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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Complementary Relationship for Estimating Evapotranspiration Using the Granger-Gray Model: Improvements and Comparison with a Remote Sensing Method" *by* Homin Kim and Jagath J. Kaluarachchi

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The method used in this study is not outdated and we disagree with this comment. The starting point of this study was further refinement to the model proposed by Anayah and Kaluarachchi (2014). Their ET model was successfully applied to estimate groundwater recharge in Ghana (Anayah et al., 2013) and in a follow-up study to assess the drought conditions across the United States by Kim and Rhee (2016). Therefore the comment to state that this model is outdated is incorrect. Meanwhile, we further improved the GG-NDVI of Anayah and Kaluarachchi (2014) to better accommodate arid

conditions and provided further validation compared with other CR methods; such as CRAY, GG, and AA models. These efforts were clearly demonstrated in an earlier publication by Kim and Kaluarachchi (2017). Additionally, the Granger and Gray (1989) model is still an important model in today's research (Zhu et al. 2016, Gao et al. 2016) and no means an older model.

The purpose of this study is to further demonstrate the validity of the earlier ET model of Kim and Kaluarachchi (2017) using the widely used USGS remote sensing model, SSEBop (Senay et al., 2013). According to Senay et al. (2013), SSEBop was validated using 45 eddy covariance stations in the United States while Velpuri et al (2013) used 60 eddy covariance stations of AmeriFlux for a comprehensive evaluation of MODIS global ET and SSEBop. Therefore this work follows clear and consistent validation in line with the earlier studies. We collected level 4 measured meteorological data and latent heat flux (LE) data from 76 eddy covariance AmeriFlux stations. Thereafter, we excluded those stations with actual vegetation type different from MODIS land cover type from locations of 500 m by 500 m pixels. We also excluded those stations with less than half a year of measurements during 2000-2007. Finally, 60 sites were selected and used in this study without heterogeneous vegetation conditions.

It should be noted that we did not disregard the recent study of Szilagyi et al. (2017) and Crago et al. (2016). In the latter study, they mentioned that coefficients, a0, a1, a2, and a3 in their model may be selected based on physical basis or through calibration. In their work, these values were obtained through model calibration. Szilagyi et al. (2017) noted that calibration of parameters alpha and s0 were performed by a systematic trial and error approach and the objective function of calibration consisted of minimizing RMSE between mean annual ET estimates and ET values derived from water balance. This process is similar to the work proposed by us. The Omega value in Eq. (7) was derived through a curve fitting procedure that minimizes RMSE between the measured and predicted evaporation ratios as mentioned in Line 16-17 at Page 6. Moreover, our model's parameters, alpha and beta in Eq. (18), do not need further calibration in the application to other study areas and or future applications.

k in Eq. (14) is a constant and the recommended value is 1.2 for United States. We excluded the additional sentence of Line 23-24 at Page 7 to avoid confusion and added studies of Szilagy et al. (2017) and Crago et al. (2016) as references. Please see Lines 15 and 31-32 in Page 2. Unfortunately, we did not have much time to compare and review the study of Szilagy et al. (2017) because the current study was done before Szilagy et al. (2017). As the reviewer mentioned, it would be interesting to assess the scale issue and compare with Szilagy et al. (2017) for a possible future study.

New References for reviewer

1) Anayah, F. M., Kaluarachchi, J. J., Pavelic P., and Smakhtin, V.: Predicting groundwater recharge in Ghana by estimating evapotranspiration, Water International, 38, 4, 408-435, http://dx.doi.org/10.1080/02508060.2013.821642, 2013. 2) Kim, D., and Rhee, J.: A drought index based on actual evapotranspiration from the Bouchet hypothesis, Geophys. Res. Lett., 43, 10, 277-10,285, doi:10.1002/2016GL070302, 2016. 3) Gao, Y., Gan, G., Liu, M., Wang, J.: Evaluating soil evaporation parameterizations at near-instantaneous scales using surface dryness indices, Journal of Hydrology, 541, 1199-1211, 2016. 4) Zhu, G.-F., et al., Evaluating the complementary relationship for estimating evapotranspiration using the multi-site data across north China. Agric. Forest Meteorol., http://dx.doi.org/10.1016/j.agrformet.2016.06.006, 2016.

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