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

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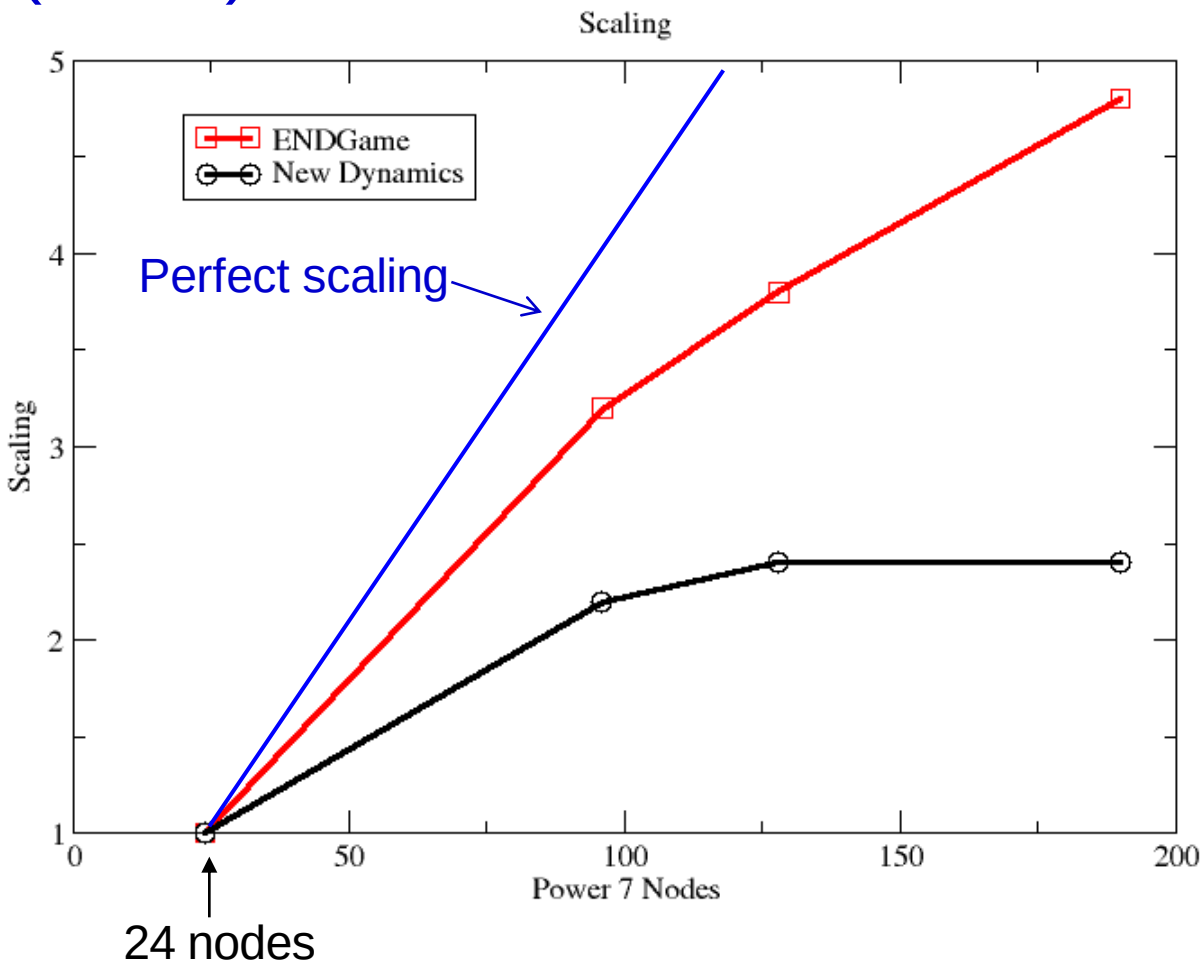
Outline

