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Comparison between SERE and RCP scenarios in Temperature and Evapotranspiration under Different Climate Zone in Egypt

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Abstract: *The Intergovernmental Panel on Climate Change (IPCC) reports that the impacts of climate change has occurred and is going to continue, driven by both past and future greenhouse gas (GHG) emissions. The aim of this study was the comparison between SRES and RCP scenarios for temperature and ETo under different Agro-climate regions in Egypt. The major agro-climatic regions in Egypt are Delta, the Middle Egypt and the Upper Egypt region. The SERS scenario was used (A1F, B2 and B1) while the RCP scenario was (RCP8.5, RCP6 and RCP 4.5). In this study the comparison between the different types of scenario was done at 2025s, 2050s and 2100s. The paired t– test was used to recognize the significant differences among the monthly ETo between SRES and RCP scenarios. The obtained results show that the annual mean temperature in the Delta region was increased in RCP than SERS scenarios at 2025s, 2050s and 2100s; the average increased was ranged from 0.27 to 1.21 ^{o}C. The annual mean temperature in the Middle Egypt region was increased in RCP8.5 and RCP6 than SERS-A1F1 and SERS-B2 scenarios while, temperature was lower under RCP4.5 than SERS-B1 scenario. The mean temperature in the Upper Egypt region was lower in RCP than SERS scenarios under two 2025 and 2100 and was higher at 2050s. The comparison of ETo value between RCP and SRES scenarios was not significance for Delta region; while the differences between RCP and SRES was significant under Upper Egypt The comparison of ETo value in middle Egypt between (RCP8.5 and A1F1) and (RCP6 and SRES B2) was significance at 2025s, 2050s and 2100s.*

Keywords: *AR4, AR5, GHG, agro-meteorological data, global circulation model and climate change downscale*

I. Introduction

As the 5th assessment report is being finalized, some comparisons to the last two reports are already possible. The 4th assessment report (**IPCC 2007**) provided a narrower range of for the likely future of the global climate stating that temperatures will likely be between 2.0 and 4.5°C warmer than the period from 1961- 1990 (with 66% likelihood), and it also stated that temperature increases of more than 4.5°C are also within the realm of possibility (**Rogelj *et al.*,2012**); however, the most likely temperature increase will be 3.0°C by 2100. Human influence on the climate system is clear. it is extremely likely (95-100 % probability) that human influence was the domination cause of global warming between 1951-2010. First indications from global climate modeling studies for the 5th assessment report of the Intergovernmental Panel on Climate Change (**IPCC 2013**), states that ECS is likely (>66%) in the range of 1.5–4.5^{o}C, extremely likely (>95%) larger than 1^{o}C, and very unlikely (<10%) larger than 6^{o}C.

The SERS scenarios have close analogues in the RCP scenarios. For example, the A1B scenario used as the high-end scenario in many Pacific Northwest impacts assessments is similar to the newer RCP 6.0 scenario by 2100, though closer to the RCP 8.5 scenario at mid-century. In both cases, the high end is a “business as usual” scenario (RCP 8.5, SRES A1FI) in which emissions of greenhouse gases continue to increase until the end of the 21st century, and atmospheric CO_2 concentrations more than triple by 2100 relative to preindustrial levels. The newest scenarios, used in the 2013 IPCC report, are referred to as Representative Concentration Pathways (RCPs; **Van Vuuren *et al.*, 2011**). The previous greenhouse gas scenarios, used in the 2001 and 2007 IPCC reports, are described in the Special Report on Emissions Scenarios (SRES; **Nakicenovic *et al.*, 2000**).

The importance of differences between the old and new climate change projections will depend on the specific impact under consideration and the sensitivity of the decision being made. For example, projected changes in annual average temperature are likely to differ by less than 1°F under similar greenhouse gas scenarios from IPCC 2007 and 2013, while projected changes in annual average precipitation are likely to differ by only a few percentage points. Other differences between the scenarios have not yet been explored (**Snover *et al.*, 2013)**

Global mean temperature projections by the end of the twenty-first century for the RCPs are very similar to those of their closest SRES counterparts. However, the transient trajectories differ in various ways. These different warming rates between SRES scenarios and RCPs with similar year 2100 forcing are due to different transient forcing up to then. These differences can be of importance when assessing shorter-term climate impacts under RCPs and comparing them to earlier literature (**Joeri Rogelj *el al* ., 2012**).

The aim of this work to comparison between SERE and RCP scenarios in temperature and Eto under different Agro-climate zone in Egypt (Delta, Middle and Upper Egypt).

II. Materials and Methods

Agro-climatic regions

Egypt has been divided into several agro-climatic regions according to the average temperature values. The most important agro-climatic regions are: the Delta region, represented in this study by seven governorates (Kafr El-shiekh, Dakahlia, Sharqia, Ismailia, Portsaid, Suez and Cairo); the Middle Egypt region represented by four governorates (Giza, Fayoum, Beni Suif and Menya) and the Upper Egypt region represented by five governorates (Asyut, Sohag, Qena, Luxor and Aswan). Due to uncorresponding the borders of the studed governerates with the latitude lines we could characterize approximately the location of Upper Egypt region between (24°N – 28°N), Middle Egypt region between (28°N – 30°N) and Delta region between (30°N – 31°N).

Representative Concentration Pathway scenarios (RCPs)

The climate change data were obtained using the ClimaScope is a data visualization engine providing maps and data on projected climate changes for a range of global greenhouse gas emission scenarios. Outputs are stamped with metadata on which GCM was used, which carbon cycle was used, which emission scenario was used, and the source of the data in order to provide traceability. The data come from peer-reviewed models linked together within the Community Integrated Assessment System (CIAS) developed at the Tyndall Centre for Climate Change Research within the School of Environmental Sciences at the University of East Anglia. **(Warren et al., 2008; Mitchell and Jones, 2005 & Osborn,2009)**. the projection changes in air temperature (Δ air temp) under the three IPCC's RCPs scenarios (RCP4.5, RCP 6 and RCP 8.5,) that are described in Table 1. HadCM3 climate model was the base model under the three scenarios.The future (2011-2040s, 2041-2070s and 2071-2100s) Δ air temperature data were downscaled according to the Egyptian coordinates.

