Response to Reviewer #3

The paper titled 'Adapting the thermal-based two-source energy balance model to estimate energy fluxes in a complex tree-grass ecosystem' by Burchard-Levine et al. aimed to improve the existing two source model in heterogeneous ecosystem.

The entire study lacks the scientific insight and adds no significant contribution in thermal remote sensing of ET science. The ambiguous resistance parameterizations need serious attention before such models could be applied in water-stressed ecosystems. My detailed comments are embedded in the manuscript.

Response: It is true that other remote sensing diagnostic models (i.e. STIC, as mentioned by the reviewer) attempt to solve some of the uncertainties related with resistance energy balance models, taking advantage that some assumptions are fulfilled. However, considering that HESS is not solely a remote sensing journal, we argue that this study, based on the use of TSEB, is still valid for a larger community of scientists working on water flux modelling, besides the remote sensing community. The major conclusion of this manuscript is that, by using a simple parameterization depending on the phenological stage, it is possible to robustly estimate water and energy fluxes over complex ecosystems such as wooded savannas. As a proof of the validity of these results, there are many soil-vegetation-atmosphere models that still rely on the Monin-Obukhov similarity theory to retrieve the turbulent transfer coefficients, either for bulk transfer, i.e. one layer models, or for two or multi-layered systems. These include widely applied and operational models for weather prediction, such as ECMWF IFS model (ECMWF, 2018), the NCAR CLM model (Collins et al. 2004, Lawrence et al. 2018), or SURFEX ISBA model of Meteo-France (Albergel et al. 2018); but also hydrological models such as Parflow (Kollet and Maxwell 2008; Dai et al. 2003), crop models such as Daisy (van der Keur et al. 2001) or STICS (Brisson et al. 1998; 2003), or dynamic global vegetation models (Ducoudré et al. 1993; Krinner et al. 2005).

All these prognostic models require the estimation of resistances or conductances, in one form or another, in order to simulate the transport of energy, water and carbon between the land surface and the atmosphere. As such, the findings presented in this study demonstrated a relatively simple and general approach to account for changes in surface conditions for tree-grass ecosystems due to phenology, with the use of a standard and widely applied modeling scheme.

ECMWF (2018) IFS DOCUMENTATION – Cy45r1, Part IV Physical Processes, Chapter 3. European Centre for Medium-Range Weather Forecasts, Shinfield Park, Reading

William D. Collins, Philip J. Rasch, Byron A. Boville, James J. Hack, James R. McCaa, David L. Williamson, Jeffrey T. Kiehl, Bruce Briegleb et al. (2004) Description of the NCAR Community Atmosphere Model (CAM 3.0). NCAR TECHNICAL NOTE NCAR/TN–464+STR, Boulder, Colorado

David Lawrence, Rosie Fisher, Charles Koven, Keith Oleson, Sean Swenson, Mariana Vertenstein et al. (2018) CLM 5 Documentation, National Center for Atmospheric Research (NCAR) Boulder, Colorado

C. Albergel, A. Boone, S. Belamari, B. Decharme, M. Dumont, P. Le Moigne, V. Masson (2018) SURFEX Scientific Documentation, Chapter 4. Ed. P. le Moigne, Météo France.

Kollet, S. J., and Maxwell, R. M. (2008), Capturing the influence of groundwater dynamics on land surface processes using an integrated, distributed watershed model, Water Resour. Res., 44, W02402, doi:10.1029/2007WR006004.

Dai, Y., X. Zeng, R.E. Dickinson, I. Baker, G.B. Bonan, M.G. Bosilovich, A.S. Denning, P.A. Dirmeyer, P.R. Houser, G. Niu, K.W. Oleson, C.A. Schlosser, and Z. Yang, 2003: The Common Land Model. *Bull. Amer. Meteor. Soc.,* **84**, 1013–1024, https://doi.org/10.1175/BAMS-84-8-1013

Peter van der Keur, Søren Hansen, Kirsten Schelde, Anton Thomsen, (2001) Modification of DAISY SVAT model for potential use of remotely sensed data, Agricultural and Forest Meteorology, 106 (3), 215-231, https://doi.org/10.1016/S0168-1923(00)00212-4.

N Brisson, C Gary, E Justes, R Roche, B Mary, D Ripoche, D Zimmer, J Sierra, P Bertuzzi, P Burger, F Bussière, Y.M Cabidoche, P Cellier, P Debaeke, J.P Gaudillère, C Hénault, F Maraux, B Seguin, H Sinoquet, (2003) An overview of the crop model STICS, European Journal of Agronomy, 18 (3–4) 309-332, https://doi.org/10.1016/S1161-0301(02)00110-7.

Nadine Brisson, Bernard Itier, Jean Claude L'Hotel, Jean Yves Lorendeau, (1998) Parameterisation of the Shuttleworth-Wallace model to estimate daily maximum transpiration for use in crop models, Ecological Modelling, 107 (2–3) 159-169, https://doi.org/10.1016/S0304-3800(97)00215-9.

