

Interactive comment on “Extension of the Representative Elementary Watershed approach by incorporating energy balance equations” by F. Tian et al.

Anonymous Referee #4

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This paper presents a framework for modeling the flow of water in its various phases in a watershed. The approach subdivides the watershed into sub-watersheds which are called representative elementary watersheds (REW). Each REW is then further subdivided into eight hydrological units, which are called subregions.

I have been trying to get to the heart of this paper and believe that it is contained in the Appendix. The authors basically formulate integral balance laws for various thermodynamic extensive properties in the various subregions. The balance laws for the eight subregions are then presented in Sections 6.2 to 6.10. The form of the balance laws is not too surprising and seems to be a straightforward generalization of the work by

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Reggiani et al. (1998), some aspects of which are presented in Section 2. The strength of the balance laws is that the fluxes between the various subregions are well defined in terms of smaller-scale variables.

I am not too familiar with the REW literature, but I am worried that this paper represents only a minor advance, that is, the extension of the REW approach by Reggiani et al. (1998) from 5 to 8 subregions. Reggiani et al. (1998) actually formulated energy balances for the various subregions (in that respect it is a little bit misleading that the authors only presented the Reggiani et al. (1998) model for the isothermal case). The only difference between the 1998 paper and this paper is that this paper expresses a change in internal energy by the product of the specific heat capacity and the temperature change. To see that compare, for example, Eq. (23) in the 1998 paper to Eq. (32) in this paper.

It is also unclear how these balance equations together with the rigorous definitions of the flux terms can actually be used to describe a given watershed. In that respect I disagree with the authors' assertion that the balance laws form 24 ordinary differential equations in time. Things are much more complicated. Take a look, for example, at the e terms in the mass balance equations, e.g., Eq. (34). The e 's are defined in Eq. (26), which in turn is an integral over time. The integrand contains quantities which are not known a priori, for example velocities of the interfaces between the subregions and velocities of the thermodynamic extensive quantity for which the balance law is formulated. We do not know these quantities, and typically partial differential equations have to be solved to determine them. So unless we make the brute force assumption that the e terms can be expressed as a function of time, the 24 equations do not represent ODE's. Such a brute force assumption might not be the worst thing to do (and is employed frequently in hydrology), but it does not require the complicated averaging procedures that have been used to derive the balance laws.

I have reservations about whether this paper contains significantly new results. As I indicated above the mere extension of the 1998 theory from 5 to 8 subregions seems

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to be a minor advance. I also feel that the paper could be significantly shortened, because many of the derivations in the Appendix have been presented elsewhere, though in a slightly different form. Unless the authors can make very clear that this paper represents a major contribution to the literature, I recommend merging this paper with the followup paper that the authors intend to publish.

In addition I have the following comments to make:

1) It would have been useful to define both a watershed and a sub-watershed. I assume one cannot just pick arbitrary areas of the entire watershed and call them sub-watersheds? The comment that a REW is a subsystem of the entire watershed is too vague.

2) The abbreviations for the subregions should be introduced in the main body of the text (in the list on pages 438 and 439) and not only in Table 4.

3) Page 441, Line 10: I do not understand the notation K is an element of $\{e|e=1..M\}$

Why the vertical bar? In my understanding K represents only one REW. Thus, it should read $K = 1, 2, \dots, M$

Similar notation is used throughout the entire paper and should be revisited.

4) Equation (16): the quantity defined by this equation should be called volume fraction.

5) Equation (23): Should the volume element dV be replaced by the position vector r ? Also is this Definition 10, which is missing?

6) Section 5.2: the authors should carefully introduce the term phase level continuum. Where is it defined, for example?

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