Simulation of autumn 1994 rainfall over Egypt using Regional Climate Model: (Part 1) Effect of Choice of Driving Forces

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Summary

The ICTP latest version of the National Center for Atmospheric Research (NCAR) Regional Climate Model (RegCM3) has been employed to investigate the mechanism of the Flash Flood that hit Egypt on the late night of 31 of October to the 2nd of November 1994. The model employs LAMCON map projection, with a domain of 180 X 190 gridpoints centered at 25.39° E, 35.48° N, and a horizontal grid spacing of 25km. The simulation period is the 1st of Aug.1994 to the end of November 1994. Several simulations have been carried out using different driving fields, which is the data assimilation products of NWP centers using global models known as reanalyses (e.g. ERA-40, NCEP/NCAR) known as NNRP1, NNRP2 and ERA40 in order to address the sensitivity of the model to the driving fields comparing to the observations and to study the ability of the RegCM to simulate both the spatial patterns and magnitude of the rainfall over Egypt and the whole domain. The results showed that; in terms of the daily mean, the use of NNRP2 lateral boundary field showed consistently fields greater precipitation amounts compared to others but good in spatial structure over Egypt. While, in terms of the monthly mean, the use of NNRP1 and ERA40 lateral boundary fields consistently yields greater precipitation amounts compared to the use of NNRP2 field. In addition, it provides a good simulation of precipitation spatial structure but varies between over and under estimation for the rainfall amounts and over the region in comparison with the CRU and CMAP data.

1. Introduction

Egypt is a 1,001,450 km² country, lies in the north east of Africa, However, the Sinai Peninsula which lies in the easternmost portion of Egypt is considered to be a part of Asia. Egypt is bounded by the Mediterranean Sea on the north; on the east by Palestine and the Red Sea; on the south by Sudan; and on the west by Libya.

The climate of Egypt is characterized by, a hot summer from May to September and a cool winter from November to March interspersed by two transitional seasons, spring and autumn which shows frequent fluctuations between summer and winter. In the autumn season, the eastern and northeastern part of Egypt is frequently affected by warm humid low level flow and upper cold flow from the north causing floods in that areas.

In the coastal regions, average annual temperatures vary from a maximum of 37° C to a minimum of 14° C. The most humid area is extended along the Mediterranean coast, where the average annual rainfall is about 200 mm. Rainfall decreases rapidly towards the south; Cairo receives on average only 25 mm of rain a year, and in many desert locations it may rain only once in several years.

Heavy rains causing Flash floods are the major causes of losses in infrastructure, property and life in many arid regions over the world. This is also true for the Egyptian Eastern Desert, as well as for some neighboring areas. There were, for example, over 500 casualties in November 1994 in the entire Mediterranean region (Krichak and Alpert, 1998) and 21 casualties in October 1997 in Egypt, etc (Dayan et al., 2001).

At the late night hours of the 1st of Nov. and early morning hours of the 2nd of Nov.1994 a Mesoscale Convective System (MCS) was developed over Egypt and produced widespread heavy rain resulting in flash flooding in many Egyptian Areas. For instance; in Assiut governorate; people has suffered so much; 63 people has been killed, in Dronka (small village); more than 200 houses have been destroyed by blazing water and at least 20,000 terrified towns folks crowded onto roads to the provincial capital Assiut city.

Lightening struck eight fuel tanks holding 15,000 tons of aircraft and motor fuel in the morning after the thunderstorm had raged for at least five hours.

Also, the flooding killed 5 people and more than 14 houses in Kalyoubia Governorate were destroyed by heavy rains. A few investigators have used synoptic climatology and flood hydroclimatology to study connections between synoptic-scale atmospheric circulation and local basin responses and have defined representative discharge events (Yarnal and Frakes, 1997).

Also, the weather systems that cause heavy precipitation in the Egypt and neighbored areas may vary substantially from one event to another and from one sub-region to another.

This work is a preliminary work being conducted to look for a possibility for using a regional climate model in order to study the frequency of flash floods that hit Egypt. The candidate model was the RegCM3. RegCM3 has been developed by the Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy and released in 2003.

Through the last decades, regional climate models (RCMs) have been used to study climate processes over various regions of the world such as Giorgi and Mearns, (1999), Giorgi et al. (1994), Jones et al. (1995), Kato et al., (1999); Seth and Rojas, (2003), Jenkins (2002); Sun et al.,(1999), Aldrian E, Dumenil-Gates L, Jacob D, Podzum R, Gunawan D (2004); Bhaskaran B, Jones RG, Murphy JM, Noguer M (1996); Dickinson R, Henderson-Sellers A, Kennedy P (1993),Fritsch JM, Chappell CF (1980); Giorgi F, Marinucci MR, Bates GT (1993a); Giorgi F, Marinucci MR, Bates GT, deCanio G (1993b); Giorgi F, Shields Brodeur C, Bates GT (1994); Grell GA (1993),Jenkins GS, Kamga A, Garba A, Diedhiou A, Morris V, Everette J (2002); Jones RG, Murphy JM, Noguer M (1995); Kato H, Hirakuchi H, Nishizawa K, Giorgi F (1999); Kistler R, Kalnay E, Collins W, Saha S, White G, Woollen J, Chelliah M, Ebisuzaki W, Kanamitsu M, Kousky V, vanden Dool H, Jenne R, Viorino M (2001); Loveland TR, Reed BC, Brown JF, Ohlen DO, Zhu J, Yang L, Merchant JW (2000); McGregor GR, Nieuwolt S (1998), New MG, Hulme M, Jones PD (2000), Pal JS, Small EE, Eltahir EA (2000) Pal JS, Giorgi F, Bi X, Elguindi N, Solmon F, Gao X, Ashfaq M, Francisco R, Bell J, Diffenbaugh N, Sloan L, Steiner,A, Winter J, Zakey A (2005), and Seth A, Rojas M (2003),

RegCM3 has been used in such studies over so many regions for like studies, as example, Maisa Rojas and Anji Seth (2003), R. V. Francisco et al (2005), .etc

In this work we use the third version of the Abdus Salam International Centre for Theoretical Physics (ICTP) regional model RegCM (Pal et al., 2005).

As recommended by Giorgi and Mearns (1999), the first step in the development and testing of an RCM is to use initial and lateral driving boundary conditions from analyses of observations in the so-called ''perfect boundary condition'' mode. Such experiments allow us to identify and possibly improve the deficiencies in the model physics and systematic biases in the model configuration. So, in this simulation we use analyses of observations to drive the RegCM.

Current analyses of observations can be characterized by substantial errors in the tropics, particularly in the moisture fields and over ocean areas, due to the paucity of observing data (e.g. Trenberth, 2001). This may be an important source of uncertainty in our model development effort, and therefore we test the model sensitivity to three sets of available analysis fields, two families (NNRP1 and NNRP2) from the National Center for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis (and those from the European Centre for Medium-range Weather Forecast (ECMWF) ERA40 reanalysis.

Finally, the observing data used for model validation, the model configuration and the experiment design are described in the next section.

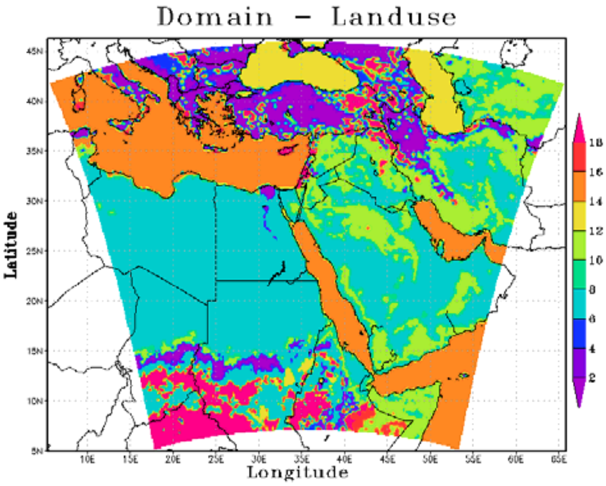

Fig. 1.a

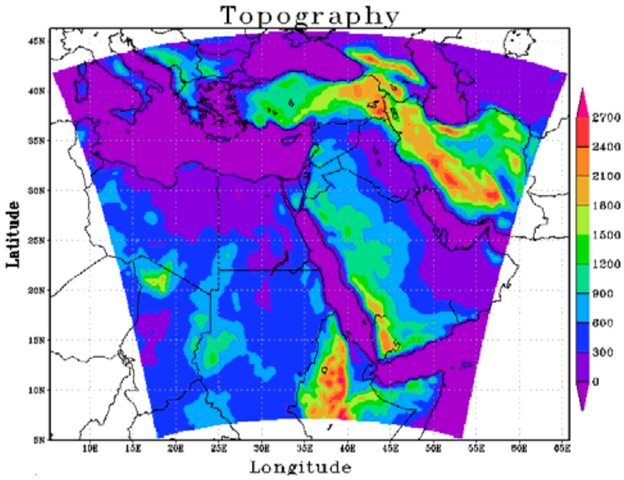

Fig. 1.b

2. Experimental design

Domain dimension: The entire domain is divided into 180 X 190 small boxes
Central Point: The central point is chosen to be Lat: 25.39^{o} N & Lon: 35.48 ^{o} E to have enough buffer zones around Egypt to guarantee reasonable representations of the coming waves from all directions
The Horizontal Resolution: The horizontal grid point spacing of 25 km
The vertical resolution**:** it utilized 18 vertical sigma levels with model top 100 mb.
Land Cover: The domain is and the USGS Global Land Cover Characterization (GLCC) dataset (Loveland et al. 2000), which are used to generate the model land surface types that are shown in fig 1.a.
Sea Surface Temperature: The Sea Surface Temperature (SST) utilized for the experiments is from NOAA optimum interpolation SST analysis and are produced weekly on one-degree grid.
The simulation period: The simulation time is only the autumn season (Sep-Nov.1994) and more focusing on the flash flood period (31st Oct. to 2nd Nov. 1994),
The Spin-up time: One month before the assimilation period (August) used as a spin-up time.
The model Topography: The model topography over the domain is shown in fig. 1.b

The Driving forces (fields):

The observational analysis used to drive initial and lateral meteorological boundary conditions are the NCEP-NCAR and the ERA40 reanalysis.

The NCEP-NCAR (NNRP1 – NNRP2) reanalysis

The NCEP-NCAR reanalysis is a retroactive record for more than 50 years of global analysis of atmospheric fields in support of the needs of the research monitoring communities (Kistler et al., 2001). It involves the recovery of land surface, ship, rawinsonde, aircraft, satellite and other data.

Although the data assimilation system was kept unchanged over the reanalysis, it is still affected by changes in the observing system, which may cause artificial jumps and trends particularly after the beginning of the assimilation of satellite data (Trenberth et al., 2001)

The ERA40 reanalysis

The ERA40 reanalysis is available from the data service of the European Center for Medium-Range Weather Forecasts (ECMWF).

It includes 6-hourly data from September 1957 to August 2002 and it is also involves a comprehensive use of satellite data, starting from the early Vertical Temperature Profile Radiometer data in 1972 and later including TOVS, SSM/I, ERS and ATOVS data.

The most serious problem diagnosed in the ERA40 reanalysis is excessive tropical ocean precipitation in the later years, particularly after 1991 (Troccoli and Kallberg, 2004).

The reanalysis is moistened over tropical oceans by the assimilation of HIRS and SSM/I data. The moistening is rejected by assimilating model in the subsequent background forecasts, leading to higher rainfall rates over tropical oceans than produced by the model, when run either in climate simulation mode or in the pre-satellite data assimilation mode.

Fig. 2.a

The Convective Scheme

The convective scheme that is used here is the Grell with Fritsch Chappell closer technique

Grell Scheme

The Grell scheme is one-dimensional mass flux scheme that consists of a single updraft-downdraft couplet. It is highly simplified version of the Arakawa and Schubert (1974) cloud ensemble parameterization implemented as a single cloud member. There is no direct mixing between the updraft and the downdraft and with the surrounding atmosphere, except at the top and bottom of the cloud. Thus, the convective mass flux is constant with height. Because all the condensed water vapor in the convective cloud is removed as potential rainwater. The convective mass flux is determined by the flux required to stabilize an unstable air column. The Grell scheme is activated using a trigger mechanism, i.e., it is not activated until a lifting-depth criterion is met, that indicates there is sufficient lift to access potential buoyant energy. Convective precipitation is calculated as a function of the convective mass flux, the amount of cloud condensate that has been removed as rainwater but not evaporated into the downdraft, and a precipitation efficiency parameter, David J. Gochis et al.,(2001).

3. The observations used for model validation

To validate the model results, three different data sets have been used

a. The point observations

The available observation data for many Egyptian observing stations can be seen in Fig. 2a. The numbers of stations are rather sparse and irregularly distributed and could not provide enough information with the entire domain in terms of the rainfall amount but it will be used as an indication for the spatial distribution.

b. Climate Research Unit (CRU) Data

The second observation data source is another station-based dataset developed by the Climate Research Unit (CRU) of the University of East Anglia (New et al., 2000). This consists of grided monthly precipitation data on a 0.5 degree regular latitude-longitude land-only grid.

Although the CRU dataset encompasses all land areas, for station-sparse regions a horizontal interpolation is performed from neighboring available stations (New et al., 2000). This implies that the CRU data over station-void mountainous regions are not very reliable.

c. CMAP Data

The third observation data source is Climate Prediction Center Merged Analysis of Precipitation (CMAP), which is an analysis of global monthly precipitation on 2.5°x2.5° grid derived from gauges observations, satellite estimates and numerical model predictions.

Although of coarse resolution, this dataset offers the advantage of providing data also over ocean areas, hence it is very important tool for model validation

4. Computer resources used in this study

A 32 bit IBM compatible pc has been utilized with CPU of 3.2 GHZ and open storage capacity, 2 G.B RAM and with PGI FORTRAN compiler, Linux Operation System (Mandriva2008) and GrADS for displaying the model output.

5. Results and analysis

1- on the daily base; RegCM output using the NNRP1, NNRP2, ERA40 as driving forces and the point observations for the first six days of Nov. 1994 over Egypt as in Figures 3-26 and

2- On the monthly averages base; the model has been verified against the CRU and CMAP observations over the whole domain as in figures. 26-47

In terms of daily average base we have:

On the first day (1 November):

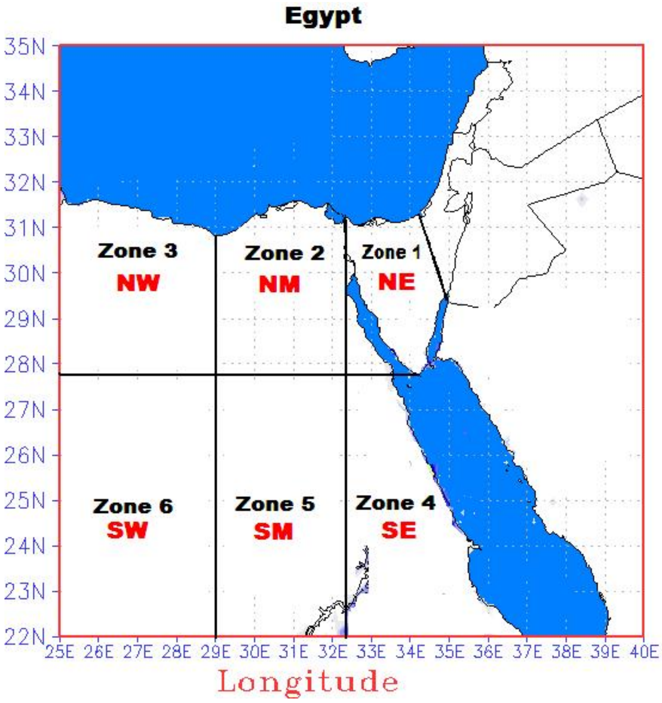

Fig. 2.b*: The rainfall zones*

Using NNRP1: The model simulation, for rainfall distribution and amounts is illustrated in (fig 4). It can be shown that the maximum rainfall gradually increase to the south of the eastern desert and parallel to the western coast of the Red sea, the rainfall amounts reaches more than 60mm in the southern part of Egypt especially between latitudes 22-26 north and longitudes 32 -36 east, some other patches, but with less amounts are distributed along the southern of Sinai especially at Sharm El-Shaikh and Dahab areas. While, there is a rain traces 1-5 mm at isolated portions in the northern coast of Egypt.