Krinner, G., Viovy, N., Noblet-Ducoudré, N., Ogée, J., Polcher, J., Friedlingstein, P., Ciais, P., Sitch, S., & Prentice, I. (2005). A dynamic global vegetation model for studies of the coupled atmosphere-biosphere system. Global Biogeochemical Cycles, 19(1), https://doi.org/10.1029/2003GB002199.

Ducoudré, N. I., Laval, K., & Perrier, A. (1993). SECHIBA, a new set of parameterizations of the hydrologic exchanges at the land-atmosphere interface within the LMD atmospheric general circulation model. *Journal of Climate*, *6*(2), 248-273.

The entire modeling scheme is dependent on multitude of parameter adjustment, which questions the soundness of the model

Response: The reviewer is right about the high level of parameterization required but, indeed, that is the reason we presented a comprehensive global sensitivity analysis. This analysis showed that the model outputs are, in fact, sensitive to only a few parameters, namely fractional cover/clumping index and green fraction, which have physical definitions and could be retrieved from different sources including passive and active remote sensing sensors. In addition, the TSEB-2S approach does not rely on parameter adjustments but only the consideration of vegetation phenology in these two-layer systems by assigning typical/standard vegetation parameter values, depending on the dominant vegetation cover of the phenological periods.

lw: How do you obtain this value for large scale model implementation?

Response: Following the sensitivity analysis, *lw* is not a key parameter since it demonstrated little effect on the output sensitivity. Therefore, *lw* is kept to standard values. In any case, other studies have already applied this model for larger spatial scales by setting *lw* (and other ancillary canopy parameters) based on land cover types as it was done, for instance, in some of the reviewer's suggested literature (e.g. Timmermans et al. 2007) or more recently in Guzinski & Nieto (2019).

Guzinski, R., & Nieto, H. (2019). Evaluating the feasibility of using Sentinel-2 and Sentinel-3 satellites for high-resolution evapotranspiration estimations. *Remote sensing of environment*, *221*, 157-172.

Timmermans, W.J., Kustas, W.P., Anderson, M.C., and French, A.N. (2007). An intercomparison of the Surface Energy Balance Algorithm for Land (SEBAL) and the Two-Source Energy Balance (TSEB) modeling schemes, *Remote sensing of environment*., 108, 369–384, https://doi.org/10.1016/j.rse.2006.11.028, 2007.

A large portion of the introduction needs to be re-written. The introduction should start with texts saying thermal based two source SEB models are used for estimating evaporation and transpiration from the terrestrial ecosystems. Then very briefly saying about the two-source model. That will be followed by saying the complexities in tree-grass ecosystems and the challenges associated with application of TSEB in such ecosystems

Response: The whole introduction was edited and re-structured based on the comments and suggestions received from all reviewers.

The first paragraph carries no relevance to the title of the paper. Authors should start with texts that include why ET modeling in Tree-Grass ecosystems is challenging. What could be the advantage of using a two-source model in tree-grass ecosystems?

Response: This section was modified according to the reviewer's comments along with considering suggestions from the two other reviewers.

Poor sentence construction. The authors should involve a native English writer throughout the manuscript.

Response: We agree that this sentence was perhaps too long. This was edited and we will review the manuscript to avoid similarly poorly constructed and long-winded sentences. However, the main corresponding author is a native English speaker and we did not receive similar comments from the other reviewers. Thus, we believe that the manuscript is generally adequately written.

The authors are struggling here. They should say that the model simulated ET dynamics is sensitive in water-limited ecosystems and model parameters need rigorous testing of sensitivity. The sensitivity of the models could be arising due to ..... This paragraph needs restructuring in some places.

Response: We have modified this paragraph following the suggestions of the reviewer (and of the other reviewers). The entire introduction was adapted for clarity purposes.

In the beginning of the paragraph, it is mentioned that the main objective of the paper is to test the simple adaptation of TSEB. Here it is said that the primary objective is to simulate the bulk fluxes. I doubt about the clarity of the objectives that the author set out for this paper.

Response: The objectives and large part of the introduction have been re-structured according to comments from all reviewers.

But TSEB model used very uncertain soil resistance parameterization, which is also empirical and without any scientific foundation.

Response: We agree with the reviewer that the soil and canopy boundary layer resistances to heat transport carry some uncertainty based on its mathematically formulation, but we cannot agree with the reviewer´s statement regarding the lack of scientific foundation. Although the nature of the soil resistance formulation in TSEB is semi-empirical, based on the scientific works of Kondo & Ishida (1997) and Sauer et al. (1995), the soil resistance mathematical models in Kustas & Norman (1999) show that the resistance to turbulent transport near the soil surface is inversely proportional to wind speed just above the soil surface (i.e. mechanical turbulence) and the gradient temperature between soil surface and overlying air (i.e. thermal turbulence). Furthermore, the resistance calculation is a sub-module of the TSEB model and other more physically-based resistance formulations have been implemented in other works (see Boulet et al. 2015 or Li et al. 2019), but testing these resistance schemes are not within the scope of this study.

