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Discussions

Interactive comment on "Remote sensing techniques for predicting evapotranspiration from mixed vegetated surfaces" *by* H. Nouri et al.

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Response to Reviewers' Comments: Manuscript HESSD 10, C1855–C1856, 2013

In the document below we have listed the reviewer's comments in italics. This is followed by our response in non-italic text and where applicable by the amended manuscript text in quotation marks (with new page and line numbers). In the revised manuscript document we have highlighted the amended text in yellow to indicate where the reviewer's comments are being addressed. In the revised manuscript the yellow highlighted text indicates where the manuscript been modified to address the comments of Anonymous Referee #1. Green highlighted text indicates where the manuscript has been modified to address the comments of the first reviewer (Dr. Long).

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Interactive Discussion

Discussion Paper

Anonymous Referee #1

General comments:

This is a review paper on methods to retrieve evapotranspiration (ET). As a number of previous studies have addressed this issue (e.g. Courault et al. 2005), the authors focus on mixed surfaces. However, it is not always clear to what extent their findings are new, valid for all types of surfaces, or only refer to heterogeneous surfaces. Moreover, the importance of biochemistry land surface models (able to account for heterogeneous landscapes through sub-grid tiles) and of techniques to ingest satellite data into models (e.g. data assimilation) is not sufficiently discussed. Direct evaporation of rain water intercepted by the leaves may contribute to a large extent to the total ET through large evaporation rates over a short period of time. How can this flux be accounted for by empirical methods relying on satellite data? What about the robustness of the methods with respect to climate change (e.g. impact of atmospheric CO2 concentration, validity of empirical parameters in a changing climate?). To what extent have the various methods been validated/ benchmarked? These are key questions, unfortunately not addressed in the current version of the manuscript. The paper lacks new original results permitting the assessment of the various methods.

We are not sure whether we adequately described mixed surfaces in the original manuscript. Therefore in the revised paper we added the term parklands to describe the spatial and temporal scales of the mixed vegetation on which we focused. To avoid this confusion we have now revised certain instances of the word “surface” to either “evaporating surface” or “vegetation surface” in the appropriate places and we have left it as “surface” only when it refers to the most general term, for instance in the description of the principles of energy surface balances. To the best of our knowledge, nobody has previously reviewed evapotranspiration from urban green spaces. In this paper, we have focused on the application of remote sensing techniques on heterogeneous vegetated surfaces in urban parklands. With a fast growing interest in the implementation of green infrastructure (which often involves parklands and/or water sensitive urban

HESSD
10, C2060–C2067, 2013

design systems with mixed vegetation types), this paper provides a novel contribution in a very important emerging research area. The following paragraphs were added to the revised manuscript in order to more specifically highlight this point: “The value of urban green spaces and particularly urban parklands has been studied comprehensively (Weber and Anderson, 2010). The important role of parklands in the areas of public health and well-being indicates the critical importance for a better understanding of parkland water demand. Consequently this study is focused on ET from urban parklands as the main component of vegetation water requirement.” (Lines 78-83 of the revised manuscript). And: “With a fast growing interest in the implementation of green infrastructure which often involved mixed vegetation types, the current study has mainly focused on the application of remote sensing techniques in heterogeneous parklands.” (Lines 104-106 of the revised manuscript). The following paragraph was also added to the Conclusion: “Increasing urbanisation, growing population and water scarcity are all major issues facing Australian society. Urban parklands will have an important role in creating a healthy society and this provides a key motivation for this study to review the water demand of urban green spaces (Nouri et al. 2012). The study has found that remote sensing provides an efficient approach for prediction of parkland water demand.” (Lines 462-467 of the revised manuscript). We appreciate the reviewer highlighting the importance of biochemistry land surface models in ET estimation. The following paragraphs have now been added to the revised manuscript” “Climate change and water availability are major concerns today, indicating the importance of water and carbon flux assessments. Satellite imagery provides the required information to assess surface water, carbon and energy exchanges through quantifying certain biochemical and biophysical parameters mainly associated with photosynthesis and chlorophyll content. Although both ET and carbon exchanges are controlled by stomata, they have been remotely-sensed and modelled in different ways using different biophysical parameters (Anderson et al., 2008).” (Lines 68-74 of the revised manuscript).

