We would like to thank Reviewer#1 for the detailed comments. Please find below our responses.

RC 1*: 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*.

AC: We will modify the sentence to read as "which makes it a crucial variable for estimating sensible heat flux (H) and ET through the SEB models". The word 'and' was missing and will be added in the revised version. SEB models are Surface Energy Balance models.

Analytical surface energy balance model is a specific SEB model. We will remove 'SEB' from the parentheses in the text "analytical surface energy balance (SEB) model"

RC 2: 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?

AC: We will correct it as 'excess resistance' in the revised version. We will also mention that the excess resistance was introduced to accommodate the differences between roughness lengths for momentum and heat/water transfers.

RC 3: 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?

AC: The corrections related to RC 2 will take care of this suggestion.

RC 4: 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.

AC: We will replace 'heat conductance' with 'thermal conductivity'. We will modify the text as 'soil thermal properties such as thermal conductivity and heat capacity, which vary with mineral, organic and soil water fractions.'

RC 5: 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?

AC: These are instantaneous time scale, and we will mention this in the revised version.

RC 6: 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.

AC: We are not comparing mechanistic G model with analytical SEB model. We mentioned about coupling a mechanistic G model with an analytical surface energy balance model for estimating evaporation. Thermal remote sensing-based evaporation estimation through SEB models commonly use empirical sub-models of G and these G sub-models are run in a stand-alone mode. Despite the utility of mechanistic G models is demonstrated in different studies, no thermal remote sensing-based evaporation study attempted to couple such a mechanistic G model with a SEB model. Therefore, the major goal of this work is to couple the mechanistic G model of Murray and Verhoef (2007) with an analytical surface energy balance model, STIC. This text will be added in line 99 – 102.

RC 7: Line 103: What is meant with "Recognizing the significant conclusions of..". ? Did you mean "Based on/in light of the conclusions.."?

AC: Yes. We agree to replace "Recognizing the significant conclusions of.." with "Based on/in light of the conclusions.."

RC 8: Line 105: What exactly is meant by "...complement the overarching gaps in SEB modelling"?

AC: The overarching gaps are, (i) accurate estimation of G and ET in sparse vegetation, (ii) testing the utility of coupling a thermal inertia-based G model with analytical SEB model for accurately estimating G and ET, and (iii) detailed evaluation of a coupled G-SEB model at the ecosystem scale. We will mention this before the sentence containing text "……complement the overarching gaps in SEB modelling". We will replace the word 'complement' by 'mitigate' in the revised version.

RC 9: 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.

AC: We will modify the text "analytical ET model" with "analytical SEB model". The analytical SEB model is STIC, and in the present study, STIC is coupled with a TI-based mechanistic G model. This coupled SEB-G model is known as STIC-TI model. We will mention this after line 107 and before the start of new paragraph.

We will modify the text **'**Remote sensing-based ET models' as **'**Remote sensing-driven SEB models for evapotranspiration (ET) estimation'.

RC 10: 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?

AC: We will modify the text as "…..any information on soil temperature". The TI-based G model does not require any deep soil temperature and it requires daily amplitude of surface soil temperature to compute noontime instantaneous G for a given day.

RC 11: 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.

AC: We mean here rapid intra-seasonal rise of G and T_S. We will modify the text as: "When LE is reduced due to soil moisture dry-down and water stress, both G and T_S tend to show rapid intra-seasonal rise"

RC 12: 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"

AC: We will replace day-night Ts with "noontime and nighttime Ts" to avoid confusion. Soil temperature amplitude computation for TI-based G modeling is given in section 3.1.1.1. We will replace 'is so far' with 'has so far'.

RC 13: 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?

AC: Here, we intend to say conventionally used empirical G models. We will modify text as **'**conventionally used empirical G models' instead of 'contemporary empirical models' to avoid confusion.

RC 14: Line 162: Most of the readers will not have heard of mulga vegetation. Can you explain it briefly between brackets?

AC: Mulga is the name given to woodlands and open-forests dominated by the mulga tree (*Acacia aneura*). We will explain this in the revised version.

RC 15: 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.."?

AC: We will modify the text as “The present study was conducted using data from nine flux tower sites”

RC 16: 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?

AC: The flux footprint for EC towers in India varied from 500m-1km (Bhat et al., 2019). In the present study, about 90% of the fluxes came from an area within 500 m to 1 km from the EC tower. This represents that relative contribution of the vegetated land surface area to the flux is close to 90% (Schmid, 2002; Vesala et al., 2008). The remaining few percentage of flux is coming from an area beyond the flux footprint.

