Performance Engineering of the Community Climate System Model (PECCSM)

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SPONSOR: US DOE, Office of Science, Office of Advanced Scientific Computing Research

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PARTNERS: Lawrence Livermore National Laboratory

PROJECT START DATE: October 1, 2009

PROJECT END DATE: September 30, 2011

PROJECT DESCRIPTION

PECCSM continues the research activities of the project "Performance Engineering for the Next Generation Community Climate System Model" (7/2006-6/2009). PECCSM has two primary goals: 1) to enable the Community Climate System Model (CCSM) to make effective use of current high performance computers systems at scale, and 2) to prepare future generations of the CCSM to make effective use of next generation high performance computing systems. The CCSM has evolved recently to become a first-generation Earth system model that treats the coupling between the physical, chemical, and biogeochemical processes in the climate system, and has been renamed the Community Earth System Model (CESM). The CESM will be used to explore new science and run simulations at higher resolution than previous state-of-the-art models. Both the improved physical processes and increased resolution come at the cost of significant increase in computational complexity. Thus, it is critical that the model run efficiently on the existing high performance computing platforms and that it be easily adapted to run efficiently on next-generation exascale-class systems characterized by massive parallelism and heterogeneous compute elements.

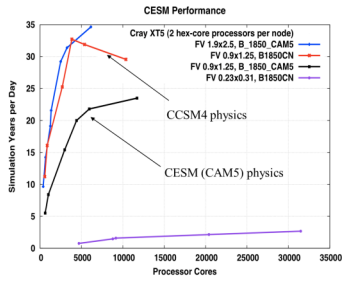
The PECCSM project is analyzing the performance of the CESM on DOE Leadership Class Computing systems, proposing and guiding performance improvements. The CESM is being evaluated not only in its present form and on current systems, but also in prototype configurations utilizing very high resolutions and comprehensive earth system processes and targeting prototype next-generation computer systems. Optimizations are being identified that will allow the CESM to more effectively use these architectures at the processor level, at the node level, and at the whole system level. Project members are collaborating with computing center, machine vendor staff and the computer science research community to identify system behavior that degrades the performance of the CESM in order to improve the relevant system software and to contribute to the specification of future-generation high-performance computing architectures.

SIGNIFICANCE

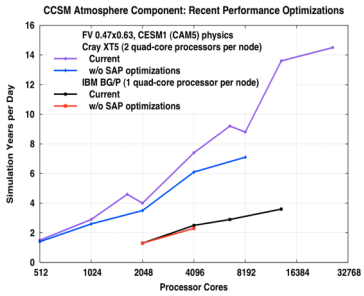
CESM is one of the world's leading climate models. Its predecessor the CCSM was an important contributor to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change and is expected to play just as significant of a role in the upcoming Fifth Assessment Report. Improved performance of CESM will accelerate climate science by increasing the ability to quantify impacts and assess strategies by increasing throughput for current simulations and making new, more computationally expensive, experiments feasible.

INTERESTING FINDINGS

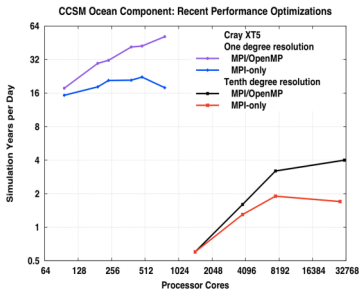
The April 2010 release of CCSM and June 2010 release of CESM included significant improvements to performance and scalability contributed by this project and its predecessor. Contributions more than doubled performance of the models.



Resolutions: 280 km ATM/LND; 100 km OCN/ICE
140 km ATM/LND; 100 km OCN/ICE
35 km ATM/LND; 10 km OCN/ICE



70 km ATM/LND grid, CAM5 physics



100 km and 10 km OCN grid
(30,000 core results preliminary, July 2010)