Block-structured AMR: Algorithms & Applications

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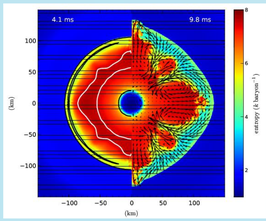
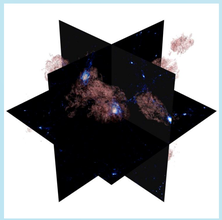
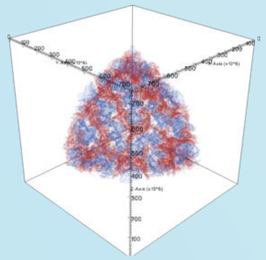
Block-structured adaptive mesh refinement (AMR) software frameworks available for the development of massively parallel, multiphysics applications



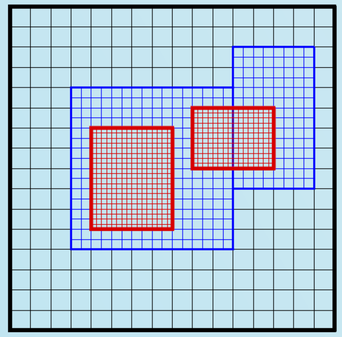


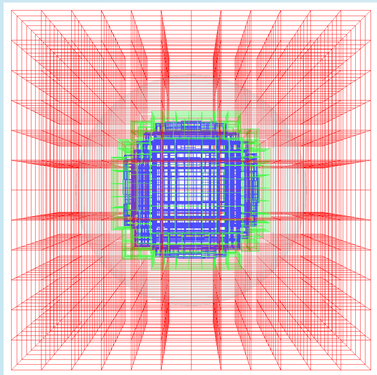


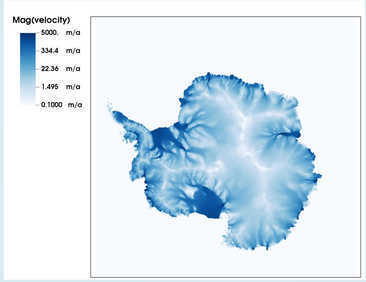
Overview

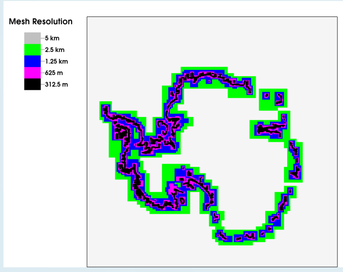
Many problems of interest can be expressed using partial differential equations, in which there are multiple length scales and strong spatial localizations. Block-structured adaptive mesh refinement (AMR) is a powerful tool for computing solutions to partial differential equations involving multiple length and time scales.

BoxLib and Chombo are software frameworks for the development of parallel block-structured AMR applications. They serve as the basis for a wide variety of application codes and are freely available for the development of new algorithms and applications. They contain support for finite difference discretization of partial and ordinary differential equations, as well as embedded boundary support for the representation of complex geometries, support for particle-mesh algorithms within the AMR framework, and higher-order methods in time and space.









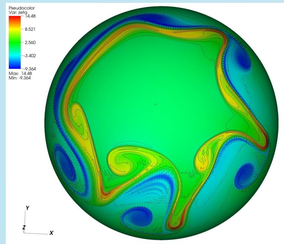
BoxLib Features

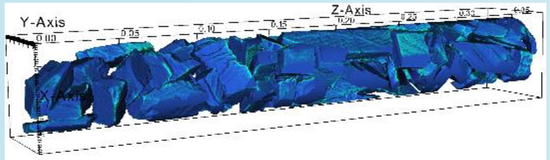
BoxLib is a publicly available software framework for building massively parallel block-structured AMR applications. BoxLib contains extensive software support for grid-based operations as well as particles on adaptive hierarchical meshes. Multilevel multigrid solvers are included for cell-based and node-based data. Parallelism is achieved using the distribution of grids to nodes using MPI as well as on-node parallelism using OpenMP. Multiple time-subcyling modes are supported for adaptive mesh simulations. BoxLib-based codes have demonstrated excellent scaling behavior on today's largest machines.

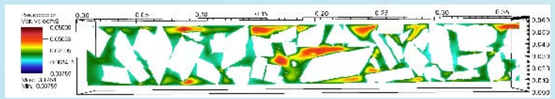
BoxLib Application Codes

Application codes based on the BoxLib framework are in active use in a number of research areas, including

- CASTRO – compressible radiation-hydrodynamics
- MAESTRO – low Mach number astrophysics
- Nyx – cosmology (part of SciDAC HEP/ASCR project)
- LMC – low Mach number combustion (part of ExaCT codesign ctr.)
- Amanzi – structured grid component of subsurface flow modeling (part of ASCEM project)







Chombo Features

Chombo provides a set of tools for implementing finite difference methods for the solution of partial differential equations on block-structured adaptively refined rectangular grids. Both elliptic and time-dependent modules are included. Chombo supports calculations in complex geometries with both embedded boundaries and mapped multiblock grids as well as higher-order finite-volume methods and particle methods. Most parallel platforms are supported, and cross-platform self-describing file formats are included.

Chombo Application Codes

Application codes based on the Chombo framework are in active use in a number of research areas, including:

- Chombo-Crunch – pore-scale modeling of subsurface reacting flow (part of the NCGC EFRC)
- BISICLES – Land-ice dynamics (part of SciDAC BER / ASCR project)
- COGENT – Gyrokinetic models of tokamak edge plasmas (part of joint FES / ASCR project)

Chombo is also being incorporated into a number of scientific codes worldwide, including cell modeling (VCell project, UCHC) and space plasmas (CSPAR, UAH).

BoxLib Outreach

The BoxLib distribution is freely available with git at

ccse.lbl.gov/Downloads

It contains an extensive User's Guide as well as straightforward tutorials which demonstrate how to build parallel adaptive application codes using BoxLib. Examples include how to build BoxLib-based AMR codes with MPI and OpenMP, how to call internal and external solvers, how to implement specialized boundary conditions, higher-order time-stepping, and much more.

Chombo Outreach

The Chombo distribution is freely available under svn at

https://commons.lbl.gov/display/chombo/

As well as the current version of the release library and examples (Chombo 3.1), there is extensive algorithmic and software design documentation (ChomboDoc 3.1), as well as a doxygen-generated reference manual. The latter can also be browsed at

http://davis.lbl.gov/Manuals/CHOMBO-RELEASE-3.1/classes.html

More Information: http://www.fastmath-scidac.org or contact Lori Diachin, LLNL, diachin2@llnl.gov, 925-422-7130