Review egusphere-2025-6361

The authors present two methods to reduce the runtimes of a hydrodynamic model and evaluate the performance increase in a test region around the city of Goslar. While the topic is relevant, the study lacks to differentiate what the authors developed themselves and where they just implemented common algorithms. This impression might also be caused by the unconventional and partially confusing structure and display of results. In the following I will address my concerns in detail.

General comments:

- Introduction: Numerous complex concepts are mentioned without leading to the own research question. A lot of direct quatations. Should be significantly shortened. Redundancies should be removed. Ends with numerous examples of the state of the art, which is rather unusual. It would improve the structure if the study objectives would follow the state-of-the-art instead.

- The structure should be improved. E.g. datasets are mentioned in “1D/2D modelling” (l.183 ff.) and “Refining the mesh” (l. 274). Use the standard structure and describe your dataset in a section “Data” and your software and new code implementations in “Methods” as usual. Mention all software. SCALGO is not described anywhere. The model is not clearly described.The current structure is confusing the reader unnecessarily.

- The authors present as one of their main innovations what seems to me as a standard algorithm to delineate sub-catchments from a digital elevation model as a basis for parallelization. Is this really something new and has not been done before? Additionally you fail to mention that the performance increase is highly dependent on the order of nodes. E.g., if you have a lot of dependent sub-division the potential for parallelization is significantly limited. Furthermore, the error increases with subdivision.

- The second innovation (quadtree refinement) turns out to be an add-in which you did not develop. However, in the abstract it sounds as if you had developed this (“We present significant progress…. Breakthrough…). Again, this might be caused by the structure and I am not able to distinguish which methods you developed and which pre-existing ones you “just” implemented and tested.

- I understand that it is difficult to present the results but the current display is not convincing. Maps and plots are too small, colors are difficult to distinguish

- Because of proprietary software the study is not reproducible.

Detailed comments:

Line 1-34: Streamline introduction? Focus on floods caused by high intensity precipitation. What has erosion to do with the topic? What do “ocean“ floods have to do with the topic?

Line 74 – 88: This seems like a rather unorganized collection of snippets all related to the idea how hydrodynamic models can be improved by either disrectisation or other parameters (e.g. roughness, sub-grid porosity). Please try to streamline, summarize and to be more concise.

Line 89ff: For my taste this part contains too much“name-dropping” and mentioning of complex methods without further explanation. This does not really help the reader who is not completely familiar with the development of hydrodynamic models. There seems to be redundancy, too. e.g. when talking again about porosity treatments (l. 100). Please streamline the Introduction

Figure 1: You could probably combine plots top left and bottom.

Line 155: I assume "g" is the standard gravity but please list it below.

Line 186: What is SCALGO?

Line 189 ff: This is essential for flood modeling. Please give more detail. What was the input data for the machine learning? Soil moisture products have usually a very low quality, especially on a 1m grid.

Figure 2: I think this Figure never gets referred to in the text. Please add more information to the caption. What is cj, what is v? What is the flow direction? Up or down? Why does orange need to be removed? Why is the bottom node on the right not red? Enlarge the symbols for the nodes so one can distinguish the colors better

Line 207-233: If I understand correctly, this is the description of a typical algorithm that delineates hydrological subcatchments from a DEM. I think it would be helpful to mention this, or to skip this section entirely and just say “We delineated subcatchments”. The headwater catchments can be computed independently. The rest needs to be updated accordingly depending on the flow graph.

Line 210: Is this the total number of cells?

Line 211: Does the threshold depend on the RAM size?

Line 217: Again, SCALGO not explained

Line 222: What would happen if a cell is flat, or evenly flows into e.g. three downstream cells? There are typically different ways to treat this. For one-directional flow typically a random choice is included which does not make the results reproduceable (when not setting a seed).

Line 225: Why do you do this? How do you decide on the threshold?

Line 233: This basically refers to subcatchments, right?

Line 236: I don't understand this step. Can you please explain further? Why do you need water transfer between watersheds?

Line 244: Does this step ensure a minimum size for subcatchments?

Line 245: What do you mean with cell-level data?

Line 245: Now you are talking about watershed extraction, but isn’t that the same as you just described before. What is the difference? Here you are you using a algorithm from SCALGO. The previously described method was developed by you. It is really difficult to differentiate where you developed own code and where you used existing methods.

