An update on MPAS atmospheric dycores in CAM/CESM

Bill Skamarock[1], Michael Duda[1], Brian Eaton[2], and Art Mirin[3]

[1]NCAR/MMM

[2]NCAR/CGD

[3]LLNL

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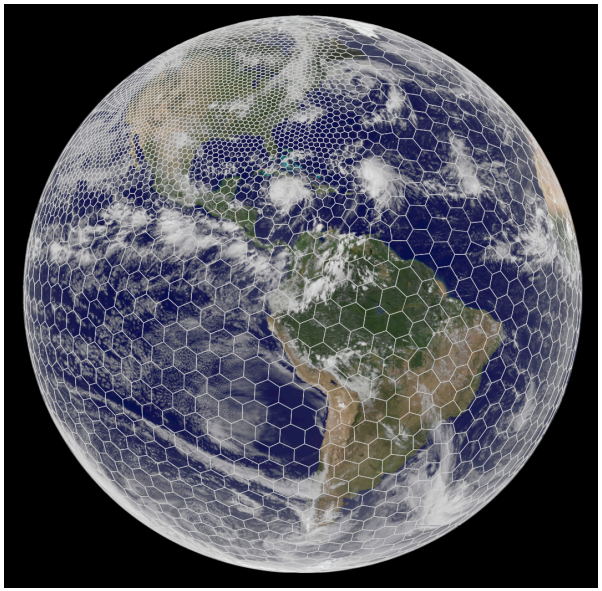
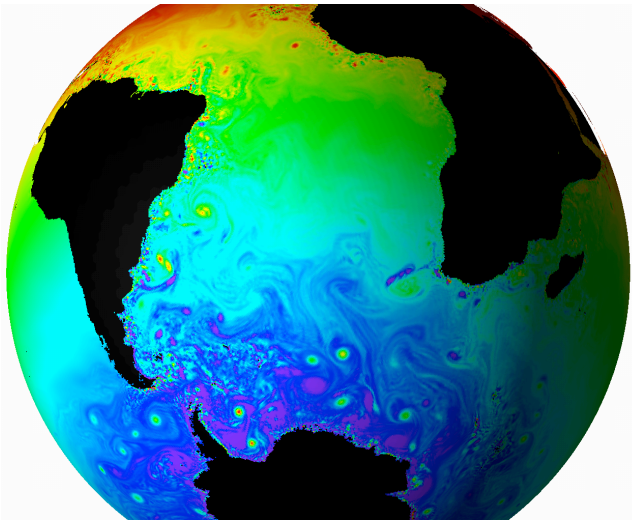




MPAS
Model for Prediction Across Scales

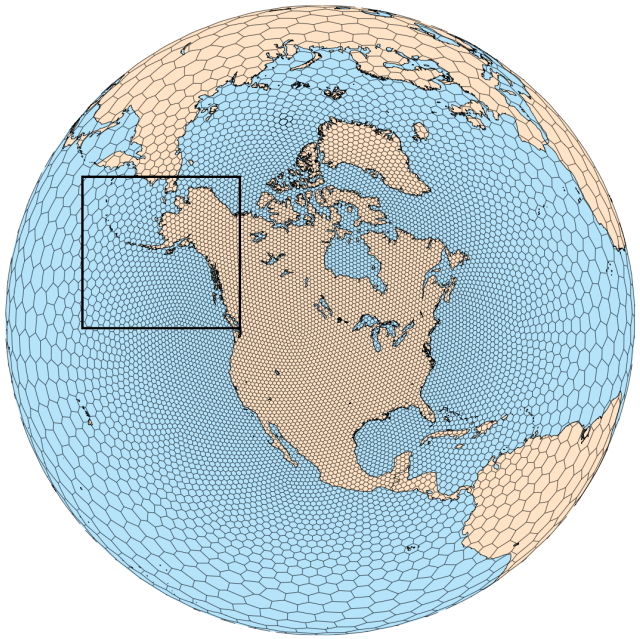
Based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.