“Due to the importance of biophysical and biochemical cycles associated with photosynthesis processes, some coupled modelling systems have benefited from the spatial and temporal correlation of ET and CO_2 to improve the accuracy of ET estimation derived from remote sensing surface energy and water balance models (Anderson et al., 2008; Kim and Leith, 2003). For instance, Anderson et al. (2008) used thermal satellite imagery to implement an analytical light-use efficiency based model (computing carbon assimilation and transpiration at the canopy scale) of bulk canopy resistance within a two source energy balance approach. Their results confirmed an improvement in energy budget assessment compared to in-situ eddy covariance tower observations mainly by reduction in prediction errors for the latent heat flux. In another study, Houborg et al. (2011) investigated integrating the analytical light-use efficiency based model using airborne images into a two source energy balance model for predicting land surface CO_2 and energy fluxes for a corn field. They found that the calibrated analytical light-use efficiency based model could be correlated with airborne leaf chlorophyll content and hourly water, carbon and energy fluxes derived from a two source energy balance model."

"For an urban area, the most sensitive parameters in the surface energy balance are the total latent heat flux of the natural surface and the total sensible heat flux of the urban surface. Local changes in the total sensible heat flux of the urban surface may result in approximately a 20% change in the total heat flux. These parameters are very important when dealing with mesoscale studies. Due to the relatively small spatial scale of parklands, the available literature does not currently support the need for including biochemistry surface parameters in the estimation of ET in parklands. This could be potentially of more concern in urban boundary layer meteorology modelling since the urban surface often involves buildings that disturb air flow and generate turbulent eddies with different physical parameters of albedo and evaporation (Flagg and Taylor, 2011)." (Lines 143-167 of the revised manuscript).

"SVAT models need detailed surface and meteorological data. The third-generation SVATs considers photosynthesis, carbon assimilation and biochemical reactions in order to determine carbon, water vapour and energy exchange (Niogi et al., 2009; Anderson et al., 2000). These models have been applied at both the leaf scale and regional scale. In these approaches, carbon assimilation is equivalent to the photosynthesis rate. Even though leaf photosynthesis leads to a carbon flux, it is dependent on light intensity, carbon concentration and water stress." (Lines 283-289 of the revised manuscript).

"Anderson et al. (2012) described the uniqueness of land surface temperature maps (thermal images) in ET monitoring and mapping over large areas. Improvement in the spatio-temporal resolution of images has both increased accuracy and reduced errors in ET estimation." (Lines 192-194 of the revised manuscript).

"Due to the importance of water and carbon budget assessment in regional water management, some researchers have recommended including biochemical and biophysical land surface models to improve ET estimation. Significant correlation of system fluxes of ET (canopy component assimilation and transpiration) with NDVI illustrates the importance of using coupled modelling considering biochemical photosynthesis models and surface energy and water balance frameworks at regional scales. However, while ET estimation approaches that rely only on vegetation indices could potentially miss temporal variability resulting from increased soil evaporation or vegetation stress (Anderson et al., 2008), the current study has chosen to adopt a computationally efficient approach which appears to work well for the case of mixed vegetation in urban parklands." (Lines 354-363 of the revised manuscript).

"However, in this approach the effects of ET from rainfall events between satellite overpasses might be missed but this does not diminish the importance of the relationship between ET and vegetation indices. There are several studies showing a strong correlation between ET and vegetation indices (Devitt et al., 2010;Johnson and Belitz, 2012;Palmer et al., 2009;Rossato et al., 2005;Glenn et al.;Nagler et al., 2007;Nagler et al., 2012)." (Lines 367-372 of the revised manuscript).

