Supplementary Materials for

Ranking of Empirical Evapotranspiration Models in Different Climate Zones of Pakistan

Mohammed Magdy Hamed[1,2,*] Najeebullah Khan[3], Mohd Khairul Idlan Muhammad[2] and Shamsuddin Shahid[2,*]

Table S1. List of the empirical ET equations and applications.

(a) o	Model (Year)	Equation	Application
(b)	Dalton (1802)	ET = $(0.3648 + 0.07223(u))(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
2	Trabert (1896)	ET = $(0.3075)\sqrt{u}(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
3	Meyer (1926)	ET = $(0.375 + 0.05026(u))(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
4	Rohwer (1931)	ET = $(3.3 + 0.891(u))(e_s - e_a)$	Valipour (2014), Rezaei (2016)
5	Penman (1948)	ET = $(2.625 + 0.000479/u)(e_s - e_a)$	Valipour (2014), Rezaei (2016)
6	Albrecht (1950)	ET = $(0.1005 + 0.297(u))(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
7	Makkink (1957)	ET = $0.61\left(\frac{\Delta}{\Delta+\gamma}\right)\frac{R_s}{58.5} - 0.12$	Lu et al (2005), Niaghi et al (2013), Rahimikhoob et al (2012)
8	Ivanov (1961)	ET = $0.00006(25 + \mathrm{T}_{mean})^2(100 - RH)$	Valipour (2014), Rezaei (2016)
9	Turc (1961)	ET = $0.013\left(\frac{T_{mean}}{T_{mean}+15}\right)(R_s + 50)$	Heydari et al (2013), Lu et al (2005), Xystrakis and Matzarakis (2010)
10	Hamon (1963)	ET = $0.1651 L_d$ RHOSAT x KPEC RHOSAT = $\frac{216.7\mathrm{ESAT}}{T_{mean}+273.3}$ ESAT = $6.108\exp\left(\frac{17.269\times T_{mean}}{T_{mean}+273.3}\right)$	Lu et al (2005)
11	Jensen Haise (1963)	ET = $\left(\frac{R_s}{\lambda}\right)(0.025T_{mean} + 0.08)$	Xystrakis and Matzarakis (2010); Heydari et al (2014)
12	Brockamp & Wenner (1963)	ET = $0.543(u^{0.456})(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
13	Papadakis (1966)	ET = $2.5(e_{ma} - e_a)$	Valipour (2014), Rezaei (2016)
14	WMO (1966)	ET = $(0.1298 + 0.0934(u))(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
15	Schendel (1967)	ET = $16\left(\frac{\mathrm{Tmean}}{\mathrm{RH}}\right)$	Bormann (2011), Djaman (2015)
16	Mahringer (1970)	ET = $(0.15072)\sqrt{3.6u}(e_s - e_a)$	Bormann (2011), Tabari et al (2013), Valipour (2014), Rezaei (2016)
17	Priestley Taylor (1972)	ET = $\alpha\left(\frac{\Delta}{\Delta+\gamma}\right)\frac{R_n}{\lambda}$	Bormann (2011), Niaghi et al (2013), Rahimikhoob et al (2012)
18	McGuinness & Bordne (1972)	ET = $(0.0082T_{mean} - 0.19)\frac{R_s}{1500}(2.54)$	Tabari et al (2013), Heydari et al (2014)
19	Szasz (1973)	ET = $0.00536(T_{mean} + 21)^2\left(1 - \frac{RH}{100}\right)^{2/3} f(u)$ $f(u) = (0.0519u) + 0.905$	Rácz et al (2013)
20	Caprio (1974)	ET = $\left(\frac{6.1}{10^6}\right)R_s(1.8T_{mean} + 1.0)$	Oudin et al (2005)

