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Interactive comment on "Two-way coupling between the sub-grid land surface and river networks in Earth system models" *by* Nathaniel W. Chaney et al.

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This manuscript represents the new two-way coupling scheme between land and river implemented in HydroBLOCK model. As the importance of surface water dynamics in land hydrology modelling and Earth system modelling is discussed recently, the model improvement proposed in this study has a contribution to the science community. The description of the model is mostly adequate, and the test simulation results look reasonable. I think the manuscript still need some improvement focusing on more detailed and kind description of the method, before acceptance.

Technical comments:

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L139: “The basins are first delineated from a 30m DEM”.

Please provide the definition of “basins”. This is a specific technical concept in the developed model, and different from the general-use meaning. As far as I understand, the river network is divided into multiple “reaches”, and the 30m pixels drained to each “reach” is defined as the “basin” corresponding to the reach. Also, I recommend to briefly explain how river channels and reaches are defined in this study. Even in the case this is mentioned in the previous paper (Chaney et al, 2016; 2018), the explanation will enhance the understanding of readers, as this is the core of the approach proposed in this manuscript.

L143: “These characteristic basins were identified using latitude, longitude, flow accumulation area, and the natural logarithm of the flow accumulations area as feature predictors.”

Please explain the background reason of using these variables as input to clustering. (for example: log-scale accumulation area to separate the small hilltop basins from large rivers; lat-lon to represent the difference of atmospheric forcing by locations).

L150: “First, all channel grid cells within a given characteristic basin”

Please explain how the “channel grid cells” are defined. Also, it is better to provide some info on “what is grid cells, and what is macro-scale grids”.

L152: “The binning involves creating groups of HAND values that have an areal coverage n (user-defined) times larger than its adjacent lower height band”.

Please explain the background reason of this methodology? Why upstream band has larger area compared to downstream band?

L159: “to represent intra-band heterogeneity of land use, soils, and elevation, among others.”

I think it is better to write the purpose of intra-band cluster implementation, rather than

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explaining the parameters to define intra-band clusters. (i.e. representation of different land type is not the ultimate purpose, rather than that, I guess authors want to represent different land hydrological reactions due to the difference of land types, such as water and heat flux.).

L210: “much larger than many of the computed channel widths of the delineated streams (∼1 meter)” This assumption is only valid for small scale river basins. The authors should mention the limitation of this assumption, and further development is needed to apply the proposed method to large-scale rivers (for example, how river channel pixels are defined appropriately, if pixel size is smaller than river width? We do need additional data source and pre-processing in this case).

Section 2.3, Section 2.6, Figure 4:

The relationship among “reach”, “basin”, “characteristic basin”, “height band”, and “HRU” is not very clear, and I need to read this parts several times to understand the model structure. To improve the explanation, I suggest followings: - Update Figure 4D, or add another figure to explain the above relationship. Figure 4D is from the previous paper, and clustering approach of Figure 4D is not consistent to the explanation in this manuscript. I recommend to add a figure/panel to clearly explain the relationship between “characteristic basin, reach/basin, reach topography”. - Clearly explain that “one characteristic basin has several reaches inside”. “each reach has its corresponding basin, and each reach has height bands information to represent flood stage; these are used for the river routine component”. (I suggest moving descriptions on delineation of the reach/basin topography just after Section 2.3, then readers can better understand the relationship between HRU generation and reach topography generation.

L222: “the inundation heights per height band are averaged across all basins that belong to a given characteristic basin (Figure 5B)”

By this process, the surface water extent in the lower bottom part of each height band is

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distributed widely to the entire land surface of the corresponding height band, causing the overestimation of the inundated water surface. This will lead to the overestimation of the infiltration from floodplain to soil, and affect the heat and water flux accordingly. This should be discussed as the limitation of current approach. In addition, “Figure 5B” should be “Figure 4B”.

L297: “lakes throughout the region.”

Is it possible to explain how lakes are represented in the proposed model? As lakes are apparent in the result figures, some explanation should be essential.

L374: “the 16 interconnected cells take 5 minutes”

It is not clear what this “the 16 interconnected cells” corresponds to. Please clearly mention that this means “16 macroscale grids within the target 1deg domain. Also, it is better if authors mentioned the expected calculation cost for potential larger scale simulations, if HydroBLOCK is planned to be applied on continental or global scales.

L405: “One approach being explored by the co-authors is to cluster the lower stream orders.”

This will also increase the discrepancy between “vector-shaped basins” and “rectangular macro-scale grid (and atmospheric forcing data as a result). This difficulty is also better to be mentioned.

L411: “update the boundary conditions iteratively”

It is not clear which “boundary conditions” authors want to mention in this sentence (e.g. upstream river inflow? Atmospheric forcing? Or between-basin horizontal water exchange?)

L424: “The flooding component of the scheme will then enable the valley to fill-up and, thus, producing a first-order representation of the time-varying reservoir spatial coverage.”

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This assumption is only valid for small-scale reservoirs which can be represented within a single grid. Further consideration is needed to represent large lakes/reservoirs which spans multiple grid boxes.

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