Standard Tests of NH dynamical kernels

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(based on results of discussion in BadOrb NH Workshop)

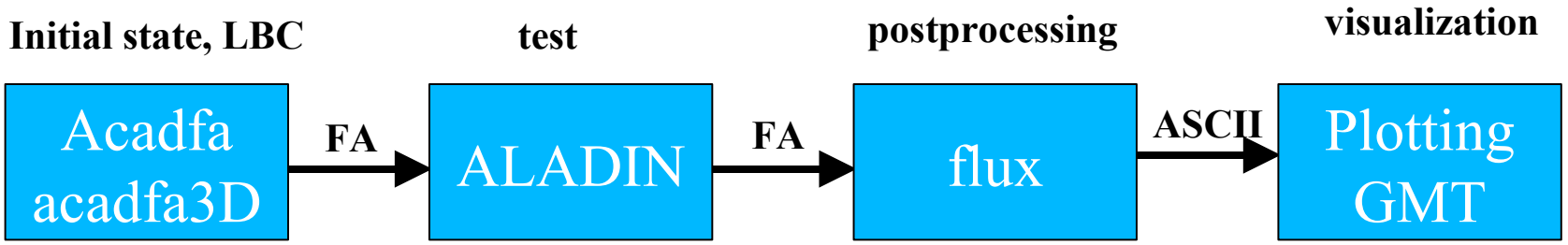
Introduction

- tests needed to verify NH solver (not full NWP models)
  - the correctness
  - the robustness
  - the accuracy
- The best approach is to use a 2D idealized framework and then move slowly to 3D more complex tests
- For each solver we need a reference:
  - The analytical solution
  - Numerically converged solution (dt->0,dx->0)
  - Published reference

Basic principles for tests

- test should test something in the solver.
- relatively simple to construct initial conditions
- results of tests should be easy to process, to visualize and to evaluate
- tests should require minimal physics (viscosity)

Testing with ALADIN



Set of tools for idealized testing with ALADIN has been developed for:

- Preparation of initial conditions (simple to introduce changes)
- postprocessing
- Visualization based on freely available GMT package

