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A Simple Model to Estimate Actual Evaporation for Iraq Based on Satellite Data

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Abstract:
The hydrological cycle plays a key role in life on our planet. It is closely related with exchanges of energy between Earth's surface and the atmosphere, which ultimately determines the climate the purpose of this study is to apply a statistical model in order to estimate and calculate Actual evaporation for Iraq in 1984-2010 based on Precipitable Water Vapor Data from Satellites. We calculated the water cycle rate for this purpose using satellite data, and we used data from the Planet Simulator model to determine the precipitation/evaporation relationship during a 10-year period. The relative error in estimating the evaporation rate using the model does not exceed 2.1%. Results showed that the actual evaporation in 1983-2009 for Iraq ranging between (0.5 - 2.4) mm/day as a monthly average and (0.79-1.43) mm/day as yearly average. and the actual evaporation decrease in the last years.

Keywords: hydrological cycle, evaporation, Precipitable Water Vapor, security healthcare

Introduction:
The hydrologic cycle, commonly referred to as the water cycle, depicts the constant movement of water on, above, and below the Earth's surface. Water is essential to supporting life on Earth and helps link its lands, oceans, and atmosphere into a cohesive whole. he energy exchanges between the atmosphere, ocean, and land that shape the Earth's climate and contribute significantly to natural climate variability are closely related to this cycle of water. Changes in the water cycle are the main cause of how climate change and variability affect human life quality. The energy cycle and Earth's climate both benefit from the water cycle. Because water vapor is the most prominent greenhouse gas in the atmosphere and because a sizeable portion of the energy released by the Earth's surface is absorbed by the atmosphere before being reemitted, the system's temperature is greatly raised. The studies which relate to estimating

evaporation rates based on satellite data have just recently appeared. Several studies have investigated the evaporation values using satellite data for some meteorological parameters like as (saturated vapor pressure, relative humidity rainfall, temperature, Wind direction and speed and solar radiation), and then applied in a statistical and mathematical models such as the Benmans model, the Priestley-Taylor model, the energy budget equation and water balance equation. DG Miralles and et al. [1] estimated the global evaporation values of the Earth's surface based on data measured by satellites (net solar radiation, temperature and rainfall) by using the Priestly-Taylor model, and they obtained important results by calculating the correlation coefficient (r=0.8) Between the estimated values and measured values of earth stations. M. Hassan [2] used the energy budget method (SEBAL) in calculating the evaporation values of Lake Nasser in Upper Egypt based on meteorological data (radiation, temperature and wind speed) measured by satellites. Rathod and Maekar [3] used satellite imagery of the satellites (LISS III and Landsat) to find the actual evaporation values of five types of land by comparing the differences in satellite images for several years and comparing the results with the calculated evaporation values of the Penman-Monteith model (the correlation coefficient between them was 0.92). Sini and et al [4] collected two methods in one model for estimating the evaporation values: temperature satellite measurements and energy budget method to calculate evaporation values. A precipitation filter was created for wet soil model simulators.

1- Data and method

Using data from the International Satellite Cloud Climatology Project (http://isccp.giss.nasa.gov), the monthly precipitable water vapour for global has been analyzed in this work for the period 1984 to 2010. the total atmospheric water vapour contained in a vertical column of a unit cross-sectional area extending between any two specified levels called Precipitable water vapour (PWV), which is expressed in terms of the height to which that liquid water would stand if completely condensed and collected in a vessel of the same unit cross section. The Global Precipitation Climatology Project (http://www.esrl.noaa.gov) provided the monthly precipitation rate (P) in mm/day for the global throughout the years (1984–2010), which we use in this example. The hydrological cycle's most crucial element, precipitation, is thought to be a good indicator of climate change. due to the fact that the Rate of Water Cycle (RWC) is comprised of P and PWV. For the same period, the yearly average of the monthly mean of PWV and P data for Iraq (400 E – 470 E and 300 N – 370 N). This was accomplished using the well-known program Climate Data Operators (CDO). Thus, 2 time series with 27 values each were produced. For 10 years, the global average of evaporation (E) and precipitation (P) were compared using climate model Planet Simulator (PSM). The Meteorological Institute of Hamburg University created the planet-scale, medium-complexity model known as Planet Simulator to conduct numerical experiments on the processes of climate change on our planet and other planets. [5];[6].