Table (1): Description of IPCC Representative Concentration Pathway (RCP)

Scenario	Radioactive forcing	Atmospheric CO2 ppm	Temperature Increase oC	Pathway
RCP 4.5	4.5 Wm2 post 2100	650 ppm	2.4 °C	Stabilization without overshoot
RCP 6	6.0 Wm2 post 2100	850 ppm	3.0 °C	Stabilization without overshoot
RCP 8.5	8.5 Wm2 in 2100	1370 ppm	4.9 °C	Rising

Special Report on Emissions Scenarios (SRES)

The climate change data were obtained using the MAGICC/SCENGEN tool (**Wigley et al., 2000**) to extract the projection changes in air temperature (Δ air temp) under the three IPCC's SRES scenarios (A1F1, B1 and B 2) that are described in Table 2. HadCM3 climate model was the base model under the three scenarios. Each simulation extracted monthly Δ air-temp, for one of the three scenarios, for the coming years 2025s, 2050s and 2100s. The resulted data from MAGICC/SCENGEN were displayed in2.5ºX 2.5º coordination grid. The future (2025s, 2050s and 2100s) Δ air temp data were downscaled according to the Egyptian coordinates

Table 2. Description of IPCC Special Report on Emissions Scenarios (SERS)

Scenario	Storylines
A1F1	Rapid economic growth, low population growth, rapid adoption of new technologies, convergence of regions, capacity building, increased social interaction, reduced region differences in per capita income. An emphasis on fossil-fuels (Fossil Intensive). Temperature increased 1.4 - 6.4ºC
B1	Convergent world with low population growth, transition to service and information economy, resource productivity improvements, clean technology towards global solutions. Temperature increased 1.1 - 2.9ºC
B2	Divergent world with emphasis on local solutions to economic, social and environmental sustainability, moderate population growth, intermediate levels of economic growth, less rapid technological change. Temperature increased 1.4 – 3.8ºC

Similarities and differences between SERS and RCPs scenarios

Table (3) show the similarities and difference between SERS and RCP. The highest RCP 8.5 would yield temperature projections close to those of the SRES A1FI scenario. RCP6 temperature projections are similar to those of SRES B2 and, likewise, RCP4.5 temperature projections to those of SRES B1.

Table (3) Main similarities and differences between temperature projections for SRES and RCPs scenarios

RCP	SRES scenario with similar median temperature increase by 2100	Particular differences
RCP2.6	None	The ratio between temperature increase and net radiative forcing in 2100 is 0.88 °C $(Wm^{-2})^{-1}$ for RCP3-PD, whereas all other scenarios show a ratio of about 0.62 °C $(Wm^{-2})^{-1}$; that is, RCP3-PD is
RCP4.5	SRES B1	Median temperatures in RCP4.5 rise faster than in SRES B1 until mid-century and slower afterwards.
RCP6	SRES B2	Median temperatures in RCP6 rise faster than in SRES B2 during the three decades between 2060 and 2090, and slower during other periods of the twenty-first century.
RCP8.5	SRES A1FI	Median temperatures in RCP8.5 rise slower than in SRES A1FI during the period between 2035 and 2080, and faster during other periods of the twenty-first century.

FAO- 56 Penman - Monteith Equation

The definition of ETo by Allen et al (1994) was the basis for FAO Penman – Monteith method in the estimation of Reference Evapotranspiration. This method overcomes the previous Penman Monteith methods and provides values more consistent results. The FAO Penman – Monteith method to estimate reference crop evapotranspiration is as follows

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

where ET_o is the daily reference evapotranspiration (mm day^{-1}), Rn is the net radiation at the crop surface (MJ m^{-2} day^{-1}), G is the soil heat flux density (MJ m^{-2} day^{-1}), T is the mean daily air temperature at 2 m height (°C), U_2 is the wind speed at 2 m height (m s-1), es is the saturation vapor pressure (kPa), ea is the actual vapor pressure (kPa), Δ is the slope of vapor pressure curve (kPa $°C^{-1}$) and γ is the psychometric constant (kPa $°C^{-1}$).In application having 24-h calculation time steps, G is presumed to be 0 and es is computed as

$$e_s = \frac{e^0(T_{\max}) + e^0(T_{\min})}{2} \quad \text{Eq (2)}$$

Where e^0(T_{max}) is the saturation vapor function and T_{max} and T_{min} are the daily maximum and minimum air temperature. The FAO Penman-Monteith equation predicts the evapotranspiration from a hypothetical grass reference surface that is 0.12 m in height having a surface resistance of 70 s m^{-1}. The equation provides a standard to which evapotranspiration in different periods of the year or in other regions can be computed and to which the evapotranspiration from other crops can be related. Standardized equations for computing all parameters in Eq. (1) are given by Allen et al (1998).

Statistical Analysis

Statistical analysis was carried out using SAS software. The paired t– test was used to establish whether there exist significant differences in the monthly ETo between SRES and RCP climate change scenarios in three time (2025 ;2050 and 2100) at significant level 0.05 **SAS (2000)**.

III. Results and Discussion

Trend of annual mean air temperature for Delta region

Fig. (1) shows the annual average trend of the mean air temperature for Delta region under SERS-A1F1 and RCP8.5 (2025, 2050 and 2100) conditions for the concerned seven governorates (Kafr El-shiekh, Dakahlia, Sharqia, Ismailia, Portsaid, Suez and Cairo). Data show that the annual mean temperature in the Delta increased in RCP8.5 than SERS-A1F1 scenarios at 2025s, 2050s and 2100s. The highest difference between SERS-A1F1 and RCP8.5 in annual mean temperature was about 0.74 °C in 2100, while the lowest difference between SERS-A1F1 and RCP 8.5 in annual mean air temperature value was about 0.27 °C in 2025.

Data in Fig. (2) illustrate the comparison of mean air temperature between SERS-B2 and RCP6 for Delta region. The lowest difference between SERS-B2 and RCP6 in annual mean air temperature values were found in 2025 about 0.47 °C, while the difference between SERS-B2 and RCP6 was about 0.52 °C in other 2050 and 2100.

