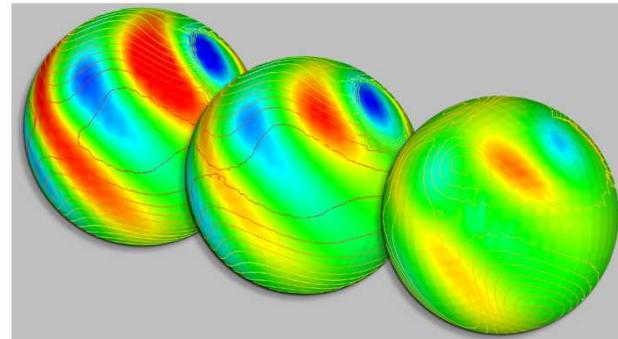


*Exceptional service in the national interest*



# Sandia's Next Generation Global Atmosphere Model

Bill Spotz, Aeras Project Principal Investigator

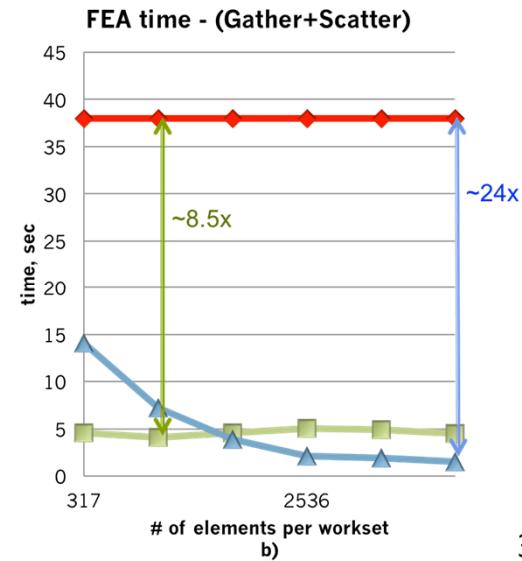
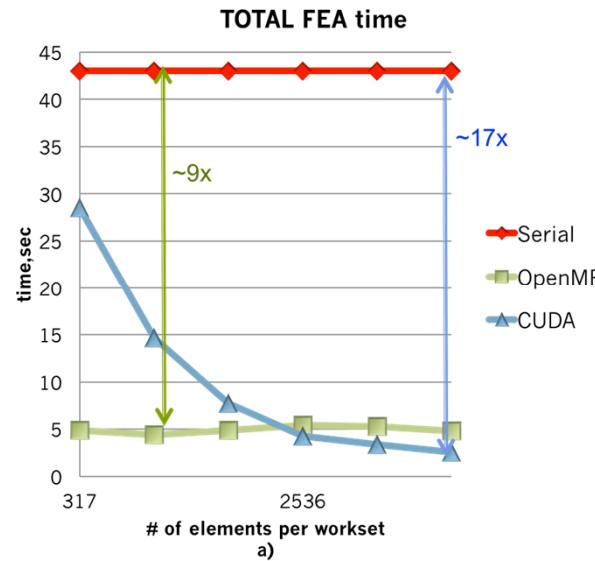


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- Aeras is a **Sandia LDRD** project whose goal is to develop a “Next Generation Global Atmosphere Model”
  - Utilize state-of-the-art libraries
  - Implement proven dycore numerics: spectral elements w/hyperviscosity
  - Demonstrate physics parameterization with simple cloud physics
- Aeras leverages leading-edge, massively parallel, C++ computational technologies from Sandia:
  - Albany (multiphysics application code base)
  - Trilinos (solvers, discretizations, meshing, coupling, **perf portability**, ...)
  - Dakota (optimization, uncertainty quantification)
- Next generation capabilities
  - **Performance portability**, enabled by the Kokkos (Trilinos) programming model
  - **Uncertainty quantification**, enabled by Stokhos (Trilinos) intrusive stochastic UQ package, and Dakota

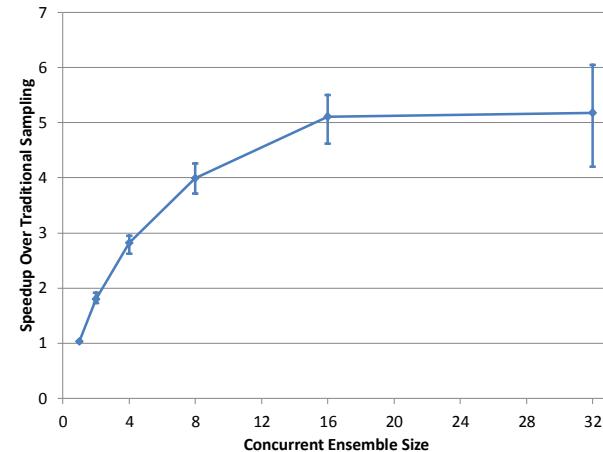
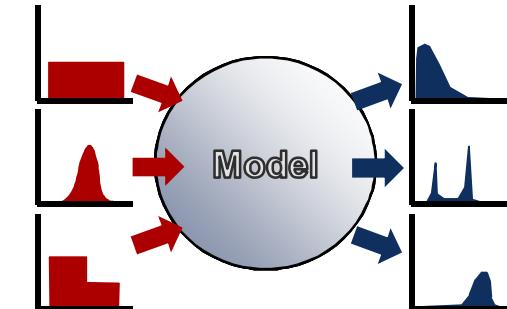
# Performance Portability in Aeras

- Aeras achieves performance portability through use of the Kokkos package and the Kokkos programming model
- Kokkos abstracts data layout and chooses the most performant layout based on the hardware
- “For” loops are replaced with calls to `parallel_for<>()`, `parallel_reduce<>()`, etc., which are specialized for the node-level programming model (CUDA, OpenMP, OpenACC, etc.)
- Single code base for all architectures



# Uncertainty Quantification in Aeras

- UQ: random or uncertain inputs → model → quantities of interest
- Every random or uncertain input adds a new dimension to the problem → curse of dimensionality
- Embedded techniques expand inputs as orthogonal polynomials
- Chaotic prognostic variables can foil these techniques → black-box techniques
- Our approach is to **utilize ensembles** to **increase computational efficiency** by computing simulations simultaneously



# Aeras Status



- Aeras is in 3<sup>rd</sup> and final year
- Shallow water equations completed
  - Timings are within **2x of CAM-SE** (serial on node)
- Hydrostatic equations implemented and being tested
  - 3D and X-Z equations use same code base
  - Some Kokkos implementations still to do
- Kessler cloud model implemented, awaiting hydrostatic
- Concurrent samples being upgraded
  - Prerequisite for Kokkos
- Non-hydrostatic equations in planning stages