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Hydrology and Earth System Sciences Discussions

Interactive comment on "Rainfall-runoff modelling in a catchment with a complex groundwater flow system: application of the Representative Elementary Watershed (REW) approach" *by* G. P. Zhang and H. H. G. Savenije

E. Zehe (Referee)

ezehe@rz.uni-potsdam.de

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General comments

The authors present the application of a model, which is based on the Representative Elementary Watershed (REW) approach, to predict rainfall-runoff in the Geer catchment in Belgium. The REW approach is (from my point of view) the most promising framework for building hydrological process models for the mesoscale and up to now only a few applications of REW models to real world catchments are documented. The presented study is therefore of high interest for hydrologists that look for innovation in hydrological process modelling and therefore highly suitable for HESS.

The authors provide a thorough introduction of the underlying equations and closure relations that determine mass balance within and mass fluxes between the five zones making up an REW. Additionally the authors propose a simple representation of interception, which is new within REW framework, as well as a simple approach to determine the effective porosity of the unsaturated zone when 2 different soil layers are present. After discussing the calibration approach and the most sensitive model parameters, the model performance is evaluated in a common split sampling approach based on the Nash Sutcliffe efficiency and the relative bias of simulated discharge. The presented results underpin: Ţ in general that models based on the REW approach are suitable to predict rainfall-runoff in real world catchments (which was doubted in past several times) Ţ that interception is important for modelling rainfall-runoff in the Geer catchment, Ţ that the calibration process yields consistent effective parameters for the soil hydraulic functions (the authors use the Brooks and Corey model).

However, the presentation of the equations and closure relations is partly to brief and, which is the more serious problem, partly seems to contradict the main credo of the REW approach, which is to avoid ad hoc assumptions within the derivation of closure relations.

My recommendation is to publish the paper after moderate revisions that should address the following comments and questions:

Specific comments

Abstract

Ţ line 10: Statement “Through flux exchanges among the different spatial domains of the REW, surface and subsurface interactions are fully coupled” doesn’t make sense. Does it mean that surface and subsurface processes are described in a fully coupled manner ?

Introduction

HESSD

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Ţ Comment on physically based models: The authors should stress that physically based process descriptions include (at least in principle) measurable state variables and parameters. I see the problem of data needs but not the problem of equifinality in this context (which means all model structures are equally likely). This should be discussed in the context of conceptual models.

Ţ 642 line 3: TOPMODEL is not a conceptual model!

Ţ 642 last paragraph: The authors talk about sub domains and closure before they introduce the REW concept. Please define the closure problem before you use these words, because a lot of readers don't know these terms.

Ţ In the context of closure the authors should refer to the work of (Lee et al, 2005)

Ţ It is of course possible to use conceptual models for estimating impact of landuse changes on water balance, if the model parameters are properly regionalized (e.g. Hundecha and Bárdossy, 2004 Journal of Hydrology)

Section 2: Mathematical representation

Ţ 644 line 2: Statement is misleading! An REW does only implicitly account for lateral spatial dimensions!

Ţ 644 line 10: "averaged" might be more suitable than "upscaled"

Ţ Please define the closure problem a little clearer, why is it difficult to assess the exchange terms in Eq. 1?

Ţ 644 line 8: Not the domains, the processes in different domains are characterised by different time scales

Ţ How are Darcy's law, Mannings law and Saint Venant Eq. related to exchange terms or balance equations in the REW? Please explain this to the reader.

Ţ 645: Eq. 1-5: Please specify the dimension of the storage S and the fluxes!

Ţ 647 line 23: It is the average width of the channel.

Ţ 648 Eq 8: To avoid ad hoc solutions, please explain why you choose this approach for interception and the meaning of the threshold. In the spirit of the REW I would expect an approach with parameters that may be somehow linked to measurable quantities like LAI

Ţ 648 Eq 9: This Eq. suggests infiltration is driven by the average pressure gradient across the unsaturated zone, which is certainly not true!

Ţ 649 Eq 12: Evaporation is reduced from potential to actual rate if the average soil moisture in the u zone drops below 50% of porosity of the soil. Explain why you use this form and a linear reduction?

Ţ 652 Eq. 22: What is m?

Ţ 652 Eq. 23: What is t in the exponent? The term insight the brackets maybe derived with elementary geometry, so far so good. Please explain why you introduce the exponent, especially t and g?

Ţ 654 Eq. 32: According to definition (10), u is the volumetric soil moisture i.e. water volume stored in the pore space divided by the volume of the u-zone. If the groundwater table is rising or falling, the volume of the u-Zone and the volume of water stored in the pore of the u-zone decrease with the same rate dys, thus the volumetric soil moisture stays the same (although the total water volume in the u-zone is changing). Hence the last term in Eq. 23 seems to be wrong!

Ţ 655 Eq. 35 and 36: It is a very good idea to introduce a layering in the soil. However, you use only the porosity of the different layers to calculate the effective porosity in 10. For this purpose you only need Eq. 35. If the porosity in different soil layers is different, Ksu will be also different in the different layers, which affects infiltration and percolation! This approach would make much more sense, if you treated the upper layer as separate zone to calculate infiltration. Please comment on this.

Section 3 Model application

Ţ Please comment on the scaling factors in Eq. 23, 24, 13Ě did you use them for calibration?

Ţ Please give information how you calculated potential evaporation which is input to Eq. 12.

Ţ Why did you use precipitation only from a single rain gauge?

Ţ 657 line 13: Please give a reference where you took the values for the realistic guess from?

Section 5

Ţ Maybe you can give an outlook on a) the most important improvements within the REW approach and b) promising approaches for assessing closure relations

Erwin Zehe ezehe@rz.uni-potsdam.de

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