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

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

John Patchett, Christopher Sewell, Jonathan Woodring, Pat Fasel, Boonthanome Nouanesengsy, James Ahrens

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

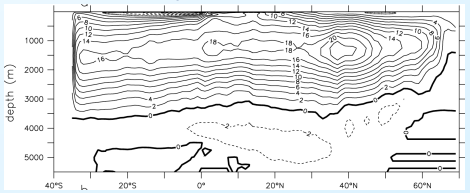
Parallel Ocean Program (POP)

http://climate.lanl.gov/Models/POP/
An ocean circulation model
Solves 3D fluid motions on sphere
Supports bipole and tripole grids
Originally developed for Connection Machines

Meridional Overturning Circulation (MOC)

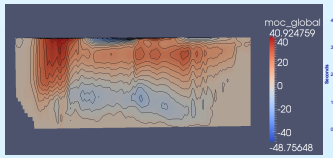
Text book diagnostic
Not scaled for high resolution
Used to understand ocean transport

Example of global MOC published in Maltrud, M. E., and J. L. McClean, An eddy resolving global 1/10° ocean simulation. Ocean Modelling, 8, 1-2, 31-54, 2005.

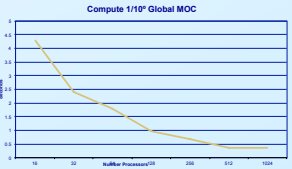


Design and Implement Parallel MOC

Stand alone serial, separate component functionality
Parallel ParaView Reader, scales well



Global MOC represented in ParaView



Strong scaling of ParaView's MOC calculation

ParaView – Catalyst

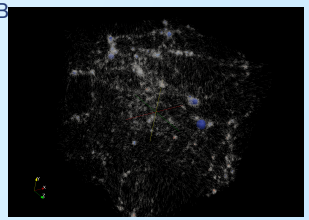
Collaboration with Kitware
In memory POP adaptor to structured grid completed
MOC calculator as a filter
Many inputs required for calculation, including grid details

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 represented as spheres with particles as vector glyphs

Halos

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

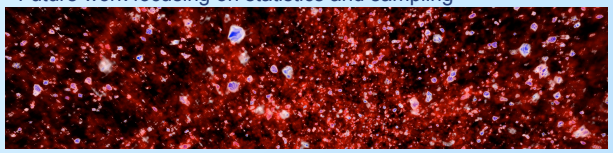
Halo Finding Solution

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



Presentation visualization from cosmology showing halos

Plasma

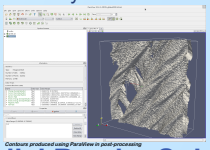
Vector Particle In Cell (VPIC)

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.

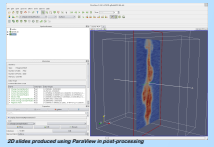
Grid sizes up to 8096x8096x448

Interactive Visualization

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



Contours produced using ParaView in post-processing



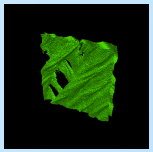
2D slices produced using ParaView in post-processing

Parallel Reader Solution

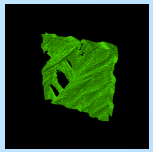
A ParaView reader was developed that supported the native output of VPIC

It was able to do striding and subsetting in order to manage data sizes in the visualization pipeline

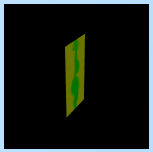
End user could then use visualization tool independently



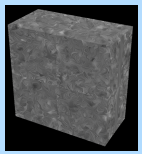
Contours produced in-situ with VPIC



Contours produced using PISTON in-situ with VPIC



2D slices produced in-situ with VPIC



Surface line integral convolution generated in VPIC in situ

ParaView - Catalyst

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

SDAV Scalable Data Management, Analysis, and Visualization

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