Dynamics & Coupling

LACE progress report 2008-2009

Filip Váňa

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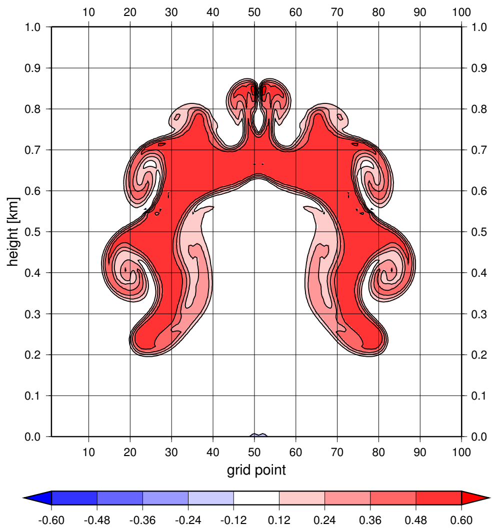
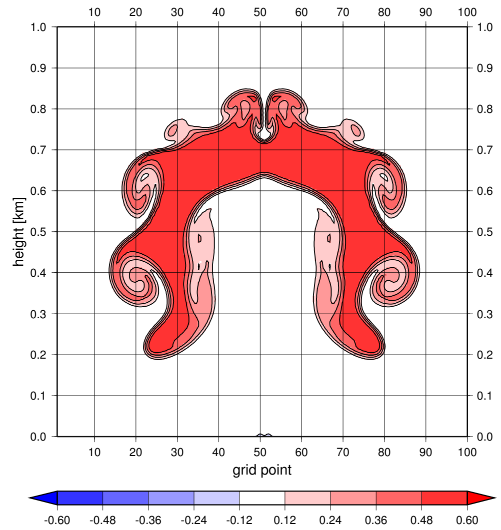
CHMI

New interpolators for SL

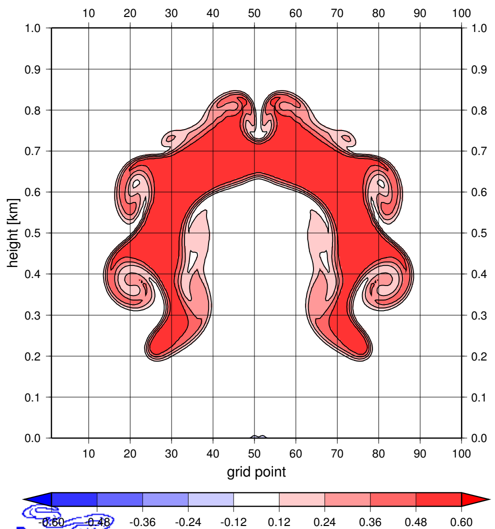
quasi-cubic spline ($\kappa = -2$)



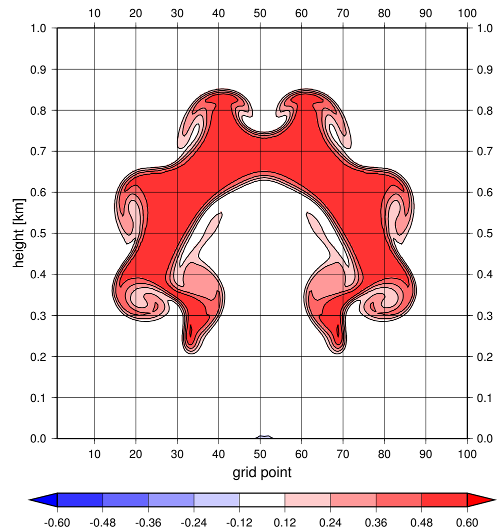
cubic Lagrange polynomial ($\kappa = 0$)



quadratic interpolator ($\kappa = 1$)

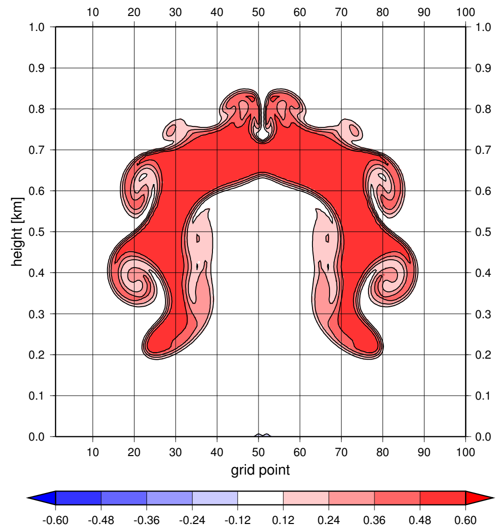


strongly diffusive interpolator ($\kappa = 6$)

