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Delft3D-FLOW on PRACE infrastructures for real life hydrodynamic applications

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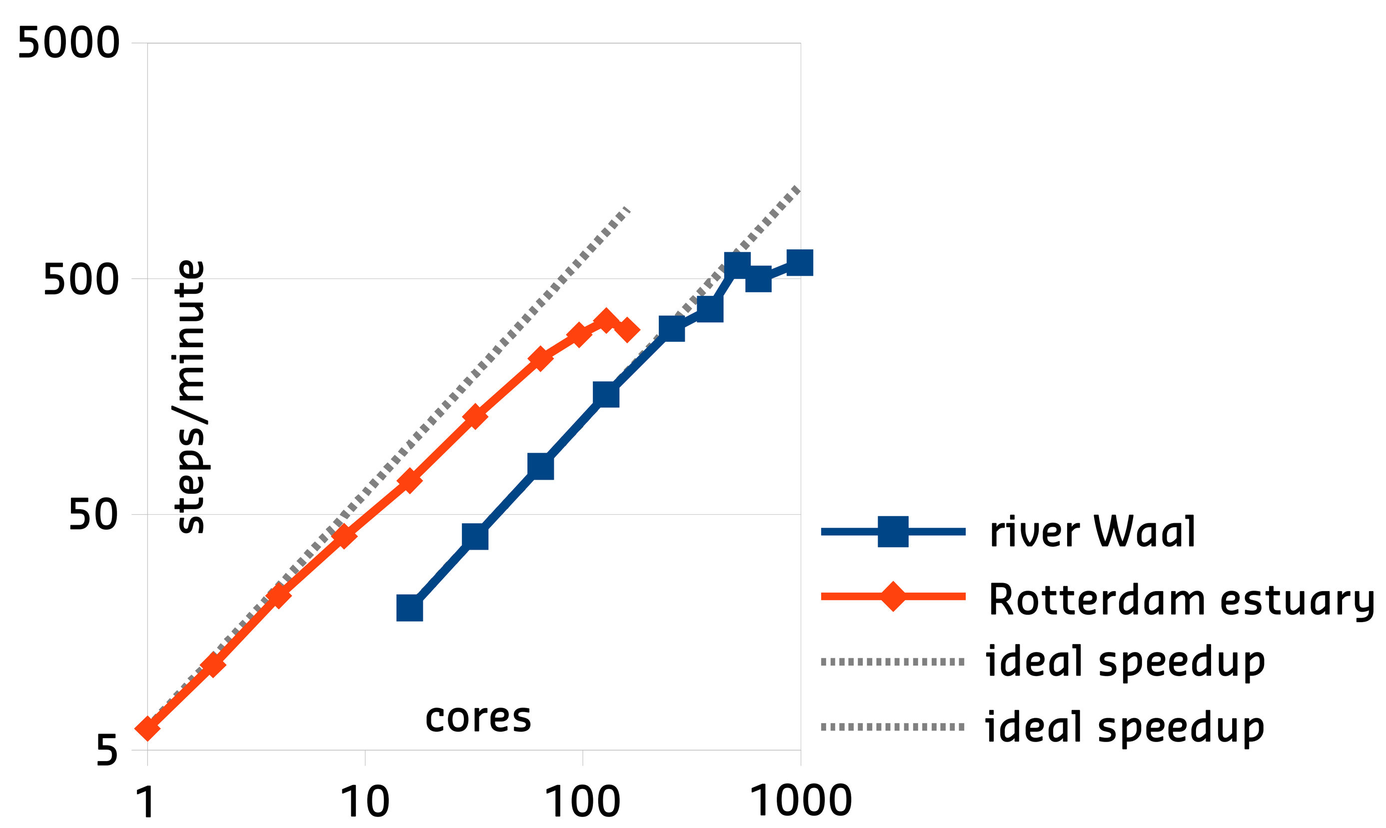
Delft3D-FLOW

Delft3D-FLOW is a 2D and 3D shallow water solver which calculates non-steady flow and transport phenomena resulting from tidal and meteorological forcing on a curvilinear, boundary fitted grid in Cartesian or spherical coordinates.

