



Review

Evapotranspiration information reporting: II. Recommended documentation

Richard G. Allen^{a,*}, Luis S. Pereira^b, Terry A. Howell^c, Marvin E. Jensen^d^a Biological and Agricultural Engineering and Civil Engineering, University of Idaho, 3793 N 3600 E, Kimberly, ID, 83341, USA^b Biosystems Engineering, Institute of Agronomy, Technical University of Lisbon, Tapada da Ajuda, 1349-017 Lisbon, Portugal^c USDA-ARS, Bushland, TX, USA^d Formerly USDA-ARS and Colorado State University (ret.), Ft. Collins, CO, USA

ARTICLE INFO

Article history:

Received 29 December 2010

Accepted 30 December 2010

Available online 26 January 2011

Keywords:

Evapotranspiration

Measurement

Equipment

Calibration and validation requirements

Accuracy

Descriptive documentation

ABSTRACT

Researchers and journal authors, reviewers and readers can benefit from more complete documentation of published evapotranspiration (ET) information, including description of field procedures, instrumentation, data filtering, model parameterization, and site review. This information is important for discerning the likely accuracy and representativeness of the reported data and ET parameters, including derived crop coefficients. Documentation should include a description of the vegetation, its aerodynamic fetch, water management and background soil moisture, types of equipment and calibration checks, photographs of the measured vegetation/equipment combinations, and independent assessments of measured ET using models or other means. Documentation and assessment should include a description of, or reference to, all weather recording equipment and parameters, including the vegetation and water management environment of the weather station. Suggestions are given for documentation describing the primary types of ET measuring systems including recommended independent testing.

© 2011 Elsevier B.V. All rights reserved.

Contents

1. Introduction	921
2. Recommended documentation for reported ET and associated data	922
2.1. Comparison against models	922
2.2. Limits on ET	923
2.3. Recommended documentation	923
3. Quality assessment and quality control	923
3.1. Solar and net radiation data	923
3.2. Weather data	925
3.3. Fetch requirements for weather stations	928
4. Conclusions	928
Acknowledgements	928
References	928

1. Introduction

Evapotranspiration (ET) information is foundational to understanding and managing water resources systems and to assessing and quantifying production of food, feed, fiber and biofuels. ET is the primary consumer of liquid water in hydrologic systems and consumes enormous quantities of water. ET is highly variable, spatially, because of high variability in vegetation and water avail-

ability. ET is highly variable temporally because of weather and climate influences. Because of the relatively large magnitude of the ET component in hydrologic water balances, even 'small' errors in ET estimates or measurements can represent rather substantial volumes of water.

ET information is used frequently as the foundation or evidence for court determinations of injury among water users, for parameterization of important hydrologic and water resources planning and operations models, for operating weather and climate change forecasting models, and for water management and allocation in water-scarce regions. ET is typically modeled using weather data and algorithms that describe surface energy and aerodynamic characteristics of the vegetation and ET is typically measured using

* Corresponding author. Tel.: +1 208 423 6601.

E-mail addresses: rallen@kimberly.uidaho.edu (R.G. Allen), ls pereira@isa.utl.pt (L.S. Pereira).

systems that require the employment of relatively complex physical principles and techniques. In many agricultural systems, plant density, height, vigor and water availability are generally uniform, and the application of estimation algorithms and the measurement of ET can be relatively straightforward, although they are still not without substantial challenge. In the case of nonagricultural systems such as forest, desert and riparian systems, the heterogeneous nature of vegetation, terrain, soils and water availability make surface energy and aerodynamic processes highly variable and poorly defined. In both cases, sufficient description of the vegetation system and the data collection and/or modeling methods are essential.

ET data and ET models or model calibrations reported in the literature for even ‘well-behaved’ agricultural systems often may contain serious biases from flaws in experimental design, measurement equipment, vegetation management, data processing, model structure, model parameterization, and interpretation of results (Allen et al., 2011). Detection of these flaws is often hampered by insufficient or poor documentation and description accompanying the data reporting. It is essential that reporting of ET measurements and derived products such as crop coefficients or parameterized models contain sufficient description of the procedures used to measure and derive ET information to give readers the capability to discern potential flaws or shortcomings in data measurement and potentially the need to question the representativeness of ET presentations. In the same manner, even when reported ET information or derived products are of exceptional quality and integrity, the use of the data by others is often impeded by insufficient documentation and description of vegetation characteristics and relative water availability. Many land surface process models, such as the Weather Research and Forecasting Model (<http://www.wrf-model.org>) used to forecast near-term weather and to simulate weather under climate change, are ‘hungry’ for useful ET data against which to calibrate or validate. Frequently the ET information available in the literature for use in various modeling or operational processes is deficient in regard to documentation to facilitate judgment of its quality.