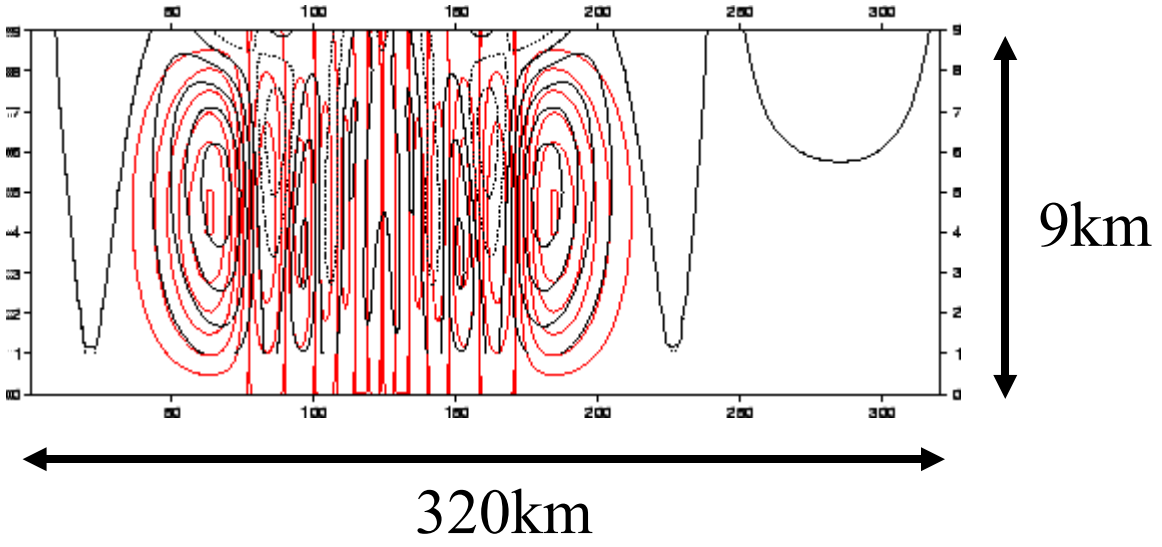
Standard set of tests

- **Idealized tests with no orography**
  - Gravity waves in the channel
  - Gravity current (Warm and cold bubble tests)
- **Idealized tests with orography**
  - Resting test
  - 2D and 3D Mountain waves in stably stratified atmosphere
  - 2D test of metric terms discretization
- **Pseudo-idealized 3D tests**
  - Idealized atmosphere above real earth surface (ALPIA, SCANIA)
- **Simple diabatic test**
  - Response of bubble to diabatic heating

Gravity waves in the channel

- Skamarock and Klemp, MWR 1994
- Analytical solution (linear)
- Test: the propagation of gravity waves in the model
- Constant height channel - not feasible with ALADIN (constant height absorbing layer could work ?)

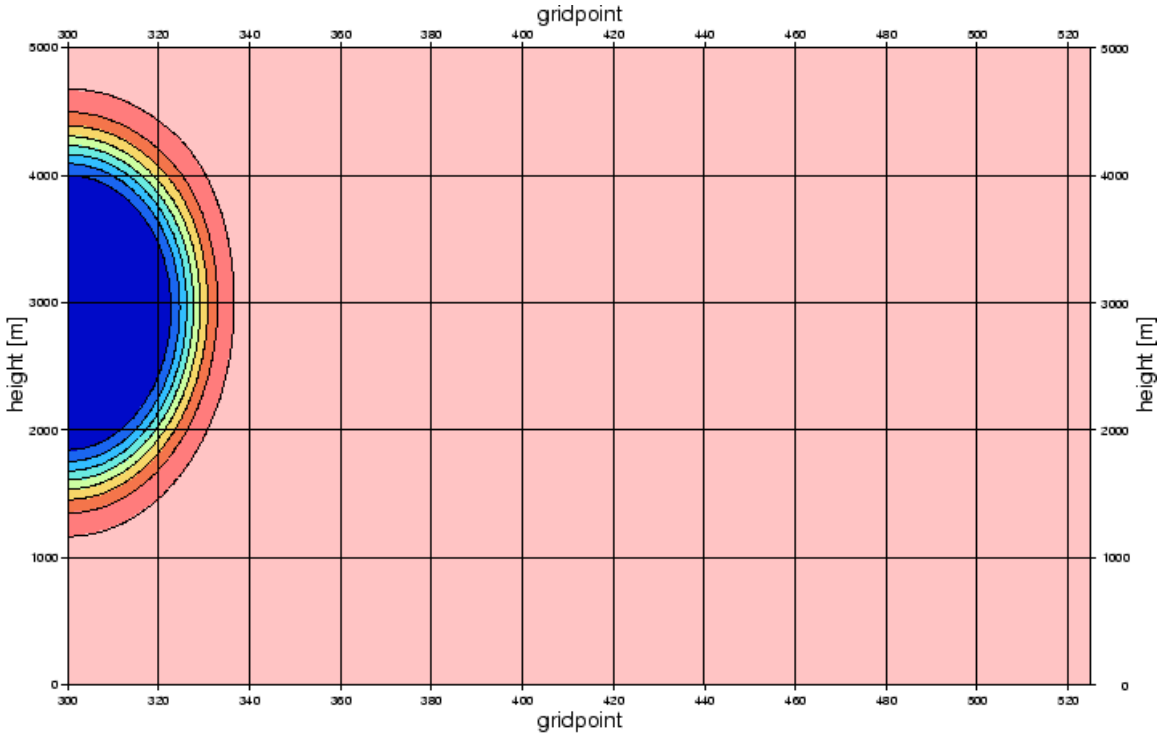
Isothermal
U=const.
Max. Θ'=0.01K



Density current (Warm and Cold bubble)

