Optimization and visualization of numerical models of flash floods in steep Norwegian rivers

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Abstract The analysis and communication of complex phenomena such as flash floods requires new approaches. The target is using a state-of-the-art model with a fast and robust predictive capability, which has been tested in a small, steep Norwegian river affected by a recent flash flood, and visualizing this model in a relatable manner. To do so, this research project aims to use optimized simulations that could be carried out in the prototype of a serious gaming engine. The incentive for such optimized simulations is that complex hydraulic modelling is data- and computationally costly. This clashes with the need for low complexity solutions in the real-time based scenarios that an immersive experience and on-site decision-making requires.

Keywords: flash floods, steep rivers, hydraulic modelling, optimization techniques, visualization of numerical models.

Methods

The following modelling techniques were implemented in Storelva river in Utvik municipality (west of Norway):

- Parallel CPU-based computing of 2D models;
- GPU-based computing of 2D models;
- Machine Learning (ML) for 1D emulation models.

The flash flood that affected Storelva river in 2017 (Bruland, 2020) has been modelled in 2D (fig. 1a) to understand the dynamics during the flood event, as well as search for an optimal numerical method for small and steep rivers. The hydrodynamic model was carried on both CPU (single and multi-thread), as well as on GPU (fig. 1b). Furthermore, the obtained 2D GPU-based model was used as input data for a ML emulation model, and their performance was subsequently compared by Son (2020).

Preliminary results

Computing performance of 2D hydrodynamic models for the 2017 flash flood in a steep Norwegian river.

GPU-based computing, as well as the use of ML, are state-of-the-art optimization techniques (Moraru *et al.*, 2020). The computing tool used for numerical modelling will determine greatly the performance of the model, nevertheless. Comparison of the computing performance of different CPUs and GPUs for the hydrodynamic model of the 2017 flash flood (fig. 1b) shows that:

- GPU-based computing is generally quicker than CPU-based computing
- the dispersion of the data is larger in the CPU tests than in the GPU tests.

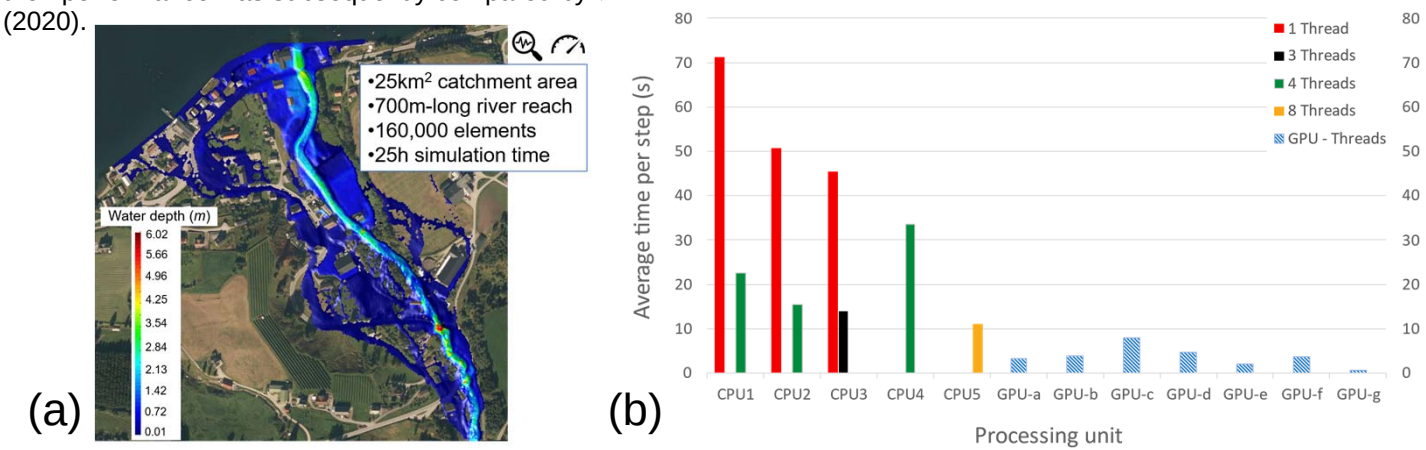

Figure 1: (a) Water depth in Utvik (t = 7.5h) simulated on GPU, (b) computing time per step for different CPUs and GPUs.

Conclusions

Numerical simulations need different computational effort depending on the number of threads available in the processing unit, i.e. 1 to 8 threads in CPUs *versus* 384 to 4352 threads in GPUs in fig. 1b. Therefore, the speedup will be larger in GPU- than in CPU-based simulations.
In conclusion, this makes a personal computer with a GPU suitable for fast numerical simulations. The precision of such models will be contrasted with observed data.
Future tests on the performance of ML emulation models compared to GPU-based numerical models would provide valuable insights into the visualization of numerical models.

References

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