

## Review Desai et al. (2022).

### General comments

This paper looks at improved estimates of the instantaneous noon-time surface energy balance (SEB) obtained from a variety of field and remote sensing data. The main emphasis of this paper is on the improved estimation of soil heat flux  $G$ , by employing the thermal inertia and soil heat flux models proposed by Murray and Verhoef amongst others. There are some good to marginal improvements compared to simpler methods used to calculate  $G$ . The STICS-TI model does a good job at predicting the noon-time latent and sensible heat fluxes for complex sparse canopies in a range of climates.

It should be applauded that the authors have managed to structure the description and analyses of a large amount of data and theory in this manuscript, also with the help of a large number of Appendices. Perhaps some of these could be Supplementary Information?. However, the English could be improved in many places. There are a number of native English speakers on the author list, so I expect to see a much improved revised version.

The introduction rambles quite a bit, and contains a number of inaccuracies and 'red herrings' as per my many minor comments below.

I still have my doubts about the validity of the STICS equations and assumptions, from a micrometeorological and soil physical perspective, but seeing that this theory has been peer-reviewed and published many times in recent years, I will not argue with this again..

I am not sure how useful these peak values of LE are from a practical point of view. Can they be used for irrigation? For land surface model data-assimilation?? They cannot really be used in water balance estimates for example.

### Introduction

Line 73-74: I have two issues with this part of the sentence "...which makes it a crucial variable for estimating sensible heat flux (H) ET through the SEB models". What is meant by "sensible heat flux (H) ET"? Is there a word missing here? Also: what are "the SEB models" exactly? You mention an "analytical surface energy balance (SEB) model" in line 71, but that is a more specific model.

Line 79-80: Remove the hyphen in "extra-resistance". Also, it is often called "excess resistance", see e.g. Verhoef et al., (1997), and it relates to the differences in roughness lengths for momentum and heat/water vapour. Is this worth mentioning here?

[https://journals.ametsoc.org/view/journals/apme/36/5/1520-0450\\_1997\\_036\\_0560\\_spnotp\\_2.0.co\\_2.xml](https://journals.ametsoc.org/view/journals/apme/36/5/1520-0450_1997_036_0560_spnotp_2.0.co_2.xml)

Line 83: how is the aerodynamic conductance ( $gA$ ) related to the extra resistance? According to the Appendix it is not, so is all this discussion here about roughness lengths, aerodynamic and thermodynamic temperatures etc. simply a distraction?

Line 86-87: replace “heat conductance” by “thermal conductivity”. This sentence is not fully correct, because soil thermal properties themselves depend on soil moisture content.

Line 87-89: Quoting these values is okay, but you need to make clear over what time period these are. Are these instantaneous values, or daily averages?

Line 99 -102: You seem to be comparing apples and pears here? I.e., a mechanistic G model with an analytical SEB model? This feels a bit contrived.

Line 103: What is meant with “Recognizing the significant conclusions of..”. ? Did you mean “Based on/in light of the conclusions..”?

Line 105: What exactly is meant by “...complement the overarching gaps in SEB modelling”?

Line 107: Is an “analytical ET model” the same as a “SEB-model”? (“new coupled G-SEB model”). And how does this fit with “Remote sensing-based ET models”. The whole introduction has been written in this very woolly fashion.

Line 117: “...any information of deep soil temperature or daily temperature amplitude”. Do we need deep soil temperature to calculate an estimate of G? Also: what temperature amplitude are you actually referring to here?

Line 127-128: ...”When LE is reduced due to soil moisture dry-down and water stress, both G and TS tend to show rapid rise”.. A rapid rise over what period? During the day? A season a year? Multiple years? Another illustration of the imprecise language used throughout this manuscript.

Line 133: What is meant by “day-night TS”? Is this day minus night TS? Is this not the same as amplitude (x 2)?

Line 135: It should be “has so far”

Line 157-158: What are these “contemporary empirical models’? Also: Later on you say that you are not comparing to SEB models (line 167). Then why exactly were these discussed in so much detail in the introduction?

Line 162: Most of the readers will not have heard of mulga vegetation. Can you explain it briefly between brackets?