- Straka, IJNMW 1993, Robert, MWR 1992
- Good references in articles
- Constant viscosity = limited size of eddies and convergence for small dx
- ALADIN – usually we run with second order horizontal diffusion only

- Density current speed
- Minima and maxima for momentum, temperature.
- Eddy structure
- Symmetry



3 km

Neutral stratification
dx=dz=100m
Max. Θ'=-16.1K

Schaer test case

$$h(x) = H \exp\left(-\frac{x^2}{a^2}\right)\cos^2\left(\frac{\pi x}{\lambda}\right)$$

- Schaer, 2002
- Consistency of metric terms discretization (mainly in PGF and D3 term)
- Steady-state solution: not a test of time integration methods (except in SL models).

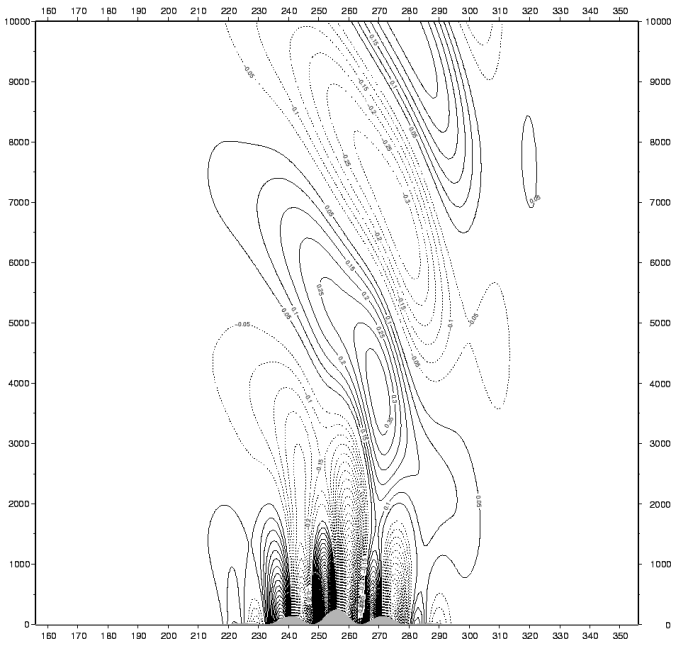
$H = 250\ meters$

$\lambda = 4000\ meters$

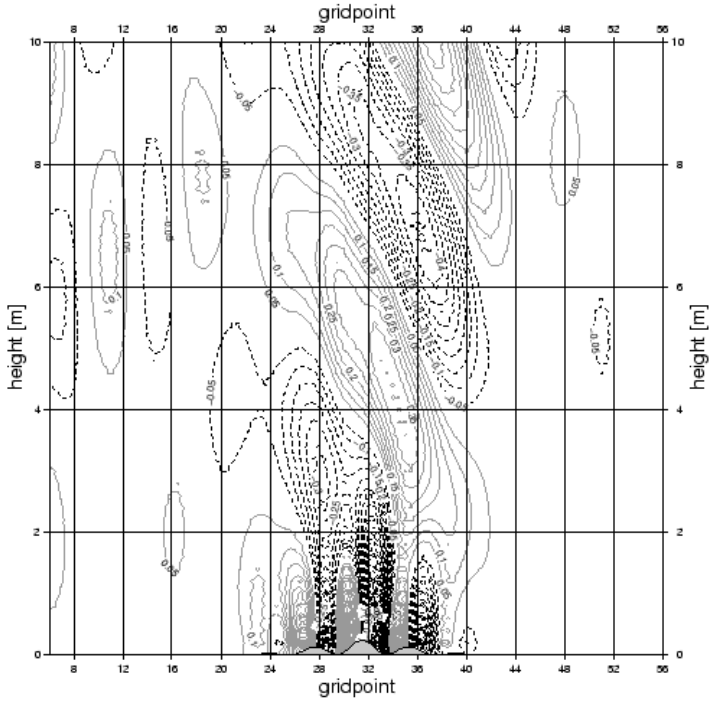
$a = 5000\ meters$

$N = 0.01 s^{-1}$

$U = 10\ ms^{-1}$



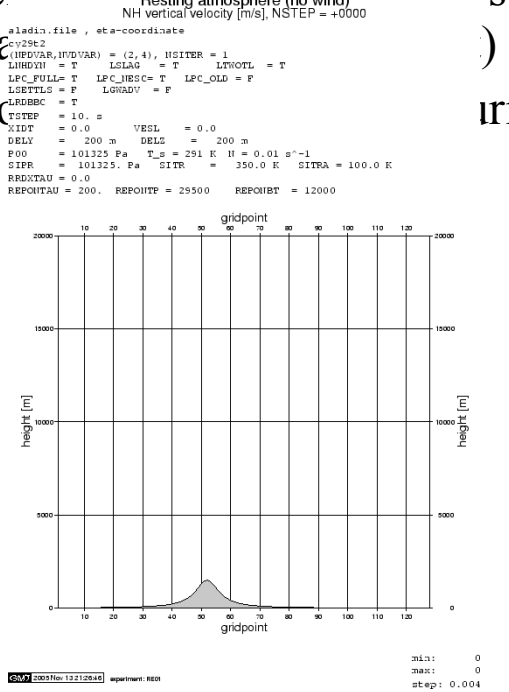
Analytical solution

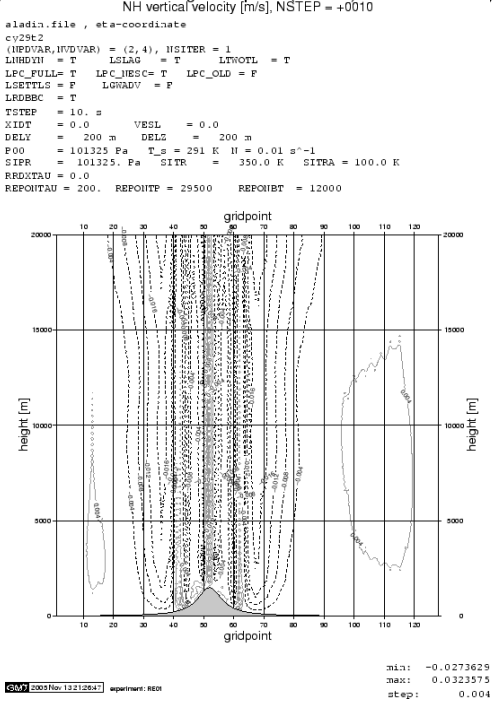


ALADIN

Resting atmosphere above orography

- Proposed by Steppeler, BadOrb
- Test: discretization errors above steep orography
- Resting atmosphere above steep orography
- No dissipative processes
- How to set up initial condition on hybrid levels ?
  - Iterative preparation of init state following exactly model discretization of pressure gra)
  - Slo uring integration





