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Interactive comment on "Disentangling the response of forest and grassland energy exchange to heatwaves under idealized land–atmosphere coupling" *by* C. C. van Heerwaarden and A. J. Teuling

Anonymous Referee #1

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The paper describes the results of a virtual sensitivity analysis experiment, and aims to explain a peculiar observation of higher sensible heat flux over forests than over grasslands during a heat wave in Europe. However, I have strong reservations about the experiment and the interpretation of the results.

The major flaws of the experiment lie in the simulation setup. There are three interrelated problems:

1) The authors assume that grass stomatal conductance is not affected by VPD (gD = 0) while in trees it is affected (gD > 0). This may be true for drought resistant crops in

a narrow range of well watered soil, but for natural grasslands it is a highly unrealistic assumption.

2) Next they assume that the deep soil and shallow soil have the same soil moisture. While this can occur, for short periods in the days immediately after precipitations, it is not a typical situation, and particularly uncharacteristic of drought or prolonged heatwave conditions.

3) They assume that the soil is well watered (soil moisture is 50%, which is typically well above the limiting range for the stomatal conductance function) In reality stomatal resistance is affected by soil moisture and air humidity in all plants, and trees and grasses typically explore soil moisture at different depths. The very unrealistic outcome of assumptions (2) and (3) are that trees and grasses in the model are equally unaffected by soil moisture and only affected by air humidity. Next, by assumption (1) only stomatal conductance in trees is stressed by humidity, while grasses stomatal conductance will remain at maximum throughout the entire range of the experimental conditions.

It is therefore an example of circular logic that a model that assumes that only trees are stressed by humidity finds that the main difference between grasses and trees in a heat wave is that the trees are stressed by humidity and reduce transpiration while grasses continue transpiring during increasingly stressing conditions. It is trivial that the sensitivity analysis will find that reversing this assumption (making tree gD =0 and grass gD>0) will make the largest impact on the results.

Figure 4 illustrates the non-realistic nature of the results, with the maximal transpiration rates in grass (∼330 W/mˆ2) almost 50% higher than in the forest (∼230) and transpiration in grass higher than the forest at almost every combination of temperature and humidity. To the best of my knowledge, this is highly unrealistic. I also strongly contest the explanation of the different feedback mechanisms illustrated in figure 2. Temperature and humidity combine to VPD regardless of what plan is involved and the only reason for not including the VPD pathway in grasses is either semantic (temperature

and humidity already have direct arrows to LE, so one might claim that VPD effects are already included) or artificial (the specific and unrealistic model parameterization assumes grasses are unaffected by VPD). If the former, than VPD should not be included for trees, and if the later it should not be presented as a general framework, as it is highly artificial and specific to a particular (and ill posed) numerical experiment.

An earlier and simpler attempt to explain the flux-forcing relationships (Page 5971 last lines – 5972 first paragraph) is a bit misleading, as it neglects to include the effects of LE or the temperature dependency of long-wave surface radiation. I have a very similar issue with figure 1 – it only shows sensible heat flux, but then the paper discusses a virtual experiment almost exclusively designed around latent heat flux. What was the observed latent heat flux during the time when the results in figure 1 were measured? If the authors are correct, there must be a strong increase in LE in the grass and a strong decrease in LE over the forest as Tmax increases, and I very much doubt that could be the case.

Similarly, what was the soil moisture during the time when Fig 1 was observed? Was it as high as used in the virtual experiment? Was its vertical profile homogeneous? If yes, it is plausible (though unlikely) that the observations in T10 catch the fleetingly rare time of very hot conditions with dry air, but moist soil, after the rain (flat vertical profile).

In figure 3, what were the observed values? These are the results of parameterized simulations, set by design to match reality. But we are not told exactly what aspects of reality the match and how well. I get the impression that only the sensible heat flux was matched, and wonder if the latent heat flux diverged wildly, or was also in good agreement? As I assume that both the observations and the virtual experiment are not a single event but spans a range of conditions (as figures 1 and 4 indicate), what is the variation around the values reported by figure 3 in the model (and in reality, which is lacking from figure 3) and what is the goodness of fit of the model for the different variables (latent, sensible heat). Why is soil moisture missing from the figure? (I can

tell that it is not because it is a model input as SWin is also a model input, but appears in the figure).

Minor comments: P5970 Line 13 – change "performed an experiment" to "performed a virtual experiment" as to not mislead reader to think that you did an actual physical experiment.

P5973 L6 "taken away" doesn't seem professional. "diffused", "advected", "transported away" may work better

P5976 L3 – I do not understand this sentence, particularly what "on the time scales of turbulence" means.

Fig 1 – there is no model, and it is not even a time series, the data therefore should not be presented as a smoothed continuous line, and using LOESS is not justified. The correct way to show this data is as an x-y scatter with a linear (in the lack of any better model) trendline and margin of error of the linear regression line. Also, show latent heat flux.

Fig 4-6 – please say what is T_0 in the caption. Also list explain T_2m,max, deltaLE and any other symbol in the figure. I could guess most of them, but I shouldn't be guessing.

Interactive comment on Biogeosciences Discuss., 11, 5969, 2014.