Community Earth Systems Model (CESM):

CESM is a fully-coupled community, global climate model that provides state-of-the-art computer simulations of Earth’s past, present, and future climate states. CESM has over 1.5 million lines of Fortran with contributions from many institutions. Such large applications challenge performance enhancements with attributes such as legacy code and correctness constraints.

CAM-Se configuration has a relatively flat profile

Active atmosphere and land with data ocean does not have any extremely long running subroutines. Thus many routines will require performance enhancement to gain an overall speed up of the entire application.

Tracing exposing computationally expensive routines

Specific wetdepav2 subroutine is enhanced via vectorization and shows benefits for increasing resolution (ne16_ne16 is about 2 degree resolution for the atmosphere and ocean, ne30_ne16 is 1 degree resolution for atmosphere and 2 degrees for the ocean). We see a 1% overall CESM/CAMS performance increase on Xeon.

Profiling exposing insufficient vectorization.

Most components behave similarly on both Xeon and Xeon Phi. Some components that are much slower on Xeon Phi account for relatively small amounts of the overall simulation time.

Correctness without bit-for-bit

New platform verification can be achieved by comparing 101 member ensembles of temperature perturbations on trusted systems to experiments on the new platform. The test is if the experiment Z-scores fall within Z-score distributions on the accepted platform. Such comparison has verified CESM [CAM_SE] on Xeon Phi (KNC is 30% as fast as Sandybridge).

Future Work

We will be extracting many CESM subroutines using KGEN (Y. Kim). This tool allows for standalone kernel construction while ensuring correctness by capturing subroutine input and outputs states for comparison. We will be implementing vectorization techniques and possible branching reductions to the kernels and then reintegrating into the CESM application respective model source codes. Once within CESM, both MPI and OpenMP enhancements can be explored for all platforms including Xeon Phi.

References: