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Hydrology and Earth System Sciences Discussions

Interactive comment on "Quantifying the uncertainty in estimates of surface- atmosphere fluxes through joint evaluation of the SEBS and SCOPE models" *by* J. Timmermans et al.

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Dear Reviewer, thank you very much for your comments on the manuscript. I have tried to adapt your comments to the paper.

Review on general comments In your review one of the general comments is about the validity of the SCOPE model. In this exercise the validity was performed over a study area for which the SCOPE model produces very good results. In the original SCOPE model paper1 the results were listed, however they were taken out of this paper on request of the reviewers to make the paper more concise. The results of this validation exercise are however at present not published in a peer review article, but is being written. The (excluded) validation part of SCOPE was over the same study area as this paper, so that I feel confident of the results of the SCOPE model. Hence other FLUXNET observations are not listed (as first SCOPE needs to be validated over those steps). I have noted this in the manuscript. At present only the sub model parts of scope have been individually validated, such as Tol et al 20092. P21, While the SCOPE has been tested over maize and forest to provide good estimations of the fluxes () it has not been validated over other vegetation types. This will be necessary to use this methodology in other areas.

Review on specific comments Comment1) P2864.L6. By saying "most remote sensing algorithms" the author seems to neglect another "school" of remote-sensing based ET algorithms based on modified Penman- Monteith/Prisley-Taylor approaches. Although it is certainly true that for the moment there are no grounds to establish that one methodology is superior to the other, most of the published global estimates currently come from this alternative approach (e.g., same journal, Miralles et al., 2011, doi:10.5194/hess-15-453-2011).

Answer: I have added a large portion in the introduction about other evapotranspiration techniques and large scale initiatives: ?Evapotranspiration cannot be detected directly from space. This has lead to a large variety in remote sensing algorithms that estimate ET from variables that are observable from space. These methods range from triangle/trapezoidal methods to the use of reference ET (by (Penman-Monteith/Priestley Tailor) together with crop coefficients to energy balance (residual) algorithms (Kalma et al., 2008;Glenn et al., 2007). At the moment most of the global products available are created using the first two approaches, because of the computational demand of the

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residual algorithms and the dependence on non-remote sensing data like windspeed and airtemperature. With the onset of high performance computing and large scale meteorological models, like GLDAS and ECMWF, these shortcomings are lifted paiving the way for global evapotranspiration calculations by energy balance models? and ?Over the last couple of years several initiatives, such as the LandFLUX Initiative (JimâĂŽnez et al., 2011;Mueller et al., 2011), have started to evaluate and develop large scale evapotranspiration products. Low resolution evapotranspiration is provided by the Satellite Application Facility on Land Surface Analysis (LandSAF) by feeding geostationary low resolution data into land surface model (Ghilain et al., 2010). Medium resolution calculations of evapotranspiration are performed using orbiting data, from MODIS (Mu et al., 2007;Mu et al., 2011;Vinukollu et al., 2011). However these products either have a low spatial resolution and high temporal resolution or a low temporal resolution and a high spatial resolution?

Comment2) P2864.L20. Eddy covariance measurements are also broadly used, it may be good to mention them.

Answer: I have added a line about eddy covariance and a reference to the footprint of such measurements: ?P4 to around 0.1 - 0.3 km2 for scintillometer stations (Hartogensis, 2006) up to 0.5km2 for eddy covariance stations (Kljun et al., 2004) depending on the reference height (Schmid, 1997)?

Comment3) P2870.L1. Energy balance fluxes? Does it mean the radiative downward and upward shortwave and longwave fluxes, so the net radiation is available?

Answer: SCOPE was used to provide upwelling long and shortterm radiation. This has been made clearer in the text. P10 ?SCOPE only requires measurements of LAI and of incoming optical and thermal radiation, air pressure, , wind speed, , and actual vapor pressure, ea. Other variables within the SCOPE model, like spectral reflectivity and emissivity of the soil/vegetation are set to default values.?