Using NNRP2: To some extent, the same texture of the simulated rainfall distribution is similar to that in (fig. 5), but with lesser amounts. While no rainfall portions have been found in the southern of Sinai. Also, the northern coast shows very lack of the rainfall amounts and also the distribution.

Using ERA40: Recognizable decrease in the rainfall amounts can be shown in (fig. 6). Also, there is a lack in spatial distributions against that of NNRP1 and NNRP2.Comparing to the observed rainfall (fig. 3 and Table 1) for the 6 zones; zone 1(Noreast), zone 2(Normed), zone 3(Norwest), zone 4(southeast), zone 5(southmed) and zone 6(southwest), we can see that the rainfall amounts reaches 60mm at Assuit stations as a maximum amount, and large areas of north coast of Egypt is fully covered by the rainfall ranging from 0.4 mm in Malwy up to 24.6mm at Cairo and 24mm at Assuit. So, in terms of areal amounts we can say that the model is able to catch the rainfall amounts with NNRP2 but in terms of rainfall distribution the model shows large difference except NNRP2 case which shows reasonable distribution especially in the south eastern part.

Table (1) Rainfall observations on the 1st of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
MERSA_MATRUH	62306	31.33° **N**	27.22 ° **E**	9.2 **mm**
DABAA	62309	30.93	28.47	3.2
ALEXANDRIA_NOUZHA	62318	30.82	29.87	4.5
ROSETTA	62324	31.4	30.4	1.6
DAMANHOUR	62339	31.03	30.47	0.3
TAHRIR	62345	30.65	30.7	0.4
ZAGAZIG	62354	30.58	31.5	4.7
WADI_EL_NATROON	62357	30.4	30.2	16.6
CAIRO_AirPort	62366	30.13	31.4	30
BAHTIM	62369	30.13	31.25	15.6
CAIRO_HQ	62371	30.08	31.28	24.6
GIZA	62375	30.05	31.22	14.2
HELWAN	62378	29.87	31.33	8
FAYOUM	62381	29.3	30.85	6.2
MINYA	62387	28.08	30.73	1
MALWY	62389	30.75	27.7	0.4
ASYUT	62392	27.2	31.17	60
ASYUT	62393	27.05	31.02	24
SOHAG_AGHMEEM	62397	26.6	31.78	3.8
QENA	62402	26.18	32.73	1.2
LUXOR	62405	25.67	32.7	1
BAHARIA	62420	28.33	28.9	5

On the Second day (2 November)

Using NNRP1: Where the raining system has moved to the east (fig. 8) .and the rainfall mounts reached 120mm in the northern part (Delta) and maximums of 40mm are distributed all over the East of Egypt; especially the south east and the north east. Other portions are noticed on the northern coast.

Using NNRP2: As shown in the Fig 9; the rainfall amounts reached 30mm in some areas distributed in the north east Delta and Sinai and more eastern areas. But some portions, especially the south eastern and north western parts have disappeared.

Using ERA40: The system has moved to the east of (fig. 10) Jordan and small traces has recorded in the north eastern desert.

Table (2) Rainfall observations on the 2nd of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
SIDI_BARRANI	62301	31.6	26	11.6
SALLUM	62305	31.57	25.13	2
MERSA_MATRUH	62306	31.33	27.22	5.7
ALEXANDRIA_NOUZHA	62318	30.82	29.87	0.1
ROSETTA	62324	31.4	30.4	1.2
BALTIM	62325	31.55	31.1	0.7
PORT_DAMIETTA	62329	31.47	31.77	2.6
DAMIETTA	62330	31.42	31.82	2.9
RAFH	62335	31.2	34.2	7.4
ELARISH	62336	31.08	33.82	24.4
ELARISH2	62337	31.08	33.82	16.6
DAMANHOUR	62339	31.03	30.47	0.4
TAHRIR	62345	30.65	30.7	0.2
ZAGAZIG	62354	30.58	31.5	1.8
SHEBIN_EL_KOM	62360	30.6	31.02	1.6
CAIRO_AirPort	62366	30.13	31.4	9.2
BAHTIM	62369	30.13	31.25	0.3
CAIRO_HQ	62371	30.08	31.28	1
HELWAN	62378	29.87	31.33	0.6
FAYOUM	62381	29.3	30.85	11.4
ASYUT	62392	27.2	31.17	8.7
ASYUT	62393	27.05	31.02	13
SOHAG_AGHMEEM	62397	26.6	31.78	14
QENA	62402	26.18 3	32.7	0.6
LUXOR	62405	25.67	32.7	0.5
ISMAILIA	62440	30.6	32.25	2.8
EL-SUEZ	62450	29.93	32.55	5.9
RAS_SEDR	62455	29.58	32.72	3.6
TABA_AIRPORT	62456	29.6	34.78	35.3
ELTOR	62459	28.23	32.62	18.6
SHARM_ELSHEIKH	62460	27.97	34.38	2.6
HURGUADA	62463	27.15	33.72	2.7
HURGUADA	62464	27.28	33.73	3.2
KOSSEIR	62465	26.13	34.15	4.5

Comparing to the observation (fig. 7 and table 2) where maximum rainfall amount (35mm) is observed over Taba airport (Zone 1) while there are several peaks of the observed rainfall has recorded over the same zone as in El-Arish (24mm), El-Tor(18.6) and in the zone 5 as in Assuit (13mm) and sohag (14mm), over zone 3, there some observations especially in Sidi Barrani (11.6mm) which represents the Zone 3 . So, for all the driving forces. Here it is clear that the rainfall simulation using NNRP2 is the most consistent one in terms of distribution but over estimation in the rainfall amounts.

On the third day (3 November)

Using NNRP1: It is clear that most areas of Egypt are free of simulated rainfall except the northern part of Delta (zone 2) where the simulated amount reached 20-25mm while in southeastern (zone 4); the maximum simulated rainfall reached 12-13 mm (fig. 12)

Using NNRP2: As shown in fig 13, few amounts of simulated rainfall with maximum (11-13mm) over the northeast portion of the Sinai (Zone 1) as well as fractions (2-3mm) over the southeastern coast area of the Red See (zone 4)

Using ERA40: As shown in fig 13, few amounts of simulated rainfall with maximum (2-3mm) over Sinai (Zone 1, fractions (2-3mm) over the southwestern area of the Red See (zone 6), and some spots over the southeastern area (zone 4) **h**ave happened.

Comparing to the observation (fig. 11 and table 3) where maximum rainfall amount (11mm) is observed over Sallum (Zone 3) and Rafah (5mm), zone 1.

Here, it is clear that the rainfall simulation using NNRP2 is the most consistent one in terms of distribution but underestimated the rainfall amounts. Over Sallum where is no rainfall has been simulated.

