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Hydrology and Earth System Sciences Discussions

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Interactive Comment

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

H. Nouri et al.

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Dear Dr. Di Long

We are very grateful for your review of our paper HESS-10-3897-2013. The following revised text has been added to the manuscript in response to your suggestions.

Reviewer's comment: Your manuscript entitled "Remote sensing techniques for predicting evapotranspiration from mixed vegetated surfaces" under review in Hydrology and Earth System Science is a comprehensive review on remote sensing-based approaches to quantifying evapotranspiration (ET) from composite land surface. ET is the largest outgoing water flux from the Earth's surface; accurate quantifying ET is critical to developing a greater understanding of a range of hydrological, climatic, and ecosystem processes, and beneficial in numerous applications, e.g., water resources management, drought monitoring, improvement of hydrological modeling, weather forecasts, and vulnerability of forest to fire [e.g., Anderson et al., 2007; Bastiaanssen et al., 2002]. I am interested in the summary of the advantages and disadvantages in section 3 of your manuscript. The SEBAL model has been widely used to estimate ET across a variety of climates, ecosystems, and land covers (primarily for consumptive water use by agricultural crops). This model enriched thermal infrared remote sensing-based approaches including triangular approaches [e.g., Carlson et al., 1994; Jiang and Islam, 2001], two-source energy balance approaches [e.g., Long and Singh, 2012a; Norman et al., 1995], and other one-source approaches [e.g., Su, 2002] as you examined in your manuscript.

Authors' response: We have added the following text in page 3903:

The SEBAL model has been widely used to estimate ET in different climates, ecosystems, and land covers, predominantly in agricultural studies. This model is a thermal infrared remote sensing-based method that includes triangular approaches (Carlson et al., 1994; Jiang and Islam, 2001), two-source energy balance approaches (Long and Singh, 2012a; Norman et al., 1995), and one-source approaches (Su, 2002).

Reviewer's comment: It would be great if you consider incorporating new advances in the understanding of these satellite-based approaches in your review, which would lend support to your conclusion that the vegetation index-based approach [e.g., Fisher et al., 2008; Zhang et al., 2010] could be one of the best approaches for ET estimation over large extents. The spatial variability models, i.e., SEBAL, METRIC, and triangular models tend to be context-dependent [Long and Singh, 2013], i.e., wet/dry pixels (edges) required to trigger these models may not necessarily exist within a specific extent of an image. As the extent of satellite image and/or spatial resolution of satellite vary, the wet/dry limits of ET could change significantly, thereby resulting in differing model outputs, i.e., the ET estimates from these models are not deterministic. Critical

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in SEBAL is that one does not know exactly how large extent of a study site of interest should be in order for the operator to properly select the so-called hot/wet pixels that can satisfy the assumptions that for the hot extreme, LE is assumed to be zero, and H for the hot pixel is equal to the available energy; for the cold extreme, H is assumed to be zero, and LE is therefore equal to the available energy for the pixel, and that metrological and surface conditions should be generally homogeneous so that the linear correlation between the near surface temperature difference and remotely sensed surface temperature holds true. In many cases, even the very large extent would not necessitate the existence of both hot and wet extremes. For instance, one would not be able to select a hot pixel from a large homogeneous forest; (2) there has not any approach for the SEBAL/METRIC models to automate selection of extreme pixels from images with varying extents, spatial resolutions, and clouds [Long et al., 2011], and (3) even though the extremes can be properly selected from relatively large images that probably entail hot and cold extremes reflecting surface conditions after cloud and terrain effects are favorably reduced/removed, the SEBAL-type algorithms appear to be limited in providing reasonable ET patterns due mostly to constant coefficients a and b in the SEBAL H algorithm that do not accommodate the effect of variations in fractional vegetation cover on ET extremes [Long and Singh, 2012b; Long and Singh, 2013].

