Current efforts for performance analysis and enhancements of CESM.

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Abstract. We will present our current methodology for identifying sections of the Community Earth Simulation Model (CESM) suitable for performance enhancement on many-core clusters. One method of performance enhancement exploits parallelisms such as vectorization. We will show current results for both the Xeon and Xeon Phi.

Keywords: optimization, performance, climate model, vectorization, Xeon Phi

Topic: Performance Analysis

CESM[1,2] is a widely used Earth system model; any performance gain is extremely valuable to both the scientific community and to the supercomputing centers where it runs. For example, in 2013 CESM users consumed roughly 200 million CPU-hours across Titan, Hopper, Mira, and Intrepid. At NCAR, where CESM accounts for roughly 50% of the Yellowstone system's workload, we've calculated that each percent of improvement in CESM performance frees up the equivalent of $250,000 in computing resources, a significant return on investment (ROI). Yet CESM remains relatively resistant to optimization for several reasons. First, CESM is large (over a million lines of code), complex (multiple component models, hundreds of routines, and many distinct run configurations) and rapidly evolving (new physics constantly being added). Second, profiling reveals that the exclusive time spent in CESM subroutines is distributed relatively evenly; there is no single "hot spot" to optimize, but instead many regions to explore acceleration methods. Third, the model's results are constrained by stringent correctness and reproducibility requirements. It is important to establish a flexible yet systematic methodology for CESM performance analyses because of these challenges and constraints.

We will present our current method of exposing possible *in-need* accelerated regions of CESM by first using profilers such as TAU [3]. We will report experiences on both Xeon and Xeon Phi with two varying complexities of CESM [Fig. 1]. We also present the result of enhancing particular subroutines and their overall impact for the CESM simulation [Fig. 2].

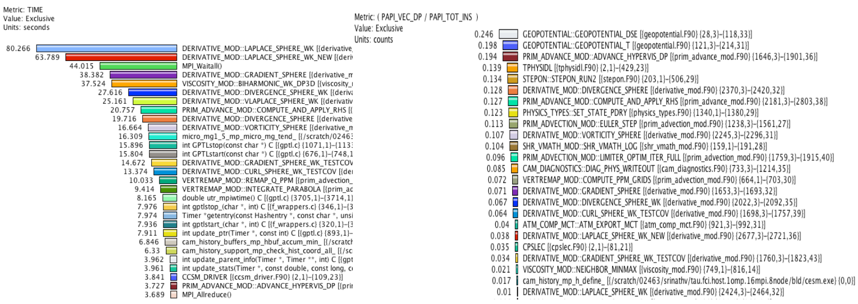

Fig.1 (a): TAU exclusive time profile highlighting subroutines in the derivative_mod module that are expensive. (b) The *vector intensity* for such routines are suboptimal (for a value < 4).

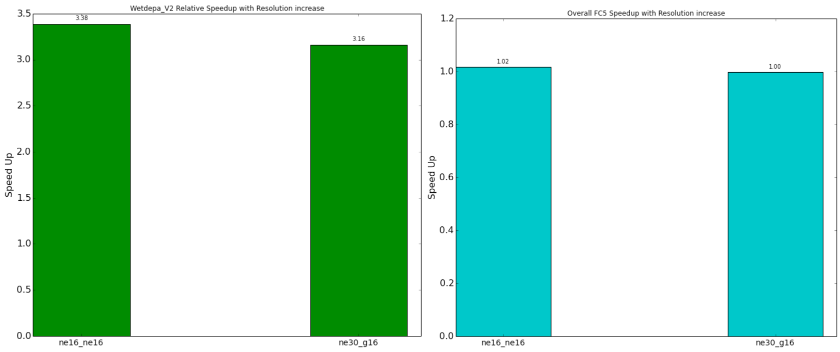

Fig. 2 (a) Specific *wetdepa_v2* subroutine is enhanced via vectorization and shows benefits for increasing resolution (ne16_ne16 is about 2 degree resolution for the atmosphere and ocean, ne30_ne16 is 1 degree resolution for atmosphere and 2 degrees for the ocean). (b) A 1% overall CESM/CAM5 performance increase on Xeon.

References

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