Article

Potential evapotranspiration of managed grasslands - a climate change lysimeter study

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Abstract:
1. Evaluate default PET models
2. Evaluate calibrated PET models
3. Sensitivity analysis and model uncertainty of calibrated PET models
4. Implication of elevated CO_2 in PET models
5. Implication of warming in PET models
6. Combined effect of warming and elevated CO_2 in PET models
7. Evaluation, Sensitivity analysis and model uncertainty of calibrated PET models
[1], [2], [3], [4], [5], [6], [7]
8. Conclusion

Keywords: keyword 1; keyword 2; keyword 3 (list three to ten pertinent keywords specific to the article, yet reasonably common within the subject discipline.)

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1. Introduction

[8] - higher PET with managed grasslands and [9]

2. Evaluation of PET models(Materials and methos)

2.1. Previous research

Sensitivity to erros in potential evapotranspiration input [10] [11] and [12](z0 = 1 for meadow grass)(details of computation)(Blaney-Criddle-only mean T, Jensen-Hasie [13]-solar radiation with T) compared 9 PET methods using onsite meteo data (PEnman with empirical wind function applicable to a short grass with rougness coef of 1cm): [14]-sensitivty of PEnman

$$f(u) = 0.35 + 0.0035 * u_2 \tag{1}$$

Search for best PE formula [15], [16]

2.2. Used PET models

[16]

Priestley-Taylor [17]

$$E = \frac{\alpha}{\lambda}\frac{\Delta}{\Delta+\gamma}R_n \tag{2}$$

α = 1.26

Makkink (default) [17] [18]

$$ET = 0.61\frac{\Delta}{\Delta+\gamma}\frac{R_s}{\lambda} - 0.12 \tag{3}$$

Blaney-Criddle [17]

$$ET = kp(0.46T_a + 8.13) \tag{4}$$

where p = percentage of total daytime hours for the used period (daily or monthly) out of total daytime hours of the year (365x12);k = monthly consumptive use coefficient, depending on vegetation type, location and season and for the growing season (May to October), k varies from 0.5 for orange tree to 1.2 for dense natural vegetation. Following the recommendation of Blaney and Criddle (1950)[19], in the first stage of the comparative study, values of 0.85 and 0.45 were used for the growing season (April to September) and the non-growing season (October toMarch), respectively.

Hargreaves [20][21][22]

$$ET = a(T_{max} - T_{min})^{0.5}(T_{mean} + 17.8)\frac{R_a}{\lambda\rho_w} \tag{5}$$

a=0.0023

Ra is average daily exoatmospheric radiation(extra terrestrial)

FAO PM for reference(potential) evapotranspiration [23]

$$ET = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T_a+273}U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \tag{6}$$

Penman

$$E = \frac{1}{\lambda\rho_w}\frac{\Delta(R_n - G) + K_u\gamma(a_w + b_w u_2)(e_s - e_a)}{\Delta+\gamma} \tag{7}$$

where a_w and b_w are wind function coefficients that are usually receive a local or regional calibration. Parameter K_u =6.43 for ET in mmd^{-1} and K_u =0.268 for ET in mmhour^{-1}. Penman [24] used for clipped grass [17] a_w = 1.0 and b_w = 0.537, respectively,for wind speed in ms $^{-1}$, $es - ea$ in kPa and grass ETo in mmd^{-1}. The equations were intended for use with daily computations. In application of the 1963 Penman, saturation vapor pressure is traditionally based on mean daily air temperature rather than on Tmax and Tmin" [15].