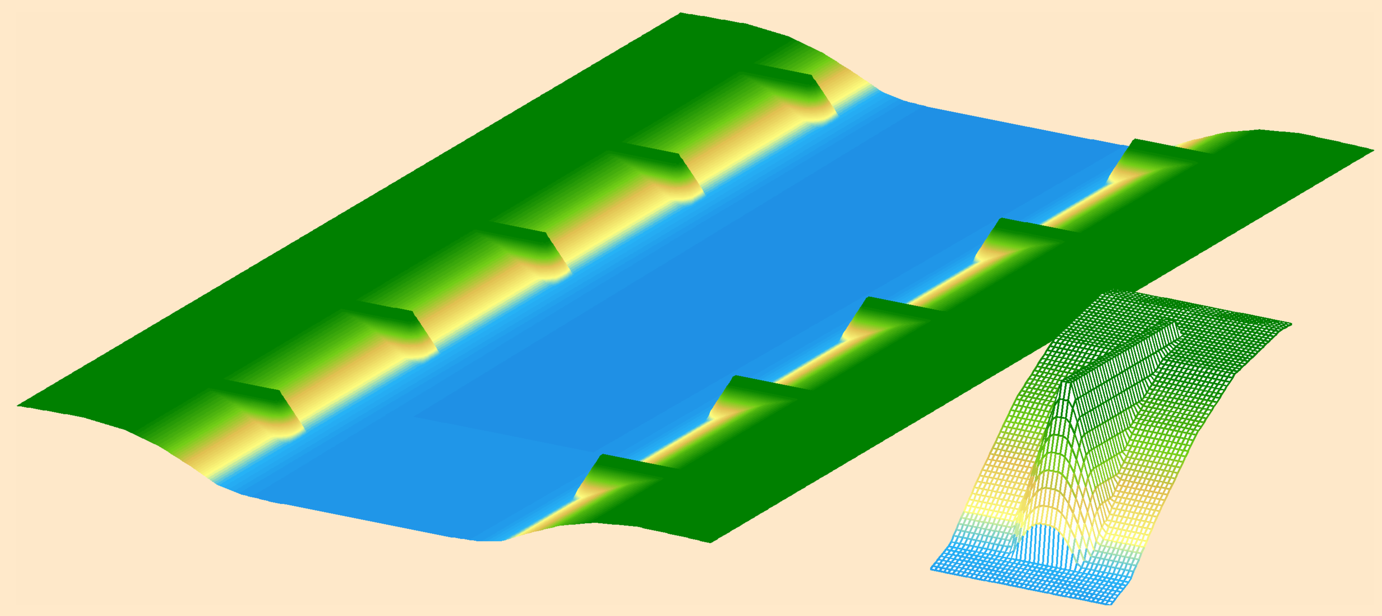
As Delft3D-FLOW has been developed over several decades, with a variety of functionality and over 350k lines of source code, porting to PRACE infrastructures needed some effort.
At the moment Delft3D-FLOW uses MPI with stripwise domain decomposition as its parallellisation approach. Although Delft3D-FLOW employs a sophisticated build system, several modifications were required to port it to PRACE systems due to the use of specific compilers and MPI-libraries. Delft3D-FLOW now has improved support for MPICH2, MVAPICH, OpenMPI and POE. To identify scaling issues, different cases with increasing complexity have been used to investigate scaling of this parallellisation approach on several PRACE platforms. We show two of them: a schematic model of river Waal and the Rotterdam estuary model.



2nd benchmark: Rotterdam estuary

For a large model with complicated geometry we moved to a 3D hydrodynamic model of Rotterdam harbour that includes sections of the rivers Rhine and Meuse and a part of the North Sea [3]. This model is used in The Netherlands to study possible measures to prevent that freshwater intake points are affected by more saline water as a result of sea level rise. Delft3D-FLOW is able to simulate the relevant processes and measures to reduce salinity intrusion.

