Review

Estimating evapotranspiration using remote sensing and the Surface Energy Balance System – A South African perspective

LA Gibson*[1,4], C Jarmain[2], Z Su[3] and FE Eckardt[4]

[1]*Agricultural Research Council-Institute for Soil, Climate and Water, Private Bag X5017, Stellenbosch, 7599, South Africa*

[2]*University of KwaZulu-Natal, Private Bag X01, Scottsville, 3201, South Africa*

[3]*University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), Hengelosestraat 99, PO Box 217, 7500 AE Enschede, The Netherlands*

[4]*University of Cape Town, Department of Environmental and Geographical Science, South Lane, Upper Campus, Private Bag X3, Rondebosch, 7701, South Africa*

ABSTRACT

Remote sensing-based evapotranspiration (ET) algorithms developed in recent years are well suited for estimating evapotranspiration and its spatial trends over time. In this paper the application of energy balance methods in South Africa is reviewed, showing that the Surface Energy Balance Algorithm for Land (SEBAL) model is the most widely used, but highlighting the potentials of the Surface Energy Balance System (SEBS) model. The SEBS model is then reviewed in the international literature and lessons learned from South African examples are expanded upon. The SEBS model has been extensively used for teaching and training purposes and has been applied in research projects across many different environments. However, there are discrepancies in the reported accuracy of the SEBS model due to known model sensitivities. It is therefore recommended that any further research using the SEBS model in South Africa should be limited to agricultural areas where accurate vegetation parameters can be obtained, where high resolution imagery with low sensor zenith angles is available, and where canopy cover is complete.

Keywords: Evapotranspiration, remote sensing SEBS, SEBAL

INTRODUCTION

Accurate estimates of temporal and spatial variations in precipitation and evapotranspiration (ET) are critical for improved understanding of the interactions between land surfaces and the atmosphere (Mu et al., 2007). Methods for monitoring the water balance at both local and regional scales are required to preserve and manage water resources (Melesse et al., 2006), particularly in light of increasing human consumption, climate impacts and the consequent decreasing availability of water resources. However, the water cycle is difficult to quantify accurately because of the heterogeneity of the landscape and the large number of controlling factors involved, including climate, plant biophysics, soil properties, and topography (Mu et al., 2007). In a water-scarce country like South Africa, with a number of large consumers of water, it is important to estimate ET with a high degree of accuracy. This is especially important in the semi-arid regions where there is an increasing demand for water and a scarce supply thereof. ET varies regionally and seasonally, so knowledge on evaporation is fundamental to save and secure water for different uses, and to guarantee that water is distributed to water consumers in a sustainable manner.

Numerous remote sensing-based ET algorithms, varying in complexity, have been developed;Verstraeten et al. (2008) provide a review and classify the different methods into 4 broad classes based on the: (i) parameterisation of the energy balance, (ii) Penman-Monteith formulation, (iii) water balance and (iv) vegetation index/land surface temperature relationships. Remote sensing-based ET algorithms developed in recent years fill an existing gap: they are well suited for estimating crop water use or ET (Allen et al., 2007) and the spatial trends thereof over time. Remote sensing technology holds great promise (Jha and Chowdary, 2006) as it can cost-effectively provide frequent data on a relatively large scale that allow specific water resource situations to be monitored on a long-term basis.

In this paper the application of energy balance methods for estimating ET in South Africa is reviewed. It will be shown that the Surface Energy Balance Algorithm for Land (SEBAL) model is the most widely applied model in South Africa. However, it is protected by intellectual property law and is not available for unaffiliated researchers to use. Conversely, the Surface Energy Balance System (SEBS) is an open-source model widely used for teaching and training purposes. Therefore the second half of the paper will be a review of local and international applications of SEBS, highlighting its strengths, weaknesses and sensitivities; some recommendations on its future use in South Africa will be made.

Estimating evapotranspiration using energy balance methods in South Africa

A number of conventional methods exist to estimate ET at field scale. These methods, such as the Bowen ratio, eddy covariance,

* To whom all correspondence should be addressed.
Current affiliation: GEOSS, Unit 19, Technostell, 9 Quantum Street, Technopark, Stellenbosch, 7600.
☎ +27 21 880-1079; e-mail: lgibson@geoss.co.za

Received 5 March 2012; accepted in revised form 8 July 2013.

http://dx.doi.org/10.4314/wsa.v39i4.5
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 39 No. 4 July 2013
ISSN 1816-7950 (On-line) = Water SA Vol. 39 No. 4 July 2013