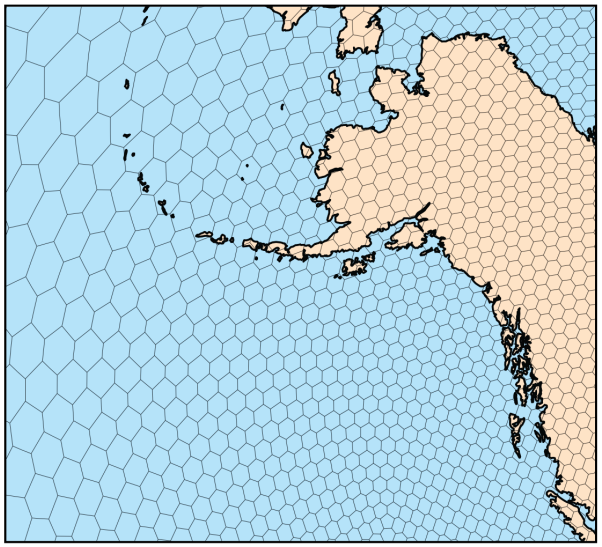
Jointly developed, primarily by NCAR and LANL/DOE, for weather, regional climate, and climate applications

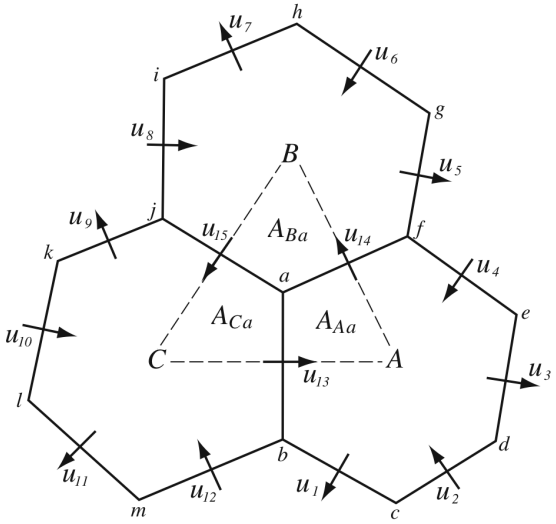
MPAS infrastructure - NCAR, LANL, others.
MPAS - Atmosphere (NCAR)
MPAS - Ocean (LANL)
MPAS - Ice, etc. (LANL and others)

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*

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

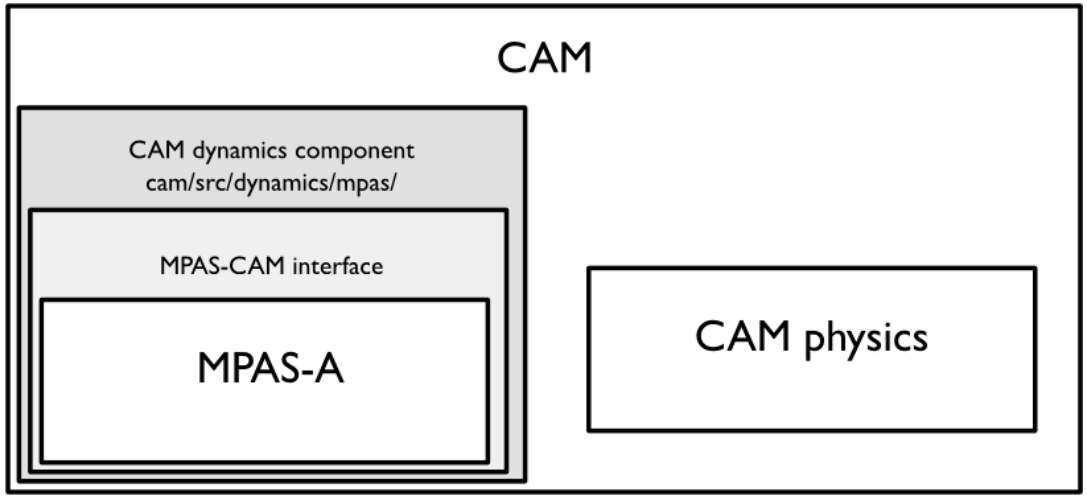
- Emphasis on accuracy for divergent modes.
- Accurate and efficient transport schemes (consistent, conservative, PD and monotonic).

