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Numerical Aspects of Nonhydrostatic Implementations Applied to a Parallel Finite Element Tsunami Model

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Based on the jeopardy of devastating tsunamis and the unpredictability of such events, tsunami modelling as part of warning systems is still a contemporary topic. The tsunami group of Alfred Wegener Institute developed the simulation tool TsunAWI as contribution to the Early Warning System in Indonesia. Although the precomputed scenarios for this purpose qualify for satisfying deliverables, the study of further improvements continues. While TsunAWI is governed by the Shallow Water Equations, an extension of the model is based on a nonhydrostatic approach. At the arrival of a tsunami wave in coastal regions with rough bathymetry, the term containing the nonhydrostatic part of pressure, that is neglected in the original hydrostatic model, gains in importance. In consideration of this term, a better approximation of the wave is expected. Differences of hydrostatic and nonhydrostatic model results are contrasted in the standard benchmark problem of a solitary wave runup on a plane beach. The observation data provided by Titov and Synolakis (1995) serves as reference. The nonhydrostatic approach implies a set of equations that are similar to the Shallow Water Equations, so the variation of the code can be implemented on top. However, this additional routines cause a lot of issues you have to cope with. So far the computations of the model were purely explicit. In the nonhydrostatic version the determination of an additional unknown and the solution of a large sparse system of linear equations is necessary. The latter constitutes the lion's share of computing time and memory requirement. Since the corresponding matrix is only symmetric in structure and not in values, an iterative Krylov Subspace Method is used, in particular the restarted Generalized Minimal Residual Algorithm GMRES(m). With regard to optimization, we present a comparison of several combinations of sequential and parallel preconditioning techniques respective number of iterations and setup/application time. Since the used software package pARMS 3.2, that provides solving and preconditioning techniques, works via MPI parallelism, in an auxiliary branch we adapted TsunAWI and switched from OpenMP to MPI with attached importance to internal partition management.