Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2017-17-AC2, 2017

Geoscientific Model Development Discussions

Interactive comment on "lumpR: An R package facilitating landscape discretisation for hillslope-based hydrological models" *by* Tobias Pilz et al.

Tobias Pilz et al.

tpilz@uni-potsdam.de

Received and published: 14 March 2017

Dear Reviewer,

thank you for your time and effort spent on reviewing our manuscript. In the following we will answer your comments point-by-point.

> General comments: This manuscript introduced a computer software lumpR that serves as pre-processing tool for the hydrological model WASA-SED. This manuscript is more like a technical document, it needs to emphasize the key features and major functions of this software. It also declared that "the first objective of this paper is to provide an overview of

> existing landscape discretisation algorithms and software", however this review need a major revision.

We acknowledge the suggestions regarding the structure and readability of the manuscript. We will revise the paper in order to better emphasise the key features and functionalities of the presented software. Furthermore, we will provide a major revision of the literature review (section 2) along with a summary of the analysed literature in the form of a graphic or a table.

> There are many literature reviews in each sections. Please move these literature reviews into Section 1 or/and Section 2.

We agree that literature reviews should be rather concentrated. That is why we concentrated our literature reviews in the manuscript in Sects. 1 and 2. The cited literature in the other sections is not part of a review, instead to refer to the specific algorithms implemented in the software (Sects. 3.2 and 3.3), introduce the study site and the employed hydrological model (Sects. 4.1 and 4.2, respectively), citation of data sources (Sect. 4.3), to explain the method used for sensitivity analysis of the software's parameters (Sect. 4.4), and to discuss the obtained results along with other studies (Sect. 5). We would therefore kindly ask for a more specific description of this concern.

> Section 1: Introduction
>
> 1) Classification of the hydrological modelling approaches into three types (fully distributed approach, lumped approach and semi-distributed approach) is often questioned. For example, many large scale hydrological model uses grid cells for the discretisation of the landscape, but the size of the grid cell is very large, so they also employ sub-grid parameterization schemes. What type do these hydrological models belong to?

We agree that the classification approach of hydrological models into the mentioned three categories can be ambiguous and is not always well-defined. We will therefore adapt the introduction in a way pointing out possible ambiguities in the conception of the classification in fully distributed, lumped approach and semi-distributed discretisations. We will furthermore explicitly refer to sub-grid parameterisation as another strategy of increasing the degree of detail in models without increasing the spatial resolution.

> 2) The logic between the literature reviews in Section 1 and Section 2 is not clear

In the introduction (Sect. 1), a classification of landscape discretisation concepts in hydrological modelling into fully distributed, semi-distributed, and lumped approaches is made while briefly explaining advantages and limitations of each concept. In the review (Sect. 2), however, the focus solely lies on semi-distributed approaches. In the revised version of the manuscript, we will focus on better pointing out that objective.

> 3) The logic between the first objective and the second objective is not clear. Before the the overview of existing landscape discretisation algorithms, authors already determined to use hillslope-based approach.

The first objective of the paper is to present existing landscape discretisation algorithms and software solutions along with their limitations. We introduced, as second objective, a new software picking up the identified limitations. Our intended logic between the two was to demonstrate the adequacy of presenting yet a further software. However, we will try to clarify the point in the revised manuscript.

> Section 2: Review of landscape discretisation in hydrological modelling
>
> 1) This section should focus on the landscape representation, not only the landscape discretization.

Thank you, we will adapt the title of Sect. 2. Indeed, the review is already focussing on landscape representation as a whole rather than the mere discretisation procedure.

> 2) Section 2.1 presents common knowledge about the DEM. What is relationship with section 2.2?

We acknowledge that Sect. 2.1 currently stands a bit apart from Sect. 2.2. Our intention was to first give a short overview over different topography representation approaches before discussing landscape discretisation as the former are the source of data for any landscape analysis and discretisation. In the revision we will try to establish a more profound relation between the two subsections.

