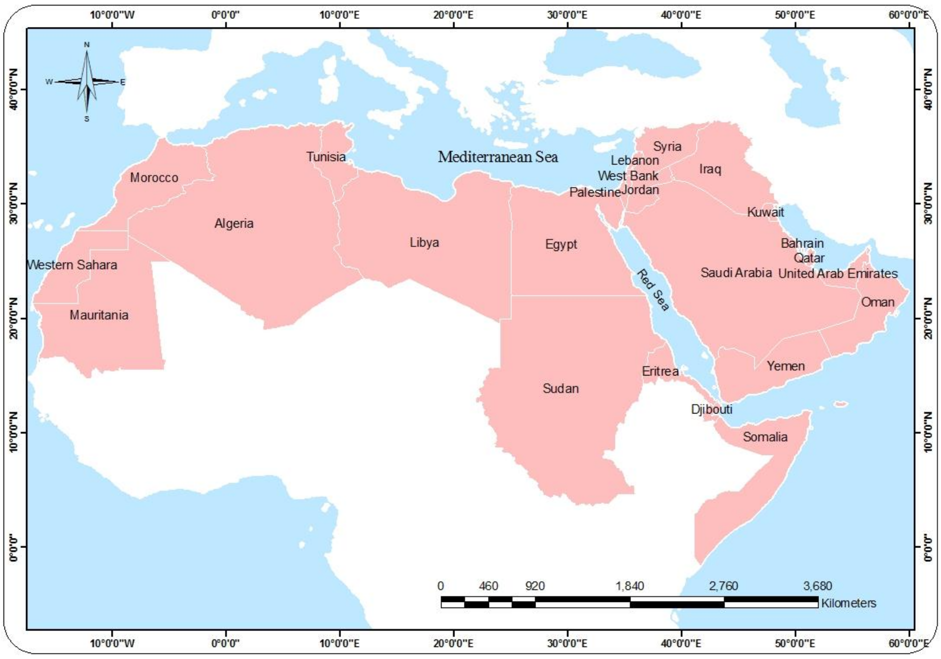

Fig.1: Location of Arab Region

2.2 Gridded data

These data cover all over the world for most of the meteorological elements such as temperature, pressure, wind, humidity, rainfall; and solar radiation. These data are monthly averages, daily averages and 4 times daily/6 hours. These data cover time periods ranging from 1948 until 2010.

2.3 GCM Data

Results of 12 GCM models for different variables of climate up to year 2100 were used. These GCM results cannot be used directly for two reasons. First, the resolution of GCMs is on the order of several hundreds of kilometers, which is too coarse for the detailed hydrological assessment required for the study. Second, GCM time series for the past climate show different patterns than observed climate records. Therefore, it was required to downscale GCM output (precipitation, minimum and maximum temperature) using a statistical downscaling approach. From the various emission scenarios, this study uses the A1B GHG emission scenario. This scenario is chosen because it is widely used. The A1B scenario is considered as the most likely scenario, because it assumes a world of rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. The A1B scenario can be seen as an intermediate between the B1 (low GHG emissions) and A2 (high GHG emissions) scenario (IPCC, 2000).

2.4 RCM Data

RCMs are high resolution models that are "nested" within GCMs. A common grid resolution is 50 km. RCMs are running with boundary conditions from GCMs. They give much higher resolution output than CCMs. Hence, much greater sensitivity to smaller scale factors such as mountains, lakes. Downscaling from GCM to RCM up to 50 Km × 50 Km were done.

3 GCM MODELS

The GCM output described in the 2007 IPCC fourth Assessment Report (SRES Scenarios), showed that there are 23 GCM Models; with 8 scenarios, produced by only 9 major developed countries. These countries are USA, Russia, Japan, China, Canada, Australia and three countries in Europe; Germany, France and England. These countries figure that they'd better developed their own technology so they don't have to trust other nations in negotiations about blame and trade-offs. There is no one GCM produced by any country among the 22 Arab countries. This means that we are compulsory forced to use the other nations results.

3.1 Prediction of total precipitation

PRECIS (RCM) model was used with forced HADCM3 (GCM) model to predict the total precipitation in mm over the Arab region as shown in Figs (2→5). By noting that these results in August and September over Egypt are in the range of 3 mm in north and 50 mm in south; while in December and January is in the range of 2 mm north and 26 mm south. But the actual measurements indicate that most of precipitation over Egypt comes in December and January. These indicate that there is a big difference between the actual measurements and model results.