The difference between SERS-B1 and RCP4.5 in annual mean air temperature was presented in Fig. (3). Data retrieve that the highest difference in annual mean air temperature in Delta region about 1.21°C was found between 2050. The lowest difference between SERS-B1 and RCP4.5 was about 0.43°C in 2100.

Final the annual mean temperature in the Delta region was increased in RCP than SERS scenarios at 2025, 2050, and 2100 by about 0.27 to 1.21 °C.

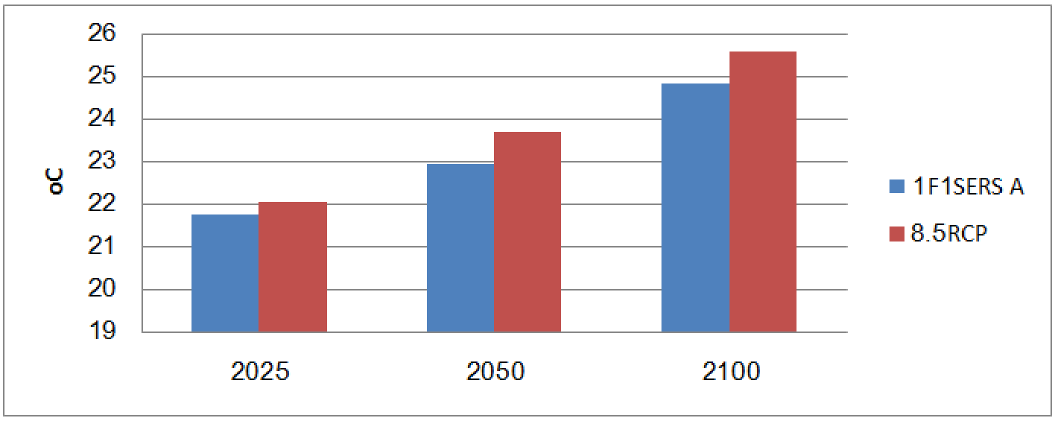

Fig. (1) The average annual mean air temperature in Delta region under SERS-A1F1and RCP8.5 scenarios for different times.

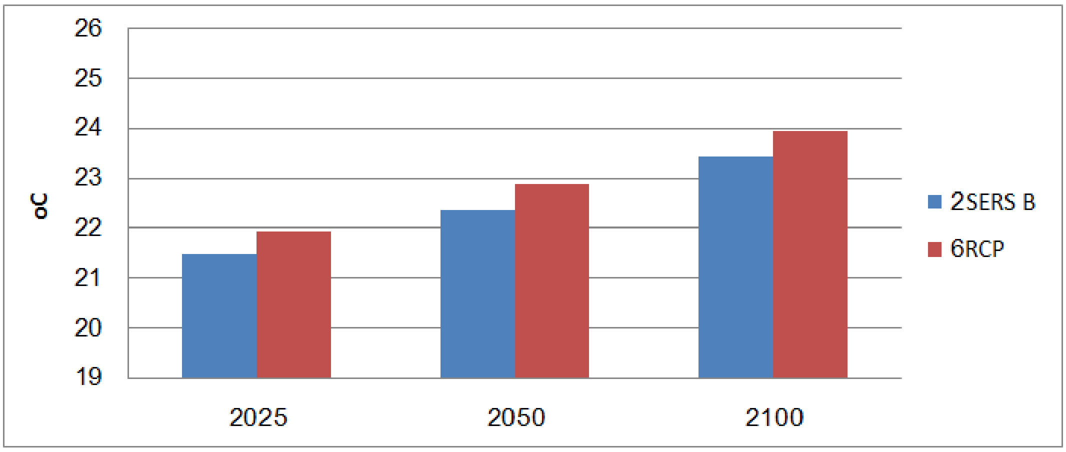

Fig. (2) The average annual mean air temperature in Delta region under SERS-B2and RCP6 scenarios for different times.

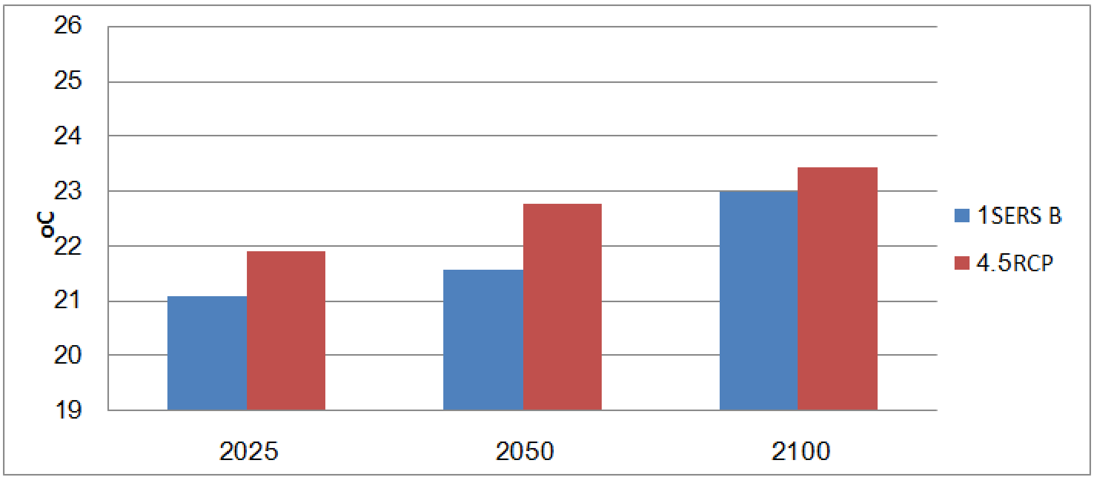

Fig. (3) The average annual mean air temperature in Delta region under SERS-B1and RCP4.5 scenarios for different times.

Trend of annual mean air temperature for Middle Egypt region

The comparison of annual mean air temperature between SERS and RCP for Middle Egypt region was illustrated in figures (4, 5 and 6). Data in Fig. (4) presented the comparison of mean air temperature between RCP8.5 and SERS-A1F1 in for middle Egypt region. The lowest difference between RCP8.5 and SERS-A1F1 in annual mean air temperature values was about 0.76 ^{o}C found in 2100, while the highest difference between RCP8.5 and SERS-A1F1 was about 1.46 ^{o}C in 2050.