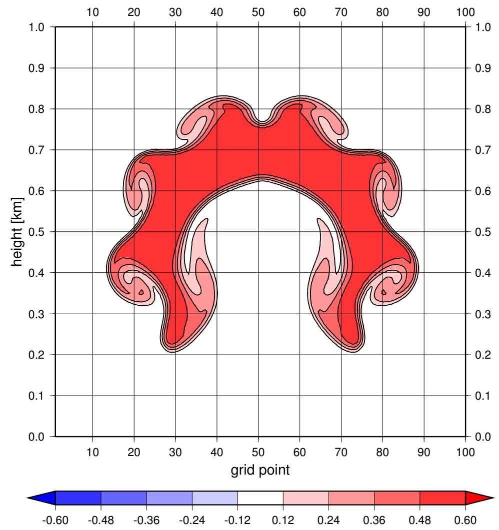


New interpolators for SL

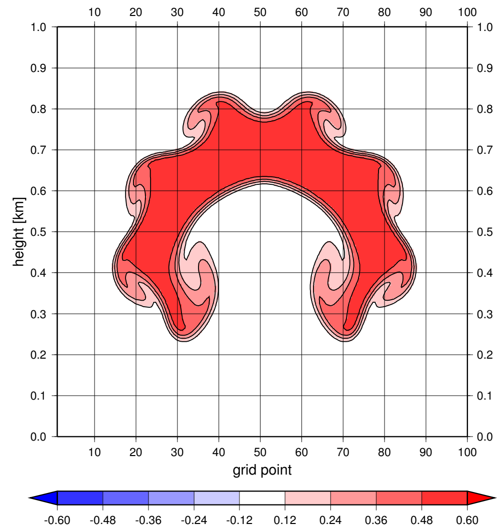
$(\kappa = 0, \varepsilon = 0.00)$



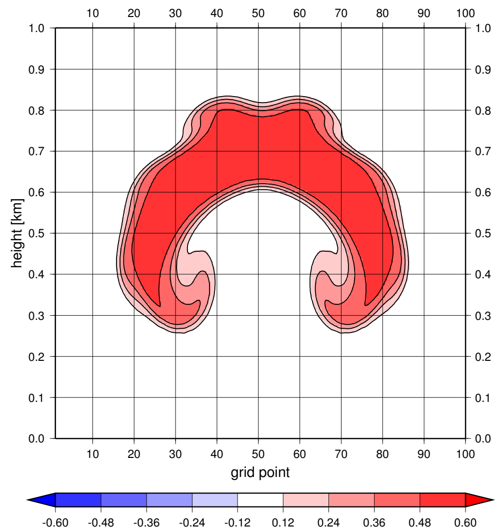
$(\kappa = 0, \varepsilon = 0.01)$



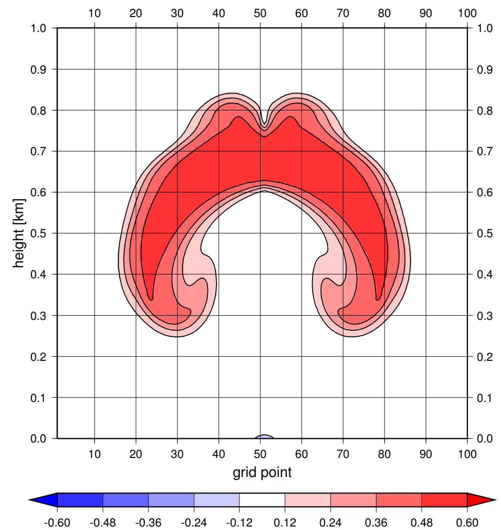
$(\kappa = 0, \varepsilon = 0.02)$



$(\kappa = 0, \varepsilon = 0.04)$



linear interpolator



New interpolators for SL

Experience from the real atmosphere
(LACE domain, Δx=9km)