Table (3) Rainfall observations on the 3rd of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
SIDI_BARRANI	62301	31.6	26	1
SALLUM	62305	31.57	25.13	11.2
MERSA_MATRUH	62306	31.33	27.22	1.3
ROSETTA	62324	31.4	30.4	3.5
BALTIM	62325	31.55	31.1	6.4
RAFH	62335	31.2	34.2	5
ELARISH	62336	31.08	33.82	2.3
ELARISH2	62337	31.08	33.82	2.8
TAHRIR	62345	30.65	30.7	0.3
SHEBIN_EL_KOM	62360	30.6	31.02	3.3
BAHTIM	62369	30.13	31.25	0
FAYOUM	62381	29.3	30.85	1.8
ISMAILIA	62440	30.6	32.25	0.2
RAS_SEDR	62455	29.58	32.72	0.2
TABA_AIRPORT	62456	29.6	34.78	0.1

On the Forth day (4 November)

Using NNRP1: As shown in fig 16, few amounts of simulated rainfall with maximum (11-13mm) over the northeast portion Delta while no significant rainfall being simulated over the rest of the country.

Using NNRP2: As shown in fig 17, very few amounts of simulated rainfall with maximum (2-3mm) over the northeast portion Delta while, also, no significant rainfall being simulated over the rest of the country.

Using ERA40: As shown in fig 18, also, only part of the southwestern part of the country has maximum of ~12mm while the rest of the country is free

Comparing with the observation

(fig. 15 and table 4) where maximum rainfall amount (21.8mm) is observed over port

Alexandrian (Zone 2), and Sallum (9mm),zone 3, and most of the coast areas

Here it is clear that there is no reasonable rainfall simulation exist except the northern part of Delta which being simulated by either NNRP1 and NNRP2

Table (4) Rainfall observations on the 4th of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
SIDI_BARRANI	62301	31.6	26	14
SALLUM	62305	31.57	25.13	9.4
MERSA_MATRUH	62306	31.33	27.22	1.1
DABAA	62309	30.93	28.47	6.1
PORT_ALEXANDRIA	62315	30.82	29.87	21.9
ALEXANDRIA_NOUZHA	62318	30.82	29.87	7.1
ROSETTA	62324	31.4	30.4	5.8
DAMIETTA	62330	31.42	31.82	0.1
RAFH	62335	31.2	34.2	3.2
ELARISH	62336	31.08	33.82	4.4
ELARISH2	62337	31.08	33.82	4.2
DAMANHOUR	62339	31.03	30.47	0.8
TAHRIR	62345	30.65	30.7	0.8
SHEBIN_EL_KOM	62360	30.6	31.02	0.2

On the Fifth day (5 November)

With NNRP1 (fig 20), and NNRP2 (fig 21) the rainfall over Alexandria being simulated with 3-4 mm while the amount is being simulated while traces of 2-3 mm being simulated using ERA40 (fig (22) with maximum 12-13mm over Alqattarah Aria

Comparing to the observation

(fig. 19 and table 5) where maximum rainfall amount (25mm) is observed over Dabaa (Zone 3), Alexandria (6mm) , Ismailia (10mm),Zone 2 while in Rafah is 21.8mm (Zone 1). Here it is clear that only the rainfall over Alexandria being spatially simulated but the amount is still underestimated.

Table (5) Rainfall observations on the 5th of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
SIDI_BARRANI	62301	31.6	26	7.4
DABAA	62309	30.93	28.47	25.3
ALEXANDRIA_NOUZHA	62318	30.82	29.87	6.1
ROSETTA	62324	31.4	30.4	1.6
PORT_SAID	62332	31.28	32	1.6
RAFH	62335	31.2	34.2	21.8
ELARISH	62336	31.08	33.82	5.3
ELARISH2	62337	31.08	33.82	6.4
DAMANHOUR	62339	31.03	30.47	7.7
ZAGAZIG	62354	30.58	31.5	1.4
SHEBIN_EL_KOM	62360	30.6	31.02	0.2
BAHTIM	62369	30.13	31.25	2.1
CAIRO_HQ	62371	30.08	31.28	0.8

GIZA	62375	30.05	31.22	0.1
ISMAILIA	62440	30.6	32.25	10.2

On the sixth day (6 November)

With NNRP1 (fig 24) traces of simulated rainfall (1-3mm) are found over the eastern coast while an detention existing to the land in Sinai (Zones 1, 2) while by using NNRP2 (fig 25) and ERA40 (fig 26), the model rainfall distribution diminish only to the north cost of Sinai (zone 1).

Comparing to the observation

(fig. 23 and table 6) showing that the model cached the rainfall distribution especially in the noreastern coast with using NNRP1 as a driving force.

Table (6) Rainfall observations on the 6th of Nov. 1994

Station Name	Station ID	Latitude	Longitude	Rainfall Amount
DAMIETTA	62330	31.42	31.82	0.4
RAFH	62335	31.2	34.2	1.1
ELARISH	62336	31.08	33.82	0.9
ELARISH2	62337	31.08	33.82	1
ISMAILIA	62440	30.6	32.25	0.7
SHARM_ELSHEIKH	62460	27.97	34.38	0.8

In terms of monthly mean on the full domain we have:

For September: By Comparing the model rainfall simulations using NNRP1 (fig 28), NNRP2 (fig. 29), ERA40 (fig 30) and the CRU field (fig 27) we see the following:

1. No CRU data are shown in Egypt.
2. The Model Rainfall Simulation captured the rainfall distribution on the southern part of the domain
3. The rainfall amounts is overestimated in case of using NNRPP1 and ERA40 and underestimated in the case of using NNRP2.
4. **Tr**aces of Rainfall over Europe are simulated using NNRP1 while it was over estimated.
5. comparing the model simulations with the CMAP field (fig 39) , the model cached the rainfall distribution and to some extent the amounts in case of using NNRP1 and ERA40 in the southern part of the domain while the model couldn't catch the northern part of the domain quite clearly.

For October: By Comparing the model rainfall simulations using NNRP1 (fig 32), NNRP2 (fig. 33), ERA40 (fig 34) and the CRU field (fig 31) we see the following:

1. No CRU data are shown in Egypt.
2. Few amounts of rains is shown in the north coast of Tunisia and Libya
3. Spreading rainfall over south of Europe.
4. Few amounts of rains are shown in the south of the domain (south of Sudan ...)

5. The Model Rainfall Simulation cached the rainfall distribution on the southern part of the domain in the case of using NNRP1 and ERA40
6. The rainfall amounts is overestimated in case of using NNRPP1 and ERA40 and underestimated in the case of using NNRP2.
7. The model failed to simulate the rainfall of the rest of the domain.
8. comparing the model simulations with the CMAP field (fig 40) , the model cached the rainfall distribution in the southern part of the domain while they didn't catch it in Europe.

For November: By Comparing the model rainfall simulations using NNRP1 (fig 36), NNRP2 (fig. 37), ERA40 (fig 38) and the CRU field (fig 35) we see the following:
1. Very few rains data are shown in the northern coast of Egypt.
2. Few amounts of rains is shown in the Ethiopia
3. Spreading rainfall over south of Europe and west of Asia, Iraq, Syria ..etc.
4. Few amount of rains is shown in the south of the domain south of Sudan ..etc
5. The Model Rainfall Simulation cached the rainfall distribution on the southern part of the domain in the case of using NNRP1 and ERA40
6. The rainfall amounts is comparable in case of using NNRPP1, underestimated in the case of using ERA40 and failed to catch neither the amounts nor the distribution of the rainfall in case of using NNRP2

By Comparing the model rainfall simulations using NNRP1 (fig 36), NNRP2 (fig. 37), ERA40 (fig 38) and the CMAP field (fig 35) we see the following:
1. No CMAP data are recoded in Egypt.
2. Some rainfall over either Europe
3. Larger distribution and amount of rainfall are shown in the southern of he domain
4. The Model Rainfall Simulation cached the rainfall distribution on the southern part of the domain in the case of using NNRP1 and ERA40
6. The rainfall amounts is underestimated in the case of using both NNRP1 and ERA40