Line 251: Describe model in a “Method” section TUFLOW and add a reference.

Line 257: Another preferred flow path are tilled agricultural areas. Wouldn't it also make sense to have a finer resolution in uneven/rugged areas?

Line 274: Hausumringedataset" -- you mentioned it before. What is it? → “Data” section

Line 281: Subgrid-sampling: Can you give some kind of reference for this? Or an example? Its hard to imagine how this works.

Line 289: You based your flow graph delineation on a 30m-DEM and now you have another finer DGM for SGS? Which one? You should consider having a "Data" section and you should describe which data set you use for what and why.

Line 296: "well-established" -- References please

Figure 4: Bottom left too small. Maybe make the maps larger and the histograms smaller. Its hard to tell if these dept differences are relevant? What if they happen exactly in the critical spots?

Line 310: Does this value come from KOSTRA? Is it a realistic structure to have uniform 50mm on 20km²

Line 314: So in this example you can compute 2 catchments parallel?

Line 317: Maybe a cumulative distribution function would be easier to read?

Line 319: Is this because of the differently sized cells?

Line 322: Does this mean, the more parallel regions I compute, the larger the error gets? How much could I parallelize until the error gets to large?

Line 324: Can show an example, why this impact is not significant?

Line 333: You mean, you use your algorithm but still don't parallelize? Is the speed up then solely to the smaller memory requirements for the individual subcatchments?

Line 346 Why do you change the rainfall amount here compared to the previous example with 50mm?

Figure 5: "lower is better" -- why is this in the caption of each subplot? Bars are really narrow and hard to read. Colors (e.g. shades of brown) are hard to distinguish.

Line 347: The quadtree increases simulation time, right? Then how do you weigh simulation time against precision?

Line 370: *“spatial variability of rainfall”.*I think that this correction is just reducing the rainfall amount but it stays spatial uniform rainfall.

Line 375: 1D and 2D model are part of TUFLoW? I think a proper model description is missing. Which model is it?

Figure 6: So, here its just about quadtree and not about parallelization, right? Couldn't you directly use quadtree on the whole grid?

Figure 7: The maps are so small, that the differences are hard to distinguish. Maybe you could zoom in? *Pi* and *Pj* not annotated in first subplot

Line 408: Can you explain, why you opted for this setting?

Line 413: It would be interesting if you could give an estimate for the memory requirement for the 1m-simulation on one core

Line 418: A linear cascade of dependend subcatchments would then significantly slow down the parallelized computation. You should mention that somewhere.

Line 437: I am wondering, why you don't parallelize on many more cores? For a sensitivity analysis you typically need to run the simulation many times. Is the speed up so significant that you could now run a complete sensitivity analysis?

Line 458 ff: It is difficult to see this in the Figure 8. Generally, in Figure 8 the different layers are overlaying each other. Is there a better way to visualize this? Maybe one plot for each scenario even though that would mean a lot of plots… About which inundation depth we are talking? Or do you just count everything above 0 cm? Can you assess this e.g. by the amount of inundated raster cells to visualize the tipping point?

Figure 8: Top left could be smaller, while the maps of the flooded areas should be larger. E.g. top left, I can't find any yellow part (highest rainfall). Brown and orange are very hard to distinguish. Scale bar missing. Mention which rainfall amount you chose.

Line 472: Did you mean “middle right”?

Line 472: Does this mean that you applied 150 mm in three hours uniformly once for each subcatchment? What would happen if the rainfall affects two or more subcatchments partially but simultaneously?

Line 481: Are you implying that your experiment is 7 times fast than the 1m resolution? Wouldn't it be a "slow-down" factor? Maybe its just a matter of formulation.

Line 500ff: You did not really do this, did you? Why not? How long would it take? What would be the memory requirements?

Line 505: *"Our quadtree refinement strategy"* Didn't you use a pre-existing library? Or did you develop this method?

Line 517: Could you give any information on how high these margins could be? Do you have any info on this?

Figure A1: Top left: Headline missing. Generally the maps are too small. Maybe you should supply them as shapefiles.

Figure A2: "lower is better" -- I would not write this on top of every plot