RC 17: Line 192: This reads as if there were 4 towers in total.

AC: In the beginning of section 2.1, it is clearly written as “……at nine flux tower sites (four sites in India; three sites in Australia; two sites in USA) equipped with Eddy Covariance (EC) measurement systems. So, there should not be any confusion that 4 towers in total.

RC 18: Line 195: “on privately owned land”. Is this relevant??

AC: We will remove the text “on privately owned land”.

RC 19: 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.

AC: We intend to say measurements of H, LE fluxes from EC systems and Rn from net radiometers. We will modify the text accordingly.

RC 20: Line 228-231: These measurements heights mean nothing if you don’t also give the vegetation heights...

AC: Average heights of vegetation are 1.15 m at IND-Naw, 1 m at IND-Jai, 1.23 m at IND-Sam, 1.5 m at IND-Dha, 6.5 m at AU-Asm, 15m at AU-How, 7 m at AU-Ade; 2m at US-Ton, 1.5m at US-Var.

We will add this information for each site in the revised manuscript.

RC 21: Line 236: soil temperature at what depths?

AC: -0.1m (IND-Dha); -0.15m (AU-Ade); (-0.02, -0.06m) (AU- ASM); -0.08m (AU- How)
-0.02m, -.0.04m, -0.08m, -0.16m (US-Ton, US-Var)

This information is already included in Table A2 of Appendix.

RC 22: 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 1.30 pm and am”?

AC: We will mention land surface temperature at 1.30 pm and am instead of noon-night land surface temperature. We will also mention Ts at 1.30 pm and am in Table 2.

RC 23: 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?

AC: We needed land surface emissivity and albedo for computing Rn. The Rn model is described in Appendix B. In addition, albedo is required to develop model for soil temperature amplitude. This has been mentioned in section 4.1.

We have used products of MODIS Aqua LST, Emissivity, albedo, NDVI as key variables to SEB modeling. As suggested by R1, it will be appropriate to keep a brief account of their generation / retrieval process as sub-section 3.2 of section 3. In that case present sub-section of 3.2 will be 3.3. Therefore, the relevant text given in sub-section 2.2.2 will be shifted to new sub-section 3.2.

RC 24: Line 296: What are “moisture constants”?

AC: We mean soil moisture characteristic limits. We will modify the text accordingly.

RC 25: 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?

AC: We agree that those 5 noteworthy features should be presented after describing the theory. We will transfer the sentences from line 290-297 after the section 3.2.1. We will modify the points as follows.

The noteworthy features of STIC-TI are: (1) estimating G by modifying the mechanistic MV2007-TI model using noon and midnight TS information from thermal remote sensing observations available through polar orbiting satellite platform (e.g. MODIS Aqua), (2) coupling the mechanistic MV2007-TI G model with STIC1.2 to simultaneously estimate surface moisture availability (M), G, and SEB fluxes, (3) introducing water stress information in G to better constrain the aerodynamic and canopy-surface conductances as well as the SEB fluxes, (4) derivation of amplitude of ecosystem-scale surface soil temperature (from top soil to 0.1 m soil depth).

RC 26: 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?

AC: It is average soil temperature between surface to 10 cm depth.

RC 27: Line 310: I thought it was 1.30?

AC: It is 1.30 indeed. We will correct this in the revised version.

RC 28: 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?

AC: We agree with reviewer suggestion on this. We will modify the text to read as “where the amplitude is maximum at the surface and it gradually decreases with depth to become 37% of surface amplitude until the damping depth (Hillel, 1982).” However, at deeper depths, soil temperatures remain constant with time and do not show much fluctuations as compared to surface or near-surface soil temperatures. This invariant soil temperature is called deep soil temperature (Mihailovic et al., 1999). We will add this sentence after the above-mentioned quoted text.

The soil depth of deep soil temperature is higher than the damping depth.

RC 29: 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?

AC: We agree with this comment. This sentence will be deleted in the revised version.

RC 30: 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??

AC: This sentence will be deleted in the revised version.

RC 31: 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?

AC: We mean θ_{fc}, θ_{*}, θ_{wp} are the characteristic volumetric soil moisture content at field capacity, maximum retentive capacity and permanent wilting point corresponding to soil water potentials at

-33 kPa, 0 kPa and -1500 kPa, respectively. We will modify the text in Line 379 in the revised version.

