Recent numerical developments at the Met Office

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Aims of ENDGame

- ENDGame:
  - Even Newer Dynamics for General atmospheric modelling of the environment
- Build on the foundations of the New Dynamics
- Aims are:
  - Improved robustness
  - Improved accuracy
    - Retain greater non-linearity
    - Reduce the need for significant off-centring of α parameters
  - Maintain/improve conservation
    - Inherent SL mass conservation
    - (Optional) inherent tracer conservation
- While maintaining/improving efficiency

Improved accuracy

- Iterative SISL scheme (Diamantakis et al QJ 2007)
- Following discrete normal mode analysis of Thuburn and Staniforth (MWR, 2004):
  - ➢v (and v alone) to be held at poles (cf. present u, w and all scalars) ⇒ improved energy properties
  - ➢Coriolis terms based on mass flux variables ⇒ improved Rossby mode propagation

Conservation

- SLICE:
  - ➢ Semi-Lagrangian Inherently Conserving and Efficient advection scheme (Zerroukat et al QJ 2002/04) =
    - SL finite-volume scheme
    - Made efficient by applying a cascade approach
    - Ie a flow dependent dimensional splitting
  - ➢All conserved variables advected via SLICE
  - ➢All other variables advected using full 3D interpolating scheme
- Flux form for gradient operators

Switchable options

- Retain deep-atmosphere, nonhydrostatic formulation
- But introduce switches to investigate sensitivities:
  - Deep-atmosphere / shallow-atmosphere / Cartesian geometries
  - Hydrostatic / nonhydrostatic equations
  - Spherical / spheroidal coords (White et al QJ 2008)
  - Uniform / stretched grids
  - Intrinsic mass & tracer conservation (on / off)

Where are we and whither next?

- Using two 2D prototype models for continued testing/development:
  - Shallow-water model;
  - Vertical slice model
- Spherical 3D prototype ready for testing
- Move to UM framework, couple to physics, DA (2009/10)
- Testing for operational implementation (2010/11?)

Analytical solutions of the full nonlinear spherical equations

- Use:
  - Much more stringent testing – what is hidden in the full fields can be revealed in the difference fields
  - Solutions of the linearised equations only test linear code, there are inevitable differences with nonlinear code
  - Without analytic solution testing is much more “eyeballing” and easier to miss errors
- Issues:
  - Stationary – this has usually meant solid body rotation
  - Nonstationary – new development (Läuter et al JCP 2005) for shallow-water equations
  - Deep atmospheres

Analytical solutions of the full nonlinear spherical equations

- Staniforth & White QJ 2007:
  - Stationary axially-symmetric flow with orography
  - Deep- & Shallow-atmosphere forms
  - Made more challenging by use of rotated grid
- Staniforth & White QJ 2008
  - Extension of Läuter et al JCP 2005 to 3D Deep- & Shallow-atmospheres
  - Allows testing of temporal aspects
- So far only used in shallow-water prototype

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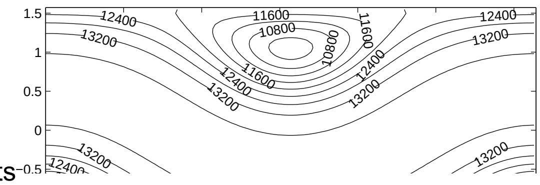


ϕ

Analytic
Height field

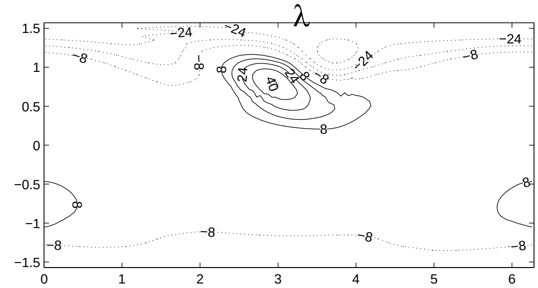
128x64 gridpoints

Δt = 1 hour

Time = 5days

No offcentring

λ



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Difference
model-analytic

Courtesy of
Mohamed
Zerroukat

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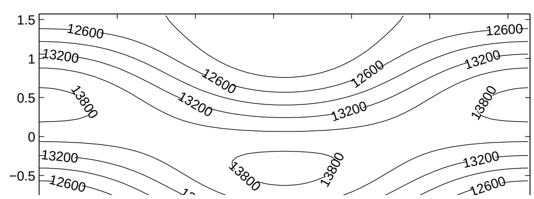

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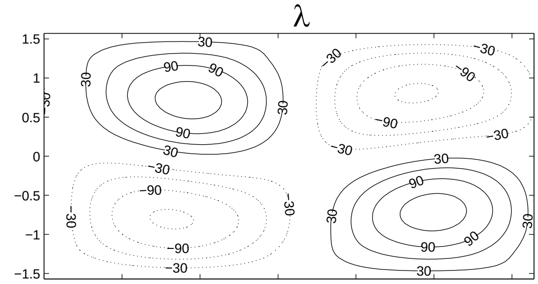

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