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

Scalability

(17km) N768 - New Dynamics vs ENDGame

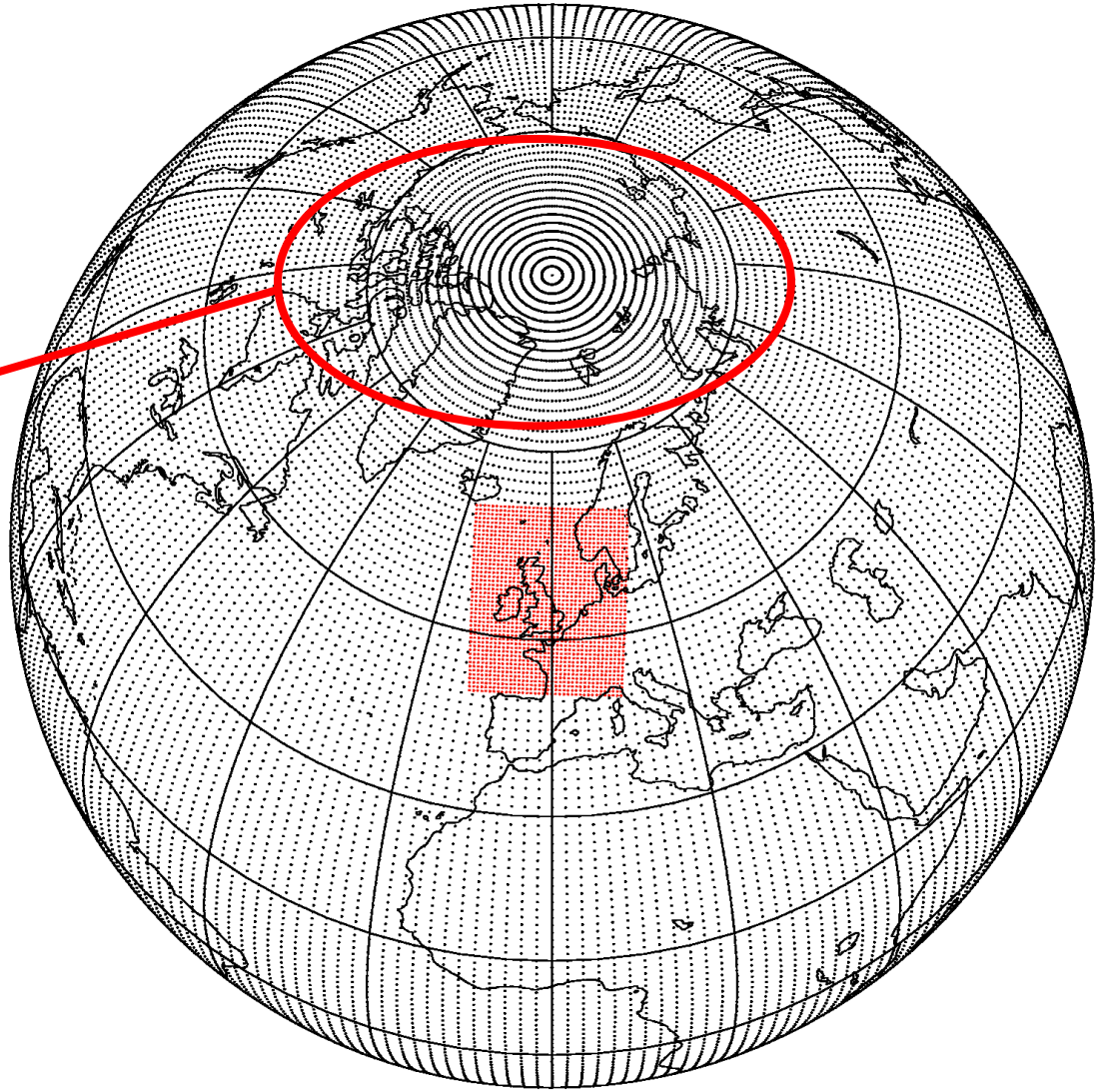


T_{24}/T_N

(1 node=32 processors)

The finger of blame…

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



GungHo!