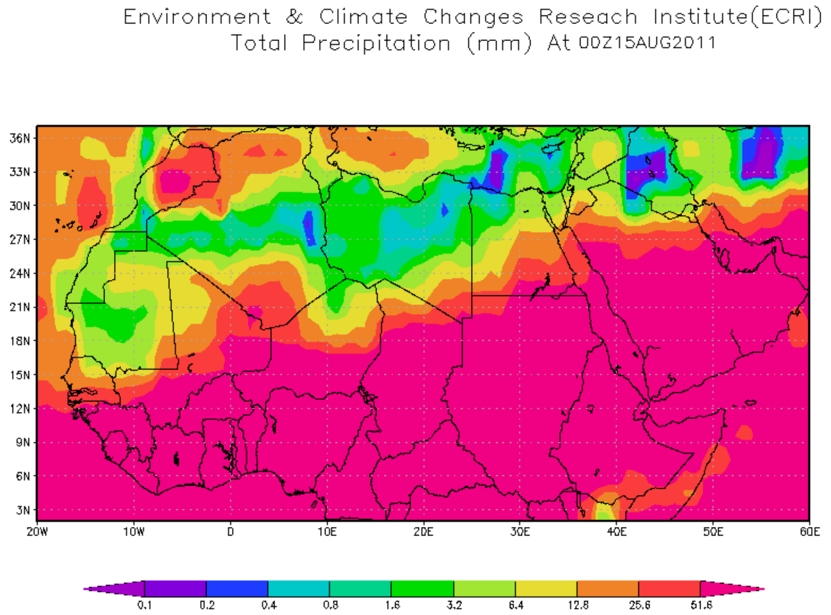

Fig. 2: Total precipitations in mm at August 2011

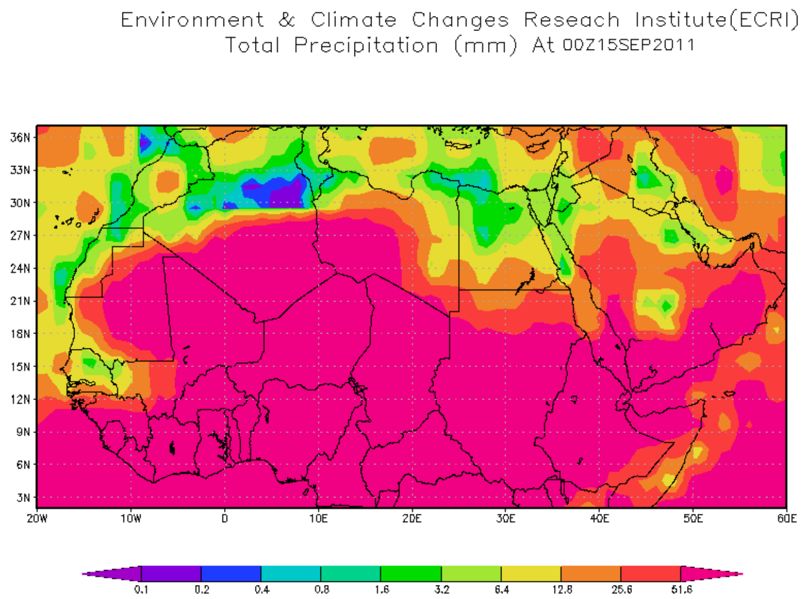

Fig. 3: Total precipitations in mm at September 2011

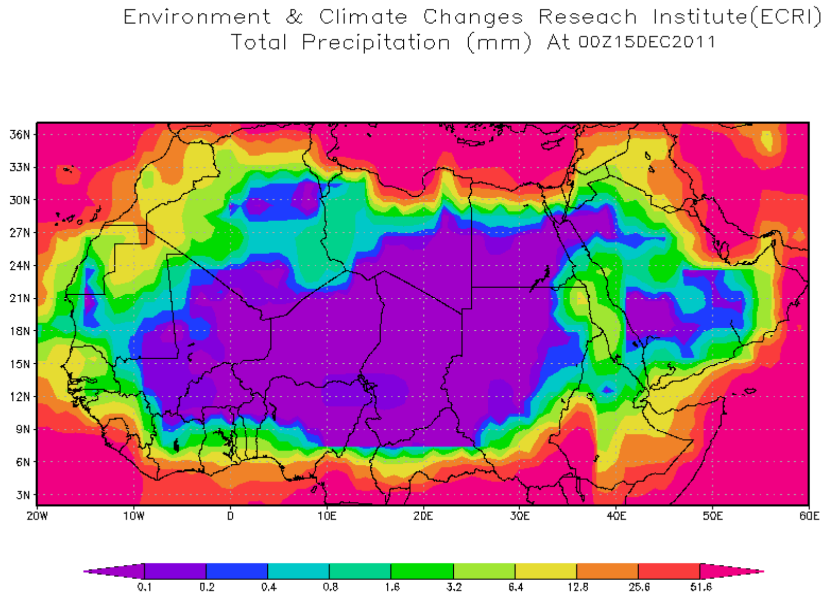

Fig. 4: Total precipitations in mm at December 2011

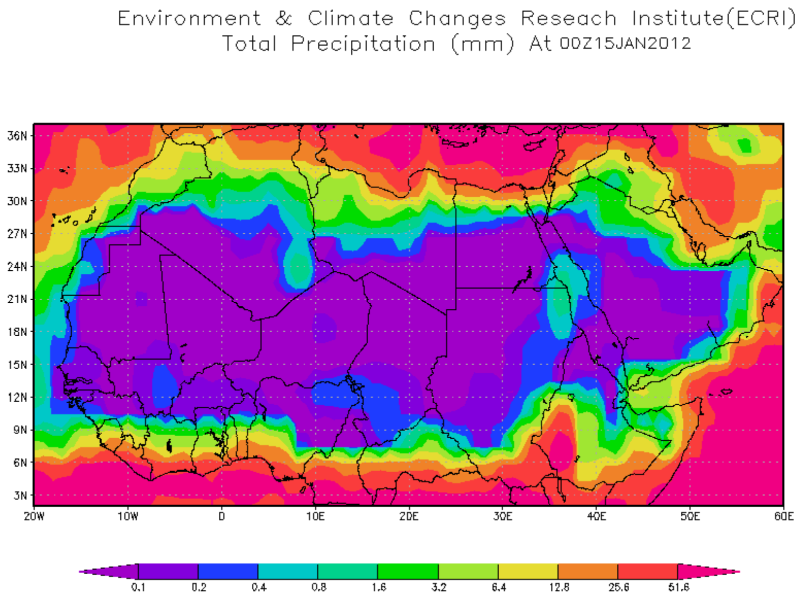

Fig. 5: Total precipitations in mm at January 2012

3.2 Prediction of change in temperature