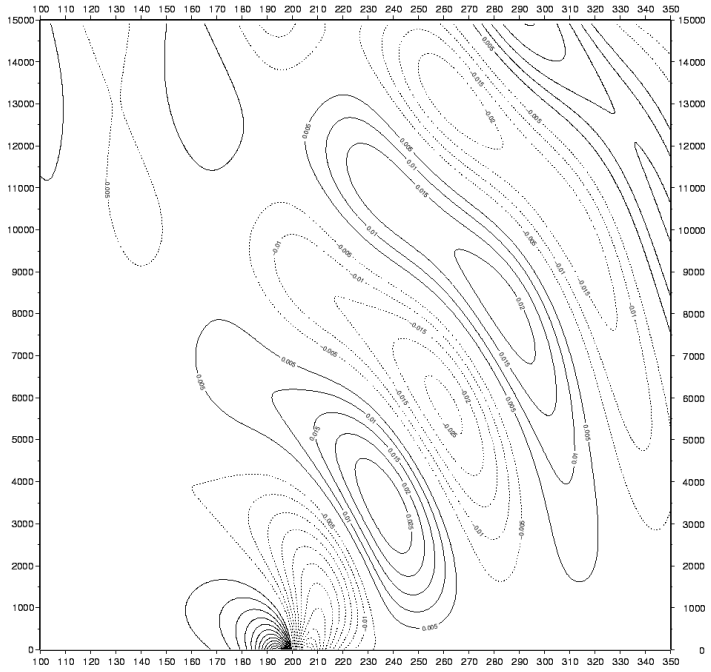
Initial state, H=1500m ,L=1000m

After 10 time steps

W, contour 0.004 ms-1

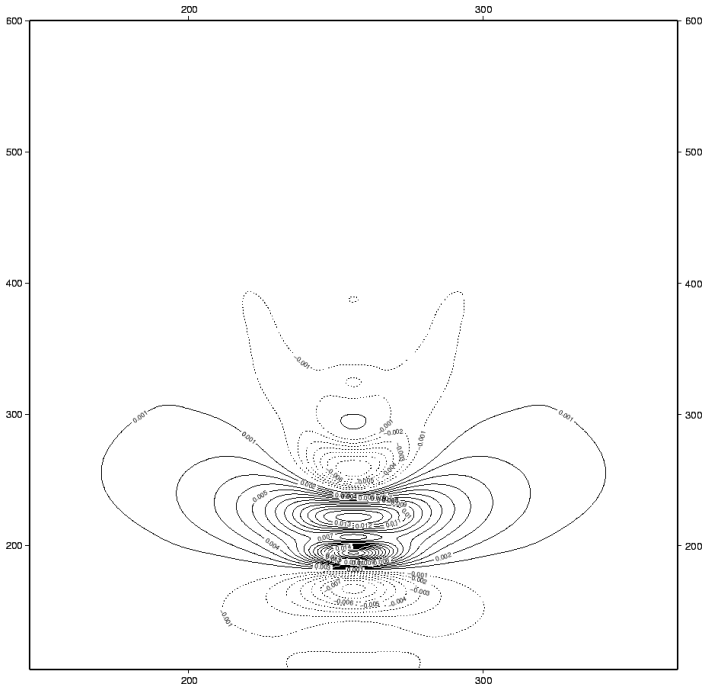
Mountain waves

- Old topic - Quenye, 1948, Long, 1953, Wurtele, 1957
- Analytical solution available even for linear and even for some non-linear regimes (more in the following presentation)
- Hydrostatic and non-hydrostatic regimes
- 2D and 3D framework