Globally

Uniform

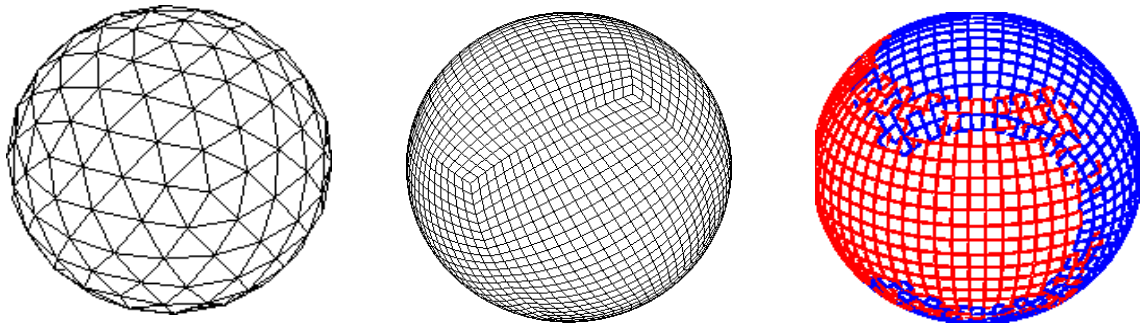
Next

Generation

Highly

Optimized

工合



NATURAL ENVIRONMENT RESEARCH COUNCIL

Science & Technology Facilities Council

"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

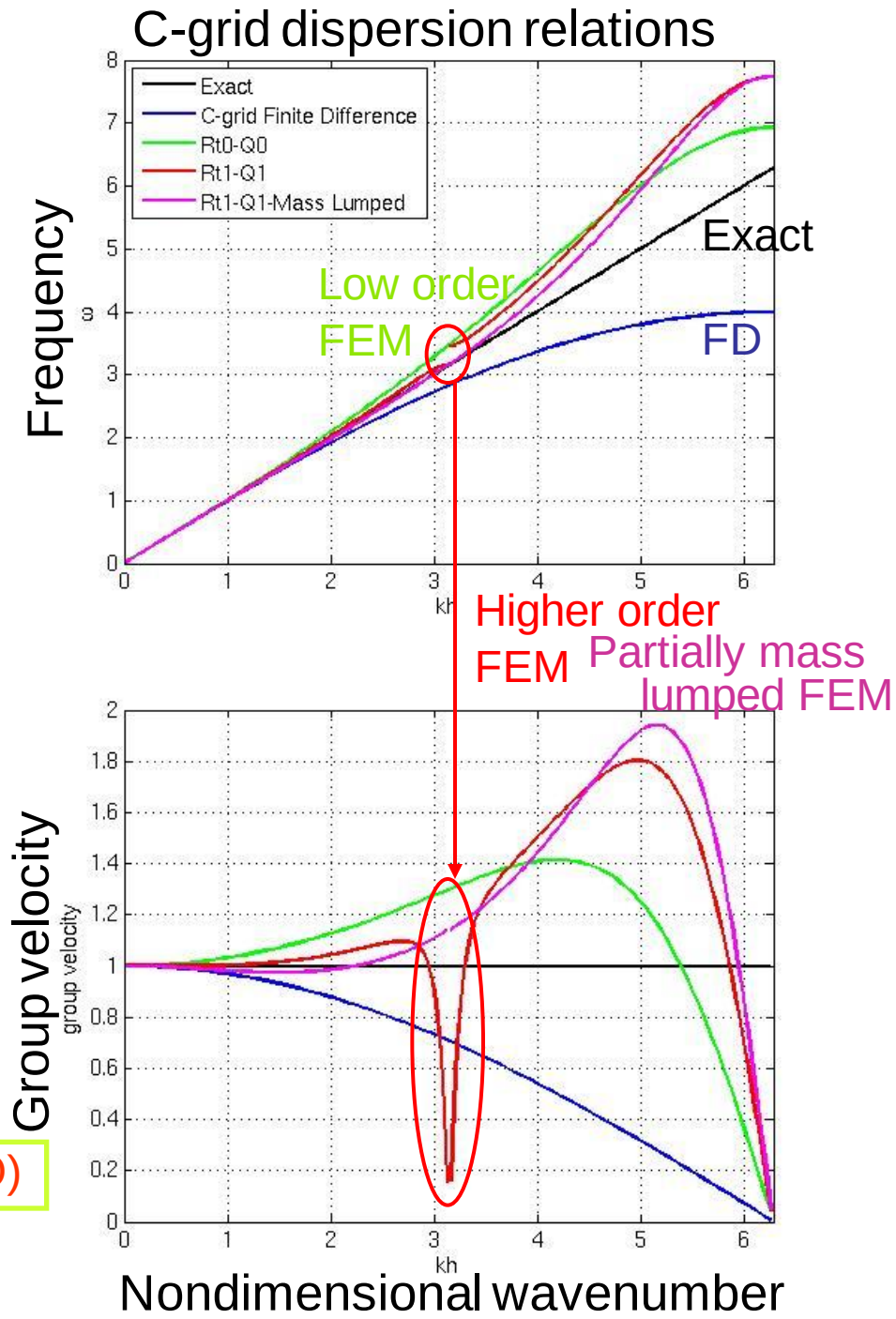
Some workpackage results

Grids

- Good dispersion
- Minimal grid imprinting
- No computational modes

⇒ Finite element approach

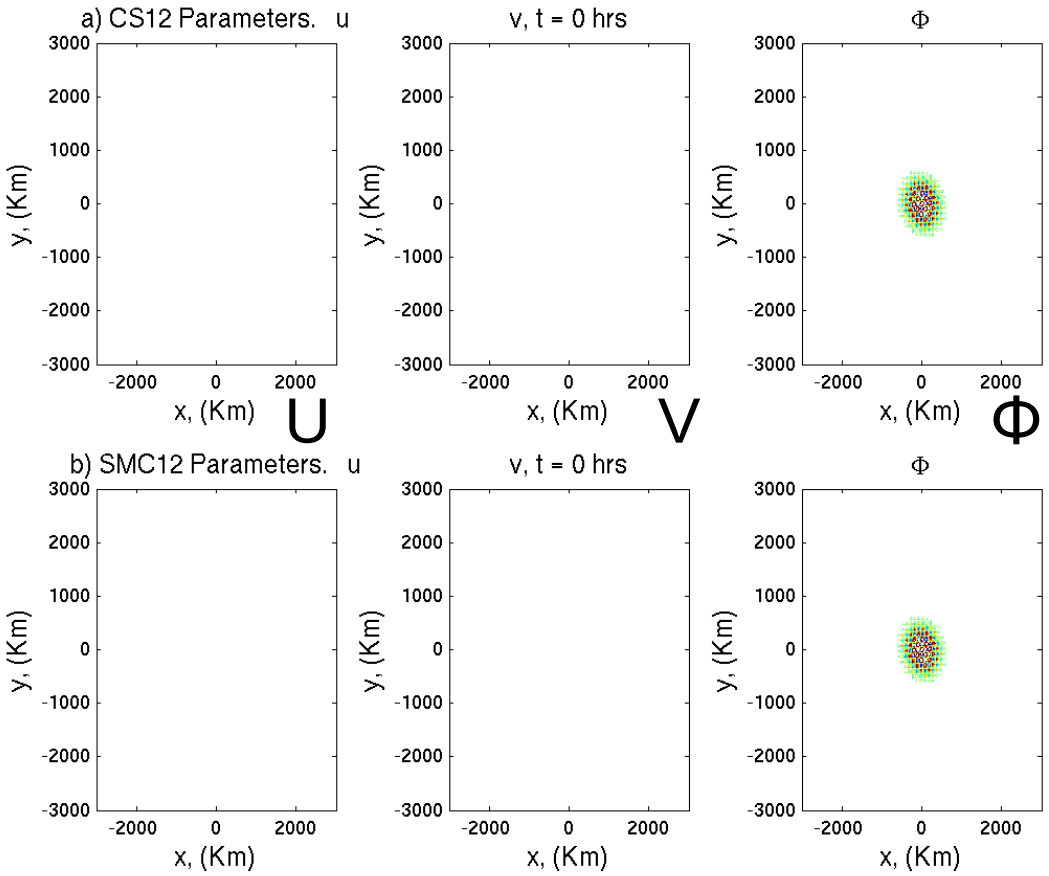