> 2) To model the catchment hydrology, water flow pathway is a key issue in landscape discretization/representation. This section lacks of representation of catchment water flow pathway. (Reference: Yang D, Gao B, Jiao Y, et al. A distributed scheme developed for eco-hydrological modeling in the upper Heihe River. Science China Earth Sciences, 2015, 58(1): 36-45.)

The term*water flow pathway* in the mentioned paper of Yang et al. (2015) basically refers to the river network of a catchment. Although mentioned briefly in the beginning of our review as part of the discretisation process (page 4, line 6, termed *river segments*), the delineation of a river network was deliberately omitted from explicit discussion. It is merely implicitly contained as pre-processing procedure in any of the introduced concepts. Our focus, therefore, lies on the discretisation of terrestrial landscape elements where eventually the equations of the water balance shall be solved. We acknowledge, however, the importance of an adequate flow network delineation for hydrological modelling. Therefore, we shall see to briefly discuss this issue (and typical pre-processing tasks in general) in the revised version of our manuscript.

3) What are the basic units of hydrological simulation in different landscape discretization approaches (different semi-distributed hydrological models)?

As we see it: the basic units of simulation in the different approaches are the spatial units a specific approach is referring to, e.g., the grid cell in a raster-based model, the HRUs in the HRU approach, the ASAs in the ASA approach. In more complex multi-scale discretisation schemes (such as used for the WASA-SED model), however, a basic unit cannot be clearly distinguished as several units are responsible to calculate the water balance. In WASA-SED, for instance, that means: At SVC level infiltration, evapotranspiration, and soil water movement are calculated; at TC level lateral runoff re-distribution processes are simulated; at LU level groundwater is considered; at sub-basin level the streamflow routing along a representative channel is assessed. We will point this out in the revision and hope to have answered the question as desired.

4) In Section 2.3, it's hard to see what kinds of software is suitable for landscape discretization?

Our goal in Sect. 2.3 was to give an overview over existing software and to identify common limitations. We then tried to address these limitations in the development of a new software package.

Section 3:

1) A flowchart is needed in description of lumpR. Figure 1 should be modified to contain both discretization procedure and major functions.

Actually, this is exactly what Fig. 1 does. It contains the package's functions (in italics) along with a short description for every function. Furthermore, the arrows highlight

the flow of information, meaning the order of application of the functions (i.e., the procedure) to derive a complete hillslope-based landscape discretisation. We will try to clarify our intention (e.g., by using different arrow types or numbering the boxes) in the revision.

2) This section should be rearranged, for example, general workflow, major functions, additional tools.

Sects. 3.2 to 3.4 contain descriptions of the software's functions as corresponding to Fig. 1 (always outlined in italic letters). The order thus represents the typical processing sequence. However, as stated in the last point, we will seek for clarification during the revision of the manuscript.

3) How to define the topological relationships between the hillslopes and subcatchment?

The topological relationship between the hillslopes (or more precisely, the hillslope type representations inherent in the Landscape units) is derived in *lump_grass_post()* by intersecting the LUs with the subbasins. We will add this information to the respective section.

4) As shown in Figure 2, how to simulate the flow discharge in the river networks? It's also important to consider the spatial variability of precipitation inputs.

Figure 2 illustrates the conception of landscape discretisation in lumpR, i.e., the steps (i) to (iv) described in Sect. 3.2. It shall therefore mainly clarify the terms EHA, LU,

and TC, their relation to a subbasin, and what these terms represent in a real catchment. Although lumpR produces a river network as part of the pre-processing (function *lump_grass_prep()*), the actual simulation of discharge along the river network is not (and shall not be) part of the discretisation software but of the hydrological model which employs the output of lumpR. The pre-processing of the model forcing data (e.g., precipitation) is again not (and shall not be) part of lumpR.

5) This is the main part of this MS, more detailed information is required.

