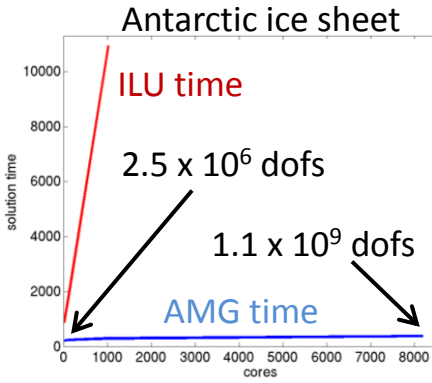
A new algebraic multigrid (AMG) preconditioner for large-scale ice sheet simulations

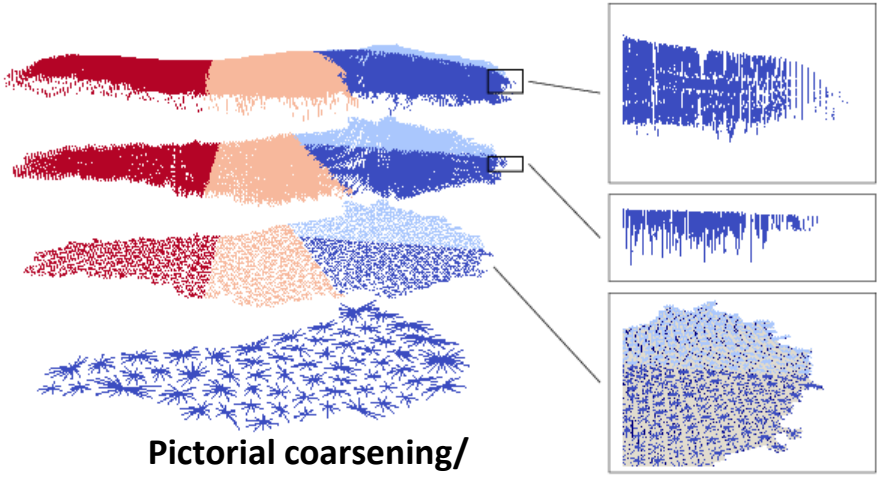
Solving linear systems within ice sheet simulations is often a major computational bottleneck due to ill-conditioning caused by ice shelves & highly stretched meshes and a loss of horizontal/vertical problem features in a traditional AMG hierarchy.



Approach

We developed a new AMG solver that retains horizontal/vertical features by first coarsening vertically to create finer hierarchy levels and then horizontally to create additional hierarchy levels. Solver includes

- specially-developed high-accurate vertical interpolation
- aggressive coarsening to prevent HPC inefficiencies of deep AMG hierarchies
- attractive theoretical properties
- leverages semi-structured nature of ice sheet meshes
- available in Albany/Felix dynamical core

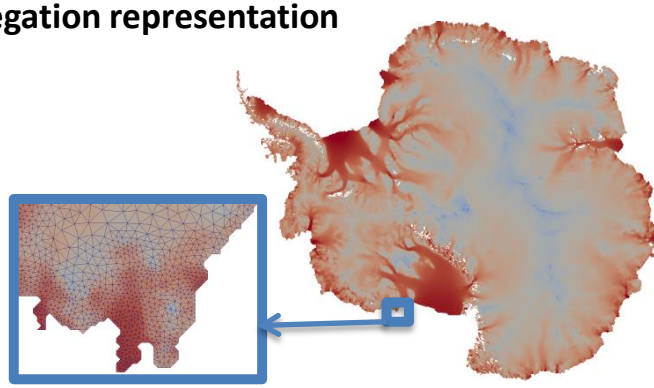


Pictorial coarsening/ aggregation representation

Impact

On realistic, large-scale Greenland & Antarctic problems, demonstrated efficiency, scalability, and robustness:

- generally *less* than ½ total simulation time
- often more than $10x$ faster than old solver
- less than *2x* solution time increase weak scaling from 2.5 million dofs $\rightarrow$ 1.1 billion dofs



R. Tuminaro, M. Perego, I. Tezaur, A. Salinger, S. Price, "A Matrix Dependent/ Algebraic Multigrid Approach for Extruded Meshes with Applications to Ice Sheet Modeling", to appear in SIAM J. Sci. Comput. (SIAM Research Nugget).