Authors’ Response to Reviews of

Technical note: Comparing three different methods for allocating river points to coarse-resolution hydrological modelling grid cells

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RC: ***Reviewers’ Comment***, AR: Authors’ Response, ☐ Manuscript Text

2. Reviewer #2

2.1. General comments

RC: ***Godet et al. provide comparison of methods to allocate river points to the most appropriate hydrological model grids. This task is important and becoming more important given the rise in number of gridded hydrological models being made available within hydrological research and operations. The paper compares three allocation methods: area-based, topology-based, and contour-based. The results indicate that contour-based methods, though computationally expensive, are more hydrologically relevant, with topology-based methods serving as a reasonable compromise. Area-based methods lead to numerous allocation errors, particularly for small catchments, and are recommended only for river points with large upstream drainage areas compared to the grid cell resolution.***
I do have some questions for the authors about the transferability of their results outside the current test area in the Eastern Mediterranean region of France covering an area of 15,000 km2 with the largest catchment size considered only 3000 km2. They define “coarse-resolution” as a 1km hydrological modelling grid size. In the context of global hydrological modelling, 1 km is the benchmark to be deemed “hyperresolution” (Wood et al., 2011). While this paper is over a decade old, there remains relatively few hydrological models running at 1km scale, even at national scales. For a user of a model running at 5km or 10km or even coarser, are the conclusions in Godet et al. still valid? What about transferability to other regions? We know hydrology is heterogenous with complex river networks such as braided rivers; we know that high quality DEMS/vector river networks are not available in all regions, and that the quality of upstream catchment size metadata information can be missing or uncertain in some regions of the world. Very few of these uncertainties are considered or at least discussed in the paper.
There has been a limited amount of research comparing difference approaches to this important technical issue, therefore the paper by Godet et al. is a very useful reference to help guide others on selecting the most appropriate method/understanding the limitations of simpler methods. However, at a minimum I suggest more effort is needed to discuss uncertainties and transferability outside the limited test case used. I recommend this paper for publishing in HESS after such changes are made.

AR: We would like to sincerely thank Reviewer#2 for their comments and for highlighting the lack of discussions about transferability, which we will take into account in the revised manuscript to improve the quality of the paper. We provide below detailed answers showing how we plan to adapt the manuscript according to these suggestions.

2.2. Main comments

RC: ***Pg3 L46-48: As per my summary above, from the perspective of gridded hydrological models that are not run at very local scales, then the definition of "coarse-resolution hydrological grid (1km×1km)" could arguably be considered "high resolution". 1 km is the benchmark to be deemed "hyperresolution" (Wood et al., 2011) for global scale models. To what extent are these conclusions/methods transferable to coarser model resolutions that are often used (e.g. 5km, 10km or coarser)? Perhaps qualifying why 1km is deemed "coarse" and if so, does this limit the transferability of methods/conclusions?***

AR: In this case, the hydrological model is intended for the regional scale, we could even imagine to implement it for the fine resolution (50m). However, the same problem could arise for hydrological modelling applied on a continental scale where the resolution will be coarser than 1km (i.e. 5 to 10 km), whereas the DTMs available worldwide have a resolution of a few tens of metres (e.g. 90m for SRTM). In that case, allocation problems will probably be even more complex, with higher risk of errors. Even if that needs to be verified, it is likely that the errors related to area-based methods will concern larger catchments (i.e. larger than $100km^2$). To make this discussion appear in the manuscript, we suggest to add the following text in the introduction (line 52):

> In this study, $1km \times 1km$ is considered as "coarse" resolution because the hydrological model is intended for the regional scale. However, the same problem could arise for hydrological modelling applied on a continental scale where the resolution will be coarser than 1km (i.e. 5 to 10 km).

