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Geoscientific Model Development Discussions
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Interactive comment on "Dynamic hydrological discharge modelling for coupled climate model simulations of the last glacial cycle" *by* Thomas Riddick et al.

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The submission "Dynamic hydrological discharge modelling for coupled climate model simulations of the last glacial cycle" presents a routing toolbox/module for coupled paleoclimate modelling. The latter is necessarily of coarse resolution relative to river and catchment scales and the challenge (from this reviewer's own experience) of appropriate upscaling from hydrologically resolving Digital Elevation Models is very non-trivial. The module is clearly validated in Figure 6. It's dynamic downslope approach makes this a useful component for any paleoclimate Earth Systems Model (ESM), especially given the growing interest in running ESMs with fully coupled ice sheets.

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Discussion paper

The only two significant but easy to address deficiencies I found were the lack of lakes and no specific mention of other dynamic sources of uncertainty that need to be considered for accurate paleo-drainage modelling, specifically glacial isostatic adjustment (GIA) and the need to consider erosional changes in controlling outlet sills.

I don't understand why the algorithm can't handle lakes. Large pro-glacial lakes were significant deglacial feature for Europe and especially North America, of relevance to both the climate (eg evaporative surface) and to the adjacent ice sheet (lacustrine calving margin). There is significant evidence in the glacial geological literature (eg, Fisher, 2005), that at least the southern outlet for Glacial Lake Agassiz experienced significant erosion and therefore lowering of the controlling sill depth over the lifetime of that lake. Higher older sills can force routing into other ocean basins with potentially significant climatic consequences. The paper should at least provide a brief explanation of why lakes aren't computed and the impacts thereof.

Fisher, T.G., 2005. Strandline analysis in the southern basin of glacial Lake Agassiz Minnesota and North and South Dakota, USA. Geological Society of America Bulletin 117 (11/12), 1481–1496.)

GIA and determines geographic and geoidal deflections and therefore errors from common simplified GIA schemes can also potentially significantly affect drainage routing. Again, all that is needed is a short statement to this effect. I note the authors do mentions "inaccuracies in the underlying topography" as a issue, but I think it would be useful to readers to spell out the key dynamical sources of this.

My only other comment (which may be due to my ignorance of conda) relates to all the listed version specific required libraries in the code archive dynamic_hd_env.txt. I suspect this was auto generated and I would strongly urge the authors to reduce this to the bare bones required. Ideally, code should port without special language features, and the only versions issues should be to avoid known bugs in specific versions.

I have some minor to moderate comments below, but once all this is addressed, I would judge this a worthwhile contribution to the community.

specific comments (quotes lack the "#" prefix)

on which an existing present-day hydrological discharge model within the JSBACH land surface module

I'm confused here. You describe this as "present-day", so presumably just a routing matrix for present-day topography, but then below you indicate this does down-slope routing, in which case this does not need the "present-day" qualifier.

has also been shown this procedure can be run successfully multiple times as part of a transient coupled climate model simulation.

shouldn't this be run continuously in async mode? Ice sheet margins can significantly change drainage routes within a century.

During the last glacial cycle, the courses of rivers in North America, ..

should provide appropriate references

however such lakes are switched off entirely in the version of the HD model used for dynamic hydrological discharge modelling by this paper

why? Can the not be run with the dynamic upscaled topography?

can be accurately reproduced on a 0.5ˆo resolution

For ice sheet modelling, the meridional grid convergence towards the poles means that it makes much more sense to use eg 0.5 longitude by 0.25 latitude degree resolution.

We define the effective hydrological height of a cell within a DEM as the height of the highest point in the ‘most likely’ river

more succinct description would be "elevation of river sill within the cell"

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Discussion paper

Upscaling effective hydrological heights could also potentially be applied beneficially to Eurasia however we decided against doing so because of the significant additional effort required.

I'm confused here as I understood from the reading that the core upscaling process is automated, in which case the effort is negligible. Farther down I note

The orography upscaling process (which need only be run once) takes approximately 25 minutes to run for the entire globe

so why not use the generated global field?

When these corrections are applied to an orography for a time other than the present day any relative corrections that are beneath ice sheets are temporarily suppressed until the region becomes ice free once more; thus the original unmodified height is always used for ice sheets

How do you handle the transition? Eg, say 200 m thick ice in the Rocky Mountains will not over-ride the existing topography?

Another important limitation is the lack of verification for time-slices other than the present day (due to the lack of easily comparable data);

This is an arguable statement. One could take the LGM topographic deflection from GIA, apply it to the hydro-1k DEM, overwrite ice topography, and then use eg the R hydrological flow solver (or equivalent in other GIS apps) to extract drainage maps and compare to your results.

algorithmic pseudocode

I found this hard to follow. eg it's not clear what all the variables such as p, d, h, i represent. As long as all the code is provided, I would suggest simplifying the pseudo code somewhat and use more descriptive names than single letter indices. Try running the pseudo code by some colleagues and see what doesn't make sense to them.

Code archive and code quality

I tried to set up the code set, but the required conda environment manager is not an available (apt-get accessible) package for Linux and installing this along with what I take are a lot of specific versions of python libraries.. was more than I was willing to go.

Figure 1,

what does upscale by "meaning" mean?

Figure 8,

would be much more informative to show change in volume flux eg in deci Sverdrups than change in water velocities.

small typos:

Artic Coast -> Arctic coast

Coast -> coast

northern Pacific -> Northern Pacific

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