Evapotranspiration Estimation of Paddy Rices in Thailand Utilizing Limited Meteorological Data

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ABSTRACT

Evapotranspiration (Et) information used for irrigation scheduling may benefit farmers in increasing the irrigations area and evaluating amount of water applied. In Thailand, there are several methods of evapotranspiration estimating. The Bowen ration technique is the method of evapotranspiration estimating which is firstly applied to paddy field in Thailand. This research is attempted to generate the basic meteorological data which are necessary for formulating simple model to determine evapotranspiration. The model is simplified evapotranspiration from Bowen ratio technique with linear regression and non linear regression method using basic meteorological data. By comparing evapotranspiration from simple model with evapotranspiration from Bowen ratio method, it shows the similar pattern of distribution over a year. Therefore, in the paddy field area of which limited meteorological data, the simple model can be applied for evapotranspiration estimating.

Keywords : Evapotranspiration, Bowen ratio, Simple model

INTRODUCTION

Evapotranspiration(Et) is a major component of the hydrologic cycle. It is represented the loss of water from both soil and plant surface and is very especially important factor in planning and developing river basin and water resources. Evapotranspiration is the combined processes by which water is transferred from the earth's surface to the atmosphere, its means evaporation of liquid or solid water plus transpiration from plants. Evapotranspiration forms the foundation for the planning and designing of most irrigation projects and irrigation development. The evapotranspiration is the same as consumptive use which includes evaporation of water from land and water surface and transpiration by vegetation. Consumptive use has been important in arid and semi-arid irrigated areas of the world and also its importance humid areas is increasing with expansion of supplemental irrigation. There are two types of evapotranspiration have been widely expressed in irrigation management, i.e , actual evapotranspiration(Ea) and potential evapotranspiration(Ep). Evapotranspiration data are essential for estimating irrigation water requirement especially for paddy rice field. In Thailand, the most important and economic plant is the rice. The rice usually is consumes great amount of water. The irrigated area in Thailand approximately 35,200 square kilometers(7% of all area). Those are total water used by rice will be very high. The estimated evapotranspiration is the one method to define the minimum of water used or water consumption in paddy field. Many Thai Scientist and Hydrologist try to computed and estimated evapotranspiration of paddy rice from Ep, are not from by Ea methods such as the Pan evaporation method, the Lysimeter method, the Blaney-Criddle method.

The Thornthwaite method, the Penman method, the Jensen-Haise method, the Combination method and others. Each method were given different values of evapotranspiration. The estimated evapotranspiration of paddy rice field is very important and should be studied delicately and intensively for water management especially in a condition of insufficient water.

Bowen ratio techniques are employs the Bowen ratio method estimate actual evapotranspiration(Eta) and used to estimated actual evapotranspiration in paddy rice field. The Bowen ratio method give high accurate value of estimated evapotranspiration.

How ever, the Bowen ratio method used many complex data and quite expensive in maintenance and data collecting. This research try to find the simple method by using basic meteorological data which be given the nearest value of evapotranspiration with the Bowen ratio method and can be used in at any paddy rices field of Thailand.

MATERIALS AND METHODS

The two Automatics Weather Station are located at two places. One is located in non irrigated paddy rice field at Sukhothai provine in lower northern region of Thailand. The other one is located in irrigated area of paddy rice field at Phitsanulok province 80 kilometers at the east of first site. The AWS are consisted of two dry and wet bulb thermometers in different level, (one was placed at 2 meters height above the rice crops), a net radiometer, three soil heat flux meters(at 1 cm depth in soil), the thermister sensor for the soil temperature, wind speed, wind direction, rain guage, water level sensor.

The instantaneous data of every one minute is collected by the data logger to get ten minutes average and finally averaged in to the daytime mean(from 8 a.m .to 4 pm).