⇒ Focus on: Cubed-sphere; possibly triangles



Cotter (Imperial), Melvin & Staniforth (MetO)

Grids

Higher order FEM



- Good dispersion
- Minimal grid imprinting
- No computational modes

⇒ Finite element approach

⇒ Focus on: Cubed-sphere; possibly triangles

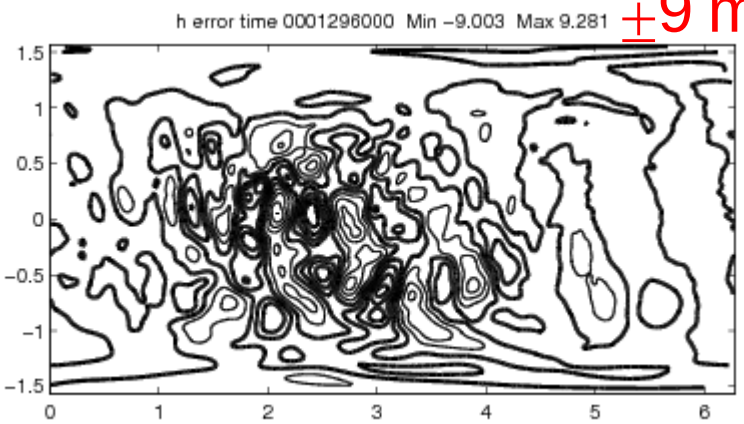
Partially mass lumped FEM

Cotter (Imperial), Melvin & Staniforth (MetO)

Recent results

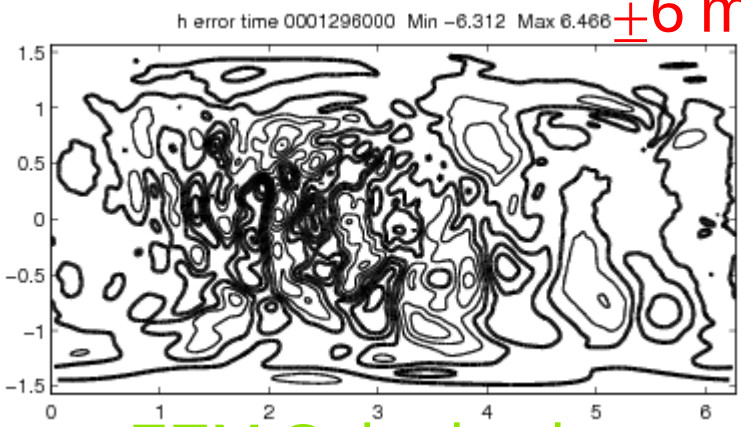
Thuburn (Exeter)

