An update on MPAS atmospheric dycores in CAM/CESM

Bill Skamarock\textsuperscript{1}, Michael Duda\textsuperscript{1}, Brian Eaton\textsuperscript{2}, and Art Mirin\textsuperscript{3}

\textsuperscript{1}NCAR/MMM
\textsuperscript{2}NCAR/CGD
\textsuperscript{3}LLNL
An update on MPAS atmospheric dycores in CAM/CESM

Based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.

Jointly developed, primarily by NCAR and LANL/DOE, for weather, regional climate, and climate applications

MPAS infrastructure - NCAR, LANL, others.
MPAS - Atmosphere (NCAR)
MPAS - Ocean (LANL)
MPAS - Ice, etc. (LANL and others)

Bill Skamarock, Joe Klemp, Michael Duda, Sang-Hun Park and Laura Fowler NCAR
Todd Ringler Los Alamos National Lab
John Thuburn Exeter University
Max Gunzburger Florida State University
Lili Ju University of South Carolina

CESM AMWG Meeting, 1-3 Feb 2012
Global Atmospheric Modeling Using Voronoi Meshes: The MPAS Model

Applications
• Regional Climate and NWP

Equations
• Fully compressible nonhydrostatic equations, vector invariant form.

Solver Technology
• Most of the techniques for integrating the nonhydrostatic equations come from WRF.

C-grid centroidal Voronoi mesh
• Emphasis on accuracy for divergent modes.
• Accurate and efficient transport schemes (consistent, conservative, PD and monotonic).
Status

• Current work with hydrostatic MPAS dycore
  – APE : Todd Ringler, Sara Rauscher, Bill Skamarock
  – AMIP : Li Dong, Todd Ringler, Bill Skamarock
  – Hydrostatic core is still on a branch

• Non-hydrostatic core progress
  – Initially using hydrostatic implementation as a template
  – Goal: First runs by end of March 2012
Non-hydrostatic MPAS-A implementation

Besides a complete re-implementation of the MPAS interface module, some cleanup and restructuring is being done in the CAM MPAS dycore-specific code

• **Work completed**
  – Generalize CAM build (file name /= module name)
  – CAM physics now completely independent of vertical coordinate
  – Robust handling of real kind-types in MPAS
PIO memory usage

• Specifics of MPAS’ use of PIO uncovered a memory issue in the “degree-of-freedom” interface

• Fix developed by John Dennis and Jim Edwards
  – Plans for an interface for describing only decomposed dimensions in unstructured meshes?

• On track to making full use of PIO in MPAS
  – PIO will benefit both MPAS-A and MPAS-O
  – Memory fix may benefit SE dycore as well!
PIO in MPAS

- Transition to PIO in MPAS
  - Complete for history and restart
  - PIO-based input coming soon

In parallel, each task reads a contiguous section of input file via serial netCDF

Cells of field are re-distributed to owning MPI task

Each MPI task sends cells of field to task 0

Task 0 writes entire field via serial netCDF
PIO in MPAS

- Transition to PIO in MPAS
  - Complete for history and restart
  - PIO-based input coming soon

Current MPAS I/O scheme

- In parallel, each task reads a contiguous section of input file via serial netCDF
- Cells of field are redistributed to owning MPI task
- MPI tasks make collective calls to PIO to write fields
- Multiple I/O tasks write field in parallel

Replaced with PIO-based output layer
Using MPAS’ PIO-based I/O layer, we can share IC files between standalone MPAS and CAM-MPAS

- MPAS already supports code to create input files with terrain height, mesh geometry and topology, and vertical grid
  - Avoid duplicated I/O code for handling these data

- Assures consistent ownership of edges, vertices

Given a block of cells for an MPI task, which edges along the perimeter of the block are owned by that task?
Remaining work

• **Re-implement the CAM-MPAS interface layer**
  – Including the use of the MPAS PIO-based I/O layer for input
• **Online mesh decomposition for MPAS**
  – Separate decomposition files currently need for different MPI task counts
• **# scalars a compile-time decision in MPAS**
  – Quick solutions exist, but we should carefully consider a long-term solution
• **MPAS build system makes use of auto-generated Fortran and pre-processing**
  – Not really compatible with CAM build system
  – MPAS-A must be compiled on its own, and pre-processed source files copied into CAM directory before building CAM
• **CAM history mechanism assumes cell-centeric fields**
MPAS and WRF-NRCM Comparisons
August 1998 forecasts

MPAS simulations
00Z 18 August 1998 start date
x1 mesh – 60 km
x4 mesh – 25-100 km

WRF-NRCM simulation
00Z 08 August 1998 start date
36-km mesh
MPAS WRF-NRCM Comparisons

NRCM – 36 km
Valid 0Z 23 Aug 1998

MPAS x1 : 60 km
valid 23 Aug 1998

MPAS x4 : 25 – 100 km
valid 23 Aug 1998
SUMMARY

• **MPAS hydrostatic atmosphere core available in a CAM branch**
  - Currently being used for APE and AMIP simulations

• **Work is underway to implement the MPAS-A nonhydrostatic dycore in CAM**
  - Using hydrostatic implementation as a template
  - Various cleanup and groundwork completed so far
  - Finishing a re-write of the MPAS I/O layer to use PIO
  - Goal: MPAS-A non-hydrostatic core running in CAM by end of March

Long-term, we will only be supporting the non-hydrostatic MPAS-A
Questions?