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



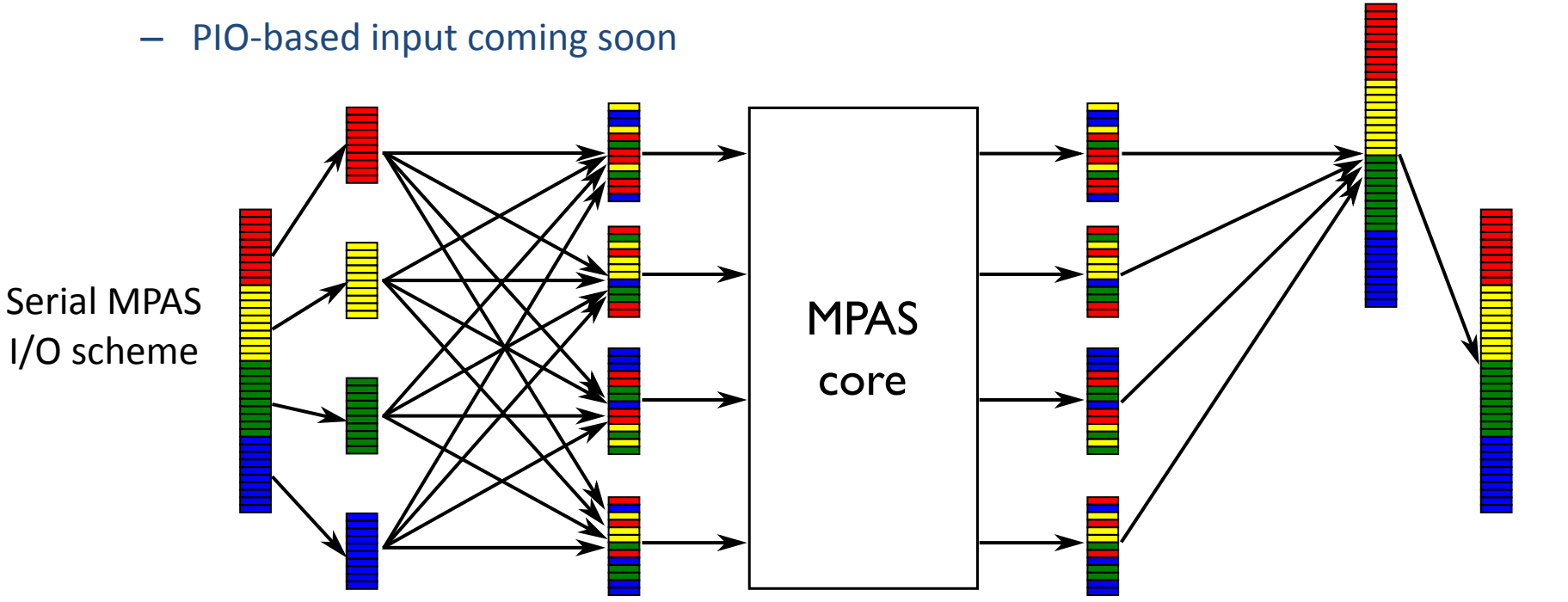
- Work completed
  - Generalize CAM build (file name /= module name)
  - CAM physics now completely independent of vertical coordinate
  - Robust handling of real kind-types in MPAS