Williamson Test Case 5 with 160K d.o.f.s (320x160)



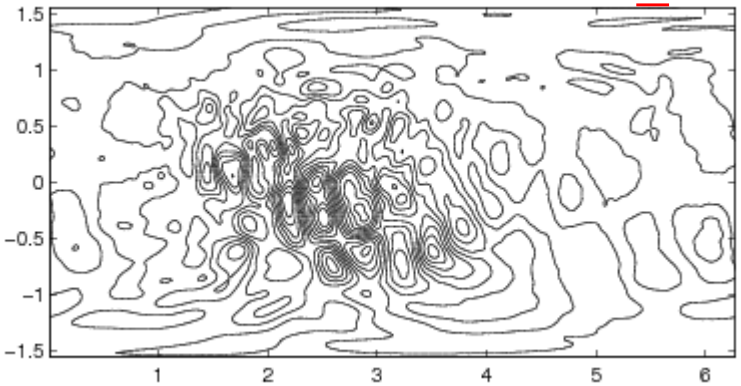
±9 m

FEM Hexagonal



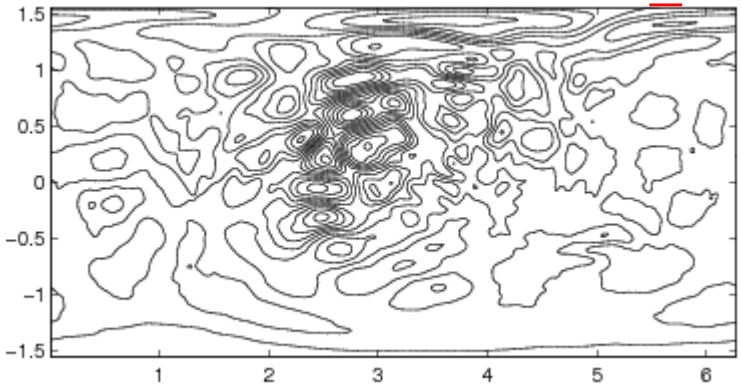
±6 m

FEM Cubed-sphere



±10 m