Comment4) P2870.L10. As mentioned above, Section 3 would benefit from some re-

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writing to clearly identify what exact in situ measurements are used by SCOPE, which outputs from SCOPE are used as inputs to SEBS, and what outputs from SEBS are compared with SCOPE outputs and/or in situ measurements.

Answer: SECTION 3 has been rewritten to make the subject clearer.

Comment5) P2871.L2. The reference seems to be missing.

Answer: The sentence has been rewritten for proper referencing.

Comment6) P2871.L13. The first line says that LAI is not part of the original formulation, but that LAI is used in SEBS-based investigations. What LAI parameterization are we trying to improve here?

Answer: The Estimation of LAI is not part of SEBS but of the preprocessing of SEBS. The analysis here was shows that using LAI provides better results than using NDVI. The text has been modified to say this. P12, ?The calculation of LAI is not considered part of SEBS core processing, instead it is assumed to be part of the preprocessing. in many researches using SEBS is calculated from NDVI using the parameterization presented in Equation 09 (Liu et al., 2011)

Comment7) P2871.L17. Where is the NDVI coming from? SCOPE simulation of vis and near-IR bands?

Answer: Yes. The NDVI is calculated from SCOPE simulated vis and near-IR bands!

Comment8) P2872.L6. How are A and B optimized? Using the SCOPE/field NDVI-LAI relation shown in Figure 3 (open circles)?

Answer: The A and B parameters are optimized by comparing the output of LAI with measured values and reducing the RMSE. P12, Here, the original parameterization by Su, the new parameterization by Song et al., and the parameterization based on Song et al., but with optimized A and B values, are shown. This optimization relied on the reduction of the RMSE between calculated and observed values.

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Comment9) P2872.L10. Su 96 seems far from the NDVI/LAI plotted, but the original Song, 08 seems to be doing a very good job, considering that it has being driven independently from this dataset (if my previous comments about the optimized NDVI/LAI relation are true). Saying that Song 08 produced too high results does not seem right based in the figure.

Answer: Song 08 produces good results except for values close to the maximum simulated NDVI, for which it produces too high values. Therefore the optimization was performed. The text has been changed to make this clearer.

Comment10) P2872.L28. The text says that the values seem to depend on the vegetation type, but then only one set of values is given. Is it valid for all vegetation types?

Answer: Indeed for different crops different values are provided in the original paper. However according to the original paper for global application (as an example) for which such a detailed crop map does not exist these values will produce overall the best results. P13 Using these optimized coefficients the difference between measured and estimated LAI resulted in a RMSE = 0.3 m2 m-2. It should be noted that these new values for A and B are not directly applicable to other vegetation types without thorough investigation. It should also be noted that within the WACMOS research the obtained from L2 products.

Comment11) P2873.L2. I may be missing something, but how can the incoming optical radiation be coming from SCOPE? Is not the incoming radiation always an input in these models? Do you mean the net radiation, taking into account incoming radiation from somewhere (field measurements/modeling) and some SCOPE parameterizations to estimate the outgoing?

Answer: Indeed the incoming shortwave and longwave radiation does not come from SCOPE but from measurements in the field. These measurements are converted to spectral radiation using outputs of MODTRAN. The text has been rewritten to make it clearer. P14 Measurements of outgoing optical and thermal radiation are also present but not used in this research, as the purpose of this research is to show the synergy between SCOPE and SEBS, in particular when the amount of measured data is minimum. I

Comment12) P2873.L8. Based on Figure 6 it seems that measurements of Rn exist. Could have we also used measured Rn as we also use the measured Go? What is the rationale of using Rn only from SCOPE to investigate the Rn/Go relationship (specially once we use observed Go and not SCOPE Go)?

Answer: See 11

Comment13) P2874.L10. What is the RMSE if the fitted (to the G0/Rn/LAI relation) parameterization is used in SEBS, instead of Kustas 93? That may be of interest to know, even if for the given reasons this parameterization is not used.

Answer: The original RMSE has been added to show the improvement of the new parameterization, p14? The high values of the ratio between ground heat flux and net radiation originate for particular sun-leaf geometries, with errors larger than 50 W m-2 in for low LAI values. For these cases the sun-beam directly strike the soil, without being attenuated by the vegetation?