Kondo, J. and S. Ishida, 1997: Sensible Heat Flux from the Earth’s Surface under Natural Convective Conditions. *J. Atmos. Sci.,* **54**, 498–509, https://doi.org/10.1175/1520-0469(1997)054<0498:SHFFTE>2.0.CO;2

Sauer, T.J., Norman, J.M., Tanner, C.B., & Wilson, T.B. (1995). Measurement of heat and vapor transfer coefficients at the soil surface beneath a maize canopy using source plates.

Kustas, W. P., & Norman, J. M. (1999). Evaluation of soil and vegetation heat flux predictions using a simple two-source model with radiometric temperatures for partial canopy cover. *Agricultural and Forest Meteorology*, *94*(1), 13-29.

Boulet, G., Mougenot, B., Lhomme, J.-P., Fanise, P., Lili-Chabaane, Z., Olioso, A., Bahir, M., Rivalland, V., Jarlan, L., Merlin, O., Coudert, B., Er-Raki, S., and Lagouarde, J.-P. (2015). The SPARSE model for the prediction of water stress and evapotranspiration components from thermal infra-red data and its evaluation over irrigated and rainfed wheat, Hydrol. Earth Syst. Sci., 19, 4653–4672, https://doi.org/10.5194/hess-19-4653-2015,

Li, Y., Kustas, W. P., Huang, C., Nieto, H., Haghighi, E., Anderson, M. C., et al (2019). Evaluating soil resistance formulations in thermal-based two-source energy balance (TSEB) model: Implications for heterogeneous semiarid and arid regions. *Water Resources Research*, 55, 1059– 1078. https://doi.org/10.1029/2018WR022981

This is a fundamentally flawed assumption. When canopy is in stress this assumption will already overestimate transpiration. Despite the soil evaporation is forced to zero to adjust transpiration, that would not fix the errors in transpiration estimates. I am surprised to see how this flawed concept is running year after year.

Response: The initial PT value at 1.26 is only used as a priori estimate for initializing the model. In subsequent iterations, alpha_PT is being reduced until realistic fluxes at daytime are obtained using the radiometric temperature as a boundary condition (as discussed in Norman et al., 1995). Fig.1 shows the daily average trend of the final effective value of alpha_PT with TSEB-2S for 2015 at the CT tower. Note that the alpha_PT (defined in the model for only the canopy component i.e. Kustas and Anderson, 2009) maintains closer to the initial value of 1.26 during the summer since the model is simulating the canopy transpiration as a scattered broadleaved evergreen tree cover (20% vegetation cover), which has an extensive root system able to withdraw water even under dry, drought conditions.

Kustas, W.P., and Anderson, M.C. (2009) Advances in thermal infrared remote sensing for land surface modeling, Agricultural and Forest Meteorology, 149, 2071–2081.

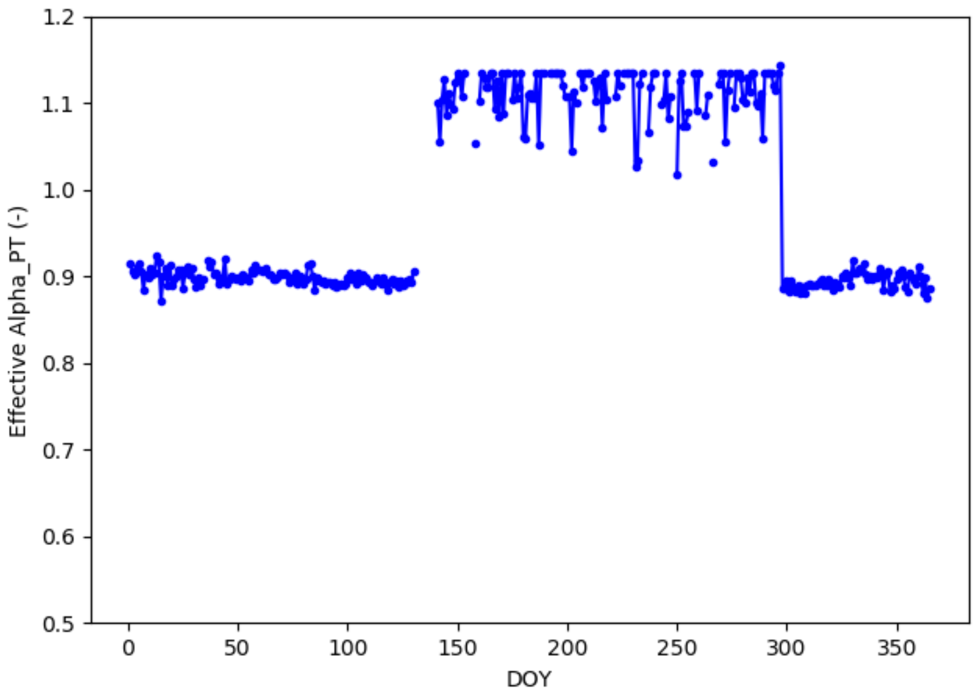

Figure 1. Time series of daily daytime average of retrieved alpha_PT for 2015 at the CT tower

