Various Methods of Evapotranspiration

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Abstract

Evapotranspiration (ET) is a process by which water us transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants. It is an important process in the water cycle because it is responsible for 15% of the atmosphere's water vapor. Without that input of water vapor, clouds couldn't form and precipitation would never fail. In simulating the hydrological effect of climate change, evapotranspiration plays a central role and the study of the predicted evapotranspiration methods in hydrological models is important. It is a significant factor for the management of agriculture and water. The methods of evaluation have significant regional differences. The Food and Agriculture Organization (FAO) recommended Penman – Monteith (P-M) method that is widely accepted, but requires a high degree of data. Various methods were employed in order to estimate the range of temperature, radiation and physical methods. Therefore, the PET values of all the above listed methods have been estimated for the study area. This paper synthesizes and classifies the evapotranspiration evaluation methods which have been used in the hydrological models into the integrated conversion methods and classifies the methods by their mechanism.

Key words: Evapotranspiration, Evaporation, Food and Agriculture organization (FAO), Hydrological effect, Transpiration, Penman – Monteith (P-M) method.

Introduction

Evapotranspiration (ET) is an important water balance process as well as an important energy balance factor. The precise prediction is not only essential for climate change analysis and the assessment of water resources; it also offers a high level of application value in the management of crop water need, the prediction and monitoring of drought, efficient production and use of water resources etc. The cycle of land evapotranspiration (ET) is invisible and difficult to measure and needs to be calculated and estimated. In 1694, a researcher used the first evaporator, introducing basin evaporation tests in order to determine the evaporation of the water surface. The Dalton law of evaporation, which provided the evaporation theory of the basin with clear physical meaning, proposed in 1802 which included the wind, air temperature and humidity effect in the evapotranspiration (ET) [1].

In the vast semi-arid and dry sub-heterogeneous regions popularly known as the precipitation-fed regions, the watershed development in India has been the strategy for the growth and sustainability of agriculture. World waters are being consumed twice a year and projected food demand increases will need irrigation to be met. Watershed development projects to boost farming conserve natural resources and ensure rural livelihoods have been undertaken since the 1980s. The primary aim of the initiative, which has drawn large government funding over the last 25 years, was initially soil and water conservation. Therefore, the process of formulation, execution and management of actions with natural and human resources in the watershed, take into account all of the factors within the watershed, involves a participative integrated watershed management from the highest point (cableline) through the outlet [2]. The primary aim of the initiative, which has drawn large government funding over the last 25 years, was initially soil and water conservation. This requires direct soil evaporation, a small water surface and a wet canopy as well as vegetation transpiration. A. F. Meyer said that the temperatures indirectly influence the water table by inducing changes in the barometric pressure and can also directly affect the level of water calculated by the measurements and tests, soil and water temperature variations that cause water migration [3].

Since 1950, the land temperatures have been growing globally, having an impact on the water cycle. In many countries around the world, water management issues are becoming more and more urgent. The Food and Agriculture Organization (FAO) has reported that 69.5% of total water recycling is of agricultural water use. A major part of the water cycle is evapotranspiration. It covers both soil evaporation and plant transpiration and makes up 90% of precipitation in the semi-arid and arid areas [4]. Because the data on evapotranspiration are not determined, however, the reference evapotranspiration (ET0) is always used for estimating the real evapotranspiration and has been commonly used in forecasting the needs of the crop water.

Many initial or updated methods for the measurement of ET0 were suggested, most of which were commonly used. In accordance with the necessary data, these methods may be classified into different types, including: (1) temperature methods, (2) radiation methods and (3) combination methods [5]. Certain methods only need a few inputs. In most combination methods different weather factors were taken into the consideration however, given that ET0 can be influenced by the multiple factors. Previous studies suggested that the spatial and temporal patterns were shown for the output of various methods, the majority of which can only be implemented in the areas in which they have been developed.

North-east China's geographic region consists of the five provinces and is one of the major agricultural regions in the country. The agricultural areas, including the Sanjiang, Songnen and Liao plains, are mostly green. The plains make up over 40% of the China's grain yield. In addition, the production of crops in northern China was significantly affected by the drought disasters. The optimal equation other than the P-M formula must therefore be sought in the north-eastern China. This research is designed to identify the optimal alternative equation in the various subregions and periods in the study area and modifies it to optimize the equations by using the FAO P- M approach as a reference. The results can provide references for water management in areas and times with limited data for the study area and other places with similar climatic conditions.