2- Results and discussion

The annual changes of the Precipitable Water Vapor (PWV) with the precipitation rate (P) during the study period are shown in Figure 1, It seems clear that the variation in Precipitable Water Vapor follows the variation of the precipitation rate, this indicates a relationship between each PWV and P as a part of the hydrological cycle. Precipitable Water Vapor values increase due to the increase in precipitation values can be seen in Figure 1. This means that when the amount of water available for evaporation increases, it will lead to an increase in the amount of precipitation.

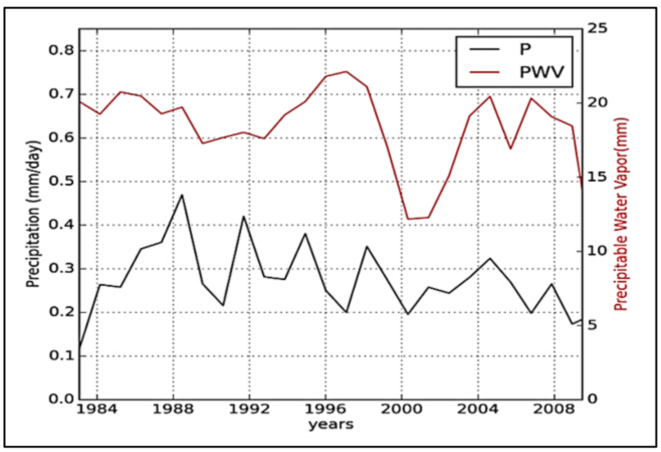

Figure 1: precipitation rate variations (mm/day) and precipitable water vapour variations (mm) in 1984 − 2010.

In the other study [7], By dividing the precipitation for the study period by the amount of precipitable water vapour, we were able to calculate the Rate of Water Cycle (RWC). The RWC, thus, stands for the ratio of precipitation volume to precipitable water vapour content. RWC changes are shown in Figure 2 (1984–2010); the average RWC for Iraq was around 0.064 1/days. So, we may say:

$$P/PWV = 0.064 \quad \text{-------------------------------} \quad (1)$$

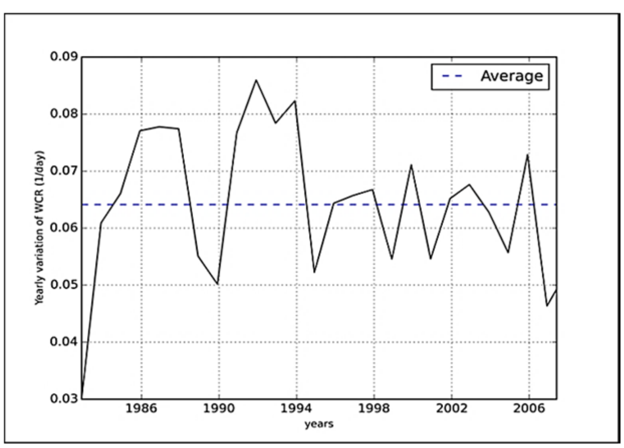

Figure 2: RWC variations 1/day in 1984 − 2010.