(a) Daily mean

Observations | **NNRP1** | **NNRP2** | **ERA40**

1 Nov. 1994

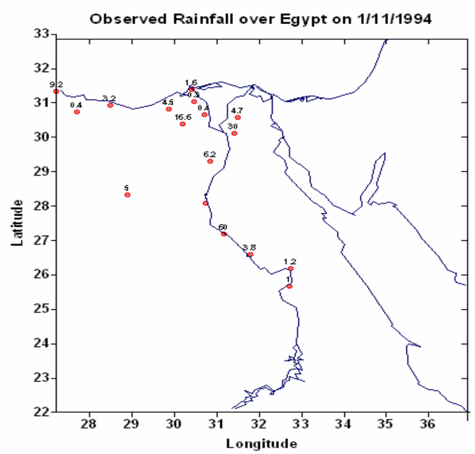

Fig. (3)

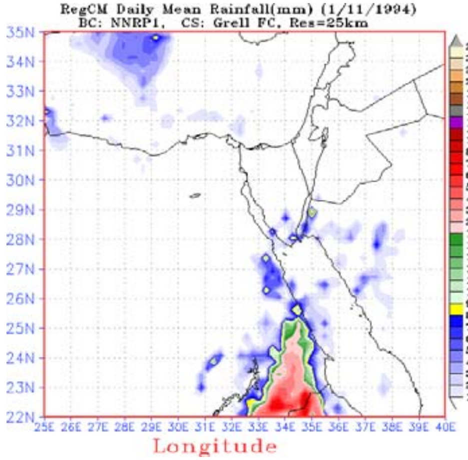

Fig. (4)

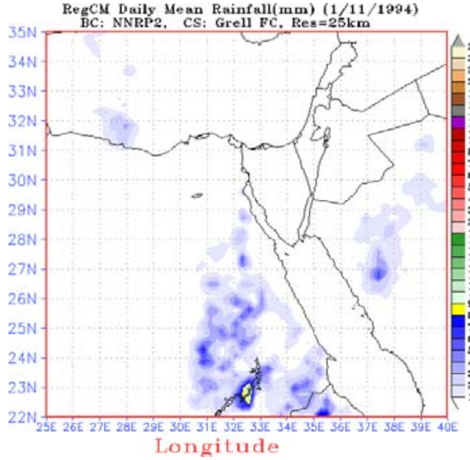

Fig. (5)

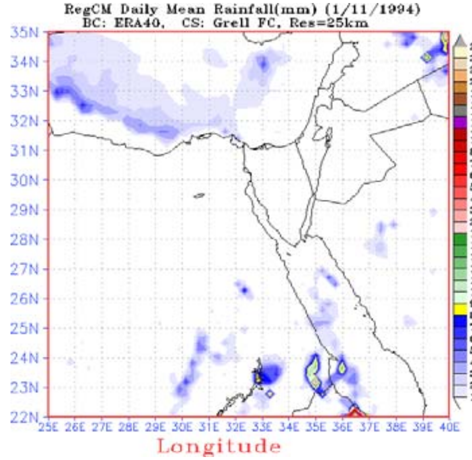

Fig. (6)

2 Nov. 1994

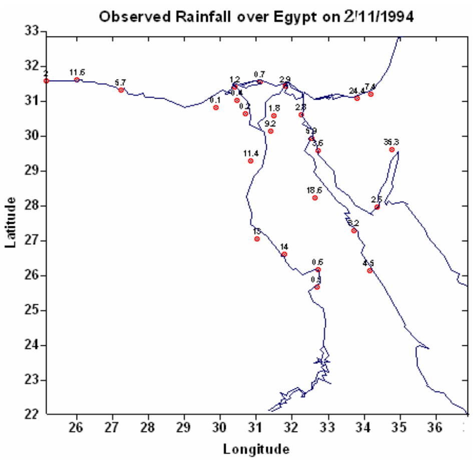

Fig. (7)

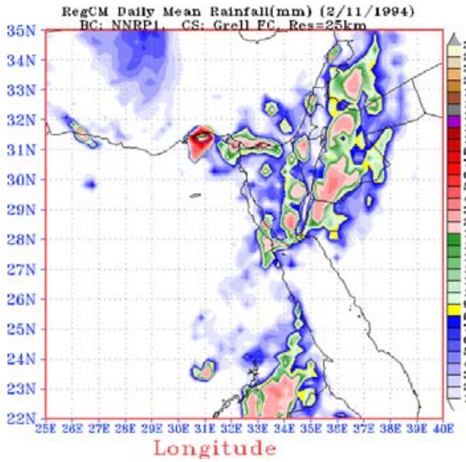

Fig. (8)

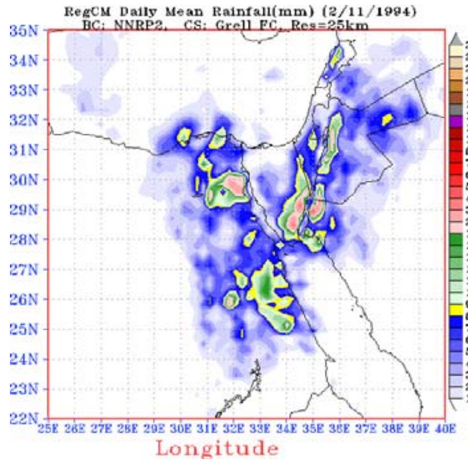

Fig. (9)

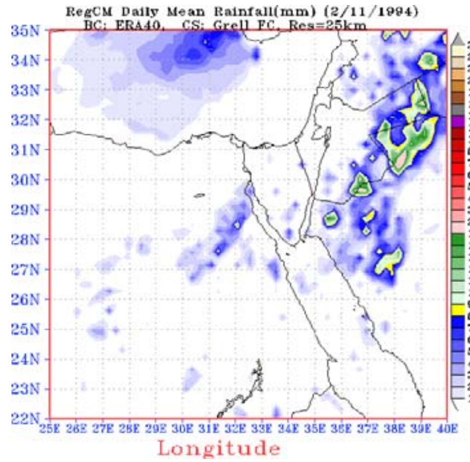

Fig. (10)

Observations	NNRP1	NNRP2	ERA40

3 Nov. 1994

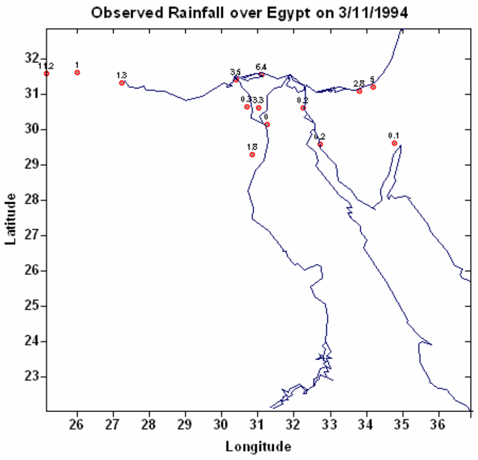

Fig. (11)

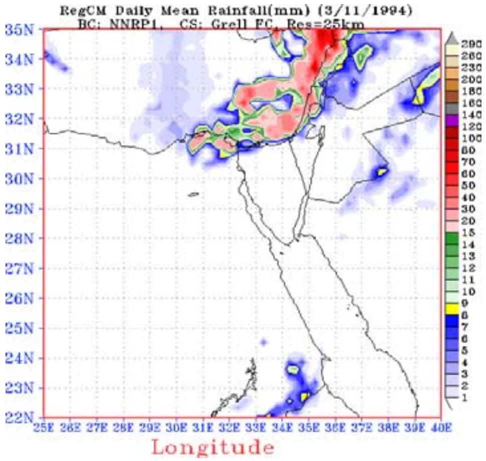

Fig. (12)