Apart from the changes announced above, we would kindly ask the reviewer for which specific aspects what additional information would be desirable.

Section 4:

1) Sensitivity analysis in this section is repeated in Section 5. I suggest move the sensitivity analysis to Section 5.

Section 4 describes the employed methodology of the SA and its results. Section 5 rather contains a discussion of the presented software package in general (Sect. 5.1) and the results of the sensitivity analysis for the case study (Sect. 5.2). As such, we prefer to leave the structure in its current state, as it better adheres to common conventions in separating methodology, results and discussion.

2) This section is very confusion. It's very hard to see how to implement the lumpR for application of WASA-SED model. Please rearrange this section.

Section 3 already describes the common application of lumpR. In contrast, Sect. 4 describes an advanced study that was enabled by the fully automatic massive replication of lumpR with different settings. We will clarify this in the introductory sentences of Sect. 4.

3) What are the inputs (climate forcing data) and outputs of WASA-SED model?

The input data of the model and their pre-processing are described in Sect. 4.3 of the manuscript. The model output used in this study is described in Sect. 4.4.2.

4) What are the major functions of WASA-SED model? Please show these functions by using the simulated results.

This manuscript shall serve as introduction into the software package lumpR as tool for hillslope-based landscape discretisation. The WASA-SED model has merely been used to exemplify its functionalities in a case study. A more detailed description of the WASA-SED model than given in Sect. 4.2 (and to some extent in the last paragraph of Sect. 2.2) is therefore not (and shall not be) part of this manuscript. For more detailed information, a reader should consider the given references of the model.

Other comments:

1) Yang et al. (2002) developed a hillslope-based hydrological model. This work should be cited. Yang, D, S Herath K Musiake (2002), A Hillslope-based hydrological model using catchment area and width functions. Hydrological Sciences Journal, 47(1), 49- 65.

2) Some references should be added in Section 1, e.g. Yang et al., (2000), Comparison of different distributed hydrological models for characterization of catchment spatial variability. Hydrological Processes, 14, 403-416.

Thank you for giving some more examples of hillslope-based models. We shall consider the mentioned references in the revised version of our manuscript.

3) P4, L32-33: Here should emphasize that the models use HRUs face the difficulty of representing water flow pathways (for example the runoff from hillslopes and runoff along the river networks) appropriately.

We will add a line pursuing this concern.

4) P5, L15-20: The difficulty of determining the size of REW should be mentioned.

Thank you, we will further comment of the REW delineation in the revision of our manuscript.

5) P6, L15: A table is needed to summarize the existing software for model preprocessing

We shall add a table giving a summary of our review.

6) P12: A table is required to summarize the model parameters.

A summary of the most influential parameters of the lumpR package is given by Tab. 1. We will further clarify the reference to this table.

7) P19: The discharge hydrograph is required in addition to the reservoir water volume shown in Figure 4.

We omitted the discharge hydrograph as it is, due to the large number of zero flow events, much less informative than the reservoir volume shown in Fig. 4. We shall, however, consider putting a figure of the discharge hydrograph into the Appendix.

8) P 20: Use a table instead of Figure 5.

We use Fig. 5 to illustrate the properties of the distributions of the indices. This is important to, e.g., justify the use of the density-based sensitivity analysis method for skewed and multi-model distributions of the target variable. We therefore argue to keep Fig. 5 as it is instead of replacing it with a potentially less accentuating table which would only show numbers in a rather abstract way, instead of illustrating the eight distributions of 12250 values.

9) P 21: Show the results of sensitivity analysis using the hydrograph too

Actually, the results of the sensitivity analysis are based on the hydrograph (i.e., the time series of reservoir inflows), see Sect. 4.4.2. We will clarify this in the respective section

We hope to have addressed your concerns and answered your questions as expected.

Yours,

Tobias Pilz (on behalf of all co-authors)

Interactive comment on Geosci. Model Dev. Discuss., doi:10.5194/gmd-2017-17, 2017.