Authors' response: We have added the following text in page 3907:

The spatial variability models, such as SEBAL, METRIC and triangular models, tend to be context-dependent. Long and Singh (2013) declared that hot and cold extremes may have a similar impact on the inconsistency between the ratio of latent heat flux to available energy and the ground-based measurements. For instance, wet/dry pixels (edges) that are required to trigger these models may not necessarily exist within a specific extent of an image. As the extent and/or spatial resolution of a satellite image vary, the wet/dry limits of ET change significantly and this results in different model outputs, i.e. the ET estimates from these models are not deterministic. One of the concerns with the SEBAL model is the extent of the study site in order for the operator

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to properly select the hot/wet pixels to satisfy the SEBAL assumptions. In the hot extreme, LE is assumed to be zero and H is equal to the available energy while for the cold extreme, H is assumed to be zero and LE is equal to the available energy. Also, the meteorological and surface conditions should be generally homogeneous so that the linear correlation between the near surface temperature difference and the remotely sensed surface temperature holds true. In many cases, even a very large extent would not necessitate the existence of both hot and wet extremes. For instance, one would not be able to select a hot pixel from a large homogeneous forest. Secondly, there is not any approach for the SEBAL/METRIC models to automate selection of extreme pixels from images with varying extents, spatial resolutions and clouds (Long et al., 2011). Finally, even when extremes can be properly selected from relatively large images, the SEBAL-type algorithms appear to be limited in providing reasonable ET patterns due mostly to the use of constant coefficients a and b in the SEBAL H algorithm. These constants do not accommodate the effect of variations in fractional vegetation cover on ET extremes (Long and Singh, 2012b; Long and Singh, 2013).

The following have also been added to the Reference section:

Anderson, M. C., J. M. Norman, J. R. Mecikalski, J. A. Otkin, and W. P. Kustas (2007), A climatological study of evapotranspiration and moisture stress across the continental United States based on 2 thermal remote sensing: 1. Model formulation, Journal of Geophysical Research-Atmospheres, 112(D10), D10117. DOI 10.1029/2006JD007506 Bastiaanssen, W. G. M., M. U. D. Ahmad, and Y. Chemin (2002), Satellite surveillance of evaporative depletion across the Indus Basin, Water Resour Res, 38(12), 1273. Carlson, T. N., R. R. Gillies, and E. M. Perry (1994), A method to make use of thermal infrared temperature and NDVI measurements to infer surface soil water content and fractional vegetation cover, Remote Sensing Reviews, 9, 161-173. Fisher, J. B., K. P. Tu, and D. D. Baldocchi (2008), Global estimates of the land-atmosphere water flux based on monthly AVHRR and ISLSCP-II data, validated at 16 FLUXNET sites, Remote Sens Environ, 112(3), 901-919. Jiang, L., and S. Islam

(2001), Estimation of surface evaporation map over southern Great Plains using remote sensing data, Water Resour Res, 37(2), 329-340. Long, D., and V. P. Singh (2012a), A Two-source Trapezoid Model for Evapotranspiration (TTME) from satellite imagery, Remote Sens Environ, 121, 370-388. Long, D., and V. P. Singh (2012b), A modified surface energy balance algorithm for land (M-SEBAL) based on a trapezoidal framework, Water Resour Res, 48. DOI 10.1029/2011WR010607. Long, D., and V. P. Singh (2013), Assessing the impact of end-member selection on the accuracy of satellite-based spatial variability models for actual evapotranspiration estimation, Water Resour Res, 49, 1-18. DOI: 10.1002/wrcr.20208. Long, D., V. P. Singh, and Z. L. Li (2011), How sensitive is SEBAL to changes in input variables, domain size and satellite sensor?, Journal of Geophysical Research-Atmospheres, 116. DOI 10.1029/2011JD016542 Norman, J. M., W. P. Kustas, and K. S. Humes (1995), A two-source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface-temperature, Agr Forest Meteorol, 77(3-4), 263-293. Zhang, K., J. S. Kimball, R. R. Nemani, and S. W. Running (2010), A continuous satellite-derived global record of land surface evapotranspiration from 1983 to 2006, Water Resour Res, 46. DOI 10.1029/2009WR008800

Thank you for your valuable contribution.

Yours sincerely,

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C1436/2013/hessd-10-C1436-2013-supplement.pdf

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

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