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



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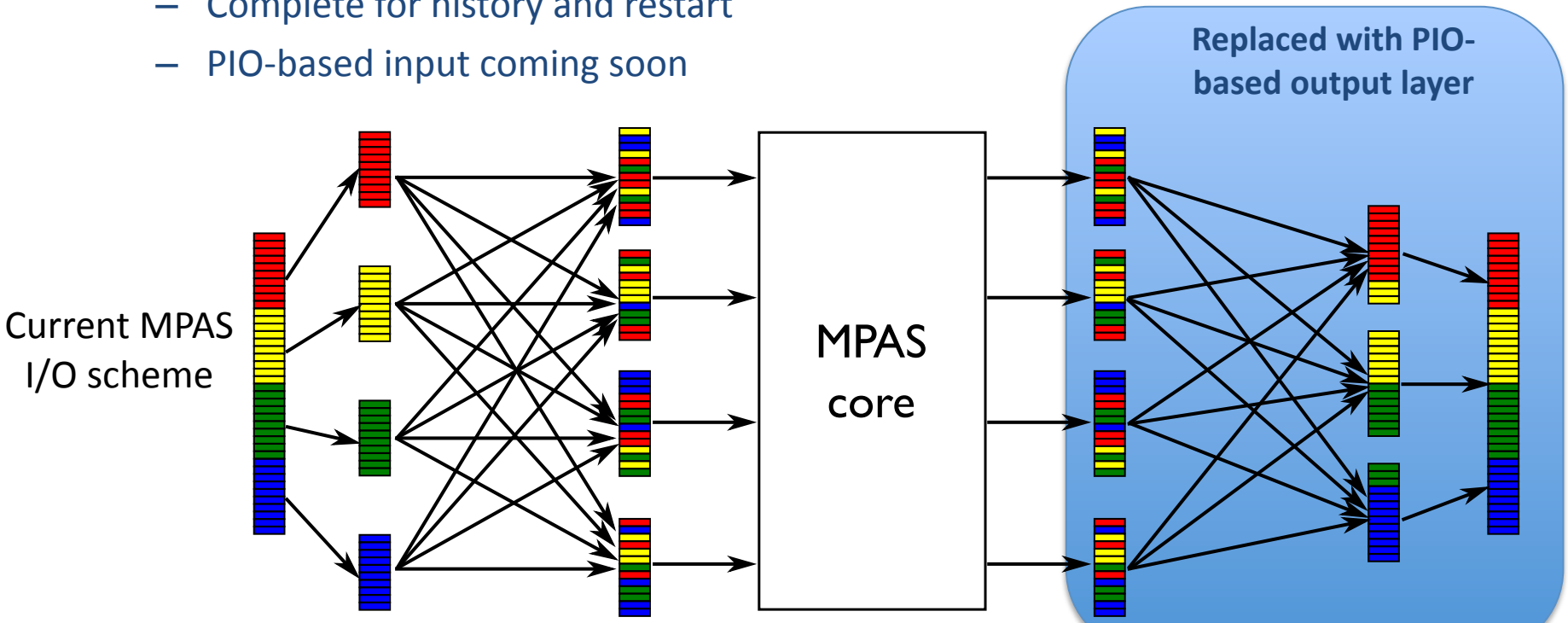
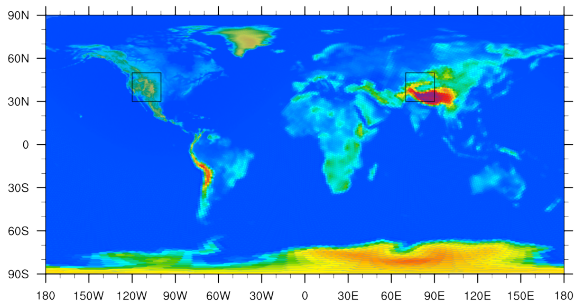
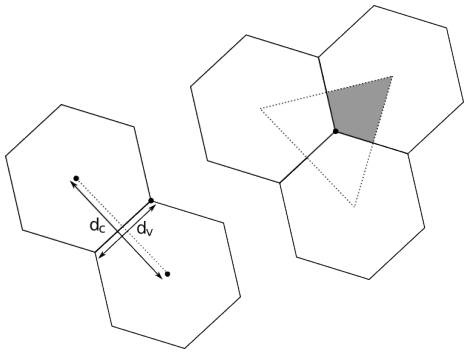
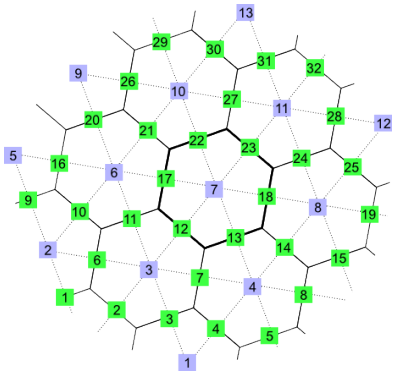


