SAMG – The Linear Solver for Groundwater Simulation

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SAMG (Algebraic Multigrid Methods for Systems) is a very mature program package being used for the efficient solution of linear sparse systems of equations in many commercial simulation codes. In particular, in groundwater and porous media simulation it has been introduced as the primary numerical solver module in FEFLOW 6.

In solving a linear system of equations, Algebraic Multigrid Methods proceed in two phases: a relatively expensive **setup phase** in which all hierarchical components are set up, and a **solution phase** in which the linear system is solved iteratively.

In the most general case, SAMG has to apply both phases to each individual linear system. However, in a time-dependent simulation process, SAMG analyzes the solver behavior for previous linear systems and exploits this information to optimize overall runtime. Most importantly, whenever possible, SAMG reuses parts or all of previous setup phases in later time steps. SAMG will even switch to an alternative (one-level) solver should this turn out to be more efficient (as may be the case for very small time steps or relatively coarse meshes). More precisely, the switching is done between an incomplete Cholesky preconditioned CG method (PCG) and an improved auto-controlled algebraic multigrid preconditioned CG method, which is well known from former FEFLOW releases. These improvements significantly enhance the applicability of the SAMG solver package.

Since the new solver control automatically switches between different solvers, the user does not have to decide which solver will be the best for a given model. In fact, the control chooses a solution process which - with respect to the overall simulation process - provides a suitable compromise between speed and robustness. Especially, for models which strongly change their numerical properties during the simulations in time, the new solver control will pay off enormously. Additionally, the whole SAMG package is OpenMP parallel, which leads to an additional performance increase on state-of-the-art multi-core computers.

In the present talk, we will investigate the performance of the new SAMG solver package in FEFLOW on several relevant - applications in groundwater modeling. Additionally, we will compare its performance to the former version (without switching) as well as standard linear solvers. SAMG provides efficiency and robustness even under extreme unstructured meshing, highly transient conditions and high parameter contrasts of large models.