Study on prediction model of crop evapotranspiration based on weather forecast

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Introduction

The key of water-saving irrigation is to carry out real-time irrigation prediction and the prediction of daily crop evapotranspiration (ET_c) is the basis of real-time irrigation prediction, which accurate prediction has important guiding significance for irrigation planning and regional water resource allocation. At present, ET_0 method based on weather forecast has been widely used. In addition, many researchers have used temperature to calculate K_c, but the combination of the ET_0 and K_c to predict ET_c was rare. The existing calculation model needs more data to predict ET_c, and it is difficult to obtain more comprehensive quantitative through weather forecast information (Park et al., 2017;. Zhao et al., 2010).

In this study, A simple, accurate calculation model of ET_0 based on temperature effect was tried to be selected, and then the crop coefficient method was used to calculate the ET_c of winter wheat, which provide relatively reliable data support for agricultural water management in irrigation area.

Model

Prediction model of crop coefficient based on temperature

$$TF_i = e^{-\left(\frac{T_i - T_0}{\beta}\right)^2}$$

$$Kc_i = K_0 e^{-\left(\frac{T_i - T_0}{\beta}\right)^2}$$

Prediction method of ET_0

$$ET_{(0,PM)} = \frac{0.408\times\Delta(Rn-G)+\gamma\times\frac{900}{T_{mean}+273})\times u_2\times(e_s-e_a)}{\Delta+\gamma\times(1+0.34\times u_2)}$$

$$ET_{(0,HS)} = 0.408K(T_{max}-T_{min})^n(T_{mean}+T_{off})R_a$$

$$ET_{(0,Mc)} = KW^{1.8T}$$

Notation: TF_i was the response to temperature on day i, T_i was the average temperature on day i, taking the average value of the highest temperature and the lowest temperature on that day; T_0 was the optimum temperature for physiological and ecological processes such as crop growth and photosynthesis, and β was the parameter to be estimated. ET_0 was the possible evaporation. Δ is the slope of the saturated water pressure curve; Rn was the surface net radiation. G was the soil heat flux, γ was the dry and wet meter constant. T_{mean} was the daily average temperature. u_2 was the wind speed at 2m height. e_s was the saturated water pressure. e_a was the actual water pressure, matching with the ET_0 value. $ET_{(0,HS)}$ was the reference crop water demand, mm/d; K was the conversion coefficient, the recommended value was 0.0023; T_{max}, T_{min} were the highest and lowest temperature,℃; n was the index coefficient, the recommended value was 0.5; T_{mean} was the average temperature,℃; T_{off} was the temperature offset, the recommended value was 17.8; R_a was the top radiation of the atmosphere, MJ/(m².d). The original parameters of McCloud K=1.24, W=1.030 as the initial value. Through the meteorological data of Daxing District, Beijing from 1961 to 2011, the parameters of Mc were calibrated, and the nonlinear regression analysis was carried out. After several iterations, the new parameter fitting values were obtained. The parameters after calibration were K=1.243, W=1.022, respectively.