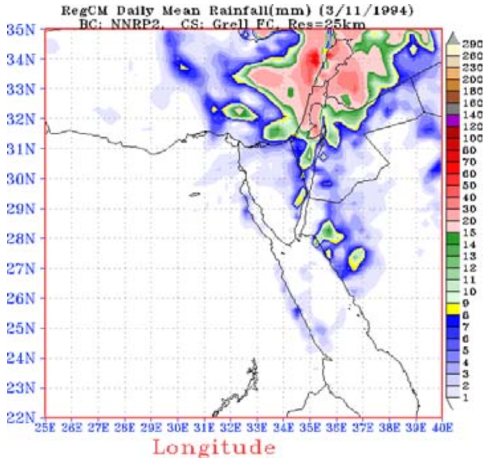

Fig. (13)

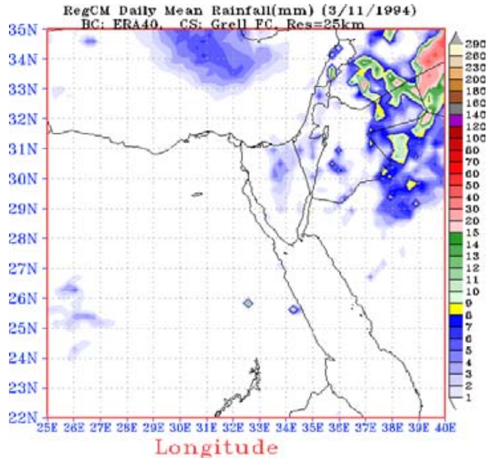

Fig. (14)

4 Nov. 1994

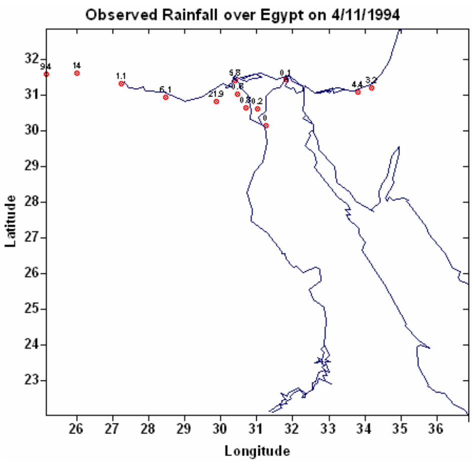

Fig. (15)

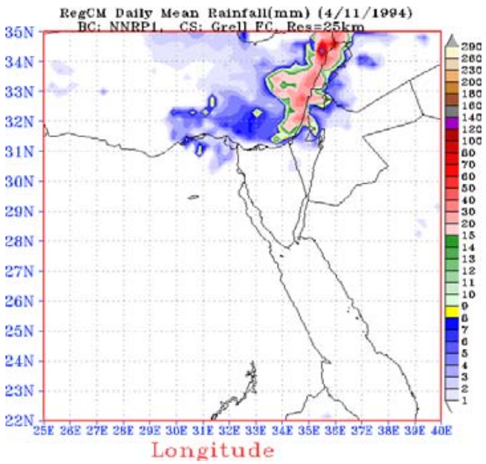

Fig. (16)

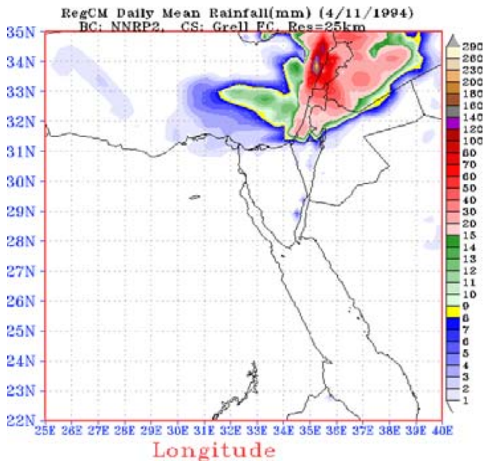

Fig. (17)

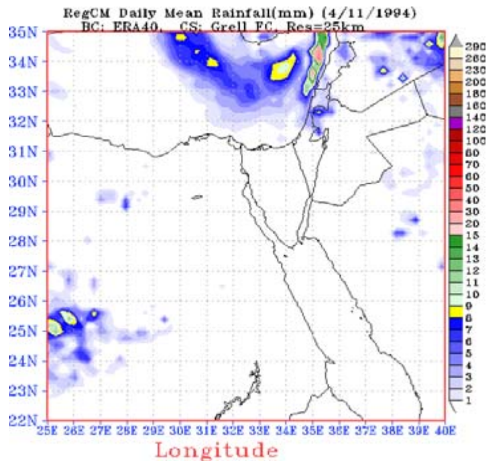

Fig. (18)

Observations **NNRP1** **NNRP2** **ERA40**

5 Nov. 1994

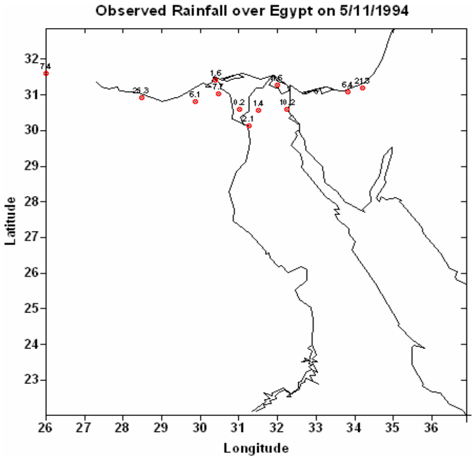

Fig. (19)

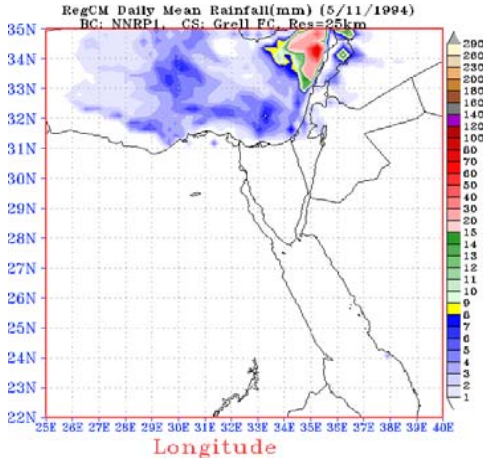

Fig. (20)

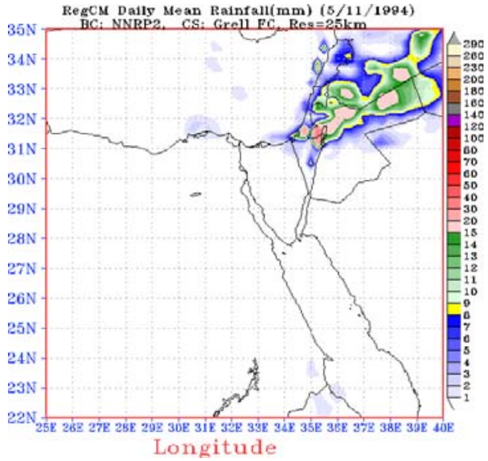

Fig. (21)

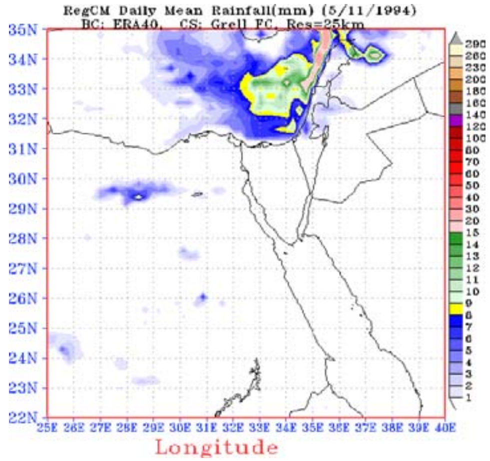

Fig. (22)