RC 32: 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?

AC: Equation 9 is a classical expression for estimating soil moisture availability (M) from the observations of actual soil moisture, soil moisture at the field capacity and permanent wilting point, respectively. The thermal inertia equation (eq. 6) was rearranged in terms of M to arrive at equation 9, and M is unknown here. Therefore, the estimation of M is done according to the procedure mentioned in 3.1.1.3, through which STIC is coupled with TI-based estimation of G. In the revised version, we will make this description more explicit.

RC 33: 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?

AC: We intend to say that the initial estimates of conductances, LE, and H are obtained. The word 'and' is missing indeed. We will modify this section description as follows:

From the initial estimates of Gi(eq. 2) and RNi (equations in Appendix B), initial estimation of LEi and Hi were obtained through the PMEB equation. **The initial conductances for estimating H and LE through the PMEB equation was obtained by solving the state equations as described in the Appendix.** The process was then iterated by updating T_{0D} [$T_{0D} = T_D + (\gamma LE/\rho c_p g_a s_1)$] and M in every time step (as mentioned in Mallick et al., 2016, 2018a), and re-estimating G_i(using eq. 3), net available energy (RN_i–G_i), conductances, LE_i, and H_i, until stable estimates of LE_i were obtained. The conceptual block diagram and algorithm flow of STIC-TI is shown in Fig. 3a and Fig 3b, respectively.

RC 34: Line 429 (Figure 3). Is surface emissivity not used to calculate net radiation?

AC: Yes, surface emissivity was used to calculate net radiation. In the revised version, we will incorporate surface emissivity in the block showing inputs in Figure 3.

RC 35: Line 481: I am not sure that I fully understand the caption for Fig. 5b. How are the different years denoted?

AC: We will modify the caption for Fig. 5b as "Validation of the ecosystem-scale estimates of A from the above functions over different ecosystems"

RC 36: *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 Ts values here, but your Gi 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.*

AC: These are noontime (1.30 pm) Gi estimates. We will modify in the caption of Figure 7 accordingly to read as 'Validation of STIC-TI derived noontime (1.30 pm) Gi estimates with respect to in-situ measurements in different ecosystems.

RC 37: *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?*

AC: Ideally diurnal latent heat fluxes are needed to estimate daily evapotranspiration (ET). In a cloudless day, the diurnal variation of latent heat flux between sunrise to sunset has sinusoidal pattern with its amplitude or peak corresponding to around noontime. Several studies revealed (Mallick et al, 2009, Bhattacharya et al, 2010) that the noontime latent heat flux computed through SEB model from polar orbiting remote sensing observation during a day can be converted to daily ET (in terms of mm depth of water) through sinusoidal integration. Validation of daily ET through such method is found to be close to in situ ET measurements. Therefore, validation of noontime LE and H fluxes and their accuracies are also very useful.

RC 38: *Should Fig. 12 be part of the results section? Also why are you not plotting thermal intertia 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?*

AC: Figure 12 is put in the discussion to highlight the reasons for reduced sensitivity of G due to Ts uncertainties. However, we agree with the suggestion to put thermal inertia in y-axis of Fig 12a. Overall, we will modify Figure 12 in the revised version which will be as follows:

(i) We will merge Fig. 12 (a) and (b): thermal inertia in y-axis and noontime Ts in x-axis with color segregation according to M. The plot of thermal inertia versus Ts is flattening due to the effects of M and we see so much scatter due to different soil types across the sites.

(ii) We will merge Fig. 12 (c) and (d): G in y-axis and Amplitude (A) in x-axis with color segregation according to the thermal inertia.

The description in the text will be modified accordingly.

RC 39: *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?*

AC: We are directly estimating ga and gs by solving the state equations as mentioned in the manuscript (Line 1093 to 1124). While the estimation of ga does not require any parameterization of surface roughness and atmospheric stability, estimation of gs does not involve any empirical

function or look-up table for biome or plant functional attributes. **We will modify the sentence in L685-687 for a better clarity.**

References:

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Mallick, K., et al. (2009). Latent heat flux estimation in clear sky days over Indian agroecosystems using noontime satellite remote sensing data. Agricultural and Forest Meteorology, 149 (10), 1646–1665, doi:10.1016/j.agrformet.2009.05.006.

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