Using MPAS' PIO-based I/O layer, we can share IC files between standalone MPAS and CAM-MPAS

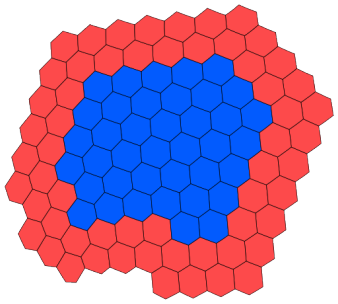
- MPAS already supports code to create input files with terrain height, mesh geometry and topology, and vertical grid
  - Avoid duplicated I/O code for handling these data



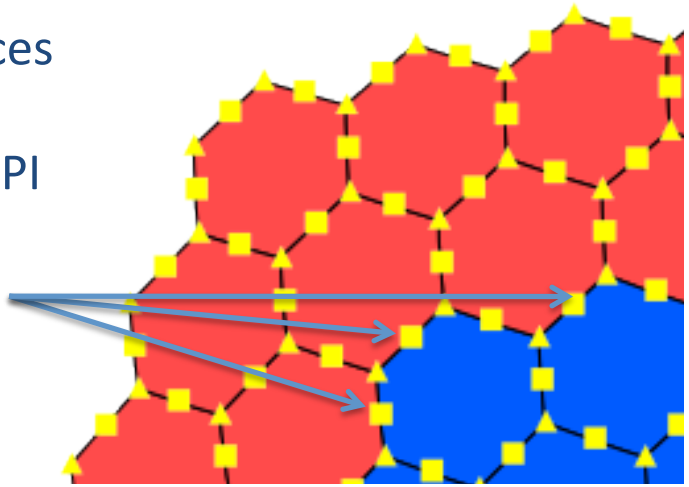




- Assures consistent ownership of edges, vertices



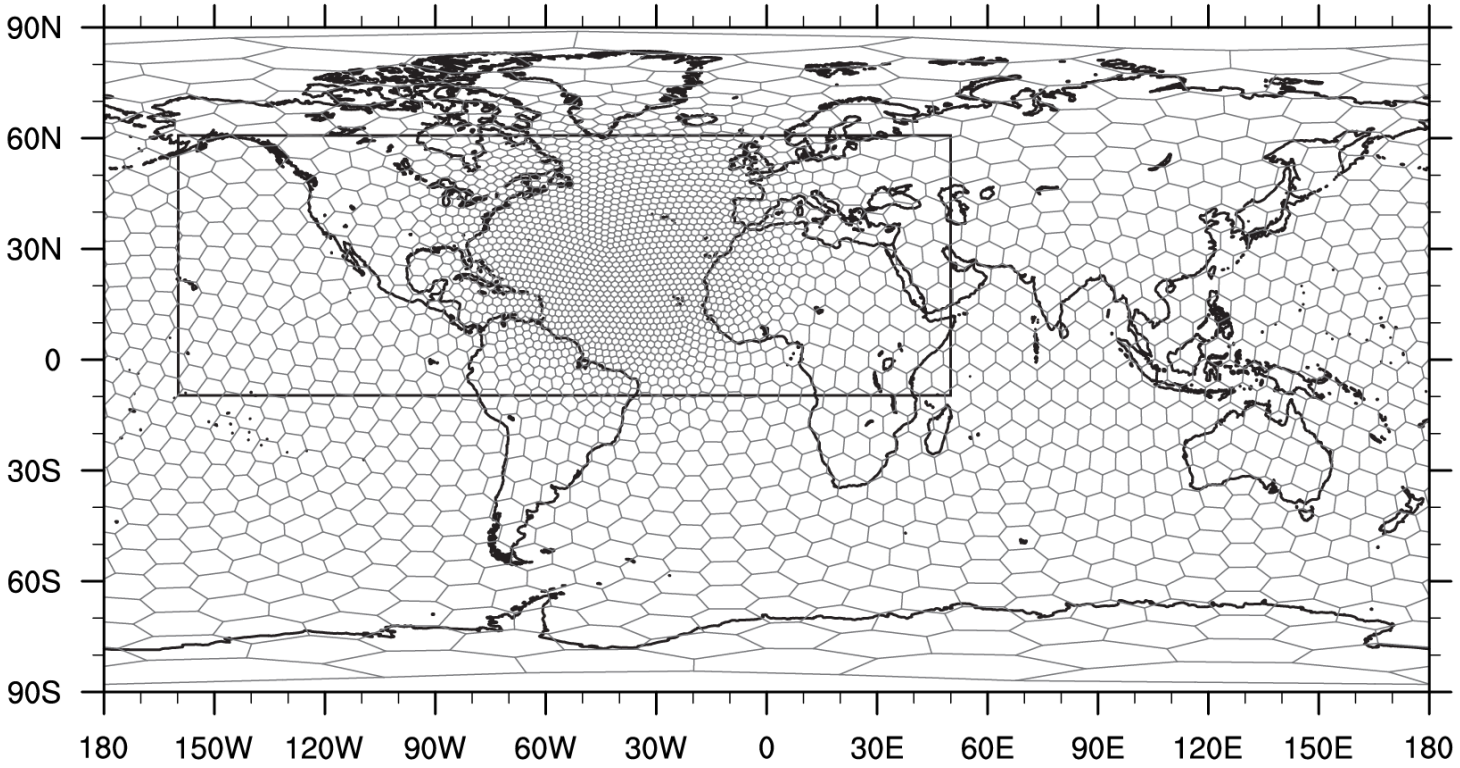
Given a block of cells for an MPI task, which edges along the perimeter of the block are owned by that task?



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

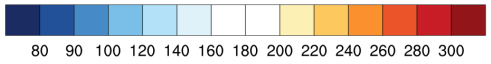
WRF-NRCM simulation
00Z 08 August 1998 start date
36-km mesh

