In climatology, the solar radiation energy balance has long been the key principle underpinning the discipline. In ecology, energy fluxes through food webs and trophic cascades are a cornerstone. In geomorphology, conservation of mass and energy is a fundamental law and tool in analyzing earth surface processes and landforms. Despite the (increasingly) tight interconnections between these and related fields, an approach to the energetics of Earth surface systems (geomorphic, hydrologic, pedologic, and ecosystems) combining the atmospheric, biologic, hydrologic, and geophysical aspects of energy is both lacking, and sorely needed. This study, following on earlier work by the author, is an important step in this direction. While the geophysical aspects of Earth system energetics are neglected here, this paper makes significant strides in linking the other components.

Some of the new results here are incremental advances of the author's earlier work, but three highly significant new developments are (1) a first approximation of physical limits (thermodynamic constraints) on bioclimatic energy fluxes; (2) a stronger statement than heretofore on energy- vs. water-limited systems, and tools for distinguishing among them; (3) significant progress on partitioning biotic and abiotic fluxes. While this is presented in the context of the so-called "critical zone," the results are highly relevant for a variety of pedologic, geomorphic, hydrologic, and ecological systems.

This is a fine contribution to the literature. The comments, suggestions, and critiques below are presented in the spirit of improving the final product, indicating some connections with other threads of inquiry, and highlighting some issues for future work and discussion. References are to page and line number (e.g., 7321.25-28 = p. 7321, lines 25 – 28).

7321.25-28: 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.

7323.7-10: This seems to be a very restricted laboratory physics definition, not necessarily applicable to real Earth systems.

7324.4-7: 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.

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

7324.16-17: AE & G may ultimately approximately balance out, but in many cases significant amounts of geomorphic and pedologic work are accomplished by these processes.

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

Eq. (3): Another state-factor type model.

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

7335.2-15: 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.

7336.5: This is representative of some text redundancies. We don't need to be told about the modified Clausius-Clapeyron equation every time the VPD limit is mentioned.

7336.8: Important point.

7337.1-8: But, some cold-climate landscapes can develop significant regolith covers, and manifest a lot of pedo-geomorphic work, due to frost-shattering and mass movements.

7339.1-11: Just speculating: to what extent could this have been predicted from an old-fashioned Thornthwaite-Mather type water budget analysis?

7339.14-19: Note, however, that HI is influenced by many, many factors other than water use efficiency.

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.

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

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

--Jonathan Phillips
15 August 2011