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Short Communication

Comparison of different methods for estimation of reference evapotranspiration at Parbhani, Maharashtra

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Evapotranspiration exhibit significance for hydrologic water balance, irrigation system design and management, water resources planning and management, ground water recharge, predicting crop yield, etc. (Zhan and Feng, 2003). There are many empirical or semi empirical methods have been developed for estimating daily reference evapotranspiration from weather parameters (Jensen *et al.*, 1990). The Penman-Monteith method ranked as the best method for all climatic conditions (Allen *et al.*, 1998). FAO has recommended the use of the Penman-Monteith method as the standard method for estimation of ETo. Various author have computed evapotranspiration by different methods and compared with Penman-Monteith method (Rahman *et al.* 2008 Khandelwal *et al.* 1999; Kingra and Mahey 2009). With this context, the present paper aims to compare the performance of broadly used ETo estimation methods against FAO-56 Penman-Monteith method to suggest the most appropriate method of reference ET estimation for Parbhani, Maharashtra.

Parbhani is located at $19^0$16' N latitude and 76^0 46' E longitude and altitude of 423.50 m above mean sea level. The daily weather data for 35 years (1982-2017) were collected from observatory at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The meteorological data viz. maximum and minimum temperature (^{o}C), morning and evening relative humidity (%), bright sunshine hours (hour day^{-1}), wind speed (m s^{-1}) and evaporation (mm day^{-1}) were used to work out mean of each parameter to calculate reference evapotranspiration following different methods.

Reference evapotransipirations were estimated by various approaches viz. temperature based method of Hargreaves (1989); ran evaporation based method of Christiansen (1968) and FAO-24 ran evaporation method (Doorenbos and Pruitt, 1977); the radiation based method of Makkink (1957), Turc (1961), Priestley-Taylor (1972), Doorenbos and Pruitt (1975), Hargreaves and Samani (1985) and Jensen and Haise (1963); energy balance based methods of Modified Penman method (Doorenbos and Pruitt , 1975) and FAO-56 Penman-Monteith method (Allen *et al.*, 1998). Penman-Monteith equation has been recommended as a standard method of ETo estimation worldwide by defining the reference surface as a hypothetical grass surface with an assumed height of 0.12 m, with surface resistance of 70 s m^{-1} and albedo of 0.23 closely resembling the evaporation from extensive green grass of uniform height, actively growing, and sufficiently watered.

The performances of the different ETo estimation methods were evaluated by comparing the output values obtained by different methods with that of FAO-56 Penman-Monteith (PM) estimated reference ETo. The standard error of estimates (SEE) and correlations coefficients were worked out between methods with that obtained by P-M methods. The method which had provided the lowest SEE and the highest coefficient of correlation (r) was selected as the best method.

The monthly mean daily ETo values for different months estimated by the seven estimation methods are given in a Table 1. Monthly mean daily ETo increases continuously from January and reaches to its maximum during May. During June ETo decreases sharply and remains low during July and August with slight increase during month of September, October, November then it decreases afterwards. The total ETo is highest in the month of May followed by June and lowest in December followed by January. Among the methods Makkink, Pristley-Taylor, FAO-24 radiation method, Hargeaves-Samani method overestimated PM- method and Turc, Modified-Penman method, Pan-evaporation, Hargeaves, Jaise-Haise method, Christiansen method underestimated PM- method. Since in the month of May there is highest temperature and also wind speed, hence more evapotranspiration, but in the month of June, July and August ETo is less due to the occurrence of rain.

Table 1: Monthly mean daily ETo values estimated using eleven ETo methods and Statistical analysis between ETo estimates by Penman-Monteith method and other methods under study

Month	Temperature based method	Pan evaporation based methods		Radiation based methods						Energy balance based methods	
	Hargreaves	Christiansen	FAO-24 Pan evaporation	Makkink	Turc	Priestley-Taylor	FAO-24 radiation	Hargreaves-Samani	Jensen and Haise	Modified Penman	FAO-56 Penman-Monteith
Jan	4.24	3.24	3.27	8.24	3.63	7.92	5.78	10.40	4.42	2.77	4.07
Feb	5.24	4.01	4.34	9.92	4.34	9.34	6.93	12.85	5.67	3.44	5.19
Mar	6.49	5.05	5.87	11.42	5.00	10.49	7.97	15.90	7.12	4.15	6.36
Apr	7.43	6.32	7.72	12.63	5.52	11.34	8.86	18.21	8.47	4.77	7.63
May	7.55	7.20	9.00	12.50	5.48	11.09	9.00	18.50	8.78	4.88	9.43
Jun	6.18	5.29	5.69	8.28	3.77	7.44	6.14	15.14	5.55	3.83	8.14
Jul	5.03	3.69	3.59	5.20	2.51	4.75	3.89	12.33	3.28	2.72	6.04
Aug	4.60	3.28	3.07	5.24	2.51	4.81	3.90	11.27	3.24	2.74	5.41
Sep	4.69	3.74	3.42	7.44	3.40	6.83	5.46	11.49	4.61	3.61	5.35
Oct	4.78	3.89	3.71	8.87	3.96	8.23	6.33	11.71	5.33	3.71	5.03
Nov	4.30	3.48	3.43	8.31	3.69	7.89	5.87	10.53	4.64	2.99	4.36
Dec	4.01	2.98	2.96	7.72	3.41	7.46	5.41	9.82	4.07	2.55	3.69
SEE	0.72	0.66	0.80	1.54	1.49	1.62	1.47	0.72	1.25	1.06	
Correlation coefficient (r).	0.84	0.86	0.80	0.28	0.32	0.20	0.34	0.84	0.52	0.66	

It is clear that among the radiation based methods, Priestly-Taylor method gives lowest coefficient of correlation (r) value and highest error values. On the other hand, among the Pan evaporation based methods, Christiansen method gives less SEE and highest coefficient of correlation (r) value. Christiansen method was found most close to FAO-56 Penman-Monteith method and Priestly-Taylor method performed poor at Parbhani.

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