Kimberley-Penman [17]

$$E = \frac{1}{\lambda\rho_w}\frac{\Delta(R_n - G) + K_u\gamma(a_w + b_w u_2)(e_s - e_a)}{\Delta+\gamma} \tag{8}$$

where:

$$a_w = 0.4 + 1.4exp - \left[\left(\frac{J - 173}{58} \right)^2 \right] \tag{9}$$

$$b_w = 0.605 + 0.345exp - \left[\left(\frac{J - 243}{80} \right)^2 \right] \tag{10}$$

Reference ET FAO with kc for grass

Jensen-Haise [17] - ET$_r$ is alfalfa reference ET

$$ET_r = \frac{1}{\lambda} C_r (T - Tx) R_s \tag{11}$$

C_r and T_x should be constant for a given area... Later Jensen defined: "Jensen and Haise (1963) evaluated 3,000 observations of ET as determined by soil sampling procedures over a 35-year period. From about 100 values for well-watered crops with full cover in the western United States, a linear relationship of a solar radiation coefficient and mean air temperature was apparent. From these data, the constants for the following linear equation were CT=0.025 and Tx=-3 for temperature in C. Rs has the same units as λ ETr."

$$C_1 = 38 - (2Elev/305) \tag{12}$$

$$T_x = -2.5 - 1.4(e_2 - e_1) - Elev/550 \tag{13}$$

Penman-Monteith [17]

$$E = \frac{1}{\lambda} \frac{\Delta (R_n - G) + \rho_a c_p (e_s - e_a)/r_{ah}}{\left[\Delta + \gamma (1 + \frac{r_s}{r_{ah}}) \right]} \tag{14}$$

Oudin [25]

$$ET = \frac{R_e}{\lambda \rho} \frac{T_a + 5}{100}, if T_a + 5 > 0, else ET = 0 \tag{15}$$

Hamon [25]

$$ET = \left(\frac{DL}{12} \right)^2 exp \left(\frac{T_a}{16} \right) \tag{16}$$

3. Evaluation of PET models with original constant values

Priestley-Taylor
Makkink
Blaney-Criddle
Hargreaves
FAO-pm-reference
Kimberley-Penman
Jensen-Haise
Penman-Monteith
Penman
Oudin
Hamon
FAO-pm-reference + crop coefficient

4. Evaluation of PET models with calibrated constant values

Priestley-Taylor

α

Makink to calibrate [17]

$$ET = f * \frac{1}{\lambda\rho}\left(\frac{0.63R_s\Delta}{\Delta+\gamma} - 14\right) \tag{17}$$

Blaney-Criddle

1. k

2. a, b Hargreaves

a

Kimberley-Penman = Penman

a, b

Jensen-Haise

Cr, tx

Penman-Monteith

rs, ra

Oudin

k1, k2

FAO-pm-reference + crop coefficient

crop coefficient(k_max)

5. Evaluation of PET models with original constant values/results

6. Evaluation of PET models with calibrated constant values/results

6.0.1. Inputs

R_n net longwave radiation

$$R_nl = f_{cd}(a_1 + b_1\sqrt{e_a})\sigma T^4 \tag{18}$$

if 24-hour or longer time steps...T^4 transforms to $(T^4_{max} - T^4_{min})/2$.
σ is for daily values 4.901 x 10^{-9} $MJm^{-2}d^{-1}K^{-4}$ with Rnl in $MJm^{-2}d^{-1}$
for hourly calculations σ = 2.042 x 10^{-10} MJm2 $h^{-1}K^{-4}$, Rnl is in MJm^{-2} h^{-1}.

Wright and Jensen [26] developed an expression for f_{cd}:

$$f_{cd} = a\frac{R_S}{R_{SO}} + b \tag{19}$$

a and b are empirical coefficients. General a= 1.3, b=0.3, a_1 = 0.39 and b_1=0.158

Bulleted lists look like this:

- First bullet
- Second bullet
- Third bullet

Numbered lists can be added as follows:

1. First item
2. Second item
3. Third item

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Text

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entry 2	data	data

Text
Text

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Please punctuate equations as regular text. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

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Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

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9. Conclusions

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	linear dichroism

Appendix A

Appendix A.1

The appendix is an optional section that can contain details and data supplemental to the main text. For example, explanations of experimental details that would disrupt the flow of the main text, but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data is shown in the main text can be added here if brief, or as Supplementary data. Mathematical proofs of results not central to the paper can be added as an appendix.

Appendix B

All appendix sections must be cited in the main text. In the appendixes, Figures, Tables, etc. should be labeled starting with 'A', e.g., Figure A1, Figure A2, etc.

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Sample Availability: Samples of the compounds ...... are available from the authors.

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