Comment14) P2876.L22. How is l derived? All maize canopy has l =0.03? Or is l fitted to this specific observations?

Answer: l has been taken from the leaf characteristic width. This has been made clear in the new text: ?P16 Here is the characteristic height for the canopy; in this particular maize canopy this leaf width was measured to be 0.03 m after vegetation stopped growing taller?

Comment15) P2876.L2. Observed values? Better to say SCOPE estimations as previoulsy?

Answer: The text has been changed to make this clearer as noted by the reviewer

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Comment16) P2876.L5. Looking at the values for LAI and hc in Figure 2, one gets the impression that for days > _230 the Bosveld 99 parameterization will not be used, as LAI<1.5. However, looking at Figure 5 one sees that even for days > _230 Bosveld 99 is much closer to the SCOPE simulated KB-1 than the Su 01 (that would be used here, if this sentence is correct). I think this requires some further explanations.

Answer: Indeed the values of Bosveld 99 are much closer to the SCOPE simulated KB-1 than the Su 01 even for days after thinning. It is assumed that although leaves are removed from the vegetation, the height of the canopy is left intact. Only taking Bosveld however will introduce larger errors when agricultural crops are investigated. I have elaborated this in the text. ?P15, . It is therefore surprising to see that even after the canopy has been thinned to LAI values lower than 1 the parameterization still produces good results, Figure 6. It is assumed that this is although leaves are removed from the vegetation, because the height of the canopy is left in tact.?

Comment17) P2876.L14. What is the time of the day for the instantaneous fluxes? Corresponding to SCOPE simulated AATSR measurements? It is indicated later on in Figure 7, it will be useful to have it here.

Answer: An overpass time of 10.30 has been considered and noted in the text

Comment18) P2877.L26. SCOPE assumes surface/canopy energy balance, right? At some days we can see that SCOPE Go can be 100 W/m2 larger than the measured values, while SCOPE and observed Rn agree relatively well. Would not that imply that H+LE[SCOPE] _= Rn-Go[SCOPE] is an underestimation of the true H+LE[OBSERVED]=Rn-Go[OBSERVED]?

Answer: This is indeed true, this extra uncertainty has been noted in the text: P18 ?For sensors with different overpass times however it could lead to an extra uncertainty, although this diurnal pattern is only apparent for low radiation values.?

Comment19) P2877.L10. It may be of interest to add the original SEBS fluxes in Fig-

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ure 6 (only one extra line) to have a feeling about the original fluxes. As the original SEBS formulations have been applied by other colleagues, that extra line may be quite informative.

Answer: I have modified the figure to show also the original values.

Comment20) P2877.L17. I may be missing something here. Based on the energy balance that SEBS assumes, it is clear that the observed underestimation of instantaneous H produces an overestimation of instantaneous LE. But if the instantaneous fluxes are discussed here, I do not fully understand how the EF may be playing a role here.

Answer: In SEBS the latent heat is calculated not as the residual but as EF*(RN-G). An overestimation of EF leads therefore to an overestimation in instantaneous LE. This has been made clear in the text? P18, . As SEBS does not calculate the latent heat as the energy balance residual, but using the evaporative fraction this also leads to a higher latent heat flux.?

Comment21) P2878.L15. What happens for 220-230 at _16h? EF > 1 means H < 0?

Answer: During times with low radiation (at night, or during very cloudy conditions), sensible heat can indeed be negative, leading to negative evaporative fraction

Comment22) P2881.L2. If the EF is estimated by SEBS by using a sensor with a different overpass time, would the EF change? I guess so, as it seems that EF is not constant with time for this type of vegetation. If that was the case, would that EF still be representative of the daily average? Perhaps this sentence need to be better discussed, here or in the previous section, to signal that the assumption of wrong instantaneous EF resulting in right daily averaged EF may only apply to this specific sensor/biome combination.

Answer: In case of a diurnal pattern in EF, The EF is estimated by SEBS is indeed different by using a sensor with a different overpass time. More investigation than needs to be performed.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 2861, 2011.

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