Data in Fig (5) show that the annual mean temperature in the Middle Egypt increased in RCP6 than SERS-B2 scenarios under three times. The highest difference between RCP6 and SERS-B2 in annual mean temperature was found in 2050 about 1.03 ^{o}C, while the lowest difference between RCP6 and SERS-B2 in annual mean air temperature values was about 0.64 ^{o}C in 2100.

The difference between SERS-B1 and RCP4.5 in annual mean air temperature was presented in Fig. (6). Data retrieve that RCP4.5 was lower than SERS-B1 scenarios under at 2025s, 2050s and 2100s. The highest difference value between RCP4.5 and SERS-B1 was about -1.57^{o}C in 2100. The lowest difference value was found between RCP4.5 and SERS-B1 was about -0.13^{o}C in 2050.

Finally, the annual mean temperature in the Middle Egypt region was increased in RCP8.5 and RCP 6 than SERS-A1F1 and SERS-B2 scenarios 2025,2050 and 2100. The average differences in Middle Egypt region ranged from 0.64 to 1.46 ^{o}C in two scenarios RCP8.5 and RCP6. The annual mean temperature was decreased in RCP4.5 than SERS-B1 scenario under 2025, 2050 and 2100. The average decreased range from -0.13 to -1.57 ^{o}C in one scenario RCP4.5.

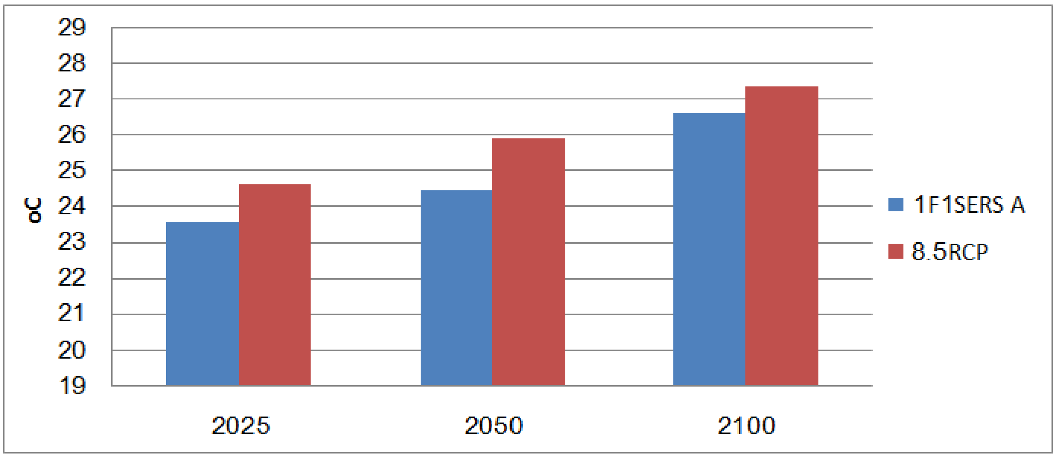

Fig. (4) The average annual mean air temperature in Middle Egypt region under SERS-A1F1and RCP8.5 scenarios for different times.

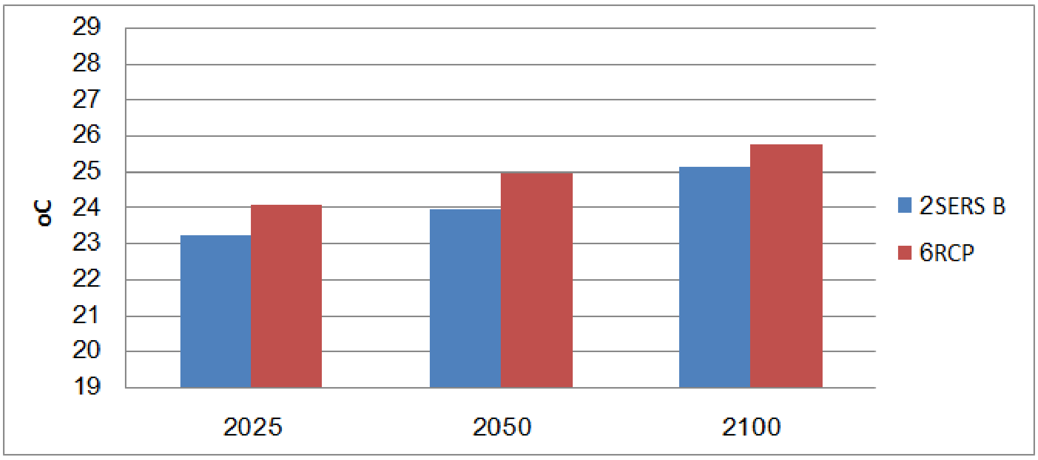

Fig. (5) The average annual mean air temperature in Middle Egypt region under SERS-B2 and RCP6 scenarios for different times.

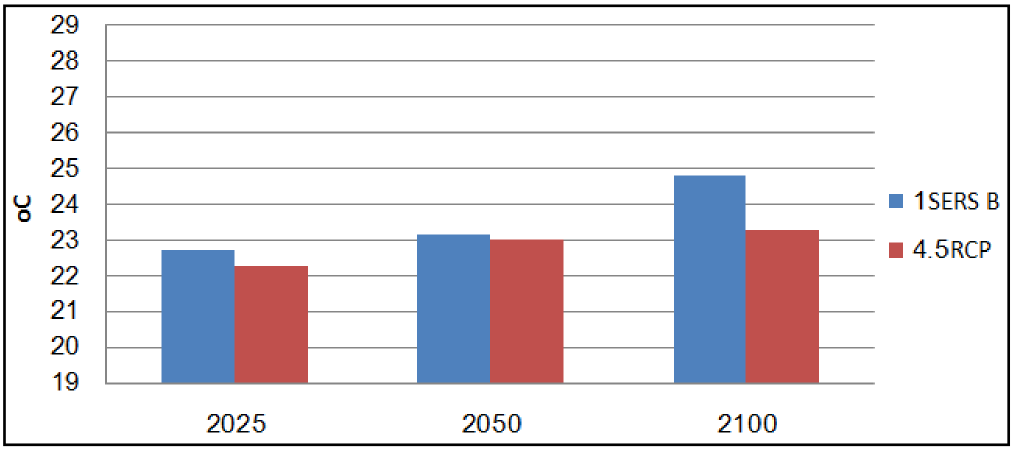

Fig. (6) The average annual mean air temperature in Middle Egypt region under SERS-B1and RCP4.5 scenarios for different times.