ENDGame lat-lon



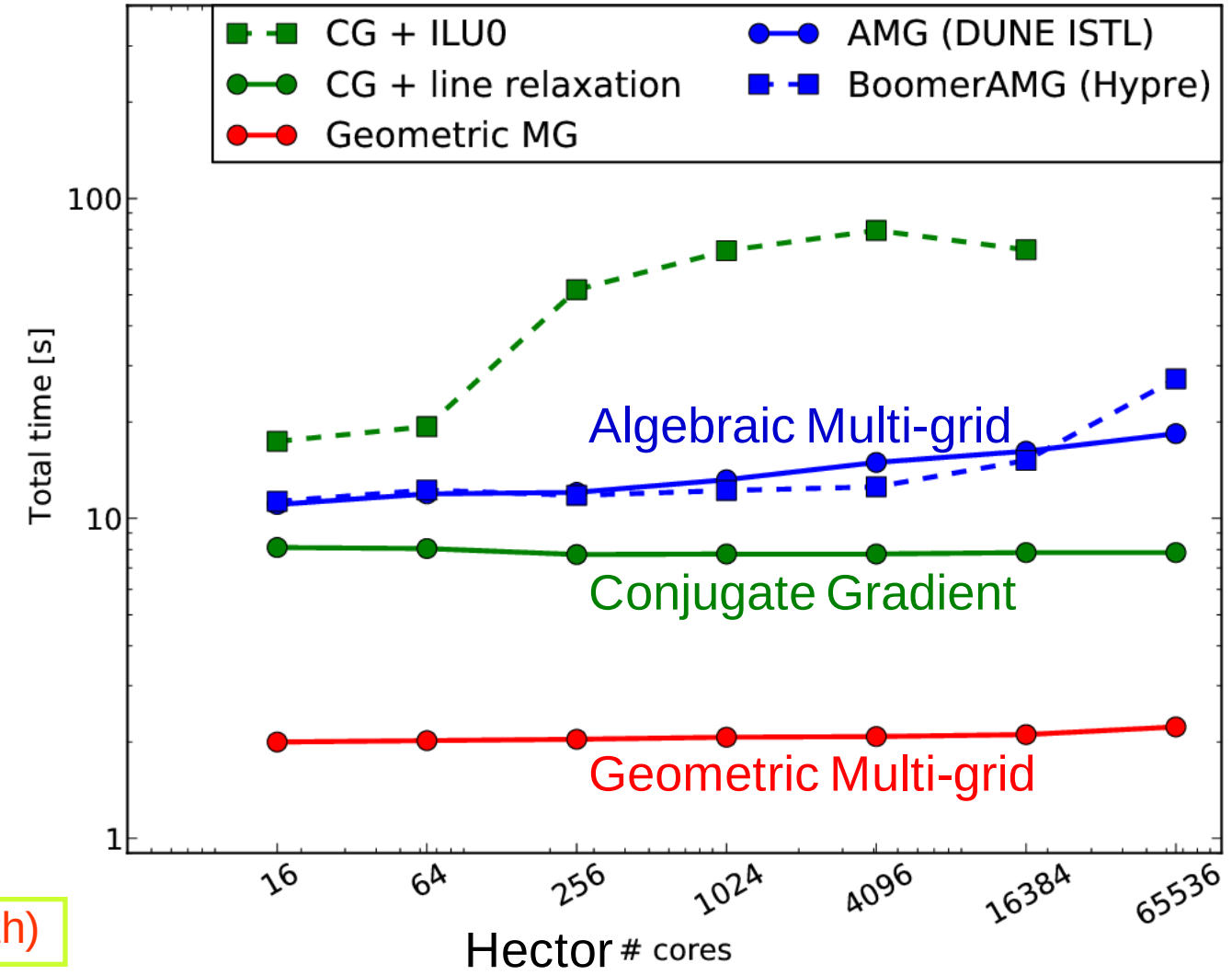
±11 m

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

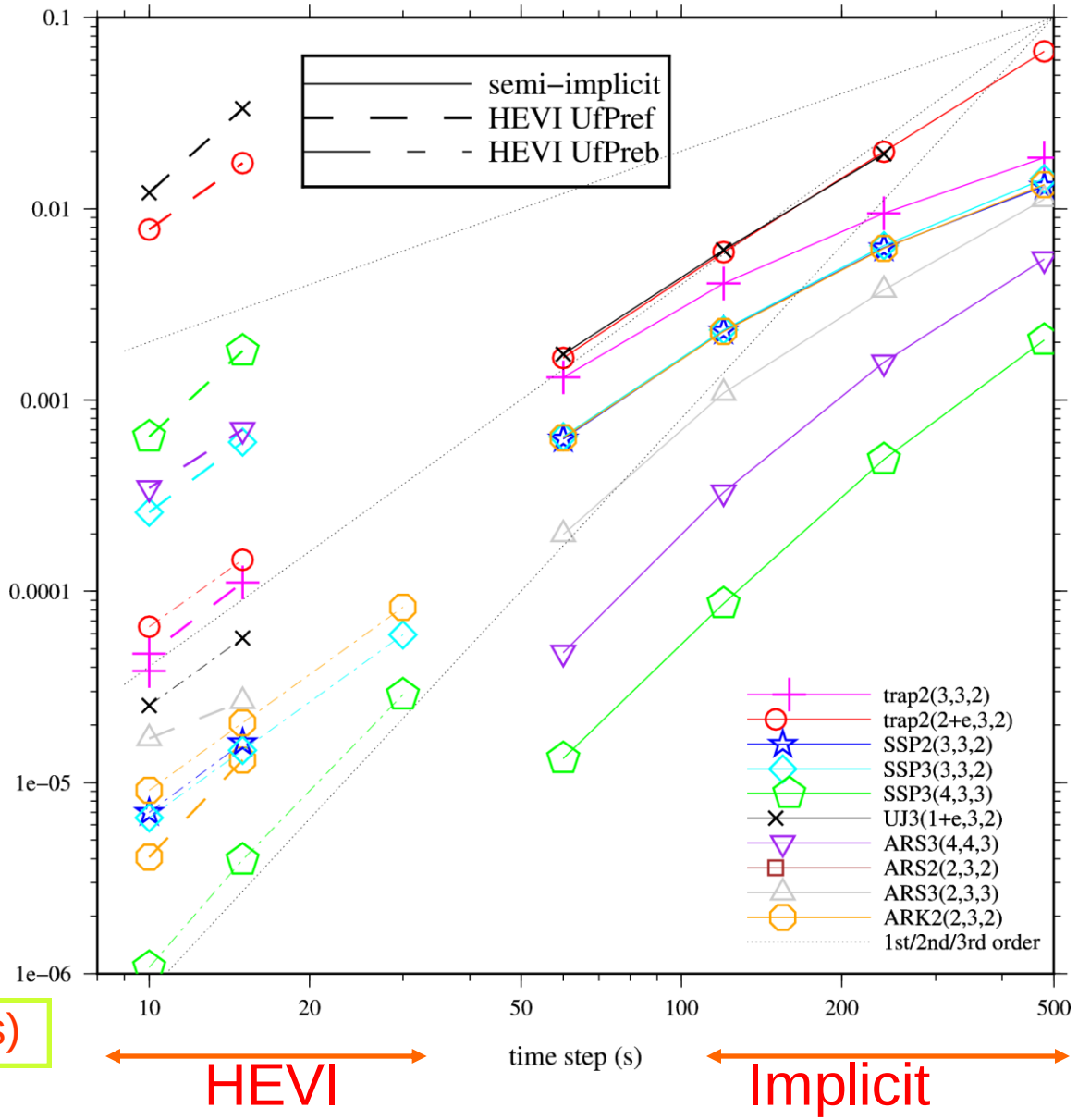


Mueller & Scheichl (Bath)