"However, the SEBAL method does not use precipitation as an input parameter in ET estimation so the rainfall impact cannot be mirrored in the results (Anderson et al., 2008).” (Lines 213-215 of the revised manuscript).

Particular comments: - P. 3901, L. 9-13: what is the added value of this study w.r.t. previous classifications?

- Even though we reviewed the same classification, we have described the advantages and disadvantages (including new technologies that were not available in 2005). More importantly we have suggested a coupled ET-Vegetation Index approach as a parsimonious model in two categories for agricultural and non-agricultural vegetation.

- P. 3909, L. 2: "ET0 from a weather station" in the context of rising atmospheric CO2 concentration (now approaching a global mean value of 400 ppm), impacting plant growth and stomatal closure, is the ET0 concept still valid ?

- ET0, the potential evapotranspiration, was replaced by reference ET based on the following study: Irmak, S., Haman, D.Z., Evapotranspiration: Potential or Reference. ABE 343, one of a series of the Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Reviewed October 2011.

- The impacts of climate change are important but at the spatial scale of urban parklands, the concept of ETref was considered valid in this case. However, ETref is still commonly used as the basis for ET estimation at the spatial scales used in this study (Nouri et al., 2012).

- P. 3910, L. 21: "tress"?

- This was corrected to “trees” (Line 437 of the revised manuscript)

- P. 3924, Fig. 1: the captions are not complete for understanding. Units of ET rates ?Where, when ?

- Units of ET rates were added (Fig 1 in the revised manuscript).

- P. 3925, Fig. 2: Units of ET rates (cm/yr?)

- This was revised to yearly ET (Fig 2 in the revised manuscript).

We have also added the following citations to the references: Anderson, F.: Hydrological modelling in a semi-arid area using remote sensing data, PhD thesis in University of Copenhagen, 2008. Anderson, M. C., Allen, R. G., Morse, A., and Kustas, W. P.: Use of Landsat thermal imagery in monitoring evapotranspiration and managing water resources, Remote Sensing of Environment, 122, 50-65, 2012. Anderson, M. C., Norman, J. M., Kustas, W. P., Houborg, R., Starks, P. J., and Agam, N.: A thermal-based remote sensing technique for routine mapping of land-surface carbon, water and energy fluxes from field to regional scales, Remote Sensing of Environment, 112, 4227- 4241, 2008. Anderson, N., Norman, J., Meyers, T., Diak, G.: An analytical model for estimating canopy transpiration and carbon assimilation fluxes based on canopy light use efficiency. Agric. For. Meteor., 101, 265–289, 2000. Devitt, D. A., Fenstermaker, L. F., Young, M. H., Conrad, B., Baghzouz, M., Bird, B. M.: Evapotranspiration of mixed shrub communities in phreatophytic zones of the Great Basin region of Nevada (USA). Ecohydrology 4, 6, 807–822, 2010. Flagg, D.D. and Taylor, P. A.: Sensitivity of mesoscale model urban boundary layer meteorology to the scale of urban representation. Atmos. Chem. Phys., 11, 2951-2972, 2011. Glenn, E., Huete, S., Nagler, P., and Nelson, S.: Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: what vegetation indices can and cannot tell us about the landscape. Sensors 8, 4, 2136-2160, 2008. Houborg, R., Anderson, M. C., Daughtry, C. S. T., Kustas, W. P., and Rodell, M.: Using leaf chlorophyll to parameterize light-use-efficiency within a thermal-based carbon, water and energy exchange model, Remote Sensing of Environment, 115, 1694-1705, 2011. Irmak, S., Haman, D.Z.: Evapotranspiration: Potential or reference. ABE 343, one of a series of the Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Reviewed October 2011. Kim, S. H., and Lieth, J.H.: A coupled

HESSD

10, C2060–C2067, 2013

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C2060/2013/hessd-10-C2060-2013-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 3897, 2013.