6 Nov. 1994

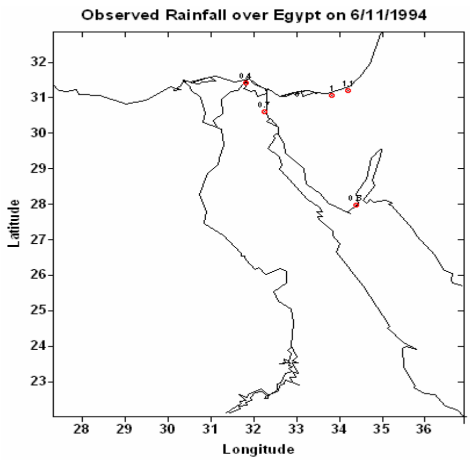

Fig. (23)

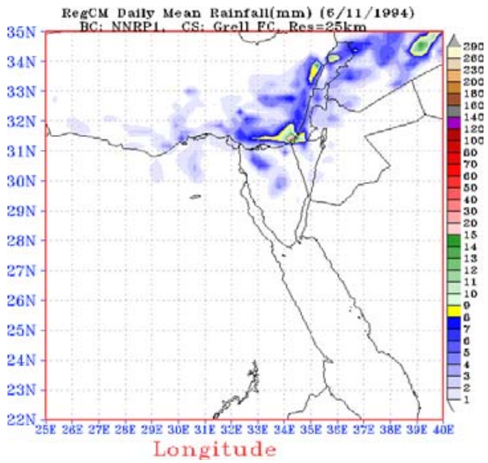

Fig. (24)

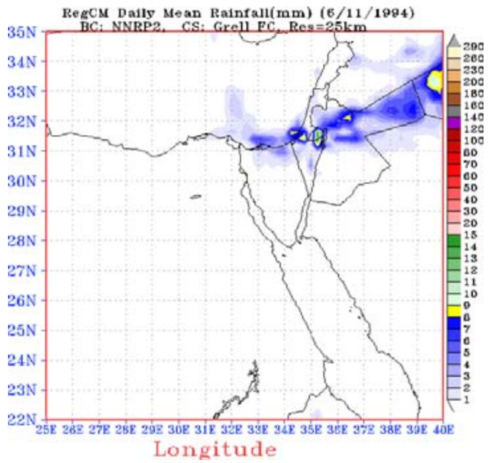

Fig. (25)

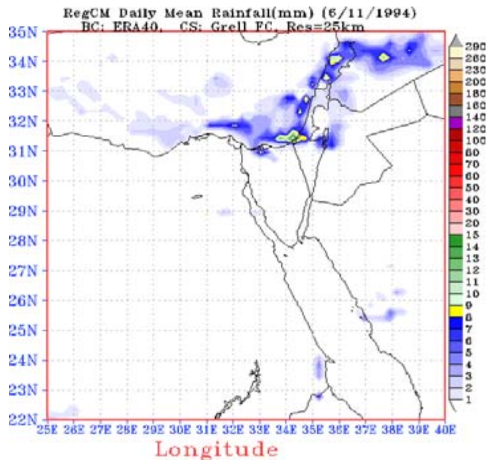

Fig. (26)

(b) Monthly mean

Sep.1994 Mon Mean

CRU

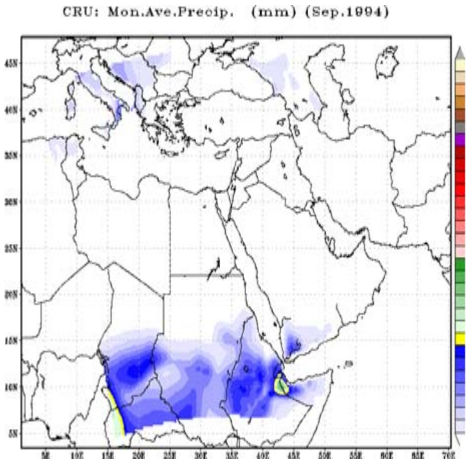

Fig. (27)

NNRP1

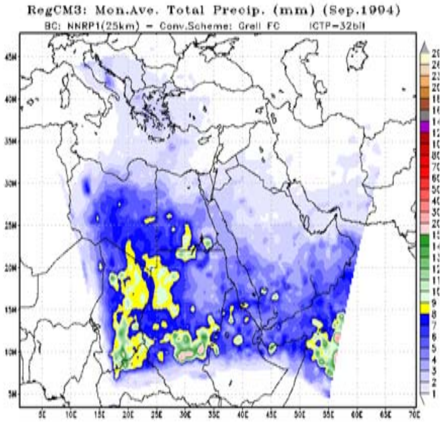

Fig. (28)

NNRP2

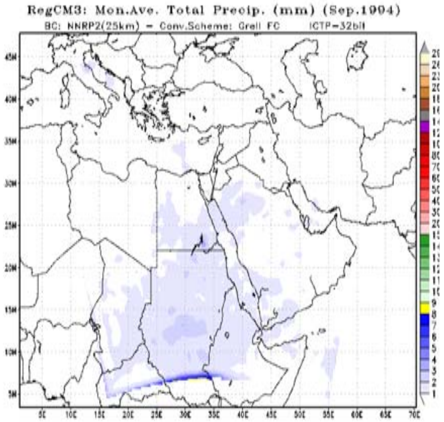

Fig. (29)

ERA40

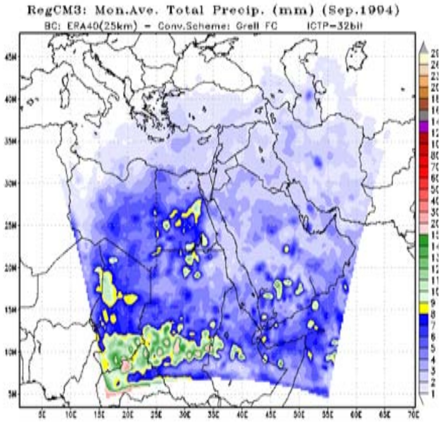

Fig. (30)

Oct.1994 Mon Mean

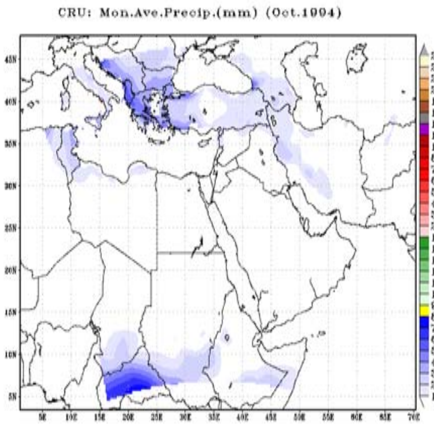

Fig. (31)

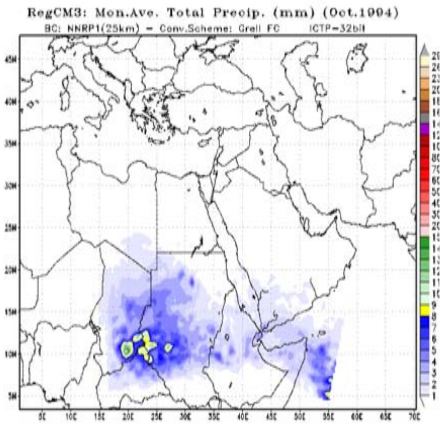

Fig. (32)

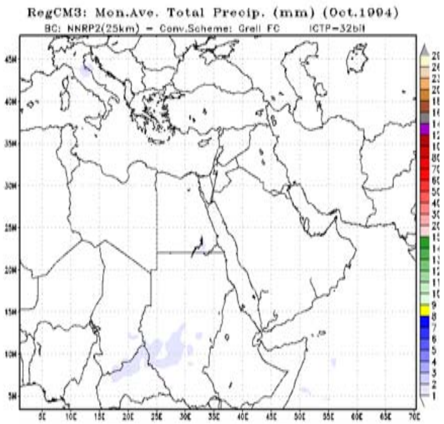

Fig. (33)