Because of the wide range of complexities in making ET and associated weather measurements and the abundance of opportunities for biases to enter ET and weather data sets (Allen et al., 2011), researchers and users of ET literature need sufficient information to be reported in articles on ET to assess the likelihood for opportunities of bias or error to enter reported data as well as sufficient information to utilize reported data in ET models. This article is part two of a two-part series on ET measurement requirements and accuracies (I) and ET reporting recommendations (II). The first article (Allen et al., 2011) describes common ET measuring or estimating systems including water balance, lysimeters, Bowen ratio, eddy covariance, scintillometry, sap flow and remote sensing. Common errors, biases and shortcomings of common ET measurement systems are discussed to provide support for why the supporting reporting information is needed. This second article lays out recommendations for the type and nature of useful documentation and description of information that should accompany ET findings reported in ET-related articles.

2. Recommended documentation for reported ET and associated data

A wide range of ET measurement and calculation methods exist and a wide range of errors can occur during measurement and during data reduction as reviewed by Allen et al. (2011) (Part I). Users of ET data and reviewers of publications on ET benefit from access to information describing the context of the ET measurements. This information provides the ability to transfer data to other areas and environments, and provides the means to evaluate the integrity

of reported data. In addition to documentation on ET measurements and associated weather data that may be used in models, ET documentation is needed to describe the nature of the vegetation measured, including type, variety, density, age, health, water availability, timing of development and senescence, height, fraction of ground cover or leaf area index, type of irrigation, if practiced, and other features useful to users of the data or users of derived crop coefficients and other ET parameters. Sufficient description of canopy architecture is needed to assist modelers in setting model parameters and, more simply, to compare against findings from similar studies. In the case of crop coefficients, the documentation should describe whether the reported crop coefficient(s) represent potential (i.e., well-watered and nonstressed) conditions and whether they are intended to represent the basal (ET from vegetation having a mostly dry soil surface condition) or an average crop coefficient condition (Allen et al., 1998, 2005, 2007).

2.1. Comparison against models

Besides careful study and critique of the measurement method and application procedure prior to publication, authors of ET data and model results are encouraged to compare ET data or derived K_c 's against ET estimates derived from more-or-less standard models and/or prior published K_c 's. Dependable models, when parameterized based on description of the vegetation, weather and soil and water conditions, can be expected to reproduce general magnitudes of calibrated data within some error tolerance, for example, $\pm 20\%$, and preferably even closer, on average. The model estimates should include estimation of both soil evaporation and vegetation transpiration and should consider all weather parameters impacting evaporation (air temperature, humidity, solar radiation and wind speed). Models that can be employed include single layer resistance-type models such as the Penman–Monteith (PM) model, which are useful when the vegetation nearly covers the soil. Examples of PM model application include Kustas (1990), Farahani and Baush (1995), Schaap and Bouten (1996), Daamen and McNaughton (2000), Ortega-Farias et al. (2005), Were et al. (2008), Zhang et al. (2008), Irmak and Mutiibwa (2009) and Zhao et al. (2010). Surface conductance in the PM model can be inversely determined as a fitting parameter and then compared against literature values (Garratt, 1992; Kelliher et al., 1993, 1995; Allen et al., 1996).

When vegetation cover is less than 60 to 70%, a multilayer or multi-source model may be necessary that employs separate surface and aerodynamic functions in the PM (or similar) equation to capture evaporation from soil and interaction between soil and canopy. Multi-layer models couple aerodynamic resistances in series between layers, with the layers comprising soil and one or more layers of vegetation canopy. Multi-source models often couple aerodynamic resistances from soil and canopy in parallel, rather than, or in addition to, coupling resistances in series, and may contain multiple sources of soil (shaded and sunlit, wet and dry). Common implementations of multi-layer models include Shuttleworth and Wallace (1985), Brisson et al. (1998), Choudhury and Monteith (1988), Shuttleworth and Gurney (1990), and Dolman (1993) and common implementations of multi-source models include Kustas (1990), Evett and Lascano (1993), Brenner and Incoll (1996) and Daamen and McNaughton (2000). Examples of multilayer and multi-source model applications include Brenner and Incoll (1996), Sene (1996), Daamen (1997), Iritz et al. (1999), Domingo et al. (1999), Gardiol et al. (2002), Fisher et al. (2004), Mo and Beven (2004), Villagarcía et al. (2007, 2010), and Hu et al. (2009).

Multilayer and multisource models are relatively complicated to apply and parameterize, especially in regard to within-canopy transfer mechanisms and soil evaporation parameterizations, both

Download English Version:

<https://daneshyari.com/en/article/4479362>

Download Persian Version:

<https://daneshyari.com/article/4479362>

[Daneshyari.com](https://daneshyari.com)