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Interactive Comment

Interactive comment on "Uncertainties in using remote sensing for water use determination: a case study in a heterogeneous study area in South Africa" *by* L. A. Gibson et al.

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The manuscript is pointing to some aspects of the uncertainty in the calculation of remote sensing based evapotranspiration through the case of a single source surface energy balance model (SEBS namely), which is physically based but also a relatively complicated model. The paper is addressing the uncertainties through testing the sensitivity of SEBS to several important parameters namely temperature gradient between land surface and near surface air, fractional vegetation coverage, displacement height and study area heterogeneity. The insights provided by the manuscript are limited mainly due to: some issues like the land surface temperature (and gradient with near surface air) being the most sensitive parameter of SEBS (and in general surface energy balance models) is already well documented (e.g. Van der Kwast, 2009), the limited field validation data (only apple orchard field with a short duration) is also utilized to a limited extent (only in checking the relation b/w soil heat flux and fractional vegetation coverage and calibrating Fc), lacking a quantified analysis regarding the effect of study area heterogeneity on ET uncertainty. Still the article is addressing in a structured way the important issue of uncertainty in RS based evapotranspiration calculation, and I have the below specific comments with some further technical details which might help improving it.

Specific issues:

(1) In the introduction section (p.6583, L.3-7 and p.6584, L.10-14), the author indirectly concludes a high error/uncertainty in ET calculation by SEBS referring to a project finding (Gibson et al., 2010) which revealed the total annual ET calculated by SEBS exceeded the total rainfall for the study area. Although the uncertainties can be still there in a complex model like SEBS, the higher total annual ET than precipitation doesn't necessarily need to be an overestimation of ET, if there is water use from the groundwater storage for irrigation. And from the details of the paper, it is understood there are also irrigated agriculture activities in the basin. Therefore, it would be better to define the conditions briefly (or validation) why it is considered unrealistically high the calculation of ET by SEBS rather than providing such a generic statement (also considering the project report by Gibson et al. (2010) was not accessible through web by the date of 15th Oct., 2010).

(2) As it can be seen in Eq.23 in Su (2002), sensible heat flux (H) is directly related with temperature gradient between land surface and near surface air (T0-Ta), while it is inversely related with aerodynamic resistance term in the denominator. As the author mentions, Su (2002) indicates the sensitivity of H as $\Delta H = 10\ \Delta(T0\text{-}Ta)$, which is similar by the finding of the author for wheat land cover. In theory (according to Eq 23 in Su,

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2002), higher the temperature gradient, higher H gets. And, since SEBS calculates LE as the residual of the surface energy balance, higher the H gets lower the LE becomes for the same available energy. This is also confirmed by the decreasing trend of daily ET with increasing (T0-Ta) in Fig2 (p.6605) for wheat land cover. However, there is a completely different correlation between daily ET and (T0-Ta) for the case of apple orchard as shown in Fig. 2, and stated in p.6590 between L5-10. It would be good to discuss in more detail why daily ET start to decrease with decreasing (T0-Ta), when (T0-Ta) gets smaller than 8, assuming other parameters are the same? For example, in p.6588, L16-19, it is mentioned the role of T0 in the calculation of aerodynamic resistance? Could it be explained more explicitly how?

(3) Fractional vegetation coverage (Fc) is one of the key (intermediate) parameters of SEBS, which is not only used in the parameterization of H (through the calculation of T0, and also aerodynamic resistance), but also G. The author takes attention to the choice of Fc formula through testing the sensitivity of SEBS to the selection. However, one must be careful checking how Fc is utilized differently in different modules of SEBS: although physically they are supposed to be the same, sometimes different formulations of Fc are used in different modules of SEBS intentionally, since they are meant to fit particular parameterizations: For instance, NDVI based Fc equation proposed by Sobrino and El Kharraz (2003) is meant for calculating emissivity and then the land surface temperature as the title of their article implies "Surface temperature and water vapour retrievals from MODIS data". In deed, also in SEBS model, the algorithm by Sobrino is used in calculating land surface temperature (T0). As the author highlight, this particular equation uses constant min. and max. values of NDVI (0.2 and 0.5) for defining bare, mixed and full vegetation conditions. So, in the case of Fc formula for T0 parameterization, what is more important is the calibration of these boundary values to the particular study area rather than the selection of the formula. The author already presents several examples of calibration (e.g. NDVI time series), and in deed adapts the NDVImax to 0.65 using field data of G in the case of the study area in South Africa.

