Interactive comment on “A coupled remote sensing and the Surface Energy Balance with Topography Algorithm (SEBTA) to estimate actual evapotranspiration under complex terrain” by Z. Q. Gao et al.

Anonymous Referee #2

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1 General Comments

This paper introduces a method for estimation of evapotranspiration based on energy transfer equation and with inclusion of topographical parameters of terrain (e.g. slope, aspect) using MODIS images over a large area in Northeast of China. Inclusion of the topography parameters is mostly used for estimation of net radiation. In addition, the
authors used these parameters for adjustment of temperature difference. This paper has a good structure for presenting the research, however, there are some concerns regarding formulation of the methodology and validation of the results which are addressed in the “Specific Comments” section. Another important issue is the use of English grammar and appropriate use of technical words and phrases throughout the text. This paper is publishable if proper modifications applied to the text.

2 Specific Comments

Abstract

What you mean by “limited” in “limited temporal and spatial scales”?

What do you mean by complex terrain? Where the complexity of terrain addressed in the formulations given in the subsequent sections of the paper?

Does this paper gives “Full account” for the dynamic impacts of complex terrain and changing land cover with some varying kinetic parameters over time? I guess it is better to use another appropriate word instead of “full” as still there are still unknown issues about effects of terrain on ET, especially in regard to advection and atmospheric turbulence.

The phrase “in concert” replaced with more appropriate word.
How the dynamic impact of terrain and land cover with roughness parameters are addressed “over time”? Where in this paper the effect of time is addressed in the formulation?

**Introduction**

Soil evaporation is not negligible, especially when soil moisture content is relatively high.

Comparison or accompanying of soil moisture and evaporative power of the net radiation is not correct. They are basically different.

Portioning of $R_n$ is not only dependent to the soil moisture, but also to the atmospheric turbulence.

The statement in the first paragraph for relating ET with the sustainability and climate change is ill. Rephrasing is necessary.

Point measurement of ET can be done by other methods as well. The basis for separation of the ET measurement methods at point scale must be given in a more appropriate way.

Eddy-covariance method is not just an energy balance method, as it works based on both energy and mass (water vapor) transfer.
The phrase “high precision” in ET estimation by remote sensing should be adjusted or proper references regarding this level of precision are cited.

This kind of categorization of the remote sensing ET methods is not good. Provided cited papers for this sentence have not a such a categorization.

Surface radiation temperature replaced with “surface radiative temperature”

“at first” is not correct English phrase

Link of roughness length parameters with surface parameters in SEBS is not based on “similarity theory”. In SEBS, the similarity theory is rather used for estimation of sensible heat flux

Replace “ET ratio” with “evaporative fraction”

Please change the phrase “based on the SEBS”. SEBS includes a number of methods for different parameters. In exact words, in SEBS, after determination of the evaporative fraction, ET is determined by multiplying this fraction to the available energy ($R_n - G$)

Replace “one and two layer model” with “two-source energy balance” or “dual-source energy balance”.

C1988
The sentence “They were in good agreement” should be included with the previous sentence with more coherent English grammar.

Why residual methods are the best?

How “time period” is addressed in the formulation of SEBTA?

Higher than what in “higher resolution”?

Put “with” between “areas” and “complex”

2.1 The fundamental theory of the SEBTA

Is the latent heat the driving factor of ET? The driving factors of ET are seems to be the available energy ($R_n - G$), the moisture availability of the soil, and the water content in the crops.

The phrase “the closure in the energy balance equation can be confirmed” has no relation with the first part of the sentence.
Do you mean aerodynamic “diffusion” theory or aerodynamic “turbulence” theory?

The sensible heat flux is heat exchange between the surface and a level in the atmosphere not between surface and “atmospheric turbulence”

What do you mean by “sample size”?

How dry and wet pixels are “always” present in satellite images? What about mixed pixel issues?

What is “stable aerodynamic resistance”?

As here you referred $U_{200}$ to the wind speed at mixed layer, a logarithmic function cannot be used. In the mixed layer the change of wind with elevation is not logarithmic and does not follow the Monin-Obukhov Similarity theory.

Replace “dynamic roughness” with “roughness length for momentum transfer” as for $z_0m$ (and for other parts of this paper)

Why at 0.06 m height?

How $z_{0h}$ in SEBTA is determined?
Include $d$ in the equation as 
\[ \frac{1}{u_*} = \frac{1}{k\pi(z)} \ln \left( \frac{z-d}{z_{0m}} \right) . \]
Also refer to your figure 2 for correct equation.

Z is the height for wind speed measurement

Explain how local advection effects addressed in equation 10, especially for the regions of image where irrigated vegetation is in vicinity of bare soil?

How $a$ and $b$ in equation 10 are determined?

What do you mean by “effective heat fluxes”?

Correct the equation in this line to:
\[ LE_{wet} = R_{n,wet} - G_{wet} \]

Correct the equation in this line to:
\[ LE_{wet} = R_{n,dry} - G_{dry} \]

Correct the equation in this line to:
\[ dT_{dry} = (R_{n,dry} - G_{dry}) \frac{r_{ah,dry}}{\rho_a c_p} \]

How the values for $k_{wet}$ are determined? Give reference.
Why the reference height is the average height of the region?

How this adjustment done?

Give reference for equation 14

$L$ is the Obukhov length

In equation 20 for $L$, as stated in the original papers including SEBS paper, $T_s$ should be replaced with $\theta_v$ (the virtual potential temperature), especially as your atmospheric reference level is at 200 meter in the mixed layer. Also, $T_s$ in the land surface temperature. As $L$ is for quantification of atmospheric stability, air temperature must be used, not land surface temperature.

