The GFDL FMS: Progress for Climate Science on Multi-Core Platforms

Denial....Anger....Bargaining....

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Overview

• Introduction
• Four Research Initiatives
• Big Picture
• Summary
Introduction

• The “Flexible Modeling System” (FMS)
  – 2011: How do we enable collaborative scientific software development?
  – 2012: Can FMS be a testbed for what’s next?

• Starting in 2012: A multi-year, cross-discipline effort to enable new levels of parallelism
  – Increase concurrency
    • Concurrent radiation
  – Extend notion of “physics window” to blocking atmospheric dynamics
    • Control memory footprint
    • Increased parallel content
  – Study FMS components on GPU
    • OpenACC
The Quest for Threads

Coupler Main do loop (dt_cpld)

Atmos Pelist

Atmos Down

Land

Ice

Atmos Up

Radiation

Mom6

Ocean Pelist
MPI Scaling Performance @ 64K Ranks

Performance of Held-Suarez: Non-hydrostatic Atmospheric Dynamical Core at 3.5km with 32 Levels on IBM:BGQ

Model Days/Wall Clock Day vs. Number of Hardware Threads

Ideal Time

Actual Time (8-MPI Ranks/node and 8-OpenMP Threads Per Rank)
Held-Suarez 3.5KM MPI (wait) times
Additional Projects and Goals

• Performance of selected FMS kernels on MIC
  – Effects of subdomain blocking with (non-symmetric) halos
  – Deep dive into compiler output and performance results

• Sub-Domain Blocking in the Atmos Cubed Sphere Dynamic Core and MIC performance
  – Introduce subdomain blocking throughout the CS DyCore
  – Analyze and improve performance and scaling

• Concurrent radiation targeting the GPU on Titan
  – Enable Single Column Model (contains radiation) on GPU using Cray compiler and OpenACC
  – Radiation a concurrent (shared memory) component
    • Excellent performance & OpenMP scaling on Gaea (32 core AMD Interlagos)
  – Put radiation on GPU via Cray compiler, OpenACC and “glue layer”
Four Research Initiatives

- Performance of selected FMS kernels on MIC: Kaust (Vu Nguyen), Intel Compiler and Research Groups (Mike Greenfield et al), GFDL (Chris Kerr / Zhi Liang)
- Sub-Domain Blocking in the Atmos Cubed Sphere Dynamic Core and MIC performance: NASA (Craig Pelissier / Kareem Sorathia), Intel (Chuck Yount), GFDL (Chris Kerr / Rusty Benson)
- Concurrent radiation targeting the GPU on Titan @ ORNL: Cray (Eric Dolven / Cray Compiler Dev), ORNL (Duane Rosenberg), GFDL (Rusty Benson)
- Scaling behavior of the GFDL 3.5KM resolution atmos model on the IBM BG/Q (Mira) @ Argonne: Samara Technology Group (Jeff Durachta / Tushar Mohan), Center for Computational Learning Systems @ CU (Haimonti Dutta), GFDL (Chris Kerr)
Big Picture

• Real code and real models for GFDL Earth System Research
  – Cubed Sphere High resolution, non-hydrostatic atmosphere model (HiRam 3.5KM): tropical cyclones, seasonal hurricane prediction and mean climate
  – Forecast-oriented Low Ocean Resolution (FLOR): seasonal to interannual predictions
  – Ensemble coupled data assimilation (ECDA): ocean variability
  – CM4: Next gen coupled model (1/0.5deg atm and 1 / 0.25 deg ocn)

• General approaches applicable across multiple architectures
  – Threading and concurrency
  – Memory footprint control
  – Scaling
  – I/O off loading
Summary

• **2013 -> 2014: 4 Initiatives to enable real science on highly threaded architectures**
  – Invest in generally applicable techniques
  – Use *all* the resources
  – Examine all dimensions of performance

• **Denial -> Anger --> Acceptance**
  – Can we perhaps skip Bargaining and Depression....?