Linear NH 2D mountain wave

W

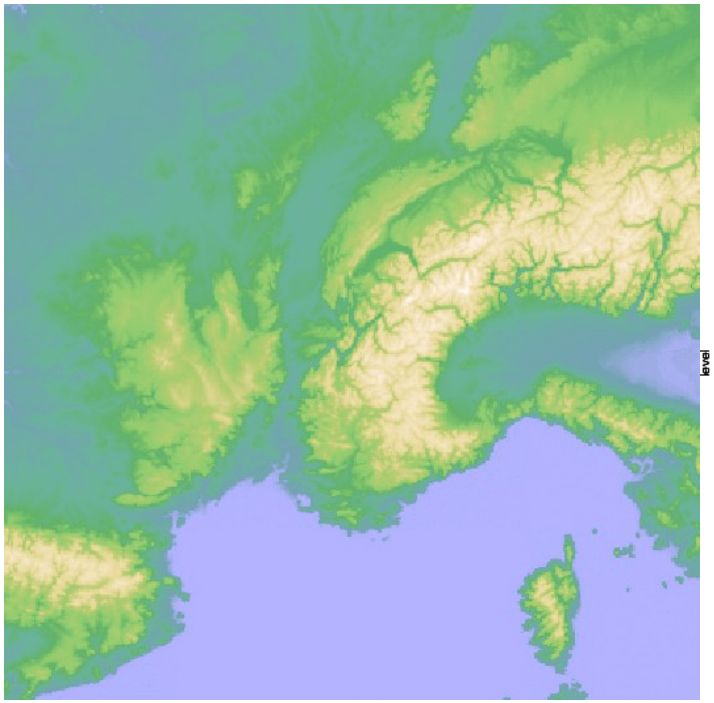


Linear NH 3D mountain wave

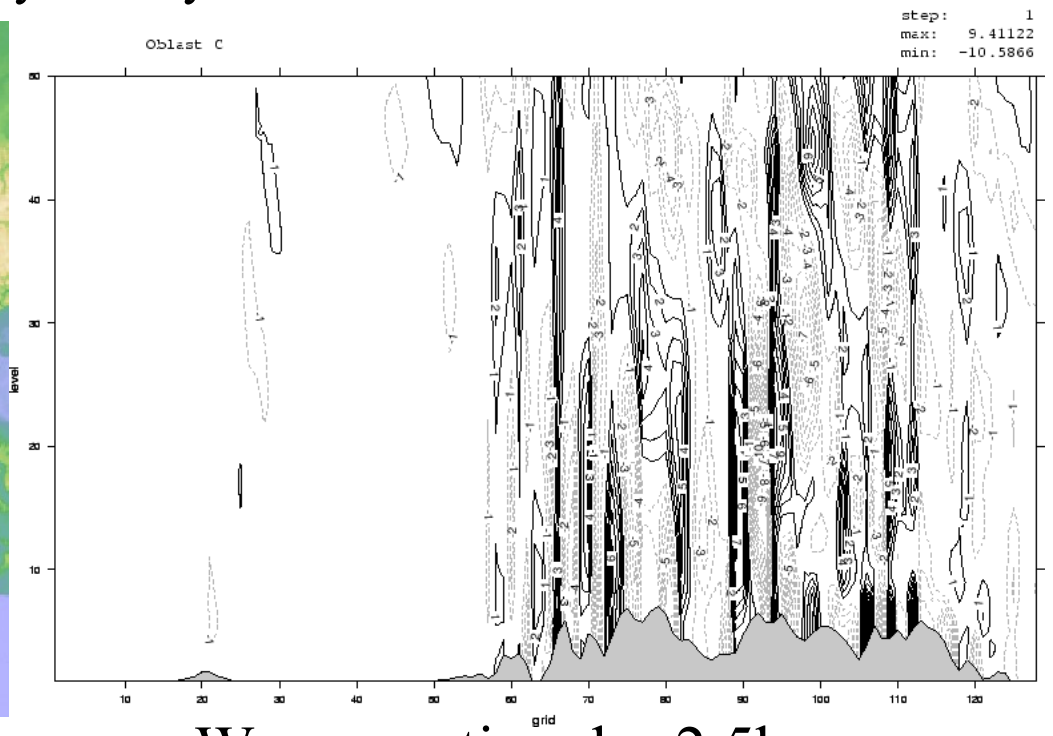
V

Idealized atmosphere above real earth

- Bubnova, 2000
- Test: measure the robustness of dynamics and its ability to response to the forcing similar to one expected from physics at very high resolution
- Adiabatic tests: ALPIA, SCANIA
- Diabatic tests: used to tests physical-dynamical interface



Orography 1.25km, (from Catry)



W crossection dx=2.5km

Proposed standard tests for model intercomparison

Adiabatic flow with no terrain

Inertia gravity waves in a periodic channel

Density current

Adiabatic flow with terrain

Resting atmosphere

Potential flow over a mountain

2D mountain waves – hydrostatic and nonhydrostatic, linear and nonlinear

3D mountain waves

Schaer (*MWR 2002; Klemp et al 2003*) mountain wave test

Moist Convection (squall-lines?, supercells?)