This talk will give an overview of Sandia’s land-ice modeling efforts under the SciDAC-funded PISCEES and ProSPect projects, aimed at delivering a next-generation land-ice solver known as Albany Land-Ice (ALI) to the U.S. Department of Energy. As a part of the DOE Energy Exascale Earth System Model (E3SM), this land-ice solver will enable actionable scientific predictions of 21st century sea-level change including uncertainty bounds.

I will cover the following topics:

- Equations, algorithms and software used in ice sheet modeling.
- The development of the Trilinos-based Albany Land-Ice steady stress-velocity solver.
- Coupling of Albany Land-Ice to the CISM and MPAS codes for transient simulations of ice sheet evolution.
- Some advanced concepts in ice sheet modeling, namely a large-scale inversion approach we have developed for obtaining optimal ice initial conditions, and our workflow towards quantifying uncertainties in land-ice models.

I will highlight various algorithms and software we have developed as a part of these projects that have contributed to our model’s robustness and scalability, including a robust automatic-differentiation-based nonlinear solver, scalable algebraic-multigrid-based iterative linear solvers, and performance-portable Kokkos kernels. I will show results which demonstrate that the Albany Land-Ice solver is scalable, fast and robust for production-scale land-ice problems on state-of-the-art HPC machines. I will discuss a recent validation study in which this solver was used to simulate the Greenland ice sheet during the period 1991-2013 with realistic climate forcing, and the simulation data were compared with observational data collected by NASA satellites. Finally, I will show some predictive dynamic experiments and simulations we are beginning to perform using the Albany Land-Ice model.

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