INSTALLING THE FINITE ELEMENT CODE CITCOMS ON THE UWEC COMPUTING CLUSTER

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Abstract

We discuss the installation and test of a geophysical fluid dynamics code CitcomS on the UWEC computing cluster. Use of the cluster's multiple nodes and performance of the cluster compared to a single processor system will be discussed. The application of the CitcomS program will be to modeling of convection in the Earth's mantle.

Introduction

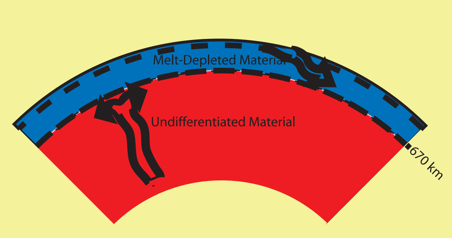
The nature of mantle convection remains an important question in the Earth sciences. Knowledge of how the mantle circulates is critical for understanding the evolution of the Earth. Currently, there are a variety of models that depict motion in the mantle, but none can address the available geochemical and geophysical observations that constrain mantle behavior. Recently, a new model of mantle convection, the Penetrative Convection model, has been introduced to account for the geochemical and geophysical constraints. The Penetrative Convection Model invokes the phase transition at 670 km depth as a filter through which some slabs do and others do not pass. The boundary that separates the Lower Mantle from the Upper Mantle thus serves as a barrier that allows for the distinct (but not necessarily independent) evolution of two geochemical reservoirs. Our aim is to employ the fully three-dimensional finite element code **CitcomS** to test the parameters that control slab penetration into the lower mantle.

Motivation

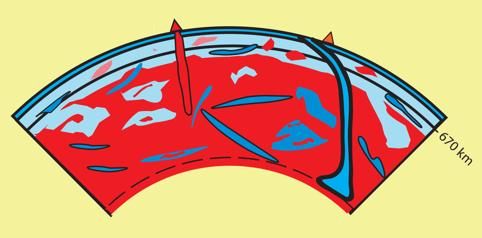
A variety of mantle models have been proposed to explain the geophysical and geochemical observations of the Earth.

Four broad models are illustrated below.

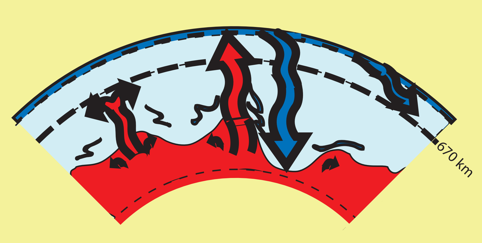
Fully Layered Model (DePaolo and Wasserburg, 1976)



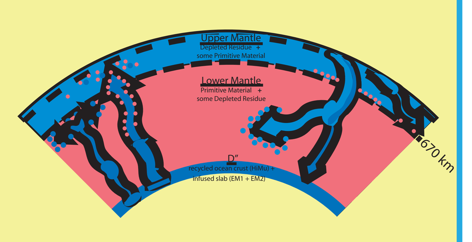
Whole Mantle Model (Davies, 1984)



Hybrid Model (Kellogg et al., 1997)



Penetrative Convection Model (Ihinger, 1995)



Cluster Computing

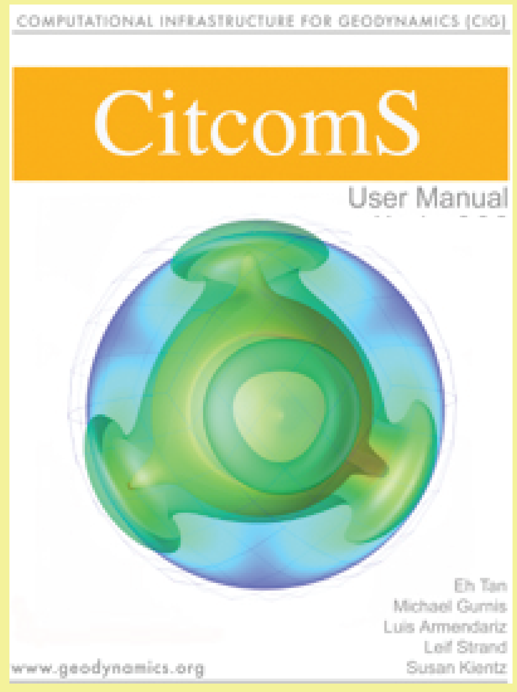
UWEC's Cluster: Hardware diagram and software employed

Cluster Resources

UWEC's high performance computing cluster consists of eight Dell PowerEdge 1950 Servers, each containing two 2.66 GHz E5430 XEON quad core processors with 16 GB RAM. One PowerEdge 1950 serves as the master node, and a PowerEdge 2650 serves as the storage node allowing access over fiber channel to 1.8 TB of SAN storage space.

CitcomS

CitcomS is a finite element code developed by researchers at Caltech (Tan et. al., 2008) that models thermal convection within Earth's interior. It incorporates the effect of pressure and temperature on viscosity and density of mantle minerals, and can include the role of heat diffusion, stress, and latent heat associated with phase transitions.