Evapotranspiration is a major water balance and energy balance variable on the Earth's surface as well as a key climate system mechanism. In the future climatc conditions, the need for evaporations or possible evaporation is expected to rise almost throughout the planet. This is due to the atmosphere's water holding capacity which increases with the higher temperatures, but relative humidity is not expected to significantly change. The best non-combination equation solution was the FAO radiation form. Because of its persistent overestimation, the FAO-Penman process was poorly rated. Data quality for Indian conditions has several limitations. Moreover, PET must be calculated in order to determine the demand for crop water using crop specific coefficients [6].

Methods of evaporation include hydrological method, micro-meteorological method, plant physiology method based on the legislation and method of scintillometer. This hydrological method is based on the water balance principle to determine the entire evapotranspiration basin or sub-basin. Evapotranspiration is evaluated in this method either at a long time scale (usually in years), or in a small regional scale, cell scale or point scale (lysimeter method, water flow method). In order to determine evapotranspiration in a selected area, the micro-meteorological process is based on the energy equilibrium equation or aerodynamic equation. Nonetheless, it is difficult to achieve conclusions about the micro-meteorological system and it causes major mistakes (the Bowen ratio method of energy balance and the aerodynamic process), as well as complicated equipment manufacturing, thereby causing the maintenance problems and high costs [7]. All these problems make it hard to popularize this method. The physiological methods used in the plants are based on the law to assess the water consumption of plants and to calculate their transpiration in the basin.

Evapotranspiration can be measured by many methods, ranging from evaporating from water to a variety of potential evapotranspiration and specific evaporation, but most of them find evapotranspiration from one surface only, such as water, bare soil and vegetation, thus neglecting the water balance. Evapotranspiration is regarded by these approaches not as an important hydrological mechanism but as a static quantity which is to be calculated. Nonetheless, due to the technical constraints, it is difficult to estimate the time-scale needs, typically instantial as well as susceptible to external conditions, so its precision is not good. New remote sensing methods can estimate evapotranspiration at a Basin Scale. Evapotranspiration is regarded by these approaches not as an important hydrological mechanism but as a static quantity to be calculated. Estimates of real evapotranspiration based on hydrological models take account of water and energy impact and can be calculated on different spatial and temporal scales in order to satisfy the water resource assessment and management requirements. There are several types and different data input requirements for evapotranspiration estimation procedures that are based on the existing model hydrology. At the same time, their findings are rarely equivalent in their precision. In the following sections, the modules of the evaluation of evapotranspiration based on the current hydrological models, their variations are evaluated and categorized according to their principles of estimation [8]. Eventually, the prospective evapotranspiration patterns are estimated on the basis of hydrological models.

Evapotranspiration estimation methods in hydrological models:

There are two different evapotranspiration methods in hydrological models: firstly, the estimation of surface water evaporation, the soil evaporation and the vegetable transpiration, and then the evapotranspiration of the basin depending on the pattern of land use. The second calculates the ETp (evapotranspiration) and then transforms it into the actual evapotranspiration (ETa) which is assessed by the Soil Moisture Extraction Method. The first type method is considered as the classification gathering methods, while the second type method is considered as the integrated converting methods [9].

Table 1 lists certain methods that are commonly used in the hydrological models for testing evapotranspiration. The integrated methods of conversion are widely used in the lumped principles, models and distributed models, while physically-based hydrological models usually use classification methods for estimating basin evapotranspiration.

Table1: Selected evapotranspiration estimation methods applied in hydrological models (HM)

Type	Kind of input ETp
	Input
	Evapotranspiration rate
	Input
	Jensen-Haise
Integrated Converting Methods	Penman; Priestley-Taylor
	Water surface ETp
	Hargreaves; Water surface ETp
	Input
	Hargreaves; Water surface ETp
	Penman-Monteith; Preistley-taylor; Water surface ETp
	Thorthwaite
	Penman-Monteith
Classification Gathering Methods	Penman-Monteith
	Penman-Monteith
	Penman-Monteith

Differences among integrated converting methods:

In evaluating evapotranspiration, the integrated converting methods have the following advantages: they are user-friendly, require few input variables and are very adaptable. They are therefore commonly used in the hydrological models. According to several studies, it has been found that there are two variations with hydrological models: one is the different method to estimate the potential evapotranspiration which is usually used by the researchers based on the available data; the other has a different function for extracting the soil moisture, which differs considerably in complexity despite the same basic format. The following sections address these two variations.

a) Soil moisture extraction function:

Actual evapotranspiration is based on the probable evapotranspiration and the availability of water in soils in hypothetical hydrological models. Effectual soil moisture, separated by the field soil moisture, reflects the degree of soil humidity. When the actual content of the soil moisture is greater than the evaporation-limited soil moisture content with evapotranspiration limits, evapotranspiration is constrained only by the climatic conditions and water can evaporate more easily. The rate of evapotranspiration often decreases with declining soil humidity until the actual moisture content of the soil is less than the amount of moisture withering, or in other words, soil water has the largest deficit. Evapotranspiration is only at that time constrained by the conditions of water supply and evapotranspiration to zero levels. The basic formula for the extraction of soil moisture function is given below:

$$ETa = ETp\ [SMT/SMC]$$

Where; SMT is actual soil moisture and SMC is field capacity soil moisture.

According to some researchers, the hydrological model utilizes the soil moisture extraction functions. With water availability in soil, the ratios of the actual evapotranspiration and potential evapotranspiration changes. Fig. 1a shows their relationship; their format is related to the soil type and the Leaf Area Index (LAI), which is very similar to but hard to define the stage of growing vegetables. Fig. 1b displays different soil moisture curves of soil moisture extraction functions [10].

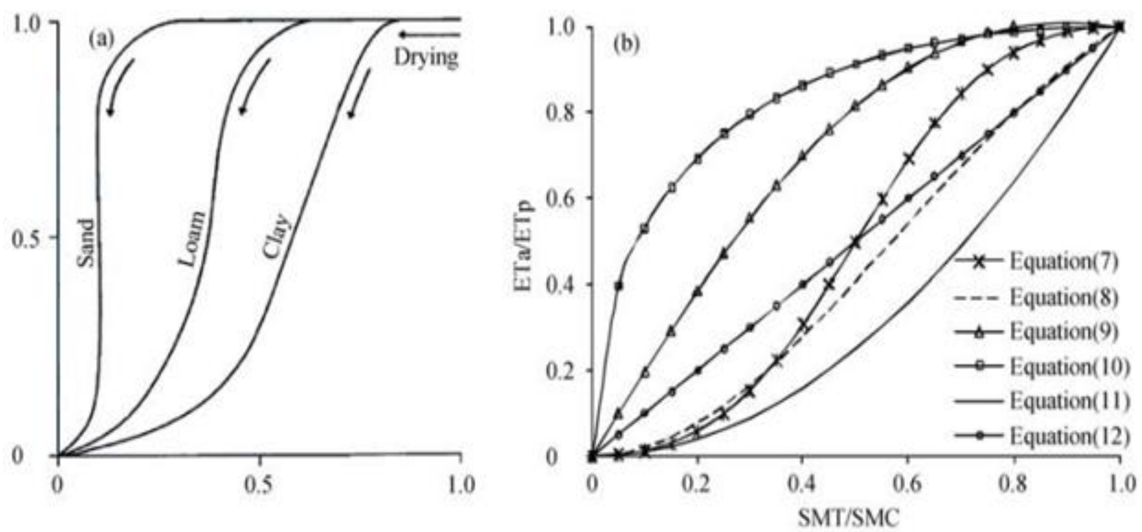

Fig.1: Nonlinear relationships between Eta and ETp.

Conclusion

Evapotranspiration plays a significant role in the balance of energy. Water is consumed through evapotranspiration from plant interception, surface water and ground water. Statistics show that evapotranspiration accounts for around 50% of the annual precipitation in humid areas, while evapotranspiration accounts for about 90% in arid regions. Evapotranspiration observations are extremely complicated and vulnerable to the external factors, so indirect estimation methods are used frequently. PET values dependent on the different parameters are obtained from various relationships. Estimates of the actual hydrological simulation evapotranspiration are of great significance in the sustainable management of water resources under changing environments. There are however a large number of methods of hydrological calculation of evapotranspiration.

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