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Towards exascale shallow-water modelling with SERGHEI model and Kokkos

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The **S**imulation **E**nvi**R**onment for **G**eomorphology, **H**ydrodynamics and **E**cohydrology in **I**ntegrated form (SERGHEI) model framework is a model framework for environmental hydrodynamics, ecohydrology, morphodynamics, and, importantly, interactions and feedbacks among such processes. SERGHEI is designed to be applicable to both geoscientific questions of coupled processes in Earth system science such as hydrological connectivity and river stability, as well as engineering applications to flooding and transport phenomena.

In this contribution we present the SERGHEI model framework, its modular concept and its performance-portable implementation. We discuss the implementation of SERGHEI including the specifics of a highly efficient parallel implementation of the numerical scheme (based on augmented Riemann solvers) and how we achieve portability using the Kokkos programming model as an abstraction layer. The experience in SERGHEI suggests that Kokkos is a robust path towards performance-portability, and sets a realistic path for SERGHEI to be ready for the upcoming European exascale systems.

We focus on the SERGHEI-SWE module which solves 2D shallow-water equation. We show that this fully operational module is performance-portable across CPUs and GPUs in several TOP500 systems, as well as first results on portability across GPU vendors. We discuss the computational performance on benchmark problems and show its scalability into the range of hundreds of scientific-grade GPUs. Additionally, we show first results of performance of the upcoming transport module in SERGHEI, and discuss the computational implications and outlook considering further integration of new modules and solvers in SERGHEI.