Figure.3 shows the behavior of the precipitation rate and evaporation rate, which they calculated by (PSM) for ten years. An inverse correlation can be observed between the fluctuation of the evaporation rate and the fluctuation of the precipitation rate. So that the sum of their averages is zero, it can be seen the rate of evaporation equal the rate of precipitation, and the average sum of them =0, as shown in Figure 4. Thus, (Evaporation = Precipitation), so equation (1) can be written as follow:

Evaporation = 0.064 PWV ------------------------------------(2)

By equation (2), calculated the monthly values of evaporation for Iraq in (1984 −2010) as shown in Figure 5 and the yearly evaporation values for Iraq in (1984 −2010) as shown in Figure 6, depending on the monthly PWV for Iraq in (1984 −2010). These figures show that the actual evaporation ranging between (0.5 - 2.4) mm/day as a monthly average and (0.79-1.43) mm/day as yearly average. we can note the actual evaporation decrease in the last years. It is the result of many causes including low amount of precipitation, agricultural land degradation and decrease rivers supply.

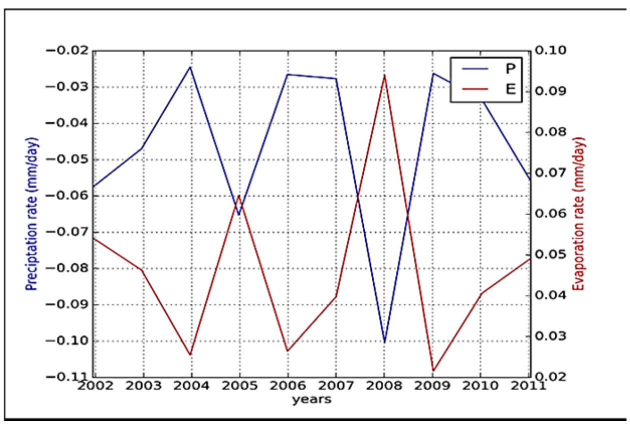

Figure 3: The rate of evaporation and the rate of precipitation for ten years by (PSM).

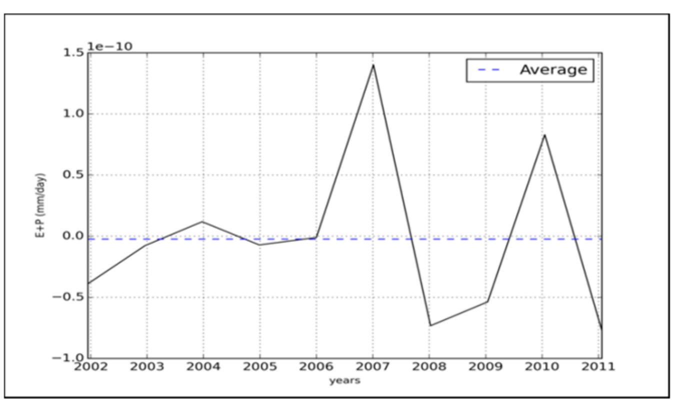

Figure 4: (Evaporation + Precipitation = 0) for ten years by (PSM).

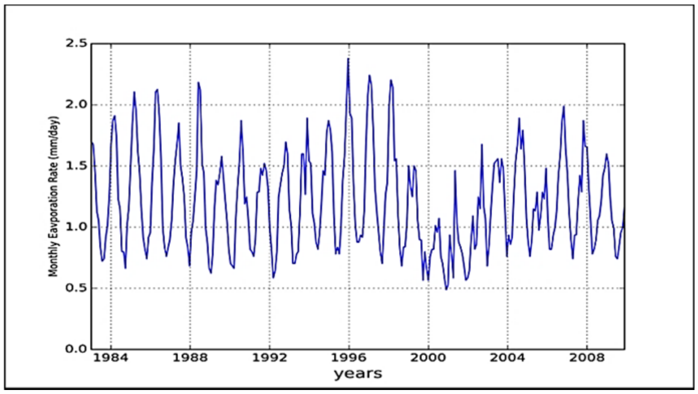

Figure 5: Monthly evaporation rate for Iraq in (1983 −2009) (mm/day)

