Title: Applications of In Situ Visualization for Ocean, Cosmology, and Plasma

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This is a poster for the Office of Science SDAV All Hands Meeting on 2/20/2013. It describes our work with three domains of science: ocean modeling (POP), cosmology (HACC), and plasma (VPIC). In particular it presents work that was directly related to in situ analysis and our future work with these models under SDAV.
Applications of In Situ Visualization for Ocean, Cosmology, and Plasma

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1. Find applications that run big. 2. Find associated analysis task that isn’t running big. 3. Develop a parallel, scalable solution. 4. Provide appropriate interfaces to the solution. 5. Support and repeat.

Ocean
Parallel Ocean Program (POP)
http://climate.lanl.gov/Models/POP/
An ocean circulation model
Solves 3D fluid motions on sphere
Supports bipolar and tripole grids
Originally developed for Connection Machines
Meridional Overturning Circulation (MOC)
Text book diagnostic
Not scaled for high resolution
Used to understand ocean transport

Example of global MOC published in

Cosmology
Hardware/Hybrid Accelerated Cosmology Code (HACC)
“The Outer Rim” simulation
Currently running up to 1 trillion particles
Full restart dumps around 100 TB
Full particle dumps around 40TB

Halos
Areas of higher density
Important cosmological features
Features can be identified and characterized
Halo Catalogs are relatively very small

Halo Finding Solution
Friend of friends halo
3D connected component for particle data
Linking length
Implementation
spatial kd tree with union-find
similar to merge sort
Example 2012: 15-20 hours on 65k cores – no restarts written

Continuing support
Improved memory usage
15-32 bit values/particle reduced to 6-32 bit values/particle
Future work focusing on statistics and sampling

Plasma
Vector Particle In Cell (VPIC)
Magnetic Reconnection is a basic plasma process involving the rapid conversion of magnetic field energy into various forms of plasma kinetic energy, including high-speed flows, thermal heating, and highly energetic particles.

Interactive Visualization
Because of the extremely large size of the grid, visualization was extremely difficult and thus not performed.

Parallel Reader Solution
A ParaView reader was developed that supported the native output of VPIC
It was able to do striding and subsetting in order to manage data sizes in the visualization pipeline
End user could then use visualization tool independently

ParaView - Catalyst
Hard coded in situ operators:
Surface Line Integral Convolution, slice, contour
In Situ + PISTON
Contour Operator
Functionality delivered to user