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River network and hydro-geomorphological parameters at 1/12° resolution for global hydrological and climate studies

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Author response to reviewer #4

Reviewer comments are in italic and blue font.

This paper uses the DRT method to upscale MERIT-Hydro hydrography datasets to 1/12 degree, and used it for CTRIP streamflow simulations and compare it with a coarse resolution CTRIP run. While this work is very interesting and involves lots of work, I found it lacking sufficient justification to be published in ESSD, as this journal focused more on "data" instead of "model simulation".

We thank the reviewer for his/her valuable comments. Bellow are our answers to each comment.

"First, the 1/12 degree river network data and its hydro-geomorphology data seems to be specifically designed for CTRIP and I am wondering what is the wider use of this dataset for other models."

The main purpose of this paper is to present the global river network at 1/12° and corresponding consistent hydro-geomorphological parameters. This dataset is mainly designed for all global or regional scale grid-based river routing models (RRMs), although it could be used in a variety of hydrology-related studies that need flow direction at a medium spatial resolution (see, e.g., Catalán et al., 2016; Robinne et al., 2018; Scherer et al., 2018; Wan et al., 2015; Zhou et al., 2015). A majority of large-scale RRMs uses a gridded structure for global hydrological studies (see technical review of Kauffeldt et al. 2016) and most of them are still running at a coarse spatial resolution. So with the entire dataset described here (flow direction, river length, river slope, river bank-full depth, river roughness, floodplains roughness, major groundwater basins boundaries, aquifer transmissivity, and aquifer effective porosity), many hydrological models could improve their river routing module by increasing the spatial resolution. Moreover, this consistent and comprehensive dataset can help the modellers to integrate some important processes (such as inundation and groundwater) that are still neglected in some models.

For clarity, we change the title to: "River network and hydro-geomorphological parameters at 1/12° resolution for global hydrological and climate studies".
Also, we added the following references in L26: Arora and Boer (1999), Getirana et al. (2021), Guimberteau et al. (2012), Schrapffer et al. (2020).

Arora, V. K., & Boer, G. J. (1999). A variable velocity flow routing algorithm for GCMs. Journal of Geophysical Research: Atmospheres, 104(D24), 30965-30979.

Catalán, N., Marcé, R., Kothawala, D. N., & Tranvik, L. (2016). Organic carbon decomposition rates controlled by water retention time across inland waters. Nature Geoscience, 9(7), 501-504.

Getirana, A., Kumar, S. V., Konapala, G., & Ndehedehe, C. E. (2021). Impacts of fully coupling land surface and flood models on the simulation of large wetlands' water dynamics: The case of the Inner Niger Delta. *Journal of Advances in Modeling Earth Systems*, 13, e2021MS002463. https://doi.org/10.1029/2021MS002463

Guimberteau, M., Drapeau, G., Ronchail, J., Sultan, B., Polcher, J., Martinez, J.-M., Prigent, C., Guyot, J.-L., Cochonneau, G., Espinoza, J. C., Filizola, N., Fraizy, P., Lavado, W., De Oliveira, E., Pombosa, R., Noriega, L., & Vauchel, P. (2012). Discharge simulation in the sub-basins of the Amazon using ORCHIDEE forced by new datasets, Hydrol. Earth Syst. Sci., 16, 911–935, https://doi.org/10.5194/hess-16-911-2012

Kauffeldt, A., Wetterhall, F., Pappenberger, F., Salamon, P., & Thielen, J. (2016). Technical review of large-scale hydrological models for implementation in operational flood forecasting schemes on continental level. Environmental Modelling & Software, 75, 68-76.

Robinne, F. N., Bladon, K. D., Miller, C., Parisien, M. A., Mathieu, J., & Flannigan, M. D. (2018). A spatial evaluation of global wildfire-water risks to human and natural systems. Science of the Total Environment, 610, 1193-1206.

Scherer, L. A., Verburg, P. H., & Schulp, C. J. (2018). Opportunities for sustainable intensification in European agriculture. Global Environmental Change, 48, 43-55.

Schrapffer, A., Sörensson, A., Polcher, J., & Fita, L. (2020). Benefits of representing floodplains in a Land Surface Model: Pantanal simulated with ORCHIDEE CMIP6 version. Climate Dynamics, 55(5), 1303-1323.

Wan, Z., Zhang, K., Xue, X., Hong, Z., Hong, Y., & Gourley, J. J. (2015). Water balance-based actual evapotranspiration reconstruction from ground and satellite observations over the conterminous U nited S tates. Water Resources Research, 51(8), 6485-6499.

Zhou, Y., Hejazi, M., Smith, S., Edmonds, J., Li, H., Clarke, L., ... & Thomson, A. (2015). A comprehensive view of global potential for hydro-generated electricity. Energy & Environmental Science, 8(9), 2622-2633.

