Parallel Computing with SEAWAT

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ABSTRACT

Fresh groundwater reserves in coastal aquifers are threatened by sea-level rise, extreme weather conditions, increasing urbanization and associated groundwater extraction rates. To counteract these threats, accurate high-resolution numerical models are required to start optimizing the management of these precious reserves. Major model drawbacks are long run times and large memory requirements, limiting the predictive power of these models.

Distributed memory parallel computing is an efficient technique for reducing run times and memory requirements, where the problem is divided over multiple processor cores. A new Parallel Krylov Solver (PKS) for SEAWAT is presented. PKS has recently been applied to MODFLOW and includes Conjugate Gradient (CG) and Biconjugate Gradient Stabilized (BiCGSTAB) linear accelerators. Both accelerators are preconditioned by an overlapping additive Schwarz preconditioner in a way that:

a) subdomains are partitioned using Recursive Coordinate Bisection (RCB) load balancing,
b) each subdomain uses local memory only and communicates with other subdomains by Message Passing Interface (MPI) within the linear accelerator,
c) it is fully integrated in SEAWAT.

Within SEAWAT, the PKS-CG solver replaces the Preconditioned Conjugate Gradient (PCG) solver for solving the variable-density groundwater flow equation and the PKS-BiCGSTAB solver replaces the Generalized Conjugate Gradient (GCG) solver for solving the advection-diffusion equation. PKS supports the third-order Total Variation Diminishing (TVD) scheme for computing advection.

Benchmarks were performed on the Dutch national supercomputer (https://userinfo.surfsara.nl/systems/cartesius) using up to 128 cores, for e.g. a synthetic 3D Henry model (100 million cells) and the real-life Sand Engine model (~10 million cells). The Sand Engine model was used to investigate the potential effect of the long-term morphological evolution of a large sand replenishment and climate change on fresh groundwater resources. Speed-ups up to ~40 were obtained with the new PKS solver.

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