Trend of annual mean air temperature for Upper Egypt region

Data in Figures (7, 8 and 9) show the comparison of annual mean air temperature between SERS and RCP for Upper Egypt. The SERS was increased than RCP scenarios 2025, 2050 and 2100 except two records. Fig. (7) presented that the annual mean temperature in the Upper Egypt increased in SERS-A1F1 than RCP8.5 scenarios except the RCP8.5 at 2050 was higher than SERS by about 0.3 ^{o}C. The highest difference between RCP8.5 and SERS-A1F1 in annual mean temperature was about -0.93 ^{o}C in 2025, while the lowest difference between RCP 8.5 and SERS-A1F1 in annual mean air temperature values was about 0.20 ^{o}C in 2100.

Data in Fig. (8) illustrate the comparison between SERS-B2 and RCP6 in mean air temperature for Upper Egypt region . The SERS was lower than RCP scenarios in all data. The lowest difference between RCP6 and SERS-B2 in annual mean air temperature values was about -0.12 ^{o}C in 2050, while the highest difference between RCP6 and SERS-B2 was about -0.90 ^{o}C in 2100.

The difference between SERS-B1 and RCP4.5 in annual mean air temperature was presented in Fig. (9). Data retrieve that the highest difference between RCP4.5 and SERS-B1 was about -0.40^{o}C at 2025. The lowest difference between RCP4.5 and SERS-B1 was about -0.16 ^{o}C in 2100. On the other hand RCP4.5 was higher than SERS-B1 by 0.8 ^{o}C at 2050.

Finally, the annual mean temperature in the Upper Egypt region was lower in RCP than SERS scenarios under two 2025 and 2100; while, RCP was higher than SERS at 2050.

These results are in line with **IPCC (2006)** which mentioned that "temperature will increase by uneven values in different climatic regions under climate change conditions". Moreover, Climate changes may have important impacts on agriculture. **Ayub and Miah** (2011) mentioned that "temperature will increase by uneven values in different climatic regions under climate change conditions. The RCPs span a large range of stabilization, mitigation and non-mitigation pathways. The resulting range of temperature estimates is therefore larger than the range of the SRES scenarios, which cover only non-mitigation scenarios (**Joeri Rogelj *et al.*, 2012**).

Snover *et al.* (2013) reported that the RCP scenarios were created in a different way and span a wider range of possible 21st century emissions, many of them are similar to scenarios used in previous assessments (SERES).The importance of differences between the old and new climate change projections will depend on the specific impact under consideration and the sensitivity of the decision being made. For example, projected changes in annual average temperature are likely to differ by less than 1°F under similar greenhouse gas scenarios from IPCC 2007 and 2013.

Comparing carbon dioxide concentrations and global temperature change between the SRES and RCP scenarios, SRES A1FI is similar to RCP 8.5; SRES A1B to RCP 6.0 and SRES B1 to RCP 4.5. The RCP 2.6 scenario is much lower than any SRES scenario because it includes the option of using policies to achieve net negative carbon dioxide emissions before end of century, while SRES scenarios do not (**Melillo *et al.*, 2014**). **Van Vuuren** et al. (2012) reported that The SRES scenario A1b lies above RCP6 but below RCP8.5 (which is closest to SRES A1FI). The lowest SRES scenario, B1, lies between RCP4.5 and RCP2.6. The newest scenarios (RCP) do project similar warming trends as the 4th IPCC assessment report (SRES), although some scenarios point to somewhat higher warming trends than those calculated for the 4th report (**Rogelj *el al.*, 2012**)

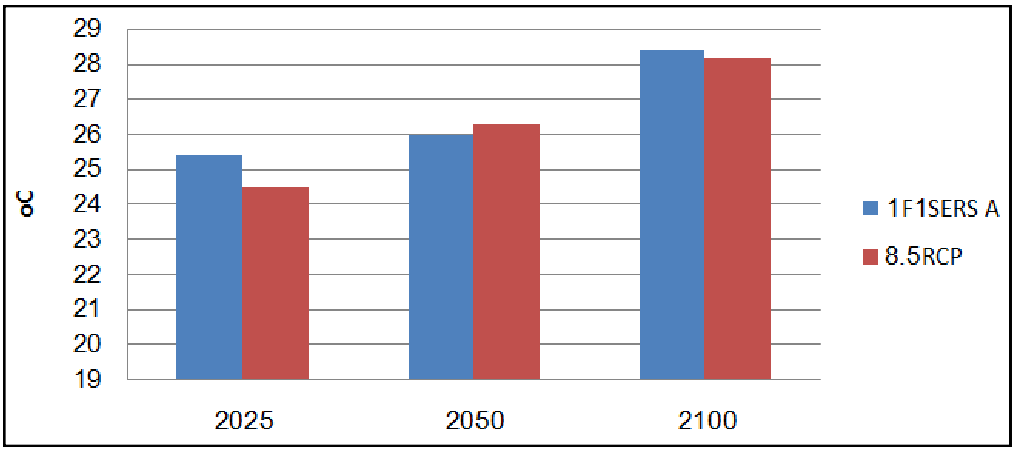

Fig. (7) The average annual mean air temperature in Upper Egypt region under SERS-A1F1and RCP8.5 scenarios for different times.