Four GCM models were used to predict change of temperature at Delta Region of Egypt for the period (2000→ 2100). CSIRO and GFDL GCM models indicate that there will be temperature increase up to 3.2°C and 4.3 °C respectively. While GISS and NCAR indicate that there will be temperature increase with values 3.8 °C and 4.0 °C respectively. These results are shown in Figs (6→9).

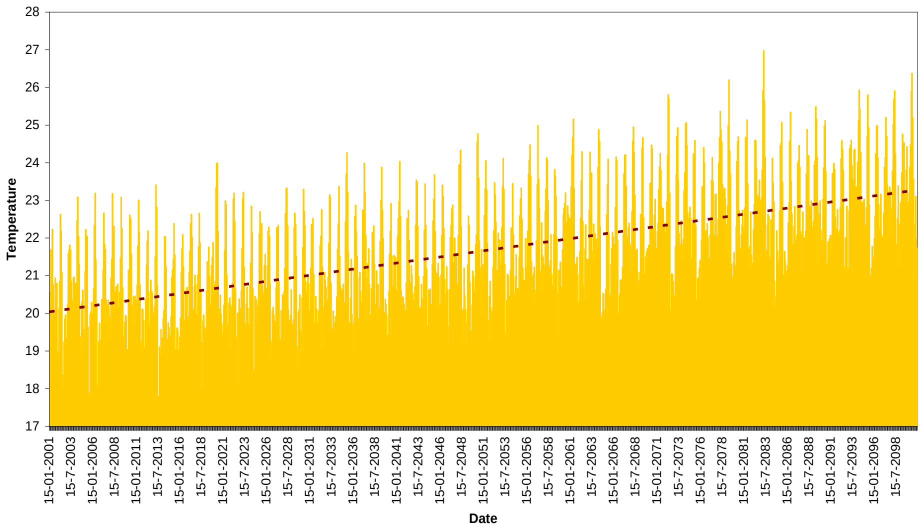

Fig. 6: Prediction of change in Temperature at Delta (2000 - 2100) using CSIRO Model