TSEB is only applicable for homogeneous surfaces without any water stress. It fails over the dry surfaces and already shown in Morillas et al. (2013) (https://www.sciencedirect.com/science/article/abs/pii/S0034425713001636); Kustas et al. (2016) (https://www.sciencedirect.com/science/article/abs/pii/S0034425716302814)

Response: We disagree with the reviewer. There are a multitude of previous works published in scientific journals with accredited quality, that have successfully implemented TSEB under stressed conditions (e.g. Timmermans et al. 2007, Kustas et al. 2016, Li et al. 2019). In fact, the papers provided by the reviewer show that TSEB is capable of tracking the trends and magnitudes of sensible heat flux, which under stressed conditions becomes the predominant turbulent flux. On the other hand, despite TSEB being initially designed for homogeneous canopies, there were subsequent studies that presented modifications to the model that successfully estimated fluxes over heterogeneous (and stressed) canopies (see for instance Colaizzi et al 2012, Kustas et al. 1999, Nieto et al. 2019, or Li et al. 2019). Finally, the local input sensitivity analysis performed in this study also showed a large sensitivity of TSEB to radiometric temperature, proving that TSEB can simulate stress conditions.

Colaizzi, Paul D., William P. Kustas, Martha C. Anderson, et al. (2012). Two-Source Energy Balance Model Estimates of Evapotranspiration Using Component and Composite Surface Temperatures. Advances in Water Resources 50: 134–151.

Kustas, W.P., and Norman, J.M. (1999). Evaluation of soil and vegetation heat flux predictions using a simple two-source model with radiometric temperatures for partial canopy cover, Agricultural and Forest Meteorology, 94, 13–29.

Kustas, W.P., Nieto, H., Morillas, L., Anderson, M.C., Alfieri, J.G., Hipps, L.E., L.Villagarcía, Domingo, F., and García, M.: Revisiting the paper "Using radiometric surface temperature for surface energy flux estimation in Mediterranean drylands from a two-source perspective", Remote Sens. Environ., 184, 645–653, 2016.

Li, Y., Kustas, W. P., Huang, C., Nieto, H., Haghighi, E., Anderson, M. C., et al (2019). Evaluating soil resistance formulations in thermal-based two-source energy balance (TSEB) model: Implications for heterogeneous semiarid and arid regions. *Water Resources Research*, 55, 1059– 1078. https://doi.org/10.1029/2018WR022981

Nieto, H., Kustas, W. P., Alfieri, J. G., Gao, F., Hipps, L. E., Los, S., ... & Anderson, M. C. (2019). Impact of different within-canopy wind attenuation formulations on modelling sensible heat flux using TSEB. *Irrigation Science*, *37*(3), 315-331.

Timmermans, W.J., Kustas, W.P., Anderson, M.C., and French, A.N. (2007). An intercomparison of the Surface Energy Balance Algorithm for Land (SEBAL) and the Two-Source Energy Balance (TSEB) modeling schemes, *Remote sensing of environment*., 108, 369–384, https://doi.org/10.1016/j.rse.2006.11.028, 2007.

The authors should show how Rs and Rx vary through out the experimental phase.

Response: Fig. 2 and 3 show how the daily average Rs and Rx vary for 2015, respectively. Differences are apparent for the two phenological periods due to the different assumptions in the vegetation cover within TSEB-2S. Rs decreases substantially during the summer since it is inversely related to the temperature difference between vegetation and soil (eq. 11 in the manuscript), which increases during summer. While Rx increases during the summer largely due to the decrease in LAI (eq. 12 in the manuscript). During the summer, landscape tree LAI is used since the grass-soil substrate is considered not to contribute to LAI during this period.