From the energy balance

$$\mathbf{Rn + H + LE + G = 0} \qquad (1)$$

And from the Bowen ratio technique

$$\mathbf{B = H/ LE} \qquad (2)$$

B = Bowen ratio, H = sensible heat,
G = ground heatflux, Rn = net radiation
LE = latent heat flux

Then evaluated actual evapotranspiration and get the equation as:

$$\mathbf{Eta = -(Rn+G)/(1+\gamma dT/de)} \qquad (3)$$

Where Eta is actual evapotranspiration
γ is psychrometric constant
$= Cp.P/0.622L$
Cp is specific heat of air
P is atmospheric pressure
dT/de is gradient of temperature and humidity in air
L is latent heat of vaporization

From evapotranspiration which computed from equation (3) at both sites of AWS, then using linear and non linear regression related with meteorological data and gets the simple models as:

$$Et = a + bT + c\,RH + d\,WS \qquad (4)$$

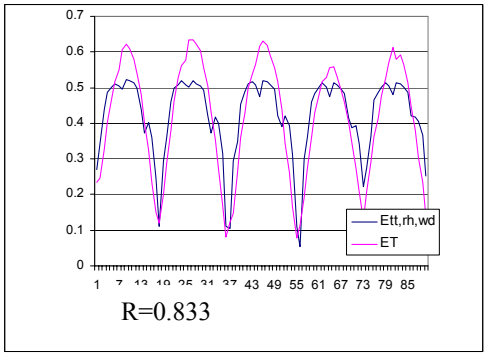
$$Et = a + bT^{c} \qquad (5)$$

$$Et = a + bRH^{c} \qquad (6)$$

$$Et = a + b\,WS^{c} \qquad (7)$$

Where Et is evapotranspiration
T is air temperature
RH is relative humidity
WS is wind speed

RESULTS

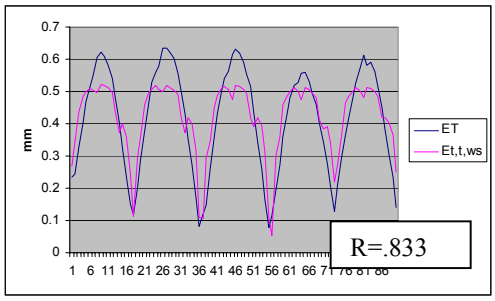


R=0.833

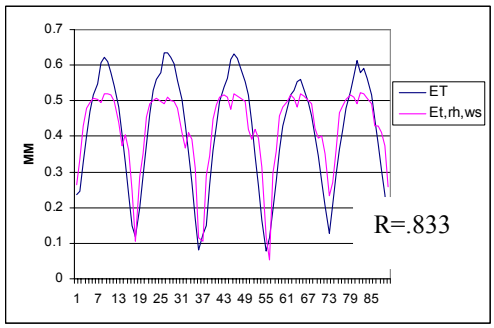
$Et(t,rh,ws)=-23.1+4.2x10^{-3}T+2.76x10^{-4}RH + 8.829x10^{-2}WS$

The hourly evapotranspiration calibrated from the Bowen method are following in the same shape and the values of hourly Et are quite equal.

The relation between Simple Et from wind speed and temperature with evapotranspiration from Bowen ratio as follow;

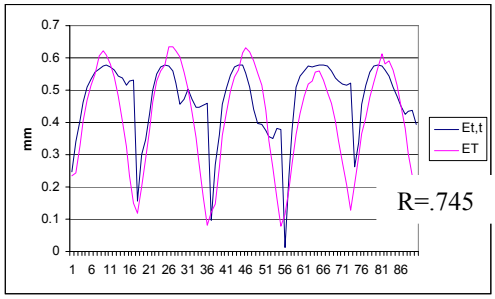


Et(t,ws) = -23.57-.0904T+0.00681WS



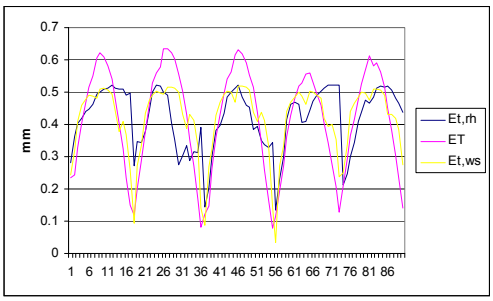
Et(rh,ws) = -22.822+0.0867WS+0.001RH

This relation of Et from Bowen ratio method and Et calibrated with wind speed and humidity going in the same direction.