Results

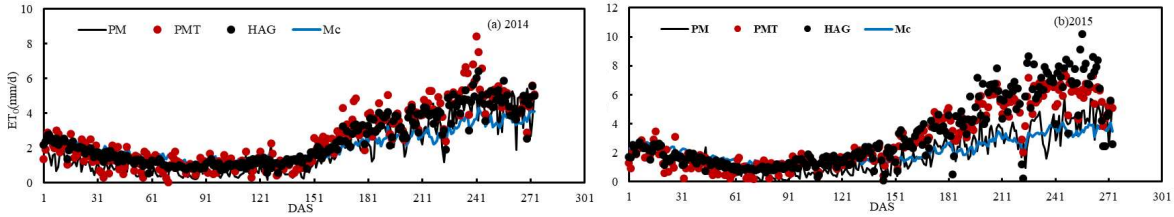

Figure 1. The models of PM, PMT, HAG and Mc

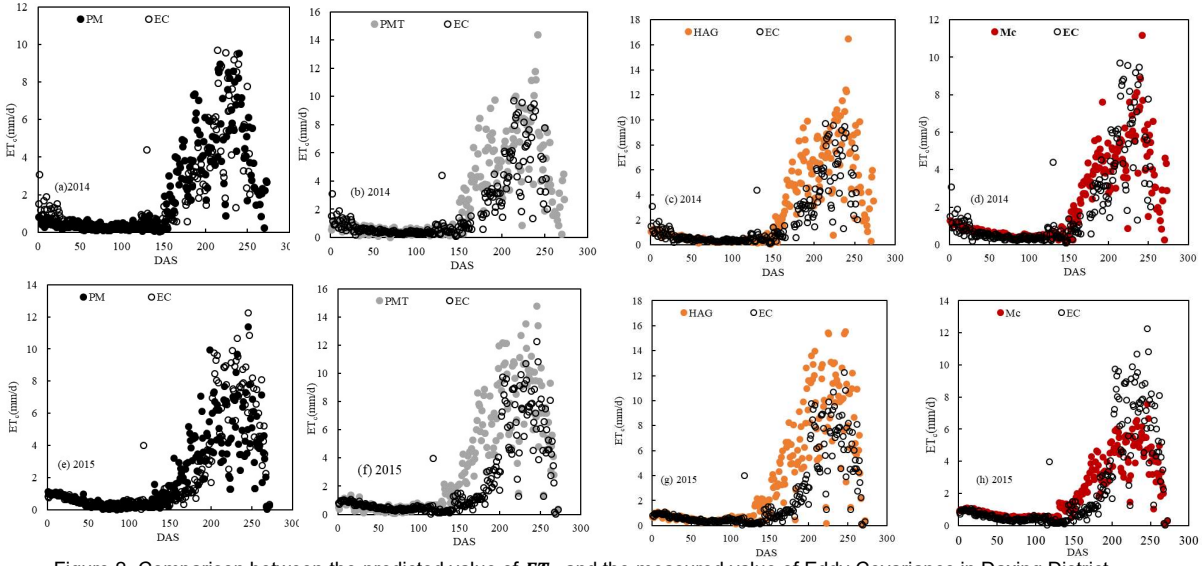

Figure 2. Comparison between the predicted value of ET_c and the measured value of Eddy Covariance in Daxing District

Table 1. Prediction of ET_c accuracy evaluation of winter wheat

Year	Model	Mean (mm/d)	a	b	r^2	MAE (mm/d)	RMSE (mm/d)	d_{IA}	Accuracy (error<1mm/d)	Accuracy (error<2mm/d)
2014	EC	1.96								
	PM	2.87	0.78	0.44	0.63	0.14	2.36	0.81	67.40	78.39
	PMT	3.80	0.62	0.36	0.62	0.17	2.75	0.75	62.64	73.26
	HAG	3.03	0.57	0.41	0.61	0.18	2.94	0.73	61.17	70.70
	Mc	1.86	0.87	0.15	0.61	0.14	2.26	0.78	68.86	80.59
2015	EC	2.05								
	PM	3.35	1.07	0.04	0.75	0.16	2.63	0.92	69.60	84.25
	PMT	3.61	0.68	-0.07	0.80	0.21	3.40	0.90	60.07	77.66
	HAG	2.02	0.62	-0.02	0.83	0.22	3.68	0.88	55.31	69.60
	Mc	2.22	1.41	-0.64	0.81	0.15	2.42	0.90	63.37	80.95

✓ Taking winter wheat as an example, this paper verified the prediction model of ET_0, then the prediction model of winter wheat ET_c combining with crop coefficient model were established, and the prediction ET_c was verified by Eddy Covariance. The conclusions were as follows:

✓ Compared with the calculation results of FAO56-PM model, the accuracy of three prediction models (PMT, HAG, Mc) were different, which the Mc prediction method was the most advantageous, and the consistency index between the calculation results of Mc and PM method was close to 1. The 1d accuracy (error < 2mm) in the study area were 97.4%, 84.5% (year of 2014 and 2015).

✓ There were also differences in the accuracy of the four winter wheat ET_c prediction models based on the crop coefficient calculation method. According to the results of Eddy Covariance verification, Mc prediction method was the best, and the consistency index were 0.776 and 0.887(2014 and 2015), which were close to 1. The accuracy of 1d prediction were 80.59% and 94.14%. This method has a wider application prospect in the prediction of ET_c.

References

Zhao et al., 2010, Scientia Agricultural Sinica.

Park et al., 2017, Catena.