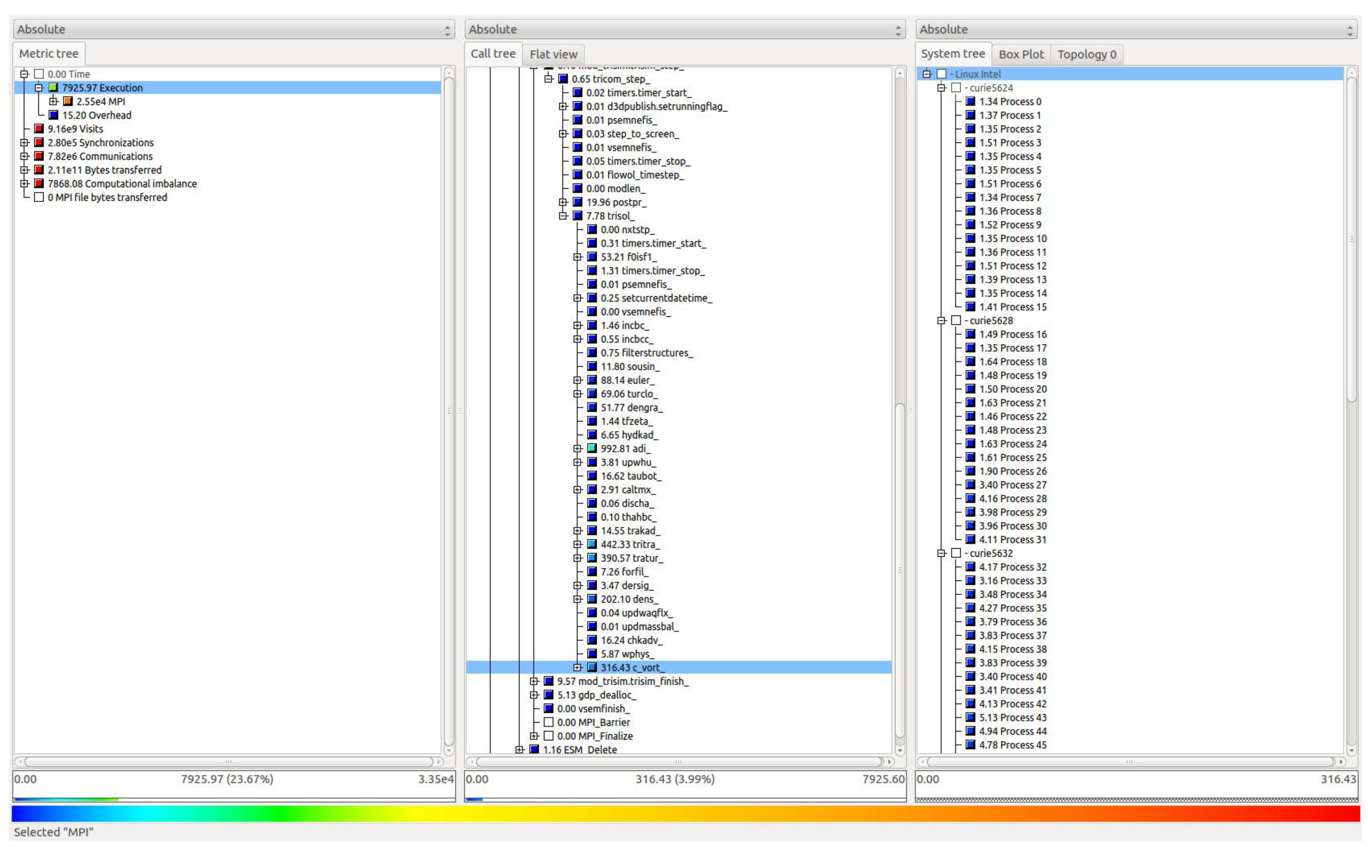
Due to the complicated geometry , processor domains have a highly varying fill-factor. This creates imbalances, which limits the scalability. The performance is improved by about 20% by using loop masks and removing optional routines. The performance profiles show that there is room for further improvement by minimizing the local domain size and the communication.



1st benchmark: River Waal

As a base reference case we started with a schematic high-resolution 2D hydrodynamic model that has characteristic dimensions of river Waal in the Netherlands. Originally, the model was developed to study the effect of lowering groynes on design flood level [4]. Groynes are represented as bed topography (see figure above) in a symmetrical compound channel of 30 km length including floodplain (width of 1200 m) and main channel (width of 600 m). The floodplain is schematised with grid cells of 2 m x 4 m and the main channel with grid cells of 2 m x 2 m, resulting in more than 9 million unknowns. A time step of 0.9 seconds is used.

Because of the geometry (straight channel without dry/inactive points) and the high number of unknowns, it is known from [2] that this configuration scales well up to 96 subdomains (strips). However, the parallellisation approach of Delft3D-FLOW differs at some points and from forehand it was not clear what to expect. It turned out that for this schematic model Delft3D-FLOW scales well up to 512 cores on the highly-parallel PRACE machines.



Performance profile of Delft3D-FLOW with Scalasca [5].

Conclusions and outlook

The Delft3D-FLOW shallow water solver was ported to several PRACE systems and, as a result, Delft3D-FLOW now supports more MPI-libraries. Delft3D-FLOW shows a good scalability with a suitable, but idealized, benchmark. Performance analysis of a realistic model has shown 20% CPU time in little-used routines. It is expected that scalability can be increased somewhat, but will be limited by the strip-wise domain decomposition.

A third benchmark includes also sediment transport and morphological changes. An initial analysis shows possible improvements by inlining some routines.

Abstract

Delft3D [1] is an open source software package for simulating complex water management systems. It includes components to simulate shallow water flow, sediment transport, morphological changes, waves, water quality and ecological processes.

This poster describes results of porting the hydrodynamic component Delft3D-FLOW to PRACE infrastructures. Analysis of the performance on these infrastructures has been done for real life flow applications.

PRACE

PRACE, the Partnership for Advanced Computing in Europe, offers access to the largest high-performance computing systems in Europe. PRACE invites and helps industry to increase their innovative potential through the use of the PRACE infrastructure. We acknowledge PRACE for awarding us access to resource Curie based in France at CEA, Fermi based in Italy at CINECA, and Hermit based in Germany at the High Performance Computing Center Stuttgart. The support of John Donners from SURFsara, The Netherlands to the technical work is gratefully acknowledged.

References

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