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A review on impact of climate change on evapotranspiration

Sushanta Sarkar and S Sarkar

Abstract
Climate change is expected to intensify the hydrological cycle and to alter evapotranspiration (Huntington, 2006), with implications for ecosystem services and feedback to regional and global climate. Evapotranspiration changes may already be under way, but direct observational constraints are lacking at the global scale. Until such evidence is available, changes in the water cycle on land a key diagnostic criterion of the effects of climate change and variability remain uncertain. Land evapotranspiration (ET_0) is a central process in the climate system and a nexus of the water, energy and carbon cycles Acceleration or intensification of the hydrological cycle with global warming is a long-standing paradigm in climate research (Huntington, 2006). A global network (FLUXNET) of continuous in situ measurements of land–atmosphere exchanges, including of water vapour, has been established over the last decade. The recent climatologically studies found that the global surface air temperature increased by 0.76 °C from year 1850 to year 2005. Moreover, the linear warming trend over the last 50 years is recorded by 0.13 °C per decade (IPCC, 2007). Now a days many researchers are addressing the impact of climate change on status of evapotranspiration in relation to increase in atmospheric temperature, vapour pressure deficit, precipitation and wind speed (Harmsen *et al*., 2009) [5].

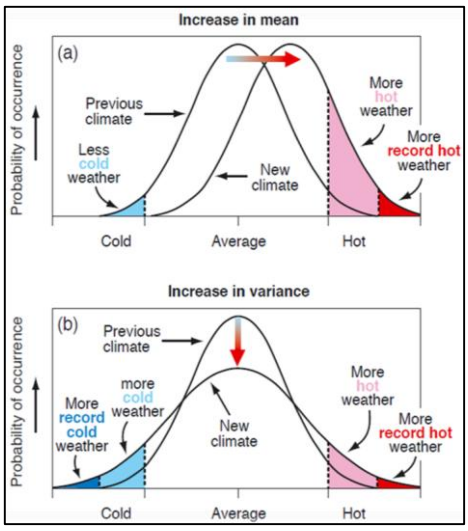
Keywords: Evapotranspiration, ET_0, hydrological cycle, vapour pressure deficit etc.

Introduction

1. What is climate change?

According to the Intergovernmental Panel on Climate Change (IPCC, 2007): "Climate change refers to a statistically significant variation in either the mean state of the climate or in its Variability, persisting for an extended period (typically decades or longer)".

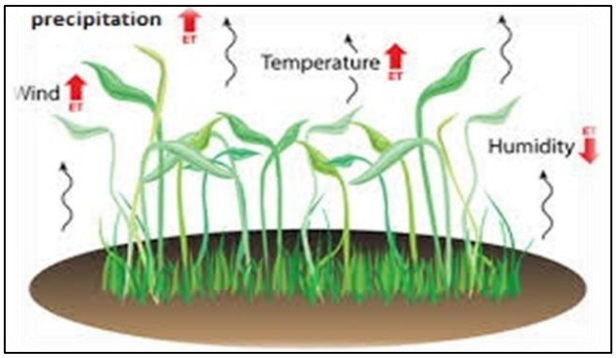
Climate change is a long-term shift in the statistics of the weather (including its averages). For example, it could show up as a change in climate (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next. We know that the global climate is currently changing. The last decade of the 20th Century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record, starting in the mid-19th century.



Concept of Climate Change

2. Impact of climate change on evapotranspiration

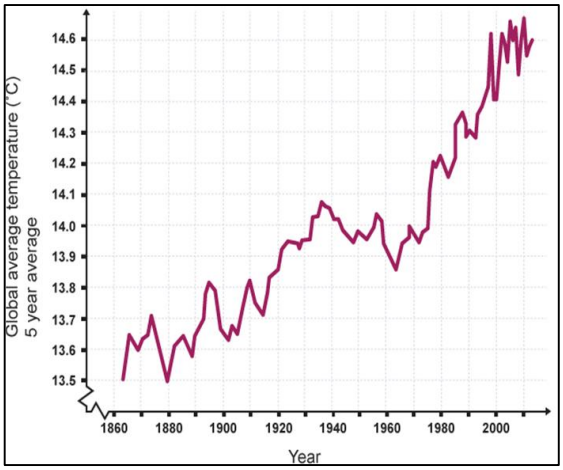
Evapotranspiration (ET) is the quantity of water transpired by the plants during their growth period, plus the moisture evaporated from the surface of the soil and the vegetation (Michel 1978). The rate of ET depends on energy and water availability at the evaporating site and the vapour pressure gradient. These three conditions are highly affected by the climate change, as a result of which the rate of ET changes.

