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Interactive comment on "Upscaling instantaneous to daily evapotranspiration using modelled daily shortwave radiation for remote sensing applications: an Artificial Neural Network approach" *by* L. Wandera et al.

Anonymous Referee #1

Received and published: 17 August 2016

Overview:

Loise Wandera et al., presented a study that upscaled instantaneous evapotranspiration (ET) to daily ET. I enjoyed reading the manuscript. The paper was generally well written, the method is robust, and evaluation is rigorous. It's scientifically significant in terms of improving remote sensing ET product. The overall quality of this work is good, but could be further improved by considering the following comments. Below I have several major concerns, which may require additional work.

Major comments:

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Discussion paper

1. Energy budget closure problem at FLUXNET.

Energy budget imbalance has long been identified at FLUXNET sites. The imbalance is about -40% - +20%, indicating latent heat/sensible heat fluxes might be underestimated by up to 40%. Indeed, the energy imbalance is an existing fact we have to accept, I guess there is little can be done to overcome it in this particular study. But my concerning is: if an ANN model is trained by FLUXNET data, how much confidence do we have when we apply it to satellite retrieval? The energy budget close problem affects the results in two ways: (1) the overall robustness of the proposed upscaling method (Rs method); (2) comparison of Rs method with the evaporative fraction based upscaling (EF method Eqn. 5). However, the exo-atmospheric irradiance method is not affected (Eqn. 6). I guess the authors must be aware of this issue; it would be better to literally discuss them in the results section.

2. Cloudy-sky issue

The biggest problem of the proposed upscaling method (Rs method) is that the ANN model does not include any information about “cloudiness”. Therefore, model performance under cloudy-sky condition (or low atmospheric transmissivity) is much worse than clear-sky condition. One way to tackle it, is to use climatology precipitation data. Rainfall (highly related to cloudiness) has seasonal pattern, at least for some regions (e.g., tropical rainforest, savanna). Similarly, dry season-wet seasons could provide ANN model with additional information about “possibility” of the “cloudy-sky condition” during a certain time period. In Figure 7, the overestimation of ET under cloudy sky condition is “systematic”, meaning there might be a simple way to “systematicly” down-regulate the ET as long as the ANN model knows it’s a cloudy day.

3. FLUXNET site selection.

It was stated that the partition of data into training and validation was randomly selected. However, it’s not clear whether the selected training sites are representative or not. For example, if plot out mean annual precipitation of the all training data, does

it cover a full range of (from dry to wet) rainfall regimes? For each vegetation type, how much percentage of data is selected to train the model? FLUXNET has more forest sites than grass/shrub sites. Are grass/shrub sites less represented in the training dataset?

Following question: is the ANN model sensitive the FLUXNET site selection? This could be evaluated by doing e.g., 10 ensemble of random selection of FLUXNET sites. And check the difference among the resultant 10 ANN models?

4. Crop ET

I think the proposed method might be only suitable for estimating natural terrestrial ecosystem ET. There is large bias of crop ET estimation (Figure 9). That could be due to irrigation? Land management? Those anthropogenic factors (largely alter land surface water budget) is not included in the ANN model and the ET estimation.

5. Vegetation control on ET

The proposed upscaling method is based on the idea that higher available energy (Rs) lead to higher evaportranspiration (ET) (Eqn. 1). It basically assumes that the Bowen ratio does not change during the daytime, so that instantaneous ET/Rs is equal to daily ET/Rs. However, it ignores the important fact that ET is also mediated by vegetation via stomata control. For example, trees and grass have dramatically different stamata density, stomata size. Therefore, their stomata open/closure and its control on water vapor conductance are different. The question is: it is worthwhile to add biome type information in the ANN model? Is it possible to further improve the results (Figure 9) for forest sites by considering biome type information in the ANN model and ET estimates?

Minor comments:

Page2

L4. a key challenge in mapping regional ET using polar orbiting sensors

L6. On the terrestrial surface -> remove

L8. The approach relies on . . . -> remove

L16 derived from simple mathematical computation -> replace: e.g., solar zenith angle, day length

L20. Based on the measurements from 126 sites -> remove

L20. Rs-based upscaling produced . . .

Page3

L7, Et variability is influenced by (1) available energy received, (2) soil moisture supply and (3) vegetation mediation. I think the third one is missing here. To be complete, the three key factors should all be fairly discussed in the introduction.

L9. "Therefore" is not appropriate here, there is no cause-effect relationship here. Better start a new paragraph and discuss the major challenges in Et upscaling.

Page 4

L19. Estimate Rsd form any specific time-of-day Rsi information. But isn't the value of this study is to predict Rsd based at satellite local crossing time (e.g., 10:30, 13:30)?

L22. In order -> remove

L24. ANN is a non-linear model .... Multi-layer perceptron (MLP) is . . .. These sentences belongs to method section.

Page 5.

L13. Cloudiness is a phenomenon . . .. These sentences belong to discussion section.

Page 6.

L6. Two question: (1) Does Equn. 1 assume the Bowen ratio is constant during daytime? (2) Does it ignore the night time ET, which could be large when surface wind

speed is high?

Page 8.

L16. In a percentage ratio of 80:15:15. Is this right? Shouldn't be 80:15:5 or 70:15:15?

Page 10.

L9. We first evaluate the efficacy of the ANN method for predicting Rsd.

L12. As obtained following the methodology described in the section 2.1 -> remove

L13. Showing -> including

L14. From the analysis it is apparent that -> remove

Page 11.

L1. Figure 5 evaluates the Rsd_pred under different level of clear sky transmissivity (τ).

L3. What if the ANN model includes "clear sky transmissivity (τ)", would model performance under cloudy sky condition be improved?

L16. Using Rsd_pred/Rsi as a scaling factor following eq. 1 -> remove

Page 12.

L1. Figure 7 compares ETd_pred against ETd_obs for different level of daily τ. The overall RMSE, MAPE ...

L4. Given that the overestimation is a systematic, is it possible to eliminate it or reduce it? The overestimation was due to the fact that during the specific time slot of interest (e.g., 11:30) the sky is clear while the sky is cloudy during other times. However, there could be another opposite case that sky is cloudy at e.g., 11:30 but clear at other times. It will probably lead to an underestimation of RSd_pred, and consequently underestimation of ETd_pred. I am wondering why the latter is not the case at least in

Figure 7.

L14. . . . higher errors in ETd_pred can be expected. Is there a way to overcome this problem?

L24. Again, biome specific results are related to the clear-sky issue. Tropical evergreen broadleaf forests have high ET, water tends to re-cycle locally and generate rainfall. It's reasonable to see that cloudy sky condition is more frequent at tropical evergreen broadleaf forest than e.g., at grass land.

L27. ET estimations at cropland were much worse than grass. It that because e.g., irrigation? Land management? Or any other anthropogenic factors that are not considered in the ANN model? Page 13.

L20. Based on Table 2, Figure 11, RsTOA method seems successful. Under clear sky condition, it was even better than the proposed Rs method. Further, over longer time scale (annually), there is no big difference between RsTOA and Rs.

Page 16.

L1. Briefly define what is RsTOA-based metod, what is Rs method.

L4. ETd_pred are defined early in the manuscript, consider the summary as a independent section. Better not to use these acronyms, or re-define it.

L21-25. This paragraph belongs to results & discussion section.

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