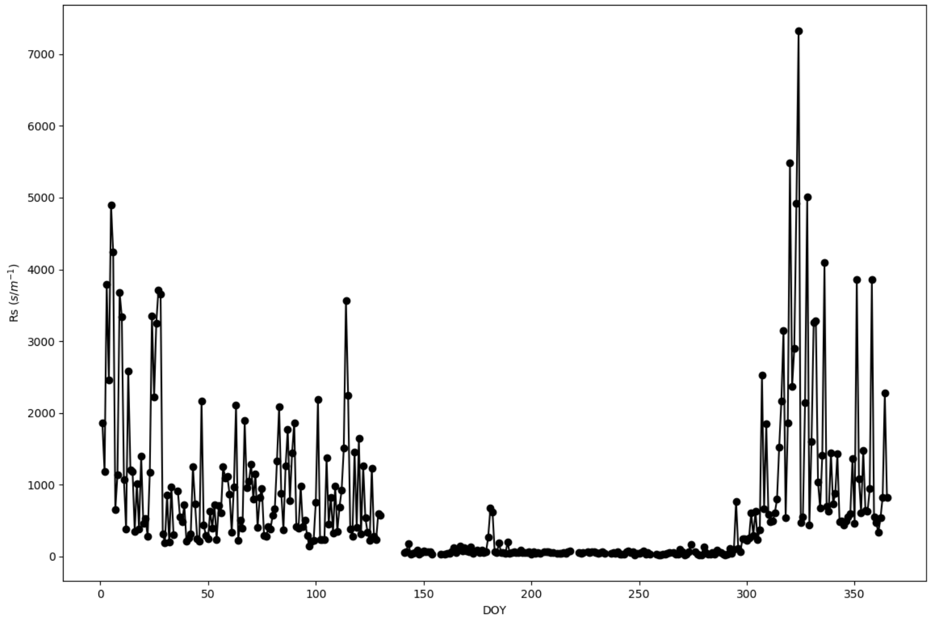

Figure 2. Time series of average daily Rs for 2015 at the CT tower

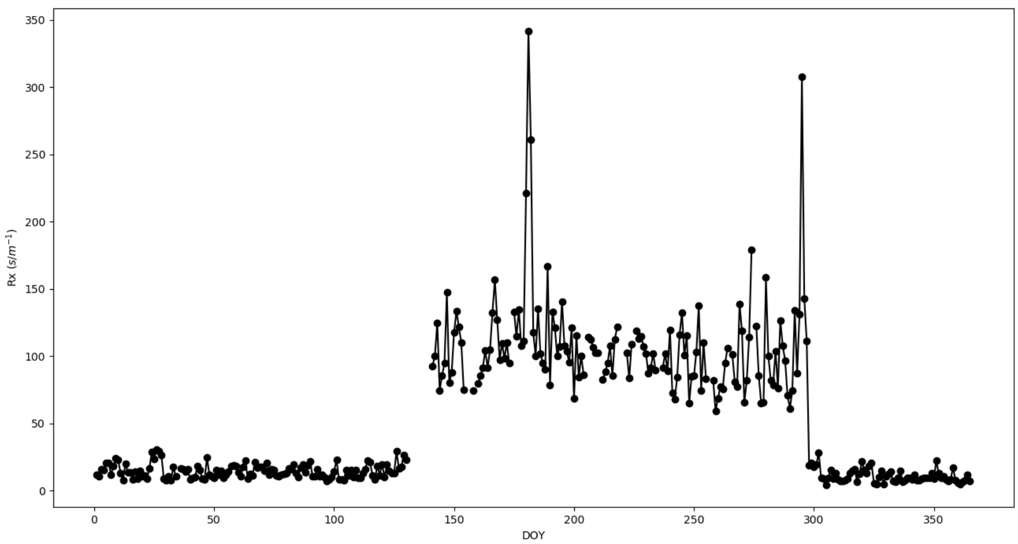

Figure 3. Time series of average daily Rx for 2015 at the CT tower

If this statement is true, that implies TSEB is largely driven by radiation and the model is not fit in the water-stressed ecosystems. Please check the paper of Timmermans et al. (2007) who did sensitivity analysis of TSEB (https://www.sciencedirect.com/science/article/abs/pii/S0034425706005013). The displacement height and roughness lengths are important parameters in aerodynamic resistance formulation. The role of aerodynamic resistance in ET

becomes predominant in cases where surface and air temperature differences are very high. Such conditions exist in arid, semi-arid ecosystems. Therefore, we should see substantial sensitivity of TSEB to d0 and Zom.

<u>**Response:**</u> This issue raised by the reviewer is mainly valid in canopies largely decoupled with the atmosphere, where aerodynamic resistance becomes the predominant factor in turbulent transport. However, in rougher surfaces such as open woodlands or vineyards (i.e. Alfieri et al. 2019), these canopies are better coupled with the atmosphere. Therefore, accurate estimates of d0 and Zom is less crucial as water vapour transport is more controlled by stomata (see Villalobos et al. 2000, Fig.4). Furthermore, Timmermans et al (2007) already showed that sensible heat flux estimated with TSEB is largely sensitive to surface temperature, confirming that TSEB is mainly driven by surface temperature under water limited conditions. In fact, Timmermans et al. (2007) stated '*[..] the other inputs for the TSEB scheme, such as vegetation properties and roughness characteristics, do not contribute to significant errors in* H *estimates'* *(section 4,* Timmermans et al. (2007)) which is in line with Alfieri et al. (2019*)* which stated, for a vineyard system, that *'The results suggest that the TSEB model is largely insensitive to changes in the roughness parameters for the range in roughness values evaluated in this study.'*