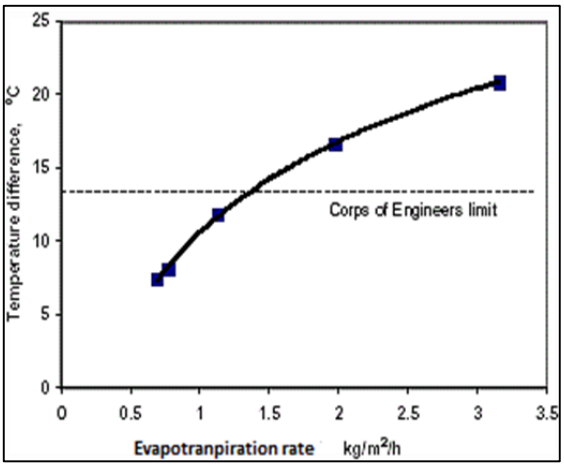


- **Effect of increasing temperature on ET**

As temperature increase due to climate change, the rate of evapotranspiration increases because there is a higher amount of energy available to convert the liquid water to water vapour.

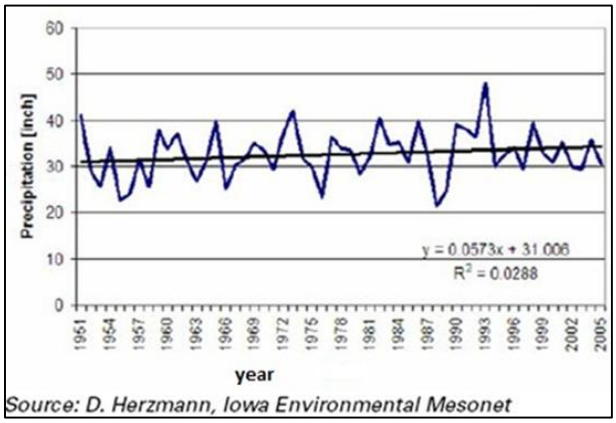
Mahmood (1997) [15] reported a 5% increase in total seasonal evapotranspiration under each 1 ^{0}C increase in temperature. Synder *et al*. (2011) concluded that the impact of global warming on ET will be less in the location with higher wind speed.

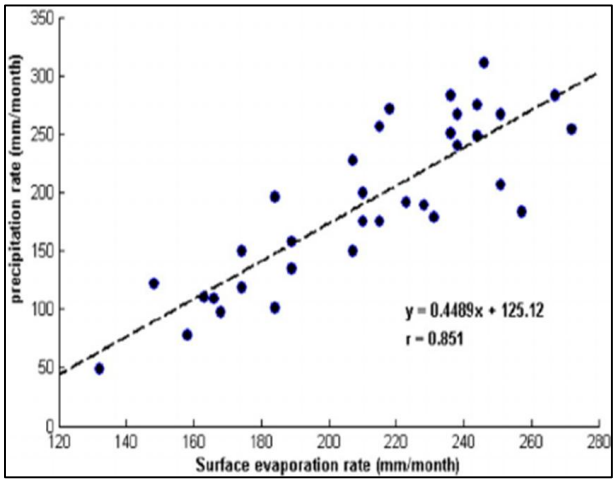




- **Effect of change in precipitation on ET**

Due to the climate change the precipitation also increases which increases the availability of moisture to the evaporating surface and as a result the rate of evaporation increases.





- **Effect of increasing concentration of CO_2 on ET**

First: As CO_2 concentration increases, leaf stomata partially close in response to maintain CO_2 concentration inside the stomata. As a result the rate of transpiration decreases.

