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Hydrology and Earth System Sciences Discussions

Interactive comment on "Thermodynamic constraints on effective energy and mass transfer and catchment function" *by* C. Rasmussen

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Reviewer 2: Geographic context: While the paper explicitly discusses three physical limits for EEMT, it does not put them in context of commonly used life zones or bio-geographical regions. In general the paper could be greatly improved by adding some simple text or informa- tion in graphs that converts units into metrics that are commonly used by most readers (i.e. K to C, precip in mm/day instead of kg m−2 s−1). For example the explanation on top of page 7336 "These upper limits represent cold/dry and hot/dry conditions. . ." could be improved by providing some context. For example, where do Tibetan Plateau, Amazon, or Basin & Range of North America fit in the "292 K EEMT" world that is described in paper? Clarifying if the temperatures and precipi-

tations are annual means or monthly values would also help the reader.

Table 1 and Figure 3 were added in addition to discussion in the results.

Carbon bias: P7324 L5 and elsewhere "the function and state of the critical zone may be directly related to fluxes of water, radiation, carbon, and sediment". Paper should briefly acknowledge the potential of nutrient limitations on growth and EBIO; N and P and micro-nutrients have been shown to limit NPP in cases where water and radiation do not. Likewise, carbon production and flux are products of the interaction of water & radiation and not independent fluxes. The term "sediment" and "denudation" are used and are general enough that it could be expanded to include nutrients and address this concern.

Text to this effect was added to address nutrient limitation. Greater discussion of tectonic/denudation gradients/processes were added.

Steady state bias; the data and analysis are based on estimated monthly values and relevant to "steady time frames" where landscapes are in equilibrium with forces acting upon them; the introduction should acknowledge this and the role of disturbances in sculpturing of landforms via landslides, floods, earthquakes etc. This is partly acknowledged on P7326 L10 where it says "critical zone energy balance includes physical and chemical weathering, and the transfer of sediment associated with tectonic uplift and gravitational forces (Phillips, 2009; Volobuyev, 1964). However, these fluxes may be orders of magnitude less than EPPT and EBIO." Evidence should be presented to justify the statement they are orders of magnitude less. Uplift and gravitational forces operate over longer time frames but when calculated on a W m2 basis they can be much larger than EPPT and EBIO; see Odum's calculations in the referenced Science paper and elsewhere. Fig 7 also indicates that EBio can be relatively large

As noted above, greater discussion of tectonic/denudation gradients/processes were added to the text – including reference to the Odum paper.

P 7333 and elsewhere: What is so magical about 292K (19C) and VPD of 1200 PA? As most plants grow well at VPD of between 800 to 1000 Pa, is 1200PA high? What areas of the planet have these conditions?

This is a common region in a number of ecohydrologic models and empirical data noting substantial decrease in carbon assimiliation. Text to this effect was added and references/discussion added. The data in Table 1 provide context for ecosystems that experience these conditions.

P7333 L5 suggests “Direct empirical measures of EEMT” are needed. I agree!

Yes - that is one of the next steps in the development of these concepts and their application to critical zone systems.

P 7336 L10 “The median absolute latitude for these locations was 42, indicating half of the locations were at high latitudes where solar radiation may be limiting.” OK but 1 2 are at latitudes less than 42 and there is not enough information on the elevations of the other sites to make this statement convincing.

Text was added to indicate the median altitude of the “lower” latitude locations – but regardless of their altitude, locations that fall in the “cold” temperature region exhibit minimal EEMT b/c of the strong impact of temperature on the estimates of NPP and EPPT. The data in table 1 now also provide an ecosystem context for where these conditions occur based on minimum and mean monthly temperature data

P 7338 L25 “Rasmussen et al. indicate” provide date of publication

Fixed.

P 7340 L 5: Conclusions of paper are optimistic (but worth developing.). Specifically the ability to scaling down monthly and regional temperature, precipitation, and derived VPD data to develop EEMT for individual hillslope catena’s to help understand “pedon scale heterogeneity” is optimistic at best; accurate estimations of EEMT will ultimately need to include wind speed (for VPD and ET) and local topographic controls

on drainage. Also note that the relationships in Fig 4 and 5 suggest that EEMT may not be as sensitive as implied over the common range of biomes. Nevertheless, the theoretical framework and underlying principles are strong and should continue to be developed and local and regional EEMT metrics should be tested.

Yes – certainly, at finer spatial resolution a more detailed accounting of meteorological parameters is needed and PET at this scale will likely be best estimated by methods such as Penman-Montieth type analyses. This is one additional challenge of going to the hillslope/pedon scale analysis.

Fig 2B: caption “using a modified from Clausius-Clapeyron..” needs re-writing

Fixed.

Fig 3: These are so closely cross-correlated because NPP and Eppt are both derived from similar empirical temperature dependent relationships. This is acknowledged on P7333 L5 “Temperature is a primary parameter in the calculation of both EPPT and EBIO through temperature controls on PET, the specific heat of water in the calculation of EPPT, and the temperature dependent modified NPP equation of Leith (1975).”

Fig 4C Location of “break-point” is not very apparent nor is it explained how this was determined. Nevertheless, the 292 K point is a central part of the paper. Describe how this break point was determined.

Text was added to the caption to describe this.

Fig 6; The points cluster in a nearly vertical pattern at temperatures below 292K and EEMT < 5. Does this figure imply that EEMT is not sensitive below 292K?

This implies the cold temperatures and low EEMT that EEMT is dominated by biological production.

Fig 7: This is not that useful. This also implies that over the wide range of temperatures (275-300K or 2 to 27C) Fbio increases at a constant rate. Is there empirical evidence

for this? Caption for 7b indicates that exponent vary as a function of temperature. This is not apparent in the graph.

This figure remains so that the relation of the model parameters relative to temperature may be visualized.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 7319, 2011.