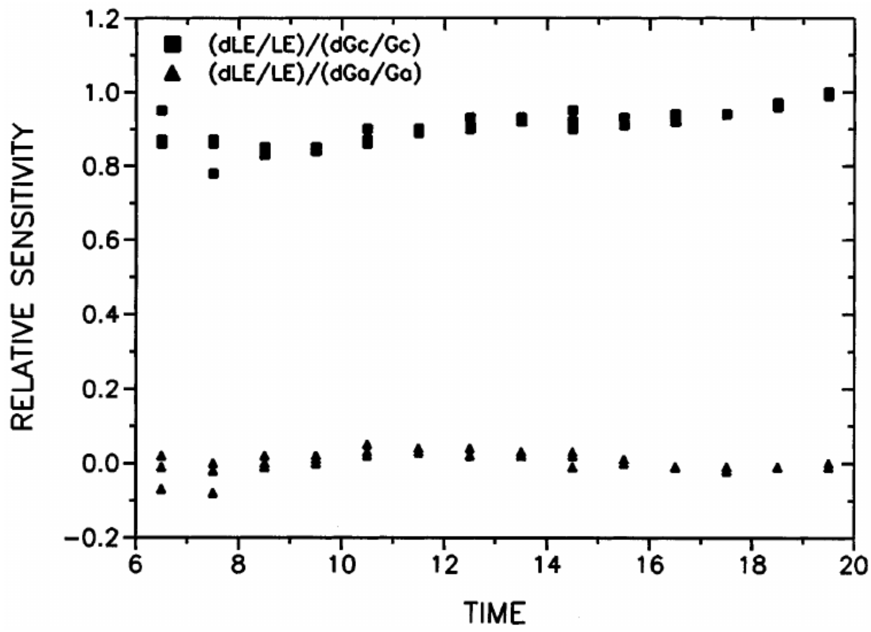

Fig. 4. Daily course of sensitivity of evaporation to canopy ((dLE/LE)/(dG_c/G_c)) and to aerodynamic conductance ((dLE/LE)/(dG_a/G_a)), Olive, Cordoba, Spain, June 1997.

Figure 4. Source: Villalobos et al. (2000)

Alfieri, Joseph G., William P. Kustas, Hector Nieto, et al. (2018). Influence of Wind Direction on the Surface Roughness of Vineyards. Irrigation Science.

Villalobos, F. J., Orgaz, F., Testi, L., & Fereres, E. (2000). Measurement and modeling of evapotranspiration of olive (Olea europaea L.) orchards. *European Journal of Agronomy*, *13*(2-3), 155-163.

I am not sure if bare soil emissivity would be that high (0.94). This would have important consequence in LST estimation.

Response: The value of 0.94 has been used for broadband bare soil emissivity in other studies (e.g. Bigeard et al. 2019**,** Nieto et al., 2019; Sobrino et al. 2005). Additionally, computing broadband emissivity of soil spectra in the TIR region (i.e. 4-14um) from the ECOSTRESS spectral library (https://speclib.jpl.nasa.gov/) obtains values ranging between 0.925 and 0.95 (estimations from 4 inceptisols).

Bigeard, G., Coudert, B., Chirouze, J., Er-Raki, S., Boulet, G., Ceschia, E., and Jarlan, L. (2019). Ability of a soil–vegetation–atmosphere transfer model and a two-source energy balance model to predict evapotranspiration for several crops and climate conditions, Hydrol. Earth Syst. Sci., 23, 5033–5058, https://doi.org/10.5194/hess-23-5033-2019

Nieto, H., Kustas, W. P., Alfieri, J. G., Gao, F., Hipps, L. E., Los, S., ... & Anderson, M. C. (2019). Impact of different within-canopy wind attenuation formulations on modelling sensible heat flux using TSEB. *Irrigation Science*, *37*(3), 315-331.

Sobrino, J.A., Jiménez-Muñoz, J.C., Verhoef, W. (2005). Canopy directional emissivity: Comparison between models, Remote Sens. Environ., 99, 304–314,

Setting the lower bound of the PT parameter as 1.26 in dry ecosystems would lead to substantial overestimation of transpiration.

Response: As it is only an initial value for model initialization and no *a priori* information is known on water stress, it is not recommended to use a value below 1.26 for model initialization (see Agam et al. 2010 or Song et al. 2016). TSEB has its internal procedures to iteratively reduce PT based on radiometric temperature under stressed conditions (i.e. Fig. 1).

Agam, N., Kustas, W. P., Anderson, M. C., Norman, J. M., Colaizzi, P. D., Howell, T. A., ... & Wilson, T. B. (2010). Application of the Priestley–Taylor approach in a two-source surface energy balance model. *Journal of Hydrometeorology*, *11*(1), 185-198

Song, L., Kustas, W. P., Liu, S., Colaizzi, P. D., Nieto, H., Xu, Z., ... & Tolk, J. A. (2016). Applications of a thermal-based two-source energy balance model using Priestley-Taylor approach for surface temperature partitioning under advective conditions. *Journal of Hydrology*, *540*, 574-587.

The authors lack the needed seriousness to explain the sensitivity results. Despite the results are shown in Fig. 3, a condensed explanation is needed. Also, in Fig.3, there are many different types of colours. Do they represent different meaning?

Response: Since the ‘results’ section is used to present the main results/findings, the sensitivity results were more elaborately discussed in the ‘discussion’ section. Nonetheless, we have put more emphasis in explaining/describing the results of the sensitivity analysis in greater detail. We highly appreciate all the comments from the reviewer. We are convinced that the revision process always leads to a better manuscript and reviewers are (sometimes unacknowledged) collaborators in the success of the paper, even if it is rejected. However, we also expect that, following established rules, reviewer comments should be courteous and constructive. In this case, we do not consider that defining the way the authors explain the results as “lack of needed seriousness” can be considered neither courteous nor constructive.

This implies, the model cannot capture latent heat fluxes during dry period, and shows consistent overestimation.

Response: Yes, the section was presenting results from the default/standard TSEB model, which largely cannot accurately capture the latent/sensible heat fluxes during the summer period. Since the roughness and resistance parameters showed less sensitivity to model performance compared to the vegetation fractional cover and green fraction, we argue that this uncertainty rather stems from inadequately characterizing the heterogeneous vegetation and surface conditions observed. The modeling structure in TSEB assumes only one vegetation layer, being more or less photosynthetically active, over a non-photosynthetically active layer (i.e. bare soil or similar). By contrast, the studied landscape has multiple vegetation layers (i.e. trees and grasses) with vastly different physical and phenological characteristics. During the summer, the grass understory becomes largely non-photosynthetically active (i.e. not transpiring). Therefore, within these types of ecosystems, we observe two major situations: 1) Tree, grass and soil sources all contribute to latent heat flux and 2) Grass is senesced and largely only the tree and soil sources contribute to total latent heat flux. This way in the seasonally adapted TSEB (i.e. TSEB-2S), we consider the senesced grass during the summer as a bare (but rough) soil, and the model performance substantially improved. On the base of these assumptions, the results demonstrated that we can apply a two-source model for what is essentially a three-source system.

The authors should show how the residual errors in SEB fluxes are associated with soil resistances. Please check Mallick et al. (2014, 2016, and 2018) which showed the sensitivity and residual error analysis of the fluxes and the effects of different environmental variables on different resistances/conductances.
https://www.sciencedirect.com/science/article/abs/pii/S0034425713003908
https://www.hydrol-earth-syst-sci.net/20/4237/2016/hess-20-4237-2016.html
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2017WR021357

Response: Fig. 5 and 6 show the residual errors plotted against the soil resistance to heat transport (Rs) and the bulk canopy resistance to heat transport (Rx), respectively.

These demonstrate no significant relationship between Rs and errors in H, and very little relationship between canopy boundary resistance and errors in H. The latter caused probably by uncertainties in tree LAI, as Rx is inversely proportional to LAI since canopy is considered as a set of single-leaf resistors placed in parallel.