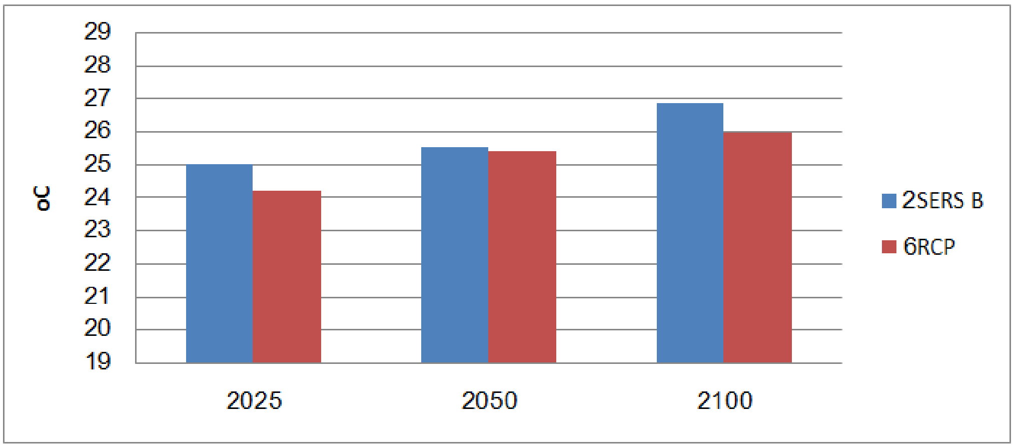

Fig. (8) The average annual mean air temperature in Upper Egypt region under SERS-B2 and RCP6 scenarios for different times.

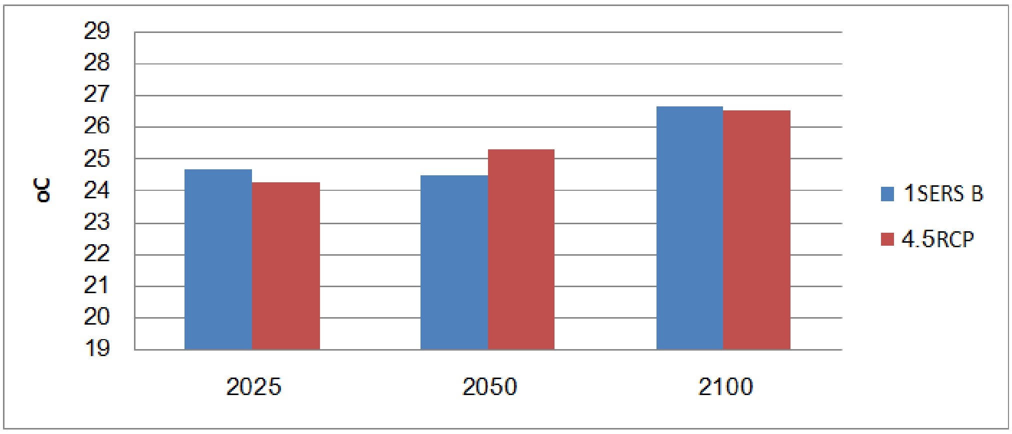

Fig. (9) The average annual mean air temperature in upper Egypt region under SERS-B1and RCP4.5 scenarios for different times.

Annual ETo for Delta Region

Data in Table 4 illustrate the results of calculation of ETo values using Penman-Monteith equation for the Delta region under SRES and RCP scenarios. Regarding the monthly ETo values, The ETo were increased from the January to July as the temperature increases and indicated decreasing trend from June to December as the temperature decreases under all scenarios. The calculation of ETo under RCP8.5 scenario gave the highest ETo values followed by A1F1scenario; while the lowest ETo values obtained by B1 scenario. The highest ETo of the Delta region was (7.36 mm) recorded during the July month at RCP 8.5 at 2100; while the lowest ETo was (2.34mm) recorded in the January months under B1 at 2025. The comparison of ETo value between RCP and SRES scenarios was not significance except the comparision between B1 and RCP4.5 at 2050. Generally, the annual ETo values under RCP scenario was higher than SRES scenario during the most months.

Annual ETo for Middle Egypt Region

The average monthly ETo values under RCP and SRSE scenarios for the Middle Egypt region was presented in Table 5; the ETo values had the same trend such as Delta in both RCP and SRES scenarios. The comparison in ETo value between RCP8.5 and A1F1 was significant at 2025, 2050 and 2100. The same trend was found in comparison between RCP6 and SRES B2. The annually ETo value in RCP (8.5 and 6) was higher than SERS (A1F1 and B2); while the annually ETo value in RCP (4.5) was lower than SERS (B1) at 2025, 2050 and 2100. The differences between ETo under RCP4.5 and SRES B1 was not significance at 2025 and 2050; while there were significance difference between RCP4.5 and SRES B1 at 2100. The differences between RCP and SRES in monthly ETo was positive under RCP 8.5 with A1F1 and RCP6.5 with B2 except one value was negative. The negative value was in September between RCP6 with B2 (2050) about -0.08 mm.

Annual ETo for Upper Egypt Region

Table 6 shows the ETo values in the Upper Egypt region for SRES and RCP scenarios at 2025, 2050 and 2100. The annually ETo value was higher under SRES scenario than RCP scenario except in RCP8.5 at 2050 with SRES A1F1 2050 and RCP4.5 2050 with SRES B12050. The comparison in monthly ETo between A1F1 and RCP8.5 was significant at 2025 and no significant at 2050 and 2100. In case of SRES B2 and RCP6 the significant was found at 2100 only; while comparison of ETo between SERS B1 and RCP4.5 were significant at 2025, 2050 and 2100. The highest annual ETo differences between RCP8.5 with A1F1 was about -0.16mm at 2050 followed by RCP6 with B2 was about - 0.14mm at 2100. The lowest annual differences of ETo value was expected under B2 with RCP6 was about -0.02mm at 2050.

These results agreed with **Farag *el al.*, (2014)** who carried out a case study of Egypt to investigate the impact of climatic changes on ETo based on air temperature changes according to different scenarios. Reported that expected climate changes in Egypt according to the SERS scenarios will cause an increase in ETo depending on the climate region. The increase in the Delta region was between 2.4% to 16.2 %, in the, Middle Egypt region between 5.9% to 21.1% and in the Upper Egypt region between 5.8% to 22.5% up to the year 2100 as compared to current situation. **Attaher et al., (2007)** reported that projected future climatic changes will increase the potential irrigation demand of Egypt by 6- 16% due to the increase in ETo by the 2100s. Moreover, **Haas (2002)** and **Nour El-Din,** (2013) found that projected that the first order impacts of climate change on the Mediterranean hydrological systems as wetter winters and dryer summers, hotter summers and heat waves, and more variability and extreme weather events will take their toll. These impacts may induce an increase in evaporation (E) from natural and artificial water bodies and soils which reduce the available water supply.

