Graduation Internship at Deltares

Improving performance of numerical methods for the shallow water equations on a GPU

Research

The main research goal is to implement a new solver for the shallow water equations on a GPU and to compare the GPU performance with existing methods. This project can be seen as a follow-up of the MSc thesis of Buwalda (Buwalda, 2020), in which several numerical methods for the shallow water equations were implemented on a GPU. This work has culminated in a publication in the journal Water; see (Buwalda et al., 2023). The main result was that impressively low computation times can be achieved on GPUs with both explicit and implicit solvers. A lot of ideas exist to continue this work, and during this internship one of these ideas will be investigated.

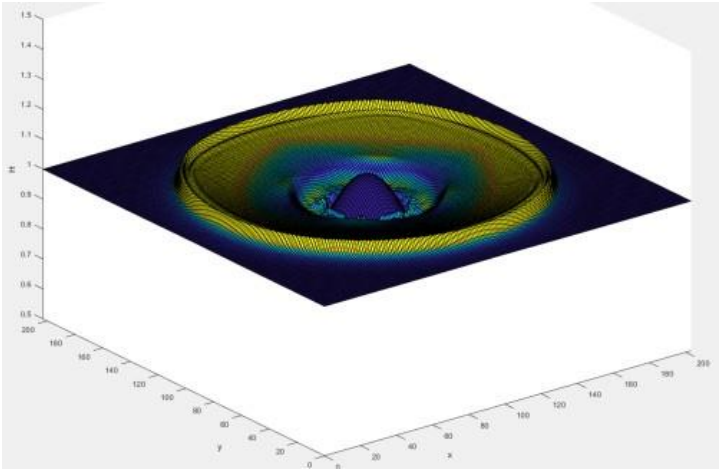

Figure 1 Illustration of a droplet computed on a high-resolution grid on a GPU; taken from Buwalda et al., 2023)

As a starting point, the implementation of the numerical schemes in (Buwalda et al. 2023) will be taken, an explicit method and a semi-implicit method which solves a pentadiagonal system. Both a MATLAB and a CUDA version exist. The goal is to extend this implementation to a so-called Alternating Operator Implicit (AOI) method. This could be seen as a combination of the two methods implemented in (Buwalda, 2023). The AOI offers several advantages, such as only requiring the solution to a tridiagonal system. In particular, the time step is constant and can be set by the user based on accuracy requirements. The current methods in (Buwalda, 2023) use a variable time step, which requires synchronization between all GPU threads, which is a costly operation. We expect that a significant reduction in computation time can be achieved in comparison with the methods in (Buwalda, 2023).

Practicalities

Supervisors:	Kees Vuik (TU Delft) Floris Buwalda & Erik de Goede (both Deltares), Maxim Knepflé (TYGRON)
Duration:	6 months, Autumn 2023 | Spring 2024
Compensation:	Yes, but not for any delays

References

Buwalda, F. (2020). Suitability of Shallow Water Solving Methods for GPU Acceleration. Master's Thesis, Delft University of Technology, Delft, The Netherlands, 2020.

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Buwalda, F.J.L.; E.D. de Goede, M. Knepflé, C. Vuik (2023). Comparison of an Explicit and Implicit Time Integration Method on GPUs for Shallow Water Flows on Structured Grids. Water 2023, 15, 1165. https:// doi.org/10.3390/w15061165. https://www.mdpi.com/2073-4441/15/6/1165

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