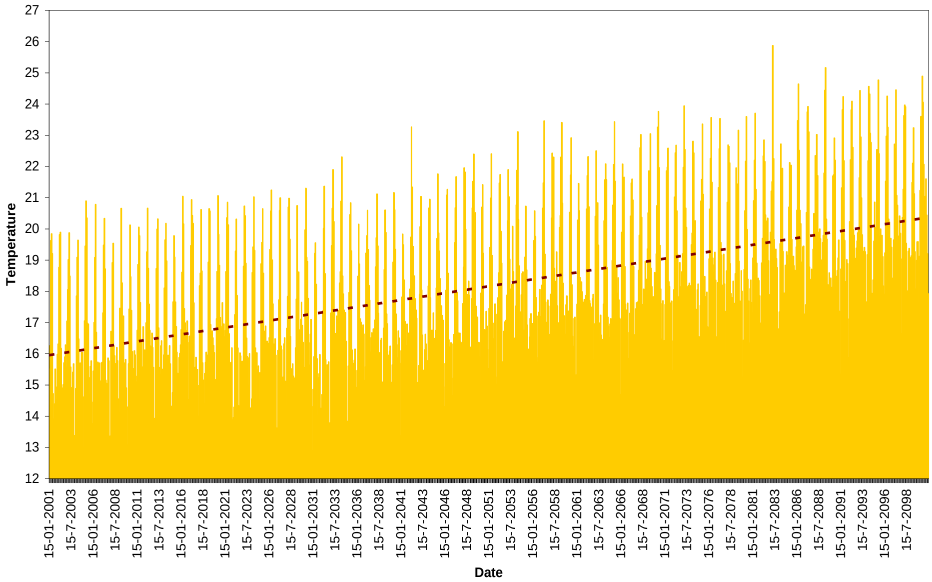

Fig. 7: Prediction of change in Temperature at Delta (2000 - 2100) using GFDL Model

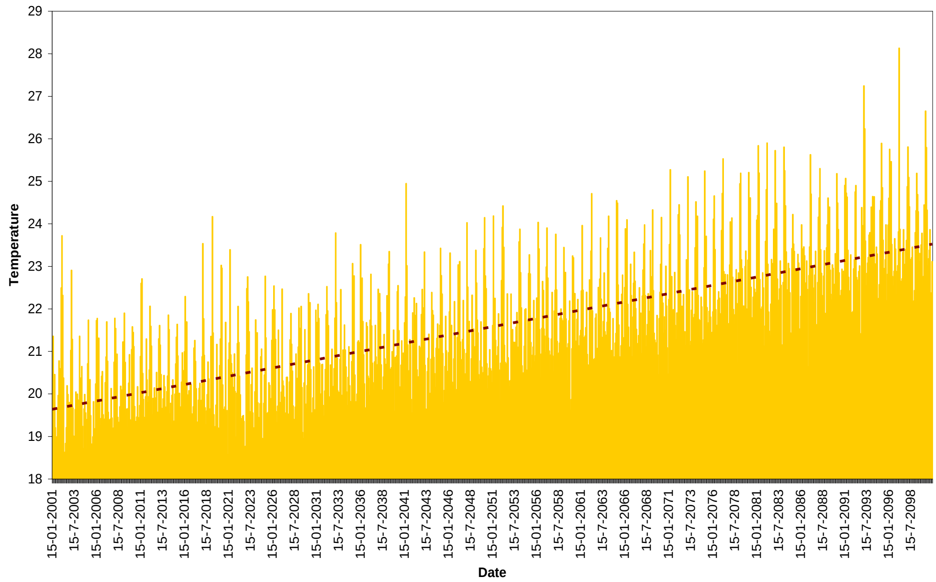

Fig. 8: Prediction of change in Temperature at Delta (2000 - 2100) using GISS Model