Adaptation options

Given this situation Egyptian agriculture is likely to need to adapt as increases in available water are not likely. This adaptation would require actions such as

- Using proper soil conditioners to improve soil water holding capacity especially in sandy soil.
- Breeding crops with improved water use efficiency.
- Improving irrigation system efficiency by reducing conveyance and application losses
- Improve different agricultural practices such as using mulch for vegetable crops to reduce the soil evaporation.
- Expand the protected agriculture for vegetables and some tropical fruit trees to improve water use efficiency.

IV. Conclusion

The mean air temperature was higher under RCP than SERS scenarios under Delta and Middle Egypt. However Upper Egypt region had different trend; the annual mean air temperature was lower under RCP than SERS scenarios at 2025 and 2100; while the annual mean air temperature under RCP was higher than SERS at 2050. The comparison of annual ETo value between RCP and SRES scenarios was not significance in Delta region; whereas, the differences between the studied scenarios was significant under Middle and Upper Egypt. From all the above mentioned we can conclude that the ETo value under RCP (8.5 and 6) was higher than SERS (A1F1 and B2); while the ETo value in RCP (4.5) was lower than SERS (B1). Further studies should be done about the comparison of water requirements for major crops in Egypt under RCP scenarios.

Table (4) Average monthly estimated ETo (mm) under RCP and SERS scenarios for Delta region.

A1F1 &RCP8.5	**2025 A1F1**	**2025 RCP 8.5**	**2050 A1F1**	**2050 RCP 8.5**	**2100 A1F1**	**2100 RCP 8.5**
Jan.	2.37	2.42	2.47	2.55	2.62	2.75
Feb.	2.77	2.79	2.91	2.96	3.11	3.12
Mar.	3.41	3.48	3.53	3.65	3.72	3.90
April	4.60	4.68	4.78	4.96	5.03	5.27
May	5.65	5.66	5.89	5.97	6.24	6.35
June	6.37	6.41	6.70	6.80	7.17	7.24
July	6.25	6.25	6.67	6.75	7.24	7.36
Aug.	6.20	6.23	6.59	6.74	7.13	7.31
Sept.	6.13	6.08	6.44	6.41	6.91	6.79
Oct.	5.78	5.77	6.08	6.13	6.54	6.53
Nov.	4.65	4.72	4.88	4.98	5.30	5.33
Dec.	3.97	4.01	4.19	4.26	4.50	4.56
P value	**N.S**		**N.S**		**N.S**	
Average	**4.85**	**4.87**	**5.09**	**5.18**	**5.46**	**5.54**
B2 &RCP6	**2025 B2**	**2025 RCP 6**	**2050 B2**	**2050 RCP 6**	**2100 B2**	**2100 RCP 6**
Jan.	2.35	2.41	2.42	2.47	2.53	2.59
Feb.	2.76	2.79	2.86	2.89	2.91	2.98
Mar.	3.40	3.48	3.47	3.57	3.54	3.61
April	4.57	4.66	4.68	4.81	4.88	5.01
May	5.62	5.65	5.79	5.84	5.95	6.05
June	6.31	6.38	6.54	6.61	6.74	6.81
July	6.16	6.22	6.43	6.53	6.76	6.86
Aug.	6.15	6.21	6.41	6.50	6.62	6.83
Sept.	6.06	6.05	6.28	6.22	6.45	6.46
Oct.	5.74	5.75	5.95	5.95	6.13	6.16
Nov.	4.61	4.71	4.76	4.84	4.93	5.05
Dec.	3.93	3.99	4.08	4.15	4.22	4.31
P value	**N.S**		**N.S**		**N.S**	
Average	**4.80**	**4.86**	**4.97**	**5.03**	**5.14**	**5.23**
B1 & RCP4.5	**2025 B1**	**2025 RCP 4.5**	**2050 B1**	**2050 RCP 4.5**	**2100 B1**	**2100 RCP 4.5**
Jan.	2.34	2.40	2.38	2.46	2.49	2.54
Feb.	2.73	2.78	2.82	2.88	2.96	2.93
Mar.	3.37	3.47	3.41	3.56	3.54	3.62
April	4.54	4.65	4.61	4.79	4.75	4.89
May	5.58	5.64	5.70	5.81	6.00	5.94
June	6.27	6.36	6.46	6.60	6.80	6.74
July	6.09	6.21	6.28	6.48	6.64	6.69
Aug.	6.07	6.22	6.23	6.46	6.58	6.65
Sept.	5.97	6.04	6.10	6.21	6.48	6.38
Oct.	5.66	5.75	5.78	5.94	6.19	6.10
Nov.	4.54	4.69	4.63	4.82	4.98	4.93
Dec.	3.87	3.98	3.96	4.13	4.25	4.22
P value	**N.S**		*****		**N.S**	
Average	**4.75**	**4.85**	**4.87**	**5.01**	**5.14**	**5.14**

: Significance and N.S: not Significance the P-values are less than 0.05

Table (5) Average monthly estimated ETo (mm) under RCP and SERS scenarios for Midle Egypt region.

A1F1 &RCP 8.5	**2025 A1F1**	**2025 RCP 8.5**	**2050 A1F1**	**2050 RCP 8.5**	**2100 A1F1**	**2100 RCP 8.5**
Jan.	2.72	2.80	2.76	2.99	2.98	3.10
Feb.	3.39	3.47	3.37	3.67	3.70	3.81
Mar.	4.21	4.31	4.16	4.53	4.49	4.62
April	5.87	6.03	5.93	6.40	6.32	6.64
May	7.16	7.44	7.30	7.65	7.83	7.91
June	7.85	8.12	7.98	8.46	8.81	8.98
July	7.80	7.95	8.14	8.47	9.13	9.25
Aug.	7.64	7.83	7.97	8.46	8.89	9.02
Sept.	7.27	7.39	7.48	7.68	8.13	8.25
Oct.	6.69	6.79	6.87	7.14	7.55	7.62
Nov.	5.04	5.26	5.14	5.51	5.70	5.81
Dec.	4.33	4.42	4.42	4.74	4.93	5.09
P value	*****		*****		*****	
Average	**5.83**	**5.98**	**5.96**	**6.31**	**6.54**	**6.68**