What to do if not…

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

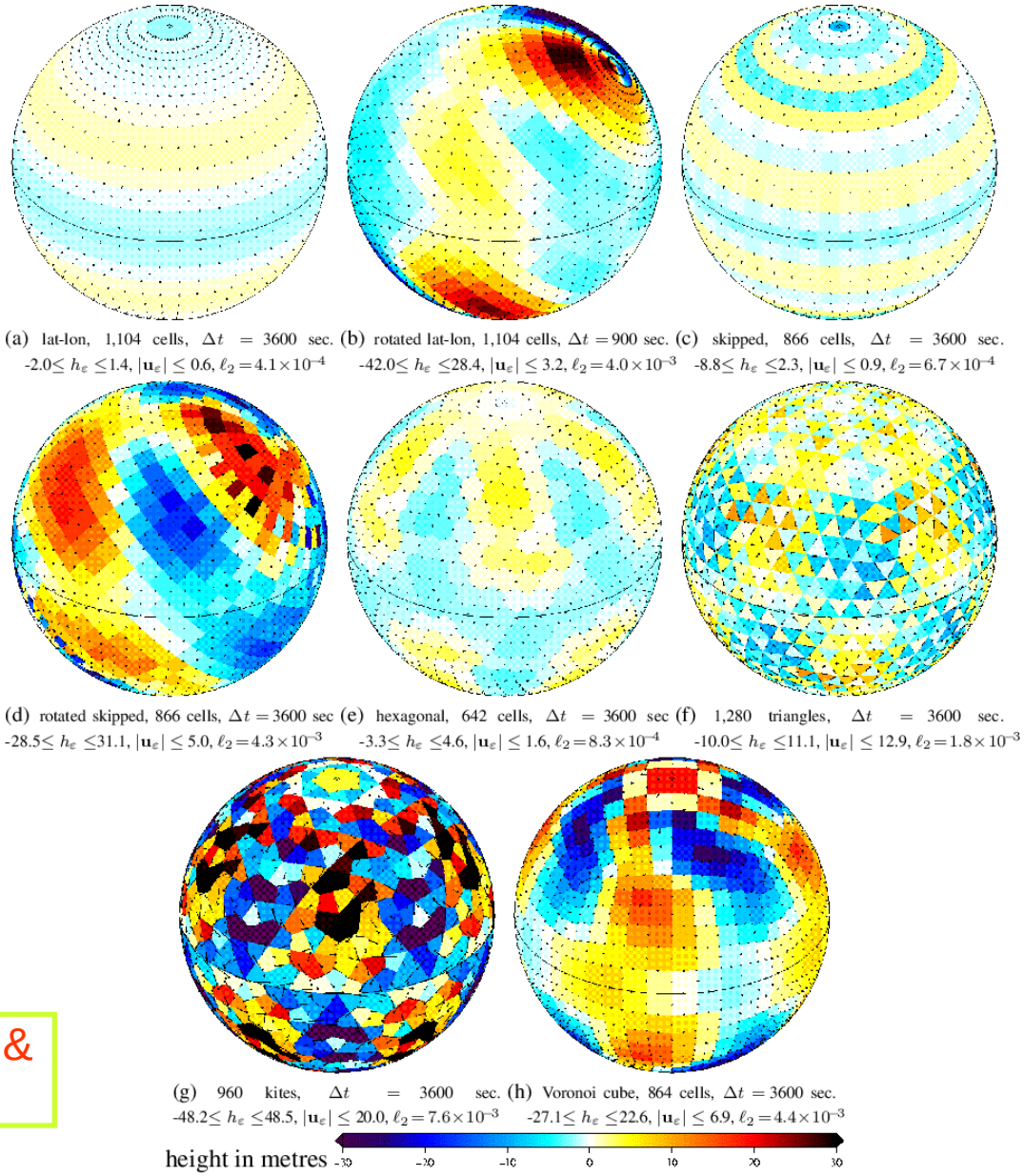
⇒ Examine range of Runge-Kutta Implicit-Explicit (IMEX) schemes



