Graduation Internship at Deltares

Performance comparison of implicit and explicit schemes for the shallow water equations on a GPU with FORTRAN90 code

Research

The goal is to implement a shallow water solver on a GPU and to compare the GPU performance of several numerical methods. A second goal is to carry out an inundation simulation for a polder in The Netherlands with a GPU code on a high resolution mesh. For example, the AHN (Actueel Hoogtebestand Nederland) data set with a resolution of half a meter might be used.

The implementation will be done in FORTRAN90. Till now, most of the GPU coding has been in C. However, the computational kernels of Deltares are in FORTRAN90. Since GPU computing with FORTRAN90 has become more mature, it is interesting the investigate the current GPU performance with FORTRAN90. To this purpose, compiler directives such as OpenACC or OpenMP might be used as well.

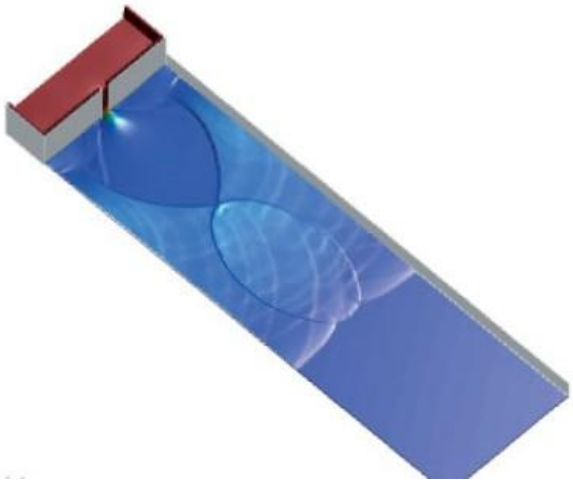

Figure 1 Illustration of dam break (taken from Stelling & Duinmeijer (2003))

As a starting point, the numerical scheme of Stelling & Duinmeyer (2003) for rapidly varied shallow water flows is one of the possibilities. The time integration method of this scheme can be written in either explicit or implicit form. This will give an impression of the GPU performance at both ends of the spectrum, because explicit methods are relatively easy to implement on a GPU while for implicit methods this is much more difficult. The Stelling & Duinmeyer method in implicit form requires the solution of a symmetric positive definite pentadiagonal system of equations, for which the GPU experience in the M.Sc. project of Martijn de Jong (2017) might be used. In order to solve the pentadiagonal system existing GPU libraries, such as the Paralution software, might be investigated as well.

Practicalities

Supervisors:	Erik de Goede & Maarten Pronk (both Deltares), Guus Stelling (Stelling Hydraulics)
Duration:	6 months, Spring 2018 | Summer 2018
Compensation:	Yes, but not for any delays

References

De Jong, M., A. van der Ploeg, A. Ditzel and K. Vuik (2017). Fine-grain parallel RRB-solver for 5-/9-point stencil problems suitable for GPU-type processors. Electronic Transactions on Numerical Analysis. Volume 46, pp. 375–393, 2017.

Stelling, G.S., S.P.A. Duinmeijer, 2003: A staggered conservative scheme for every Froude number in rapidly varied shallow water flows. Int. J. Numer. Meth. Fluids 2003; 43:1329–1354 (DOI: 10.1002/_d.537)