Modify to: $\Psi_m$ and $\Psi_h$ are integrated stability correction functions for momentum and heat transfer

It seems that the level of observation for wind and air temperature are different (200 m for wind and 2 meter for air temperature). Please note that when using Monin-Obukhov Similarity theory functions, wind and air temperature must be in the same level.

What are the formulas used to calculate $\Psi_m$ and $\Psi_h$?
How equation 20 is formulated?

Give reference for equation of λ

24 hour ET ratio is not appropriate and is not equivalent to daily ET ratio as at night time this ratio is different and normally there is no transpiration by crops.

2.2 The realization of complex terrain in the SEBTA

Is SEBTA for only generation of the solar radiation?

Here do you mean sunshine time or sunshine area?

What do you mean by “time scale” here? Do you mean time step or interval?

What are \( \omega_{sr} \), \( \omega_{ss} \) and \( \Delta \omega \) here? It should be expressed in the paper.

Equation 25 is unclear. What is “SHADOW” in this formula?

Define \( g_0 \) and \( g_i \) in equation 26

Adjust the phrase “if the Sun can shine (or shade)” as Sun can not shade!
It is obvious from this sentence that calculation of shading parameters is useful in better estimation of net radiation. However, in the subsequent sentence it is stated that this parameter is used for calculation of sensible heat flux. How this calculation done? Is this just for an adjustment on land surface temperature due to elevation change by equation 14? So, where did you account for full impacts of surface characteristics as you stated in line 12 of this page?

**2.4 Dynamic determination of surface kinetic parameters in the SEBTA**

Refer to $z_{0h}$ as another roughness parameter, as you later stated equation 29 for its estimation.

Equations 27-29 are not the cited reference (Sue et al. 1999)

Change “others” to “other”.

Even with dynamic change of effective height based on MSAVI parameter, this is not the full use of available data for determination of roughness parameters, as still effects of atmospheric turbulence on roughens parameters are not included.

**3 Case study**

3.1 Study area

Which method is used to estimate annual ET?
What do you mean by “ample light and heat fluxes”?

Give reference

3.2 Data collection and analysis

Introduce the MODIS products you named here

Did you use both daily and 8-day products of MODIS for land surface temperature (MOD11A1 and MOD11A2)?

What is the temporal resolution of climate data used here? Why only one meteorological station used? Include some comments regarding the method of observations and equipments of this station.

What do you mean here by “vectorized”? Is this vectorization applied to “all datasets” (even climate data)?

3.3 Model Validation

Change “cover” to “covering”.

As here SEBTA using energy balance approach and your observed ET are by a lysime-
ter using water balance approach, please give some comments and explanations regarding the differences of two method and the uncertainty of each method. What is the temporal resolution of lysimeter observations? How do you justify this with instantaneous ET from remote sensing?

Please give some description of the lysimeter site. What is the complexity of terrain for this site that SEBTA addressed? What is the distance between meteorological station used and this lysimeter? What are the average elevation at this site and the average elevation of the study area? What are \( a \) and \( b \) coefficients at this site? How air temperature justified for this site?

4. Results and discussion

What is the bases for classification of “rough” and “moderate” terrains? Please give reference

As in Figure 7a there is no couture line, how one can distinguee “distinct terraces on each 500 m”?

Change “one” to “on”

ET in any single time in any elevation is varying in maps. In other words, same elevations at any time have different ET. How did you prepare Figure 9 then?

As you have only one validation point in your study area, what is your assessment of the uncertainty of ET in Figures 8-12?

4.2 The impact of different patterns of LULC on ET estimation
Pages 4898 and 4899

What is the main conclusion of this analysis? What is your interpretation of the main results for this change of ET over land use? What is your assessment of the accuracy of these values?

4898-line 8

You can summarize this paragraph into a simple table. Try to summarize the text to prevent repeating of words

4899-line 1

Change “can be as biggest as”

4899-line 16

Where is the first hand for “on the other hand”?

4899-line 29

Southeast and Northeast must have first letter in capital. See also 4900-line 3

4900-line 1

A word must be missing between “and” and “regions”. This sentence is meaningless.

4.3 The impact of the inclusion of elevation, ..

4900-line 14

Change “water” to “water vapor”

4900-line 14

How you address the “full” introduction of DEM effects on water vapor and heat fluxes? Aren’t there any term not included (e.g. advection terms due to topography) which is not included here? In my understanding, the only effects of DEM on ET addressed in this
paper is on calculation of net radiation and an adjustment on temperature difference.

Although here you mentioned “1532 m” as the maximum height, the maximum elevation if Fig 11 is 1100 m.

Where are “left” and “right” curves in Fig 11? I see you combined them to one graph.

What do you mean by “delineation of terrain effects”?

Where is the source for extraction of values of Fig 12? What is the validation assessment of these values?

4.4 Final remarks

Please note that in SEBS (Su, 2002), land use is considered by its $kB^{-1}$ model for roughness parameters.

How you proved the over-estimation of ET in the areas with higher elevations and larger shade slope? What are your validation data?

5. Conclusions

What is “aerodynamic diffusion theory”?
How you addressed “full account” of terrain on ET. Refer to my previous comments.

What was your “consistency index”? Where is its definition?

24 or 48? What are these 24 datasets of MODIS?

What is your “differential analysis” here? What spatial scales you worked with? Isn’t it that your resolution for ET estimation is 1km based on MODIS thermal data? Also, what are your temporal scales? You only summarized data by averaging in seasonal time steps. Did you used remote sensing data with different temporal resolutions?

What are your validation data for evaluation of ET change in different heights over different seasons?

Table 2:
This table does not exist in the cited reference (Liu et al., 2005), see page 4910.

Fig 1
Replace “Friction wind” with “wind friction velocity”

Fig 3
In vertical axis, state MSAVI as vegetation index, as stated in 4891-line 8