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



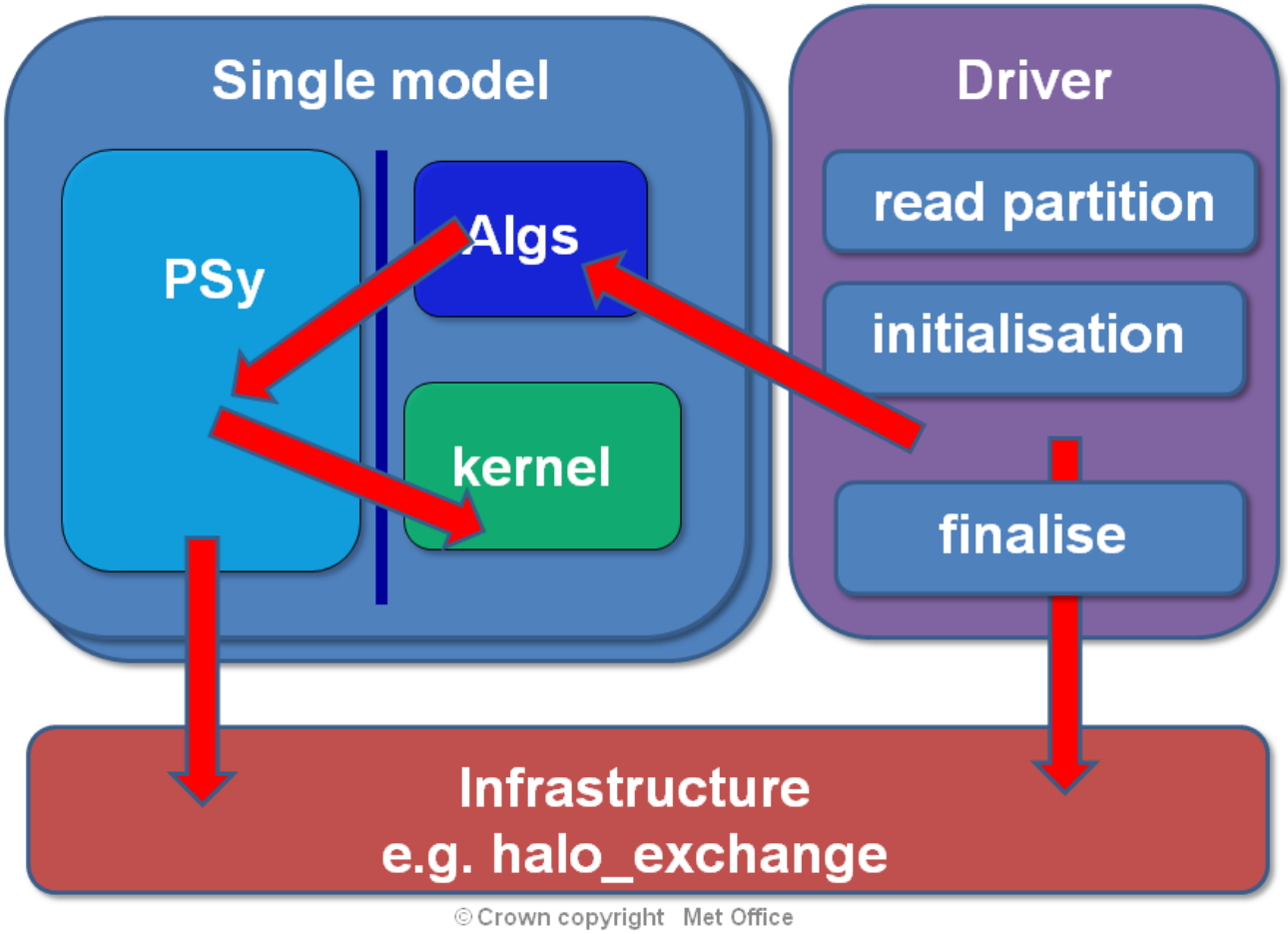
Weller (Reading), Thuburn (Exeter) & Cotter (Imperial)

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…

Computational Science

Ham (Imperial), Ford & Pickles (STFC), Riley (Manchester)



- 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

$\Rightarrow$ Long term step change in scalability

Met Office

Thank you!

Questions?