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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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HESS-2011-227 Response to Reviewer Comments:

I appreciate the critical and thoughtful comments from both reviewers. The two major changes to the manuscript made in response to reviewer comments were to: (i) improve the discussion regarding energy and mass flux associated with tectonic/gravity driven transport gradients and their importance in critical zone processes, with concomitant emphasis that the focus of this paper is only on the energy and mass flux associated with effective precipitation and primary production; and (ii) to add a table, figure and discussion that summarize the relative variability of temperature, precipitation, vapor pressure deficit, etc. by the major ecosystem types encompassed by the

data discussed in this paper to better set the environmental context for the observed limits on effective energy and mass transfer. The majority of reviewer comment was very reasonable and addressed with changes of the text throughout the manuscript.

Reviewer 1: 7321.25âĂŘ28: This kind of behavior does not require reference to any particular theory of system organization. Rather, all that is required to create structure from preferential flows is a principle of gradient selection, whereby paths associated with the strongest gradients persist at the expense of alternative paths.

This statement does not necessarily invoke a system organization theory, rather much as the reviewer indicates suggests the subsurface organization we observe is hypothesized to result from gradient driven energy and mass flow. The statement here was slightly modified to better reflect this.

7323.7âĂŘ10: This seems to be a very restricted laboratory physics definition, not necessarily applicable to real Earth systems.

A statement was added noting that in the strictest sense this thermodynamic principle applies to well constrained systems, but provides a beginning point for characterizing earth surface systems.

7324.4âĂŘ7: See also Huggett's "brash" equation; the 1994 SSSA volume on Jenny's contributions to pedology; and Pope et al.'s (1995, Annals Assoc. Am. Geog.) conceptual model of variations in weathering.

A statement was added to better reflect other previous work that uses a factorial description of soil and earth system processes as suggested by the reviewer.

Sect. 2.2: It should be acknowledged that important geophysical energy inputs (e.g., tectonics, isostasy, gravityâĂŘdriven flows) are not being considered.

More prominent statements regarding the lack of geophysical state factors and fluxes were included in Section 2.2 and denudation and mineral supply removed from Figure 1 given that T and VPD do indeed represent poor state variables for tectonic processes.

7324.16âĂŘ17: AE & G may ultimately approximately balance out, but in many cases significant amounts of geomorphic and pedologic work are accomplished by these processes.

A statement was added noting that heat flux and advected energy can affect pedogenesis through processes such as physical weathering via frost cracking and thermal expansion that can affect soil production.

7326.9: “May” is a key caveat here, as these energy sources may be dominant in some landscapes.

This has been reworded to reflect that the magnitude of gravity driven sediment transport may be on the same order of magnitude of EEMT in a number of systems. This is consistent with wording changes throughout the manuscript highlighting that this paper focuses solely on energy/mass flux associated with effective precipitation and net primary production.

Eq. (3): Another stateâĂŘfactor type model.

This is now noted in the text.

7237.23 – 7328.6: Ultimately, the test must be application to specific sites with actual measurements of NPP.

Agreed.

7335.2âĂŘ15: This essentially restates earlier material (p. 7332). More effective would be a different take on the dynamic interplay of VPD, temp, and precip in defining the limits and the state space.

This summary statement was left intact as it sets the theme for the discussion and begins to place the described limits in the context of previous empirical relations found between EEMT and critical zone properties and processes.

7336.5: This is representative of some text redundancies. We don’t need to be told

about the modified ClausiusâĂŘClapeyron equation every time the VPD limit is mentioned.

This is a good point. Here and in other places throughout the text, this redundancy was removed/ edited.

7336.8: Important point.

7337.1âĂŘ8: But, some coldâĂŘclimate landscapes can develop significant regolith covers, and manifest a lot of pedoâĂŘgeomorphic work, due to frostâĂŘshattering and mass movements.

Some text to this affect was added and also benefits from the discussion added regarding physical gradients/processes related to temperature fluctuations.

7339.1âĂŘ11: Just speculating: to what extent could this have been predicted from an oldâĂŘfashioned ThornthwaiteâĂŘMather type water budget analysis?

Likely similar, as this term is similar to both the effective precipitation calculation and the relative normalization of precipitation to potential evapotranspiration – this data presentation was chose as it corresponds to a number of papers along similar lines in the hydrologic literature.

7339.14âĂŘ19: Note, however, that HI is influenced by many, many factors other than water use efficiency.

Agreed – and a statement to this effect was added to the text.

Section 5: A good, succinct summary.

Fig. 1: Again, many geophysical parameters are omitted. Mineral supply and denudation are included, but it is hard to see how these directly influence the state variables considered.

This figure was modified to reflect the focus of this paper on effective precipitation and

net primary production and the denudation/mineral supply terms removed. The caption was modified to include text regarding this change.

Fig. 2: In (b), it is not clear from the figure alone what the lines represent. There are some typographical errors in the caption.

Typos were fixed.

Fig. 3: Isn't a close fit assured, given the way the terms on the two axes were calculated?

Yes – but these data demonstrated the validity of the modified form for calculating EEMT described in the text.

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