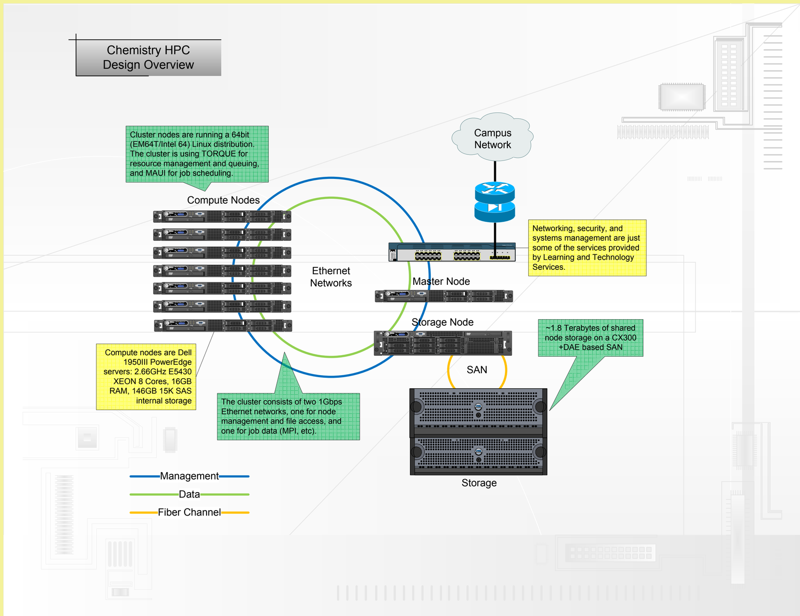


Figure 1 A schematic diagram of UWEC's high performance computing cluster, with eight PC nodes.

Figure 2 Photo of UWEC's computing cluster.

Results

CitcomS was used to solve for thermal convection within Earth's full spherical surface. The problem was divided into twelve equiproportioned regions. Each region's calculation was distributed to a processor for calculation.

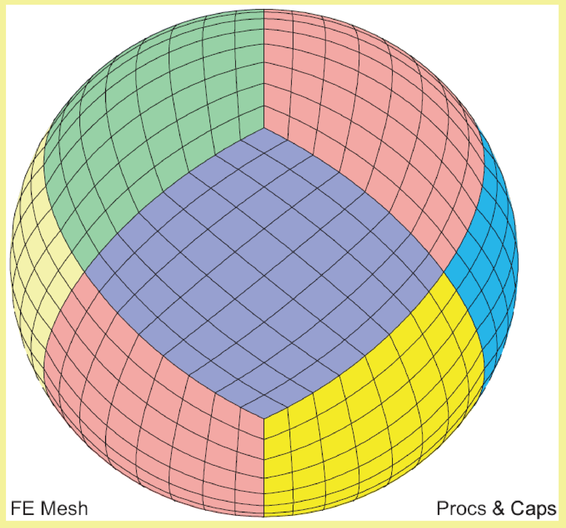


Figure 3 The twelve spherical caps used by CitcomS cookbook1 shown in three-dimensions.

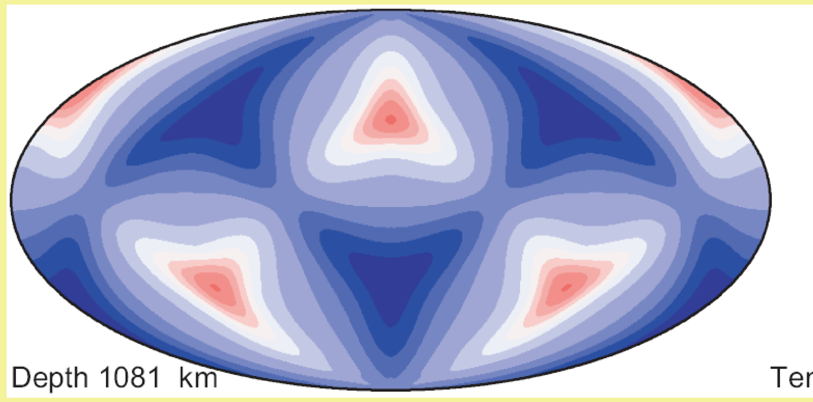


Figure 4 The temperature field shown at a depth of 1081 km.

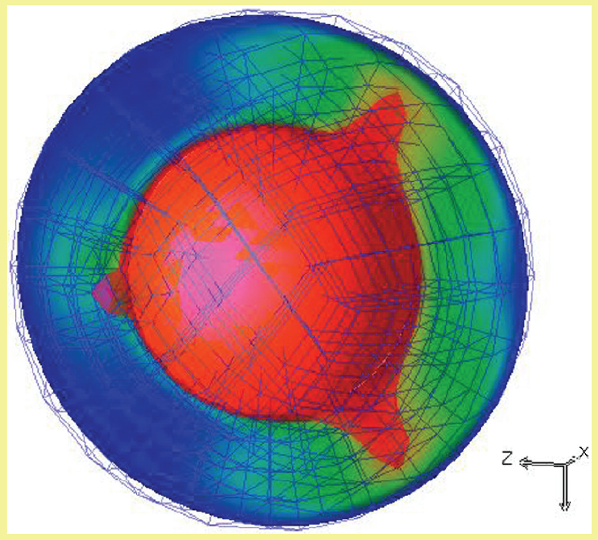


Figure 5 An OpenDX rendered image showing a cross sectional convection model. Upwelling and downwelling are depicted by warm and cool colors respectively.