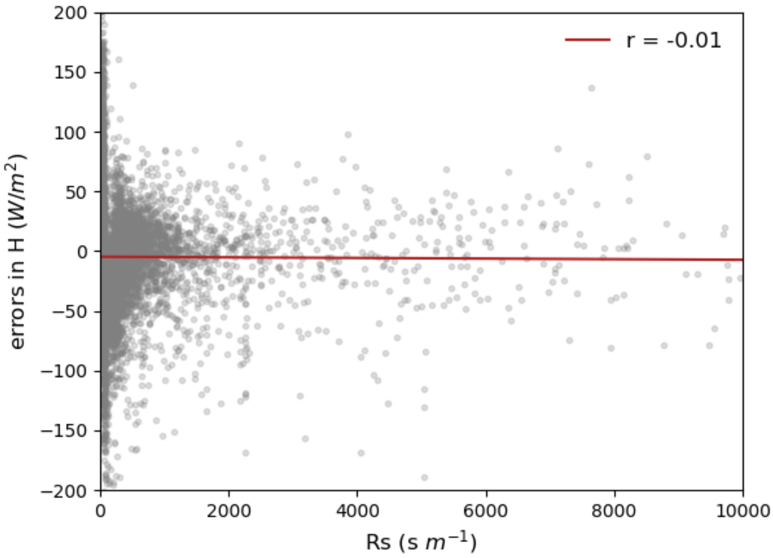

Figure 5. Rs vs residual H error

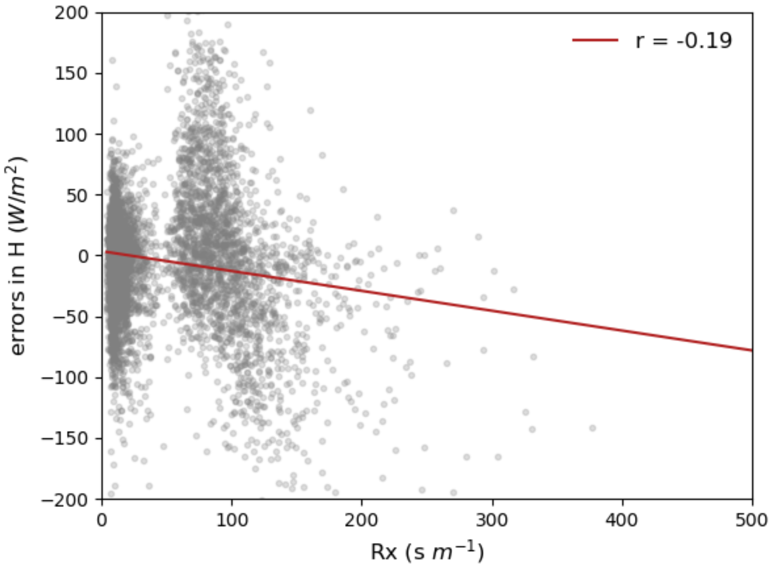

Figure 6. Daily residual H errors vs daily average Rx

This shows the fundamental uncertainty of the empirical resistance parameterizations, which needs readjustment of parameters to obtain close correspondence with the observed fluxes. Did we learn anything new? This type of analysis is outdated and it is the time to think for a paradigm shift,.

<u>Response:</u> Resistance parameters are barely touched in the model, but fractional cover is (based on the assumed dominant vegetation cover). Nevertheless, there are numerous prognostic models that must rely on the MO similarity theory in order to calculate the transfer coefficients and, therefore, we disagree with the reviewer in that this analysis is outdated.

unclear why it is named spatial here.

Response: The validation uses three distinct towers to run and evaluated the model. Indeed the towers are located relatively close to each other but they have gone through a nutrient manipulation experiment, which was shown to cause differences in surface biophysical properties and energy partitioning between the three tower footprints (El-Madany et al., 2018), therefore showing some level of spatial variability. So, it was interesting to evaluate the model runs using these different towers under the same atmospheric forcing, which have a certain degree of spatial variability in ecosystem functioning. We further clarified this in the main text.

El-Madany, T.S., Reichstein, M., Carrara, A., Perez-Priego, O., Martín, M.P., Moreno, G., Martín, M.P., Pacheco-Labrador, J., Wohlfahrt, G., Nieto, H., Weber, U., Kolle, O., Luo, Y.-P., Carvalhais, N., and Migliavacca, M. (2018). Drivers of spatio-temporal variability of carbon dioxide and energy fluxes in a Mediterranean savanna ecosystem, Agricultural and Forest Meteorology, 262, 258–278.

The partitioning results are indicating uncertain model structure of TSEB. Initial guess of PT parameter as 1.26 is clearly one of the many uncertainties. This leads to overestimation of transpiration and understimation of evaporation. Although TSEB-2S showed improved SEB flux statistics, but ET partitioning is flawed due to uncertain resistance parameterizations and model initialization.

Response: Although, the partitioning fails to capture the evaporation and transpiration magnitudes, it follows the trends, which is an indication that the model can track water stress. Furthermore, we should not forget that flux partitioning is still a challenge to measure *in situ* and that part of the disagreement shown can be due to these *in situ* uncertainties. It should be furthermore stressed the modelled transpiration from TSEB is compared against an EC LE partitioning method (i.e. Perez-Priego et al. 2018), which has itself an important uncertainty associated to it.

Perez-Priego, O., Katul, G., Reichstein, M., El-Madany, T.S., Ahrens, B., Carrara, A., Scanlon, T.M., and Migliavacca, M.: Partitioning eddy covariance water flux components using physiological and micrometeorological approaches, Journal of Geophysical Research: Biogeosciences, 2018.

Weak paragraph. Discussion should say the reasons behind the results. As stated previously, discussion should bring out the scientific reasons of the results instead of supporting own results with other literatures. This does not carry a good impression about model understanding by the authors.

We have improved the discussion section also following the comments and recommendations from the other reviewers, but we think that it is still needed to put in context the current work with previous studies.

There are many limitations of TSEB that needs clear highlight. Without fixing the uncertainties of resistance parameterization the ambiguities cannot be resolved.

Based on the sensitivity analysis, the resistance parameterization was shown not to have a large impact on the performance of TSEB, and indeed most of the parameters have been kept unchanged during the TSEB-2S modelling approach.