From ENDGame to GungHo!
A new dynamical core for the Unified Model

Nigel Wood, Dynamics Research, UK Met Office
Outline

- GungHo! – a reminder
- Some results from each workpackage
- Summary
Scalability

(17km) N768 - New Dynamics vs ENDGame

\[ \frac{T_{24}}{T_N} \]

Perfect scaling

\( T_{24} \) nodes

(1 node=32 processors)
The finger of blame...

- At 25km resolution, grid spacing near poles = 75m
- At 10km reduces to 12m!
GungHo!

“Working together harmoniously”
5 Year Project

“To research, design and develop a new dynamical core suitable for operational, global and regional, weather and climate simulation on massively parallel computers of the size envisaged over the coming 20 years.”

- Split into two phases:
  - 2 years “research” (2011-13)
  - 3 years “development” (2013-2016)

- Met Office, STFC, Universities of: Bath, Exeter, Imperial, Leeds, Manchester, Reading, Warwick
GungHo Issues

- How to maintain accuracy of current model on a GungHo grid?

- Principal points about current grid are:
  - Orthogonality
  - C-grid

- These provide a number of good numerical properties (Staniforth & Thuburn QJ 2012)

- Challenge is to retain those on a non-orthogonal grid
Some workpackage results
Grids

- Good dispersion
- Minimal grid imprinting
- No computational modes

⇒ Finite element approach
⇒ Focus on: Cubed-sphere; possibly triangles

Cotter (Imperial), Melvin & Staniforth (MetO)
Grids

- Good dispersion
- Minimal grid imprinting
- No computational modes

⇒ Finite element approach
⇒ Focus on: Cubed-sphere; possibly triangles

Cotter (Imperial), Melvin & Staniforth (MetO)

Higher order FEM

Partially mass lumped FEM
Recent results
Williamson Test Case 5 with 160K d.o.f.s (320x160)

FEM Hexagonal

Thuburn (Exeter)

ENDGame lat-lon

ENDGame rotated lat-lon
Are implicit schemes viable?

Weak horizontal scaling for a 3D Helmholtz problem

- Baseline resolution = 64x64
- Nz=128
- Grid cells per processor = 520K
- Cs*Dt/Dx=const=8.4
- One side of cubed-sphere

Mueller & Scheichl (Bath)
What to do if not...

- Horizontally Explicit – Vertically Implicit (HEVI)
- Computational modes arise from multistep schemes

⇒ Examine range of Runge-Kutta Implicit-Explicit (IMEX) schemes

Weller (Reading) & Lock (Leeds)
Test cases

- Finite difference scheme applied on a variety of grids
- Simple solid body rotation (Williamson test case 2)
- Height and velocity errors after 5 days
- Weller, Thuburn and Cotter, MWR, 2012

Weller (Reading), Thuburn (Exeter) & Cotter (Imperial)
Transport

- Mass conservation = #1 user requirement!
- Inherent part of mimetic approach
- But want to maintain non-split approach of current SL scheme
- OK in horizontal (CFL<1 on uniform mesh) – see previous simulations
- Challenge is in vertical…
- Vertical loop inner most
- Indirect addressing for horizontal
- F2003
Timetable…

- Further development and testing of horizontal [2013]
- Testing of proposals for code architecture [2013]
- Vertical discretization [2013]
- 3D prototype development [2014-2015]
- Operational…by 2020

⇒ Long term step change in scalability
Thank you!

Questions?