Cluster Increases Computation Efficiency

Running the CitcomS cookbook1 example on UWEC's high performance computing cluster (with eight PC nodes) reduced the time necessary to complete calculations by an order of magnitude. The cluster required 148.781 seconds where as a single node PC completed the same calculation in 1773.185 seconds.

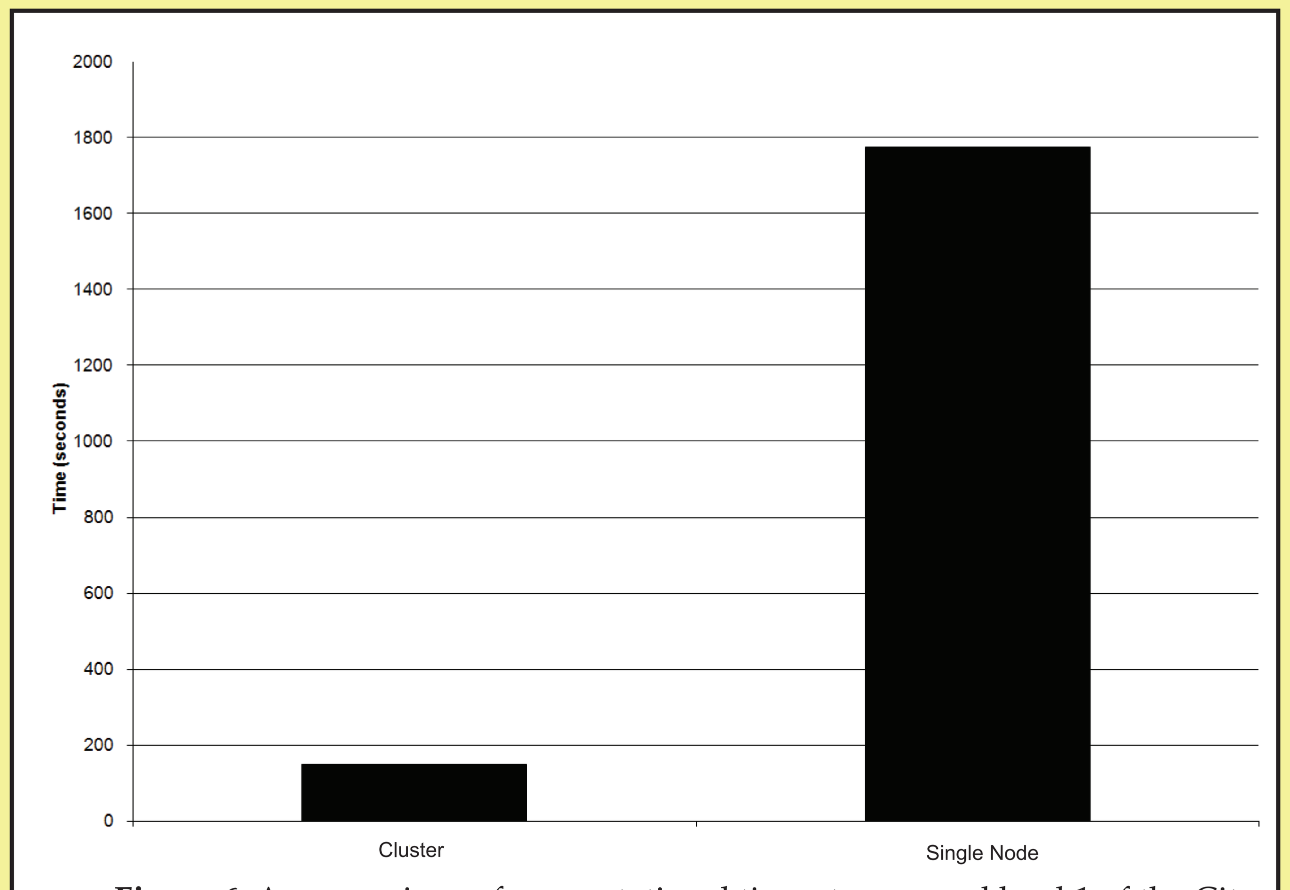


Figure 6 A comparison of computational times to run cookbook1 of the CitcomS package. The UWEC computational cluster outperformed a single node PC by a factor of ten.

Future Plans

We aim to employ the CitcomS code on the UWEC computing cluster to explore the variables that control the behavior of subducting slabs in the mantle. The code allows us to investigate the effects of pressure, temperature, and mantle composition on the variables that control flow in the mantle (viscosity and density). The results of our computations will be compared to observations so as to test the validity of current models for mantle convection.

Conclusions

We have shown that the finite element code, CitcomS can run on the UWEC computing cluster. CitcomS shows promise for accurately modeling mantle convection and test the viability of competing theories.

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