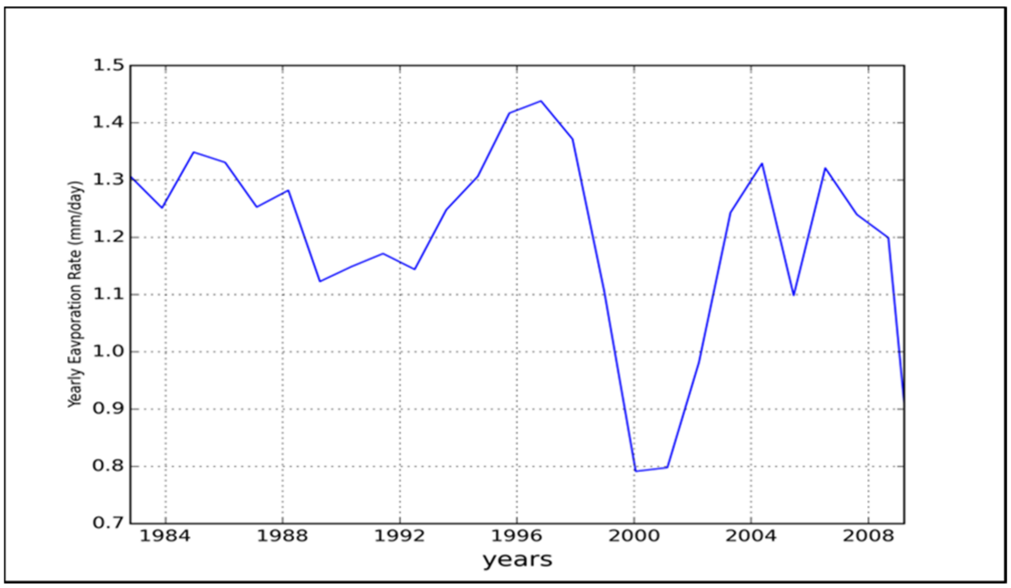

Figure 6: Yearly evaporation values for Iraq in (1983 −2009) (mm/day)

Definitely, the values of evaporation rates in this study are quite different from the potential or references evaporation/evapotranspiration rates calculated in many studies. For example, Abbas and et al [8] reached that the reference evapotranspiration in south of Iraq by Penman-Monteith equation was ranging between (2-18) mm/day, this result does not differ significantly from the values of daily Evaporation from Calculated Evapotranspiration in Iraq which was calculated by Ali and Faraj [9] and was (2-16) mm/day. Mohsen [10] found that the value of daily potential evaporation in the Abu Ghraib west of Baghdad is (1-12) mm/day. These studies based on surface weather station data covering only several regions and most of which are located in cultivated regions, As well as the shortage in measuring meteorological data in these stations because of the wars and political crises that the country has been through for more than 40 years and so far,. In addition to that, there are clear differences between Reference and Potential Evaporation/Evapotranspiration [11] on the one hand and between actual Evaporation/Evapotranspiration on the other. both Reference and Potential refers the amount of water which could have been evaporated if the soil had had an infinite amount of water to evaporate. While the Actual refer to the actual amount of water evaporated.

7. CONCLUSION

There are various methods using satellite data to estimate evaporation rates. These methods give different estimates of evaporation, due primarily to differences in the methods themselves, based on the energy balance equation and empirical formulas that take into account wind speed, temperature and atmospheric pressure. The statistical model we propose is based on using satellite data source only on the precipitable water vapor to estimate evaporation rate for Iraq in 1983-2009. The relative error in estimating the evaporation rate using a model does not exceed 2.1%. Since the evaporation process is an important part of the hydrological cycle and its rate is not measured correctly by existing methods of atmospheric remote sensing and surface weather stations covering only several regions and most of which are located in cultivated regions, As well as the shortage in measuring meteorological data in Iraq. The resulting method for estimating the evaporation rate is extremely important for understanding the hydrological cycle and studying processes in the climate system, such as climate change

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