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However, as mentioned in previous paragraph, Fc is not only used in T0 calculation but also in the parameterization of surface resistance (in the calculation of dimensionless kB-1 parameter, which relate roughness length for heat (z0h) with momentum (z0m)) and in the parameterization of G0. In SEBS, if an input map of LAI is provided, which is generally advised, SEBS uses another Fc formula based on LAI (Fc=1-exp(-0.5*LAI)) for specifically the calculation of kB-1 (in relation with roughness lengths, and H calculation) and G0. Therefore, while it is good to take attention how sensitive is SEBS to the selection of Fc formula (Fig. 4), it should be bear in mind that some specific formulation of Fc is meant to fit to a specific purpose (as in the case of Sobrino and El Kharraz, 2003) and it can be better to put the attention to the calibration of it rather than selecting which formula. In fact, it is interesting to observe in Fig.4 that, when the max NDVI is changed from 0.5 to 0.65 (eq. 3c in Fig.4), they produce the same daily ET with LAI based formula (eq.2 in Fig.4).

(4) In Fractional vegetation coverage section (4.2, P.6592, L.17-19), it is mentioned "where fc=1, sensible heat flux is at a minimum and actual ET equals potential ET. This is the case where NDVImax=0.5. However actual ET is not equal to potential ET where NDVImax equals to 0.65." When fc=1.0 (full vegetation coverage), actual ET does not necessarily need to be equal to potential ET. While the vegetation coverage can be full, there can be still water stress (which affect in turn the surface resistance, H, and LE finally) due to less soil moisture availability (in surface energy balance models, the effect of soil moisture is supposed to be indirectly reflected through land surface temperature, T0). Therefore, the same type of landcover with same full vegetation coverage can depart from potential ET depending on T0 data.

(5) The section 4.4 and the related Figs. (Fig. 6, 7, 8) are expected to address (according to the objectives of the paper given in introduction) how the heterogeneity of study area and the sub-pixel heterogeneity of MODIS pixel can affect the uncertainty in daily ET calculation. However, while all the relevant figures are indicating how much the study is heterogeneous in different ways, they are not providing any significant insight

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(in quantified manner) how the daily ET calculated by SEBS is sensitive to and affected by such a heterogeneity. Alternatively, a comparison of daily ET results from a high resolution image (e.g. Landsat) with a moderate resolution (MODIS) could provide better insights to analyze the effect of sub-pixel heterogeneity as an uncertainty in daily ET calculation. It would be good to modify this section in a manner to address the stated objective. In fact, in the case of a heterogeneous landscape and if the target is to quantify water use at farm level (p.6584, L.1-4), obviously the moderate spatial resolution provided by MODIS (1km) won't be good enough to satisfy such an objective.

Some further remarks:

P.6588, L.15-19: (T0-Ta) is stated as the most sensitive parameter of SEBS, and its role in affecting Rn, G0, and H are mentioned. It's stated that "it affect most the sensible heat flux (H) through calculation of aerodynamic resistance". According to the definition of H; H= Cp (T0-Ta)/ra where Cp is the heat capacity of air, is density of air and ra is the aerodynamic resistance. Obviously, (T0-Ta) is the main forcing magnitude and directly affects the H, independent from the calculation of aerodynamic resistance.

P.6589, L.3-6: it is stated "Additionally, the heterogeneity of the study area implies that an accurate interpolation of air temperature across the study area is needed in the absence of distributed field-based air temperature measurements." This statement is logically not correct. In the absence of distributed field measurements, and presence of topographically heterogeneous landscape, an accurate interpolation is not possible (by the definition and functionality of interpolation). Global climate data products (e.g. ECMWF) could be an alternative source for distributed air temperature.

P.6591, L.6: It is stated "... pixels with values of 0.2 or lower are considered to be sparsely vegetated or to contain bare soil". According to Eq (2), and when NDVImin = 0.2, NDVImax=0.5, Fc becomes "0" for NDVI value of 0.2, which indicate complete bare soil conditions but not sparsely vegetated or partially containing bare soil. Therefore, SEBS assign "0" values of Fc according to Eq (2) for the NDVI values of 0.2 or

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lower. The values between the min and max represent the mixed vegetation cover with different degree of sparse vegetation.

P.6592, L18-19: Grammatically it is better to say “However actual ET is not equal to potential ET where NDVImax equals to 0.65” instead of putting mathematical signs in the sentences.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 6581, 2010.