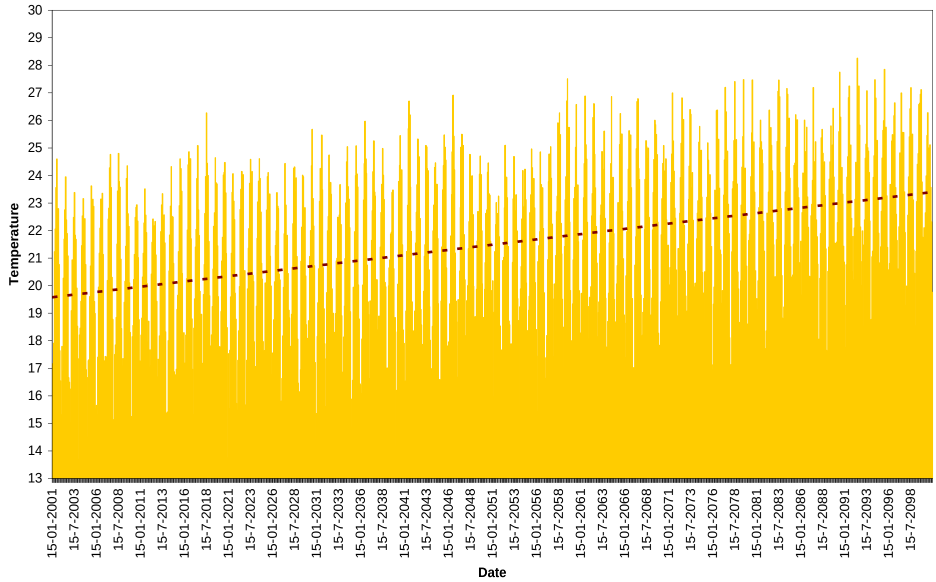

Fig. 9: Prediction of change in Temperature at Delta (2000 - 2100) using NCAR Model

3.3 Prediction of Sea Level Rise

The same four GCM models were used to predict SLR in the period (2000→ 2100). The results of CSIRO, GFDL, GISS and NCAR GCM models are increasing of SLR with values 0.26 m, 0.56 m, 0.0 m and 1.00 m respectively.

4 RESULTS AND DISCUSSIONS

The results of total precipitation indicate that there is a big difference between actual measurements and model results. It is noted that the pixel size or the resolution of GCM model is 1° × 1° which equals to 111 Km × 111 Km. This means that all Egypt is representing by only 10 points in the transverse direction and 10 points only in the longitudinal direction in the GCM model. This may explain the reason why the model results are not so accurate.

With respect to change in temperature, it is noted that all Four GCM models predict that there will be an increase in temperature with a very big values from 3.2 °C to 4.3 °C. While it is well known that the most important model results are the simulation period and calibration and verification period. These results are not shown in the 2007 IPCC Fourth Assessment report or in any GCM model results. Consequently the confidence in this prediction is not so good.

Concerning SLR; it is noted that there is a big difference in the predicted values range from 0.26 m to 1.00 m by year 2100 at North Coast in Egypt (Delta Region). It is important to realize that the Egyptian government spent about 50 million US$ to protect only one city in the North Coast which is Rosetta city based on SLR will be 0.56 m. Is it wise or is it logic to duplicate this cost to be 100 US$ based on SLR will be 1.00 m? Again this indicates that the confidence in these GCM model results is not so high. Therefore the Arab countries should have at least one special GCM developed by their scientists.

5 CONCLUSIONS

Based on the PRECIS (RCM) model with forced HADCM3 (GCM) model:-

1. The rainfall will increase slightly in most of Arab countries and will reach up to 100 mm/year in the year 2100.
2. There will be an increase in temperature by 3.7 ^{0}C in average by the end of year 2100.
3. This will cause Sea Level Rise with an average value equals 0.59m.
4. This Sea Level Rise will create many vulnerable areas along the north coast on the Mediterranean Sea.

6 RECOMMENDATIONS

1. The results of GCM models should be verified first on the national bases.
2. Do not rely too much on the results published in IPCC series in planning a strategy to deal with Climate change.
3. Depend mainly on the actual measurements of meteorological stations.
4. Increase the number of weather and meteorological stations in all Arab Countries.
5. The Arab countries have to start now developing at least one private GCM and more than one RCM models.

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