Secondly: Increasing CO_2 level promotes growth of leaf area, so a larger surface area exists for transpiration.

A 40% reduction in stomatal conductance probably provides a 10 to 15% reduction in ET.

- **Effect of change in wind speed on ET**

As the temperature increases, the wind speed also increases and it causes higher ET by bringing the drier wind and heat energy to the site of evapotranspiration.

- **Effect of change in vapour pressure gradient on evaporation**

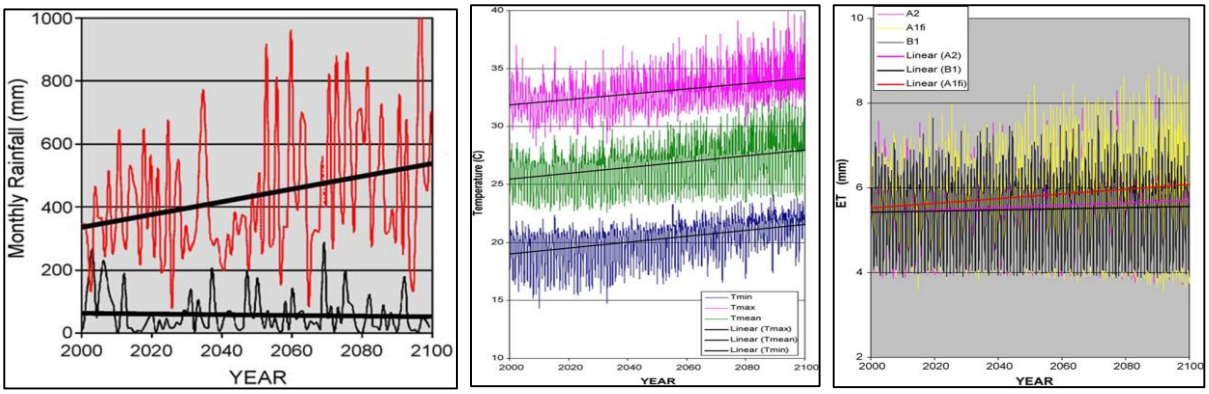
While ET rates are known to increase with higher temperature, the global humidity is likely to increase. As a result the rate of evapotranspiration decreases because the vapour pressure gradient which acts as a driving force of ET also decreases.

But when temperature and wind speed are constant but humidity increases, the rate of evaporation will decrease and when wind speed and humidity stay constant the rate of evaporation will increase because warmer air can hold more vapour than colder air.

3. Some case studies on the effect of climate change on Evapotranspiration

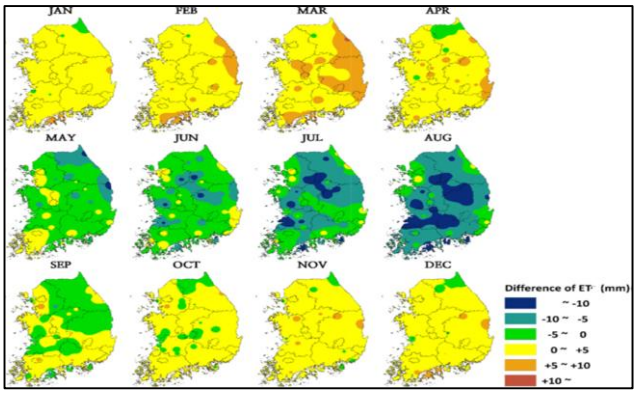
A. In India an attempt has been made to study the sensitivity of ET to global warming for arid regions of Rajasthan. The study suggests an increase of 14.8% of total ET demand with increase in temperature by 20% (maximum 8° C). ET is less sensitive to increase in net radiation followed by wind speed in comparison to temperature. Increase in vapour pressure (20%) has a small negative effect on ET(-4.31%). 10% increase in temperature and actual vapour pressure with 10% decrease in net solar radiation results decrease in ET (0.30%).

B. In the Lajas location of Puerto Rico, Eric W. Harmsen *et al*. studied on the effect of climate change on evapotranspiration. The result showed an increasing trend of evapotranspiration due to the increasing trend of temperature and precipitation.



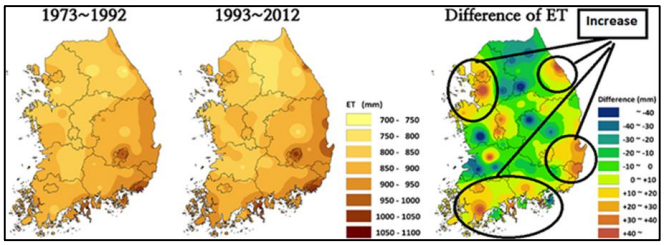
(Source: Eric W. Harmsen, Norman L. Miller, Nicole J. Schlegel, J.E. Gonzalez. Agrl. Water Management, 2009) [5]

C. In South Korea the spatial distributions of the different monthly ET values between 1973-1992 and 1993-2012, showed a significant increase from October to April, with a significant decrease from May to September during 1993-2012, compared to the past (1973-1992).



Spatial distribution of the difference in values of monthly ET between 1973-1992 and 1993-2012. (Source: Nam *et al*., 2015) [17]

D. In South Korea the spatial distributions of the annual ET change and difference values between 1973-1992 and 1993-2012, showed that over the past 20 years(1993-2012), the annual ET increased around the northwest and south areas, while decreasing around the north, midwest and central areas, compared to the past (1973-1992).

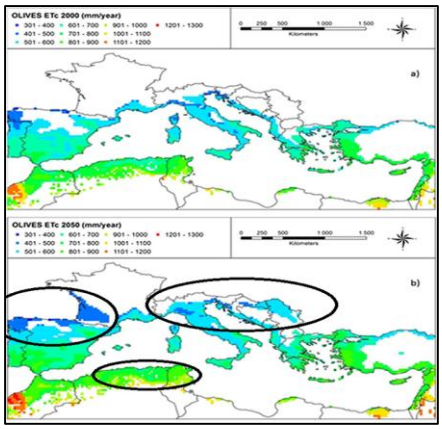


Differences in Special distribution of annual PET in Korean Peninsula (35◦50N, 127◦00W). (Source: Nam *et al*., 2015) [17]

E. In Mexico 157 meteorological stations show a positive change in the rate of evapotranspiration due to the climate change.

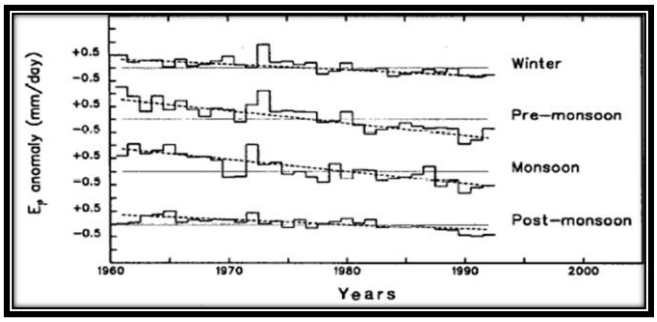
Percentage difference of ET for the month of July between 2015 and 2030 scenarios (Source: Martín Mundo-Molina, 2015) [16]

F. In the Mediterranean region a comparison between the Olive crop ET for present condition, yr 2000 (a) and future scenario, yr 2050 (b) show an increasing trend of evapotranspiration from the crop field due to the climate change.



Olive crop ET for present conditions, yr 2000 (a) and future scenario, yr 2050 (b) in Mediterranean region (Source: Tanasijevic *et al*., 2014) [20]

G. The analysis on pan evaporation in different regions over India during the period 1961-1992 have shown that evaporation have decreased during that period because during this time the amount of incoming solar radiation decreased.



(*Source:* N. Chattopadhyay, M. Hulme, 1996)

4. Conclusion

Since PET is a key parameter in determining crop water demand and irrigation scheduling, the temporal trend of PET is an important concern with reference to climate change. Due to climate change status of the conditions needed to run the evapotranspiration will vary markedly in future. In majority cases an increasing trend in atmospheric temperature, vapour pressure gradient and precipitation has been reported. The rate of ET increases with the increase in temperature, precipitation and wind speed and decreases with the increase in humidity in the atmosphere.

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