And the following text in the conclusion (line 217):

> This recommendation is valid for the tested resolutions, however, as indicated in the introduction, the problem raised in this paper will be encountered also for coarser resolutions, especially when using global hydrological models. The transferability of the results outside the test area is debatable, as there are many uncertainties and non-linearities in the representation of hydrological information at larger scales. However, it is very likely that, with coarser resolution grids, allocation problems will increase and that errors related to area-based methods will impact larger catchments (i.e. larger than $100km^2$). Even if that needs to be verified, the "contour-based" method will certainly remain more effective at coarser resolutions than the "area-based" method.

RC: ***Pg4, L71: The parameter R (here R < 3) seems to be very dependent on the model resolution and catchment size. Why was R < 3 selected and was a sensitivity done on its selection? How would varying R to be larger or smaller impact the results? It will also be depended on catchment area of the station that you are trying to allocate. For example, for a catchment area of < 3000 km2 (as is considered here) then R < 3 might be appropriate. However, if you are mapping river gauges in global gridded models and are considering stations in downstream sections of major world river basins (e.g. Amazon, Danube, etc.), then you would need an R much larger than 3 – this parameter needs to vary by both grid resolution and catchment size.***

AR: R<3 has indeed been chosen as a result of a sensibility analysis. It was found that R<3 was a good compromise between too large a radius, which increases the risk of error, and too small a radius, which risks not searching far enough for candidates, for the study area. This choice is rarely justified in other works and it does depend on both model resolution and catchment size. We suggest to add, the following text at the end of section 2.1, line 72:

> ... and distance criteria. Also, if a maximum difference between UPAs of 30% is a recurrent choice in the literature (e.g Burek et al., 2020) regardless of the studied model resolutions, the distance criterium R<3 is more study-dependant. In the present study, it appeared after some tests as a good compromise providing accurate results with reasonable computation times. However when using global-scale hydrological models and coarser grids, the value of R may have to be adjusted.

RC: ***Pg4, L74-79: How would method 2: 'topology-based method' work when the underlaying gridded hydrological model river network is different to the vector network. For example, if there are spatial mismatches where the vector for a river section does not overlap with the most appropriate model cell? Often the data source to derive a hydrological model river network grid is different from a vector river network.***

AR: It would be impossible to use Method 2 in that case, because this topolgy-based method requires the notion of "cells' outlet points", thus it needs consistancy between the hydrological grid and the vector network. This is indeed a major drawback of the method. We propose to add the following text in section 4.1, line 141:

> ... as it relies on the IHU upscaling. As a consequence, it makes this method inoperable in contexts where the coarse resolution gridded network does not coincide with the river network (i.e. both networks may come from different data sources).

2.3. Technical comments

RC: ***P6, L98-99: Can you please justify use of CSI = 0.4 and 0.6, and are these applicable to much larger catchment sizes?***

AR: Ideally, only the threshold CSI=0.6 should be used to ensure the quality of the allocation process, however it would be unrealistic for catchments which sizes are close to the pixel size $1km^2$. The threshold CSI=0.4 enables to go looking for further cells even for small catchments. As explained in section 4.4, these thresholds should be adjusted according to the users' needs. When using global-scale hydrological models, it is the threshold of $10km^2$ that will need adjusting. We propose to add the following indication line 99:

> The CSI thresholds can be adjusted (see section 4.4), as well as the surface threshold which depends on the model resolution.

RC: ***Pg 6, L99: "the search area is extended to the 49 closest grid cells": why 49, please elaborate?***

AR: In a second iteration, we aim at extending our research area (1: $3 \times 3 = 9$ surrounding pixels, 2: $7 \times 7 = 49$ surrounding pixels). As explained in lines 196-197, increasing the research area in the second iteration above than the 49 surrounding cells does not change much the results. However, as mentioned before, this will depend on the model resolution. We propose to add the following text line 99:

> ...the search area is extended to the $7 \times 7 = 49$ closest grid cells. The CSI thresholds can be adjusted (see section 4.4), as well as the surface threshold and the extended research area, since they may depend on the model resolution.