- Decreasing of κ leads to:
  - general improvement of wind speed and MSL pressure (conservation of mass)
  - other model variables improved in upper troposphere (above 500 hPa) and in atmosphere above 100 hPa
  - improvement for prognostic physical variables
  - detrimental effects in PBL and lower stratosphere

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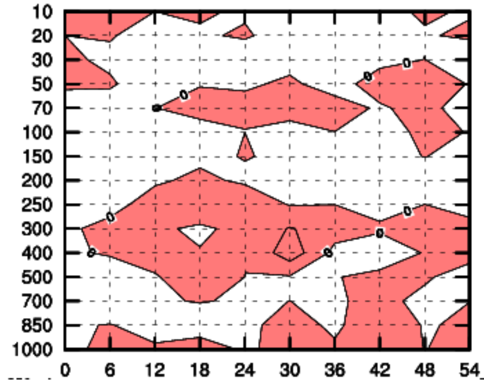
  - improvement for prognostic physical variables
  - detrimental effects in PBL and lower stratosphere
- Decreased κ needs to be compensated by increased horizontal and vertical diffusion

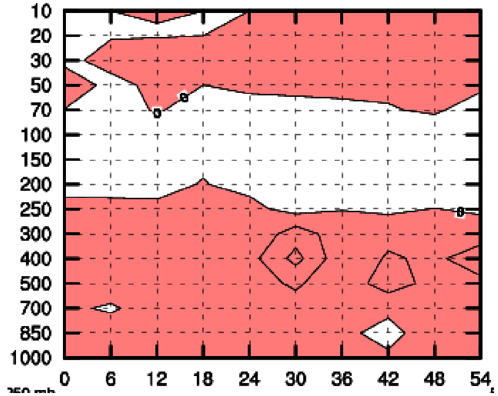
New interpolators for SL

ALADIN/CE, parallel suite (06/05/2009-08/06/2009)

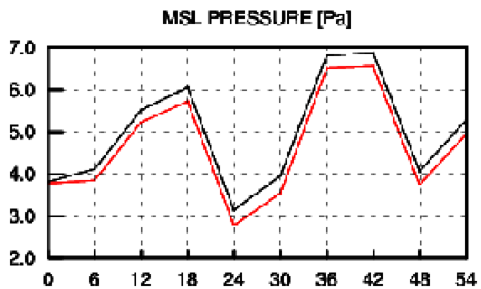
Relative humidity rmse



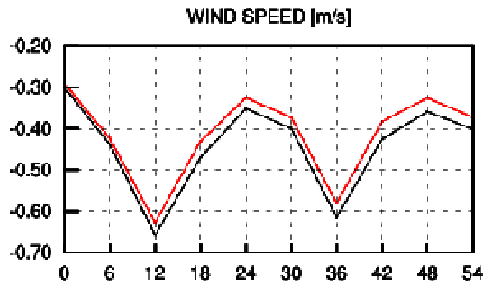
Relative humidity bias



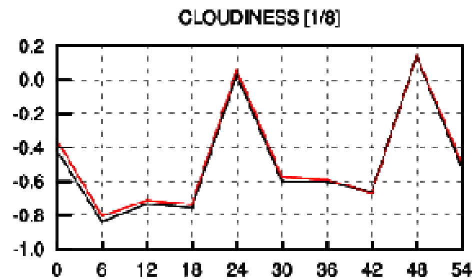
MSLP bias



wind speed bias



cloudiness bias



$\kappa = 0.,\ \varepsilon_H = 0.0025,\ \varepsilon_V = 0. \quad \Rightarrow \quad \kappa = -0.6,\ \varepsilon_{H,V} = 0.016$

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New interpolators for SL

Conclusions

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- Horizontal smoothing influences KE spectra, only weak effect to scores
- Vertical smoothing nearly no effect to KE spectra, strong impact to scores and mass conservation
- Lagrangian cubic interpolation seems to perform extremely well in the real atmosphere
- Still some space to re-distribute the SL diffusivity from the basic interpolator toward a stronger (3D acting) diffusion scheme

Toward the NH dynamics

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- Benchmark the NH dynamics with respect to the hydrostatic one: eliminating the true added value of the NH dynamics for the real atmospheric simulations.