21	Blaney Criddle (1977)	ET = $k \times p(0.46T_{mean} + 8.13)$	Niaghi et al (2013, Heydari et al (2014), Josilva et al (2016), Poyen et al (2018)
22	Linacre (1977)	$ET = \frac{\frac{700(T_{mean} \pm 0.006z)}{100 - L} + 15(T_{mean} - T_d)}{80 - T_{mean}}$	Josilva (2016)
23	Kharuffa (1985)	ET = $0.34pT_{mean}{}^{1.30}$	Heydari et al (2014)
24	Hargreaves Samani (1985)	ET = $\left(0.0023\frac{R_a}{2.45}\right)TD^{0.5}(T_{mean} + 17.8)$	Heydari et al (2013), Oudin et al (2005), Rahimikhoob et al (2012), Xu and Singh (2002), Xystrakis and Matzarakis (2010), Josilva et al (2016)
25	Ritchie (1990)	$ET = \alpha_1(3.87 \times 10^{-3})(\ R_s(0.6T_{max} + 0.4T_{min} + 29))$	Tabari et al (2013)
26	Abtew (1996)	ET = $0.53\left(\frac{R_s}{\lambda}\right)$	Abtew, 1996
27	FAO56 PM (1998a)	$ET = \frac{0.408(R_n - G) + \gamma\frac{900}{T_{mean} + 273}u(e_s - e_a)}{\Delta + \gamma(1 + 0.34u)}$	Heydari et al (2013), Niaghi et al (2013), Rahimikhoob et al (2012), Tabari et al (2013), Valipour (2014), Rezaei (2016)
28	Irmak-Rs (2003)	ET = $-0.611 + 0.149R_s + 0.079T_{mean}$	Heydari et al (2013), Niaghi et al (2013), Tabari et al (2013), Heydari et al (2014)
29	Irmak-Rn (2003	ET = $0.489 + 0.289R_n + 0.023T_{mean}$	Heydari et al (2013), Niaghi et al (2013), Tabari et al (2013), Heydari et al (2014)
30	Trajkovic (2007)	ET = $(0.0023R_a)TD^{0.424}(T_{mean} + 17.8)$	Djaman (2015)
31	Ravazzani (2012)	$ET = (0.817 + 0.00022z)(0.0023R_a)(TD^{0.5})(T_{mean} + 17.8)$	Djaman (2015)

ET is the potential evapotranspiration (mm day^{-1}). *ET is* in mm day^{-1} in all equations except Ritchie and McGuinness & Bordne models, ET is in cm day^{-1}. R_n is the net radiation (MJ m^{-2} day^{-1}). G is the soil heat flux (MJ m^{-2} day^{-1}). R_a is the extraterrestrial radiation (MJ m^{-2} day^{-1}). γ is the psychrometric constant (kPa/°C). e_s is the saturation vapour pressure (hPa). e_a is the actual vapour pressure (hPa). e_s and e_a are in hPa in all equations except Papadakis, Rohwer, Penman and FAO56 Penman-Monteith models, e_s and e_a are in kPa. Δ is the slope of the saturation vapour pressure–temperature curve (kPa/°C). λ is latent heat of evaporation (MJ/kg). T_{mean} is the average daily air temperature (°C). T_{mean} *is* in °C in all equations except McGuinness & Bordne model, T_{mean} is in degree Fahrenheit. U is the mean daily wind speed at 2 m (m s^{-1}). *f(u)* is function of wind speed. Z is the elevation (m). L is local latitude (degrees). T_d is dew point temperature (◦C). T_{min} is the minimum air temperature (°C). T_{max} is the maximum air temperature (°C). TD is maximum and minimum temperature difference (°C). RH is the average relative humidity (%). R_s is the solar radiation. R_s is in MJ m^{-2} day^{-1} in all equations except Turc, Makkink, Ritchie and McGuinness & Bordne models, R_s is in Cal/m^2 day and Caprio model, R_s is in kJ/m^2 day. e_{ma} is the saturation vapour pressure at the monthly mean daily maximum temperature (kPa). k is monthly consumptive use coefficient which depends on location, season and vegetation type. The average value of k is 0.8 which also requires local calibration (Poyen et al, 2018). p is the mean annual percentage of daytime hours for different latitudes that can be obtained from Doorenbos and Pruitt (1977). p is expressed as constant (0.274) in Josilva et al (2016). L_d is daytime length in multiples of 12 h. RHOSAT is saturated vapor density (g m^{-3}). ESAT is saturated vapor pressure (mbar). KPEC is calibration coefficient (1.2). α is constant (1.26). α_1 is constant (1.1).