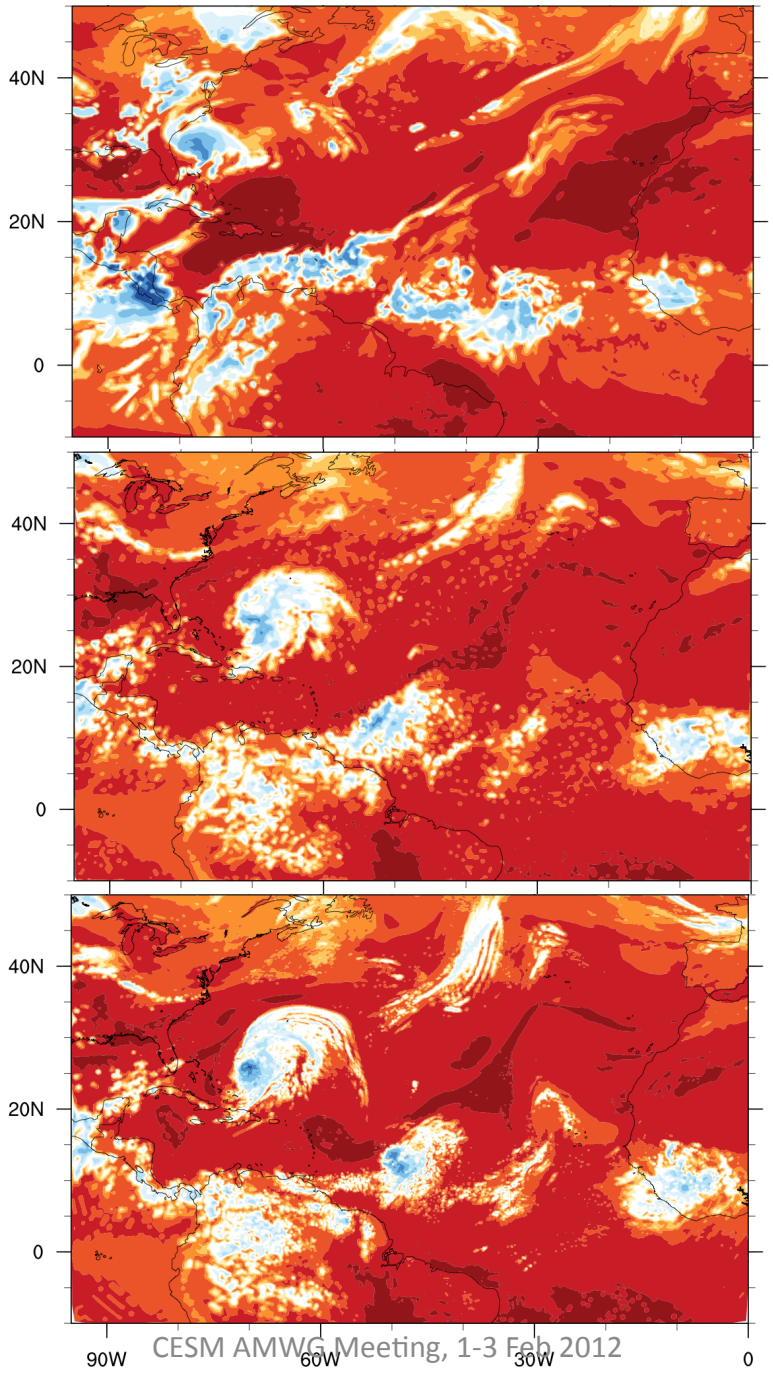
MPAS WRF-NRCM Comparisons

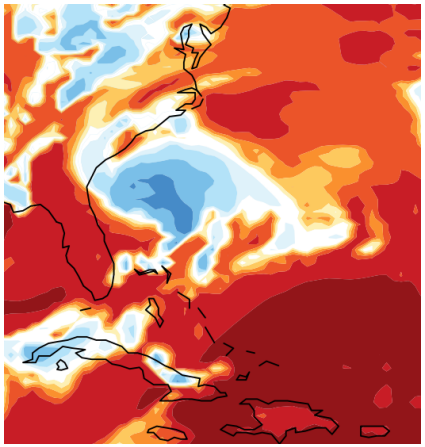
NRCM – 36 km
Valid 0Z 23 Aug 1998

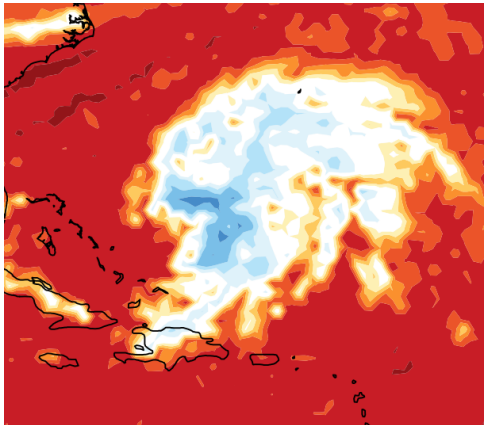
MPAS x1 : 60 km
valid 23 Aug 1998

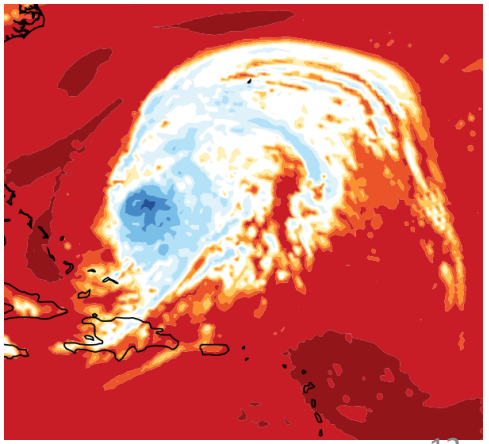
MPAS x4 : 25 – 100 km
valid 23 Aug 1998











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?