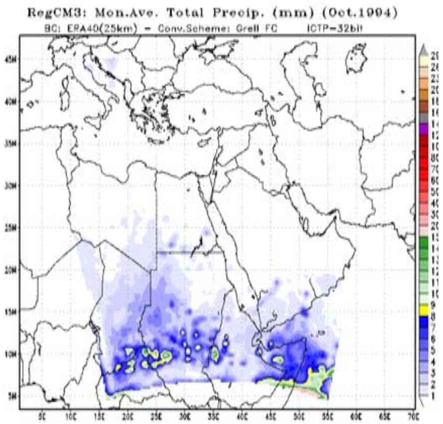

Fig. (34)

Nov.1994 Mon Mean

CRU

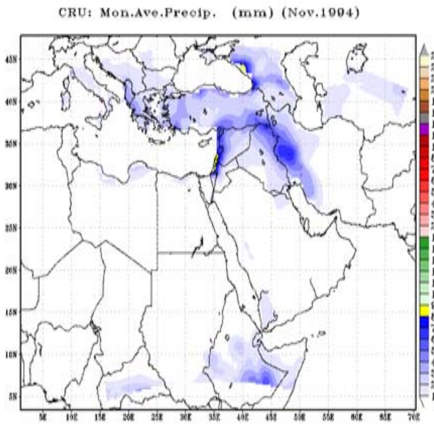

Fig. (35)

NNRP1

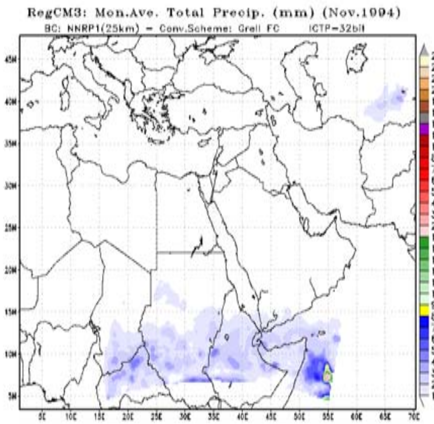

Fig. (36)

NNRP2

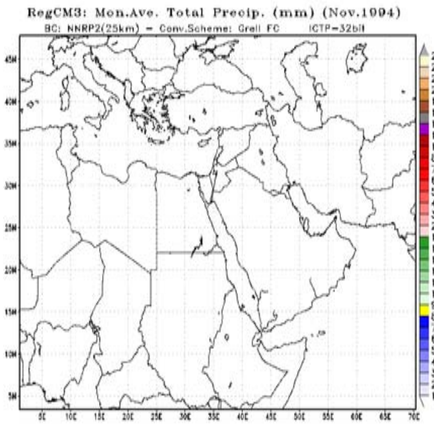

Fig. (37)

ERA40

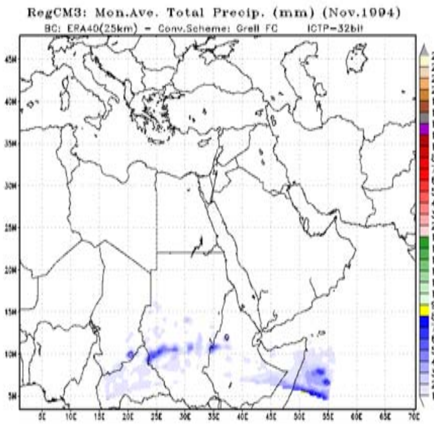

Fig. (38)

CMAP

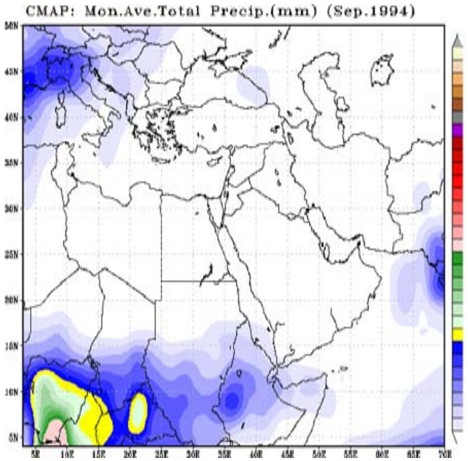

Fig (39) **Sep. 1994**

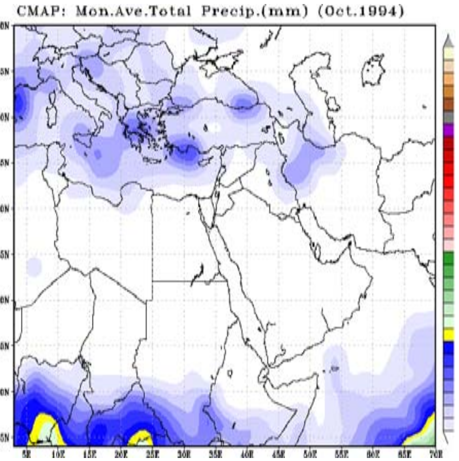

Fig (40) **Oct. 1994**

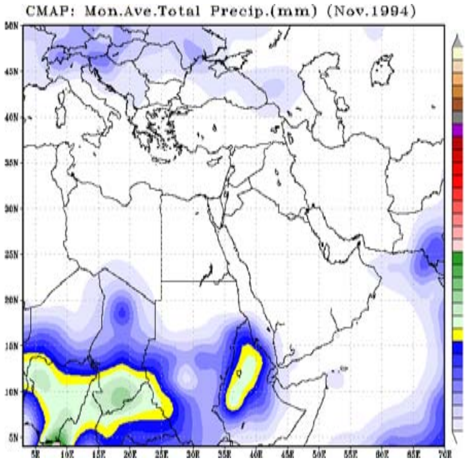

Fig (41) **Nov. 1994**

Conclusions

In terms of the daily mean, the use of NNRP2 lateral boundary field showed consistently fields greater precipitation amounts compared to others but good in spatial structure over Egypt. While, in terms of the monthly mean, the use of NNRP1 and ERA40 lateral boundary fields consistently yields greater precipitation amounts compared to the use of NNRP2 field. In addition, it provides a good simulation of precipitation spatial structure but varies between over and under estimation for the rainfall amounts and over the region in comparison with the CRU and CMAP data.

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محاكاة الامطار على مصر فى خريف 1994 باستخدام نموذج اقليمى للمناخ
الجزء الاول: تاثير القوى المؤثرة

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الملخص العربى

تم فى هذا البحث استخدام نسخة مطورة فى المركز الدولى للفيزياء النظرية بايطاليا من النموذج الاقليمى للمناخ فى دراسة الفيضان العنيف الذى ضرب مصر فى مساء اليوم الاخير من شهر اكتوبر 1994 وبداية الشهر التالى. ولتشغيل النموذج تم استخدام اسقاط لام كون مع ضبط نطاق النموذج ليتضمن 180 X 190 نقطة شبكية تتوسط عند *25.39°E, 35.48°N* وبدقة 25 كيلومتر وبعدد 18 مستوى علوى.

كما تم تشغيل النموذج على البيانات فى الفترة من 1 اغسطس 1994 الى 31 نوفمبر لنفس العام اى لمدة اربعة اشهر على بيانات نواتج تحليل مراكزتنبؤات جوية عددية تستخدم نماذج كوكبية مثل المركز القومى الامريكى او الاوروبى تعرف بـ NNRP1,NNRP2, ERA40 لدراسة تاثير تغير البيانات الحدية على المخرجات من الامطار من حيث الكميه والتوزيع خاصة على مصر وعلى نطاق الدراسة بصفة عامة .

وقد اظهرت نتائج الدراسة ان استخدام , NNRP2 ويليه NNRP1 يعطى نتائج افضل من حيث توزيع الامطار وكمياتها مقارنة بقياسات المحطات وذلك عند دراسة المتوسطات اليومية بينما عند دراسة المتوسطات الشهرية من حيث الكمية فالامر يختلف زيادة ونقصانا حسب المكان والزمان مقارنة ببيانات القياسات CRU , CMAP والموزعة شبكيا.