Et(t) = -17.42634+1.116T- 0.01735T^2

The air temperature is the important factor for evapotranspiration. The hourly evapotranspiration from Bowen ratio method and temperature calibrating are look best fit.



Et(ws) = -11.0587 + 0.00016WS^2
Et(rh) = -1.3119 + 0.068RH- 0.000645RH^2

R are 0.83, 0.619 respectively

The graph above showed that hourly evapotranspiration which used wind speed factor and humidity respectively are following with Et computed by Bowen ratio. Evapotranspiration computed by Bowen ratio method, the peak in daytime were higher than two Et.

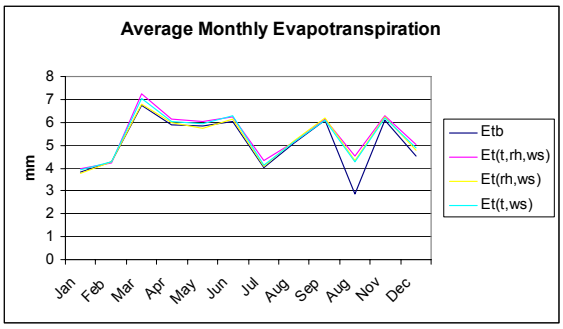
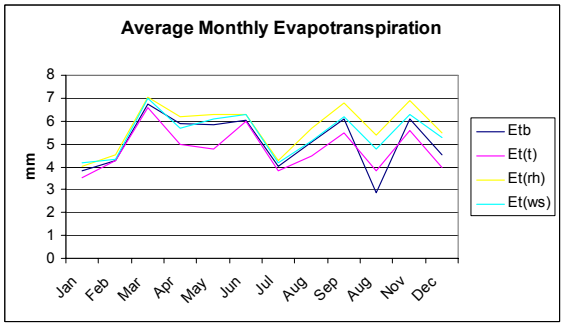
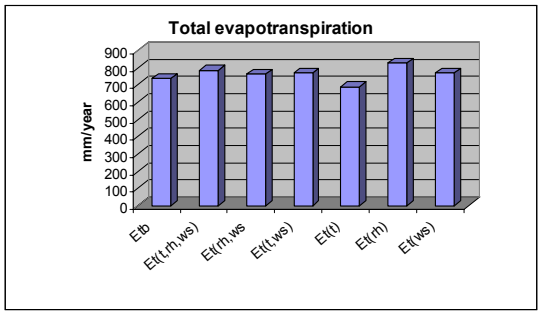


Figure above is shown that the seasonal evaspotranspiration of each methods are nearly different. So wind speed, temperature and humidity are important for evapotranspiration.



The average monthly evapotranspiration which used only one meteorological data, Et more different.



The total evapotranspiration of each method are shown at above. The evapotranspiration estimated from Bowen ration method(Etb), Et(t,rh,ws),Et(rh,ws), Et(t,ws),Et(t),Et(rh) and Et(ws) are 735.9,785.4,762,770.9,688.9,828 and 768 mm/year respectively. The amount of each evapotranspirations value are not much different. The highest of evapotranspiration is Et computed by using only humidity. The lowest is evapotranspiration computed using only temperature data. However, all data that used to calibrated and calculated are used data from 2002 year at the irrigated paddy field. Many data are missing, are damaged and also many problem. The Et that we estimated are insufficient data needed.

LIMITED CONDITIONS

!. Using data in year 2002
2. Using data only at irrigated paddy field
3. Estimated during 8.00am to 16.00 pm
4. Each Et data which get from Et formula should be multiplied by 18 to convert to daily Et if using average daily data.

CONCLUSION

The simple model to estimated evapotranspiration in paddy field can be used under limited conditions. The evapotranspirations getting from simple model are fit curve. However, those simple models equation should be accurate checking with more data and try to apply which other year. The simple models are convenient to used and estimated water consumption at paddy field in Thailand with simple meteorological data. The average total evapotransiration from simple models are 767.2 mm/year with the Bowen ratio method is 735.9 mm/year

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