Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-276-AC2, 2021

Geoscientific Model Development
Discussions
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Interactive comment on "Hydrostreamer v1.0 – improved streamflow predictions for local applications from an ensemble of downscaled global runoff products" *by* Marko Kallio et al.

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Received and published: 5 April 2021

Dear Anonymous Reviewer #2,

thank you for providing insightful comments for our manuscript. Please find below our detailed point-by-point response (marked Rx.x) to the concerns (marked Cx.x) raised.

C2.0: The study presents an R package, a software library hydrostreamer v1.0 which aims to improve the usability of existing runoff products by addressing the Modifiable Area Unit Problem, and allows nonexperts with little knowledge of hydrology-specific modelling issues and methods to use them for their analyses. The topic is well suited

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for publication in GMD, however, the manuscript has some unclear reasoning that requires significant revision before the manuscript can be accepted for publication. My major comments are provided as follows.

R2.0: Thank you for your remark. We hope you find our response and amendments to the manuscript satisfactory.

C2.1: The work was motivated by providing a tool that can be used by non-hydrologist to downscale global runoff products to river-basin scale for follow us analysis. However, Hydrostreamer requires users to provide runoff and stream network or catchment boundaries as inputs. It is not clear to me nonexperts can provide such information. Even if they can, there should be a minimal requirement to make sure that projects/coordinate systems used by these inputs are consistent with each. More descriptions on the pre-processing step are necessary.

R2.1: Thank you for this pointer. Indeed, the user does need a minimum level of GIS expertise and proficiency with R, which we previously took for granted. It does not need specialist hydrology expertise. Further, Hydrostreamer includes functions to evaluate performance and therefore support non-expert judgement about the adequacy of results.

We now make explicit our implicit assumptions about the user's expertise. We have added to the revised manuscript a section "2.1 Obtaining data and pre-processing".

To eliminate errors due to inconsistent coordinate systems, Hydrostreamer makes use of the sf-package (Pebesma, 2018) for geoprocessing, which does not allow the use (an error is produced) of input data with non-matching coordinate reference systems, and outputs a warning if a non-projected geographical coordinate system is used.

C2.2: The use of the interpolation methods implies that the resolutions of selected global runoff products shall be comparable to the catchment sizes of case studies. A threshold of watershed/catchment size should be provided so that the applicability of Hydrostreamer can be better understood.

R2.2: Thank you for the remark. When the user provides catchments for the river segments, there is no implicit limit on the resolution of input. If the target zones are larger than runoff source zones, the method effectively upscales rather than downscales. If the target catchments are of much higher resolution than source zones the method performs downscaling (see Kallio et al., 2019). Area-to-Line interpolation, however, is critically dependent on proper scales, as the reviewer notes in comment number 4. This is because all source zones must contain at least one intersecting river segment in order for runoff to be assigned to the river segment. We discuss this in the new section about obtaining data and preprocessing.

C2.3: It is not clear how the ancillary variables in dasymetric mapping are selected.

R2.3: In general, ancillary variables are selected based on their presumed or tested relationship with the spatial distribution of the variable of interest. We have now made the choice of ancillary variables clearer, and provide examples about possible sources for ancillary data.

C2.4: In the area-to-line interpolation method, it is assumed that contributing area can be replaced by the length of river segment. However, when the river network is delineated based on DEMs, it is typical to make an assumption on the threshold of stream cells. Such an assumption by itself could be subjective. Such uncertainty needs to be acknowledged.

R2.4: We agree, such a decision is indeed subjective. In an ideal case the user would be able to use a river network product built with an appropriate choice of threshold.

Since a non-expert may not be aware of the delineation techniques, we have added an explicit mention of this, as you suggest, to the new section on data and preprocessing. See also the responses to Reviewer #1 regarding the conditions required for area-to-line interpolation to be applicable.

C2.5: The two routing methods are very simplified but can be reasonable options for watersheds of reasonable sizes. The instantaneous routing method is only applicable to large basins. Please add discussions on the size threshold. The constant velocity routing method is highly dependent on its parameter, the flow velocity. However, there is no discussion on how the parameter value is selected in the text.

R2.5: We agree that instantaneous routing is limited – not just by basin size, but also temporal resolution of output. Given that flow timing can also depend on shape of a basin, it is not possible to define fixed thresholds and evaluation of performance is instead recommended. This is now emphasised in the revised manuscript.

Considering your as well as the other reviewer's comments (C1.4) on the routing, we have added an implementation of Muskingum-Cunge routing algorithm to Hydrostreamer which should increase the utility of the package for smaller basins as well as for higher temporal resolutions than a month. We have made the section on routing clearer on the assumptions made. The flow velocity in this case study is the same 1 m s-1 as adopted e.g. in HYDROROUT and LPJmL (Telteu et al., 2021). That is, in addition to using data from global runoff models, a hydrostreamer user can use the default flow velocity from those models in absence of better information, but can use spatially varying information if available.

C2.6: Based on the case study presented, the tool can be useful for downscaling global runoff products at monthly scales or above. However, without validation in other flow regimes, it is hard to tell how transferable the results. Such a limitation needs to be acknowledged in the text.

R2.6: Thank you for this remark. Indeed, our experiment is made on a monthly scale, for which the instantaneous and constant-velocity routing solutions are adequate, given that a number of global hydrological models or applications using their outputs use similar routing schemes (see e.g. Telteu et al., 2021; Lehner and Grill, 2013; Munia et al., 2018). However, we recognize these are not necessarily adequate for smaller basins or for shorter timesteps. We have added a short comparison of the three routing methods in supplementary materials.

C2.7: In general, the style of writing needs to be improved to provide additional background materials for non-expert users.

R2.7: We have revised the text, and believe it is now more approachable to non-expert users.

C2.8: The inputs/outputs of the case studies shall be provided for reproducibility.

R2.8: The code and input data are provided in a Zenodo-repository (https://zenodo.org/record/3987723). This repository contains all data except for discharge observations, which we are unable to provide openly due to the licence. Thus, the code can be run until the model averaging steps without observation data. We are updating the repository with the output runoff and discharge for all 2115 river segments for the study period 1980-2010.

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Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-276, 2020.