## 2 Study area and datasets

Line 173: “The present study was conducted at nine flux tower sites”. To me this means that you were running your models while being physically based at these sites. Can you not say”.. used data from nine flux tower sites..”?

Line 181-182: Did you mean “The fetch-to-height ratios of EC towers ? and what is meant with “representing 90% of fetch area”. Please read a paper or 2 on these topics and express it properly. Perhaps you meant that 90% of the vegetated area was within the footprint of the mast? Or something along those lines?

Line 192: This reads as if there were 4 towers in total...

Line 195: “on privately owned land”. Is this relevant??

Line 227: What does it mean “SEB measurements were carried out”..? Did you mean EC measurements? Or Rn too? Certainly not G because one can’t measure this above ground.

Line 228-231: These measurements heights mean nothing if you don’t also give the vegetation heights...

Line 236: soil temperature at what depths?

Line 256: What is meant by “noon-night land surface temperature” and why is this not apparent from the entries in Table 2? Why not just say “LST at 1.30pm and am”?

Line 269: Why exactly do you need land surface emissivity and albedo for that matter? I guess to calculate Rn? You need to refer forward to Chapter 3 then, or describe the methods first, then the data?

Line 296: What are “moisture constants”?

Line 290: there is a long list here of 5 noteworthy features of the STICS-TI model, but some of them are phrased inaccurately and it is hard to picture what is actually meant, because the theory has not yet been presented... Maybe describe the theory first?

Line 308-309: what exactly is meant by “surface soil temperature amplitude (within 0.1 m from the soil top”? Is this any soil temperature between the soil surface at 10 cm depth? Or the integrated/average soil temperature?

Line 310: I thought it was 1.30?

Line 327-328: ... “decreases with depth to become close to zero until the damping depth where soil temperature is almost invariant through day-night called deep soil temperature”. This is not my soil physical understanding? The amplitude is still 30% or so at damping depth?

Line 339-340: ...” TSTmin is thus close to deep soil temperature as well as minimum soil temperature of other sub-surface soil layers” . What evidence do you have for this statement? I am not sure that this (always) holds?

Line 340-342:.. “Both TSTmin and TSTmax represent ....lower and upper boundary conditions of soil heat flux conducting through topsoil at noontime” I do not understand this statement? The soil heat flux will be determined by the gradient in soil temperatures at two depths, at the same time??

Line 379: I think you mean “soil moisture contents”, not “soil moisture constants”? Or did you mean to say that they are parameters that remain constant?

Line 393-410: Despite the fact that I have reviewed the STICS approach a number of times (and each time I expressed my bewilderment at the ‘moisture equation’) I still do not understand how you estimate  $M$  (Eq. 9), that is clearly a below-ground soil moisture related equation, for variables that are related to atmospheric moisture that is above ground? Also, why do you rearrange Eq. 6 in terms of  $M'$  if you are then still deriving  $M$  in Section 3.1.1.3?

Line 416:  $Le$  and  $H$  are not conductances? They are fluxes! What is meant here? I believe the word ‘and’ is missing after the comma. Also, how were the conductances calculated? No detail is given about this?

Line 429 (Figure 3). Is surface emissivity not used to calculate net radiation?

## Results

Line 481: I am not sure that I fully understand the caption for Fig. 5b. How are the different years denoted?

Line 520: Figure 7. It is actually not clear to me what these data are exactly. These are instantaneous values but for what time? You have used noon and midnight  $T_s$  values here, but your  $G_i$  cannot be a daily average because its  $G$  values would be much smaller. You mention noon time in the text, so I guess this must be it.

Figures 10 & 11 look promising, but of course all these efforts only give you one value of the fluxes (around noon) for each day. How useful is this?

## Discussion

Should Fig. 12 be part of the results section? Also why are you not plotting thermal inertia on the y-axis versus  $M$ ? That would make more sense? Finally why are we not seeing the flattening off of the curve at large  $M$  values? And why is there so much scatter? Because of the different soil types at the different sites?

Line 685-687: “...this is the first ever implementation of a coupled G-SEB model that does not require any empirical parameterization of aerodynamic and canopy-surface conductance”. I am somewhat confused by this statement. I thought you were calculating  $g_A$  and  $g_S$ ? I see equations for these in the Appendices?