B2 &RCP 6	2025 B2	2025 RCP 6	2050 B2	2050 RCP 6	2100 B2	2100 RCP 6
Jan.	2.59	2.73	2.81	2.89	2.97	3.20
Feb.	3.21	3.38	3.53	3.57	3.63	3.67
Mar.	4.01	4.22	4.35	4.44	4.44	4.57
April	5.63	5.89	5.99	6.20	6.32	6.42
May	6.94	7.09	7.36	7.46	7.73	7.89
June	7.57	7.80	7.88	8.23	8.51	8.62
July	7.57	7.71	8.05	8.19	8.57	8.64
Aug.	7.48	7.64	7.96	8.17	8.54	8.60
Sept.	7.08	7.11	7.57	7.49	7.82	8.02
Oct.	6.50	6.61	6.94	6.96	7.44	7.45
Nov.	4.85	5.05	5.09	5.35	5.56	5.88
Dec.	4.13	4.32	4.45	4.58	4.60	4.77
P value	*		*		*	
Average	**5.63**	**5.80**	**6.00**	**6.13**	**6.34**	**6.48**
B1 & RCP4.5	**2025 B1**	**2025 RCP 4.5**	**2050 B1**	**2050 RCP 4.5**	**2100 B1**	**2100 RCP 4.5**
Jan.	2.59	2.61	2.70	2.76	2.85	2.84
Feb.	3.20	3.24	3.34	3.43	3.51	3.48
Mar.	3.98	4.04	4.14	4.24	4.34	4.33
April	5.63	5.64	5.79	5.96	6.07	6.11
May	6.89	6.81	7.19	7.13	7.58	7.30
June	7.55	7.47	7.86	7.88	8.21	8.02
July	7.57	7.36	7.99	7.83	8.52	8.05
Aug.	7.42	7.33	7.83	7.76	8.39	8.00
Sept.	7.04	6.81	7.43	7.18	7.81	7.34
Oct.	6.48	6.31	6.82	6.66	7.28	6.82
Nov.	4.83	4.83	5.05	5.11	5.37	5.22
Dec.	4.12	4.14	4.31	4.37	4.56	4.49
P value	N.S		N.S		*	
Average	**5.61**	**5.55**	**5.87**	**5.86**	**6.21**	**6.00**

: Significance and N.S: not Significance the P-values are less than 0.05

Table (6) Average monthly estimated ETo (mm) under RCP and SERS scenarios for Upper Egypt region.

A1F1 &RCP 8.5	2025 A1F1	2025 RCP 8.5	2050 A1F1	2050 RCP 8.5	2100 A1F1	2100 RCP 8.5
Jan.	3.58	3.44	3.62	3.72	3.89	4.02
Feb.	4.34	4.24	4.43	4.48	4.80	4.72
Mar.	5.68	5.53	5.73	5.83	6.04	6.19
April	7.74	7.59	7.86	8.06	8.28	8.59
May	9.22	8.98	9.47	9.48	10.31	10.06
June	9.91	9.83	10.36	10.39	10.99	11.03
July	10.18	9.96	10.69	10.64	11.64	11.45
Aug.	10.09	10.03	10.53	10.71	11.39	11.59
Sept.	9.56	9.20	10.00	9.67	10.66	10.20
Oct.	8.68	8.43	9.03	8.88	9.95	9.44
Nov.	6.56	6.46	6.71	6.87	7.23	7.37
Dec.	5.39	5.32	5.53	5.69	5.96	6.12
P value	*		N.S		N.S	
Average	**7.58**	**7.42**	**7.83**	**7.87**	**8.43**	**8.40**
B2 &RCP 6	**2025 B2**	**2025 RCP 6**	**2050 B2**	**2050 RCP 6**	**2100 B2**	**2100 RCP 6**
Jan.	3.51	3.43	3.59	3.51	3.75	3.69
Feb.	4.26	4.22	4.35	4.32	4.51	4.50
Mar.	5.65	5.52	5.67	5.61	5.86	5.82
April	7.68	7.57	7.84	7.72	8.14	7.93
May	9.10	8.94	9.25	9.36	9.82	9.54
June	9.79	9.81	10.14	10.09	10.51	10.48
July	10.02	9.90	10.31	10.38	10.93	10.74
Aug.	10.00	9.93	10.41	10.25	10.91	10.82
Sept.	9.32	9.19	9.45	9.69	10.13	9.74
Oct.	8.48	8.35	8.65	8.78	9.29	8.93
Nov.	6.49	6.42	6.67	6.49	6.88	6.92
Dec.	5.29	5.27	5.50	5.32	5.74	5.66
P value	N.S		N.S		*	
Average	**7.47**	**7.38**	**7.65**	**7.63**	**8.04**	**7.90**
B1 & RCP4.5	**2025 B1**	**2025 RCP 4.5**	**2050 B1**	**2050 RCP 4.5**	**2100 B1**	**2100 RCP 4.5**

Jan.	3.53	3.41	3.57	3.48	3.67	3.63
Feb.	4.30	4.19	4.35	4.28	4.54	4.47
Mar.	5.66	5.52	5.66	5.45	5.78	5.77
April	7.64	7.55	7.82	7.61	8.00	7.79
May	9.10	8.93	9.22	9.17	9.77	9.41
June	9.77	9.71	10.04	9.94	10.33	10.28
July	9.99	9.84	10.27	10.08	10.82	10.63
Aug.	9.92	9.90	10.33	9.98	10.61	10.57
Sept.	9.39	9.17	9.55	9.5	10.10	9.89
Oct.	8.48	8.33	8.63	8.6	9.34	8.92
Nov.	6.48	6.41	6.63	6.49	6.83	6.79
Dec.	5.31	5.26	5.47	5.32	5.62	5.57
P value	*		*		*	
Average	**7.46**	**7.35**	**7.82**	**7.69**	**7.95**	**7.81**

: Significance and N.S: not Significance the P-values are less than 0.05

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