“Second, a larger portion of this study is on comparing two simulations of CTRIP runs, instead of focusing on the river network dataset.“

In the present form of the manuscript, 13 pages over 23 pages for the main text focuses on the river network and hydro-geomorphological dataset, and 13 Figures over 18 Figures. The section 4 (CTRIP runs) uses 7 pages and the remaining figures. So we do not consider that a larger portion of this study is on comparing two simulations of CTRIP runs. This section 4, where the CTRIP simulations are presented, should be seen as a validation of the 12D dataset. The detailed CTRIP modelling configuration and validation can be found in other articles (e.g., Decharme et al., 2019, and references therein). Given the known quality of the CTRIP model at 0.5° resolution, we think that the overall improvement from this coarse resolution to 1/12° resolution is a good indicator of the overall quality of the dataset presented in this manuscript. Validating the different parameters derived in this study is not possible at the global scale because of lack of observed data. Hence, we chose to validate the entire dataset in the context of river routing modelling with the CTRIP model as an example. We argue that most RRMs use (or go to use) similar parametrization (river network, river length, width and slope, roughness, etc.) and could benefit from this dataset, built to ensure the consistency between the parameters.

“The authors seem to not have introduced new updates to DRT. So I cannot help asking what is their “data contribution”? It seems an existing method (DRT) was applied to an existing dataset (MERIT Hydro). To justify its publication in ESSD, I think authors will need to make more efforts to describe their contribution to data (instead of to model simulation).”

As noted by the reviewer, our 12D dataset is built by applying an existing method (DRT) to an existing dataset (MERIT Hydro). Note that our upscaling algorithm is slightly different than the one from Wu et al. (2012), for instance in the river diversion processing, in the treatment of estuaries or in the fact that rivers are treated hierarchically instead of basins. Besides, the dataset we provide does include not only the newly developed river network but also the associated fully consistent set of hydro-geomorphological parameters. We then consider that this dataset is a new product that, we think, could be useful for other RRMs and as such, deserves to be published.

So I cannot recommend publish this paper unless these questions are sufficiently addressed.

We hope that our previous and following answers will convince the reviewer of the usefulness of our dataset.

Here are more comments:

FIG. 15: Can the authors mention it is daily or monthly evaluation? Can you add both daily and monthly evaluation here? Because routing models generally matter more for daily streamflow simulations than monthly. If it is monthly then L385 “clearly shows quite good performances” should be revised a little bit.

We agree that RRMs are generally more focused on daily streamflows. In this validation section, simulated discharges are compared to observed discharge only at a daily time step. This has been clarified in the revised version.

Fig. 16: I do not think this figure is separately needed. Because there is not much information in the main text (around L384), it can be added as a subplot to Fig. 15. Otherwise, authors should describe much more about Fig. 16 to justify the use of this figure.

We agree. Fig. 16 has been added as a subplot to Fig. 15.

L405 and Fig. 17: why only show stations with KGE > -1? Didn’t CTRIP-12D do better than HD for all KGEs? This is a bit confusing and needs more description.

Despite the overall good quality of the CTRIP model, it may fail in reproducing observed discharges (arbitrarily KGE < -1), in particular for stations highly influenced by human activities which are not represented in CTRIP. For these stations, we consider that the CTRIP model is not adapted due to processes not accounted for. Consequently, we consider that improvement or degradation of model performances are not relevant and we discarded these stations. Note that considering these stations leads to the same result (70 % improvement, 30 % degradation). This has been clarified in the revised version.

Also, about the use of NIC, why not simply use KGE differences, and positive KGE means better performances?

The advantage of the NIC criterion is that it normalizes the difference between the KGE of two experiments. A given KGE difference has not the same impact in terms of performance depending on the value of KGE. For instance, if KGE_ref=0 and KGE_new=0.2 then NIC=0.2, whereas if KGE_ref=0.8 and KGE_new=1 then NIC=1. The higher NIC value in the second case means that the improvement is better (perfect in that case) although the difference is the same. This has been clarified in the text.

Fig. 18: again, this figure has little new information than Fig. 17. L408 says "a closer look at" but I didn't think this adds much information other than saying the same thing as Fig. 17.

The last paragraph of section 4.3.2 has been modified as:

Better performances could be expected for smaller basins since these basins are represented by just a few cells at HD, and the difference between the basin delineation at HD and 12D could be relatively high, then leading to different contributing areas. The better performances of CTRIP-12D for larger basins is less expected. Indeed processes and forcing are the same for both configurations and parameters are derived using similar strategies and relationships. The improvement of the correlation and variability demonstrates that a better defined river network improves the dynamics of river propagation within the basin and interactions with floodplains and aquifers.
Other potential sources of differences between both models include: 1. the reference HR dataset (HydroSHEDS for CTRIP-HD, MERIT-Hydro for CTRIP-12D), which impacts the generation of floodplains and aquifers sub-grid parametrization; 2. the use of observed-based river width for CTRIP-12D.

Minor ones:

L93: "consist of"

This has been corrected. Thanks.