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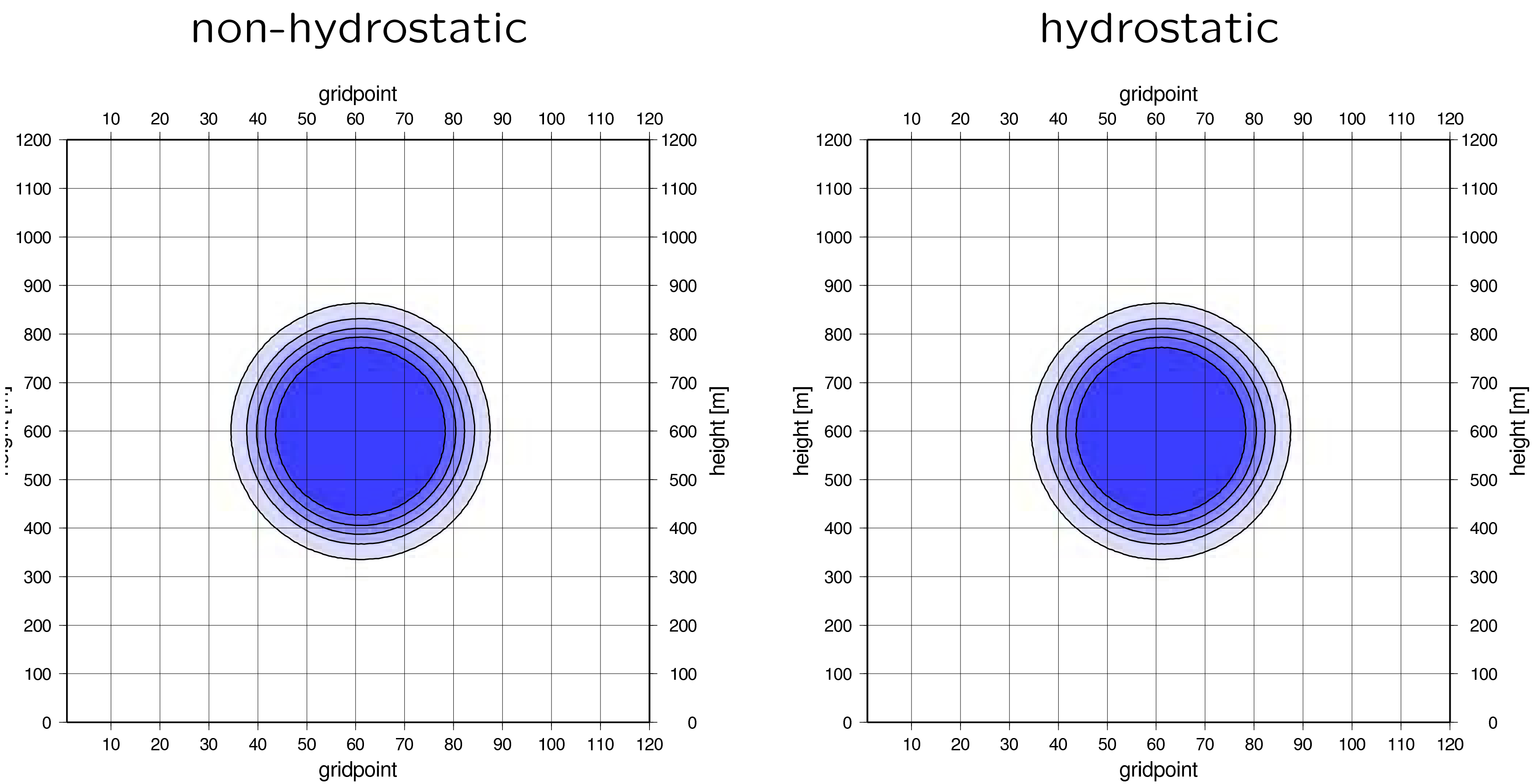
- LACE project targeted to $\Delta x \approx 4$km
- Hydrostatic dynamics of ALADIN is simply extensible to the NH one (see Bénard et al., 2009, QJRMS)
- Benchmark the NH dynamics with respect to the hydrostatic one: eliminating the true added value of the NH dynamics for the real atmospheric simulations.
- The aim is to define the resolution where it is worth to activate the NH dynamics.

Toward the NH dynamics

Cold bubble test

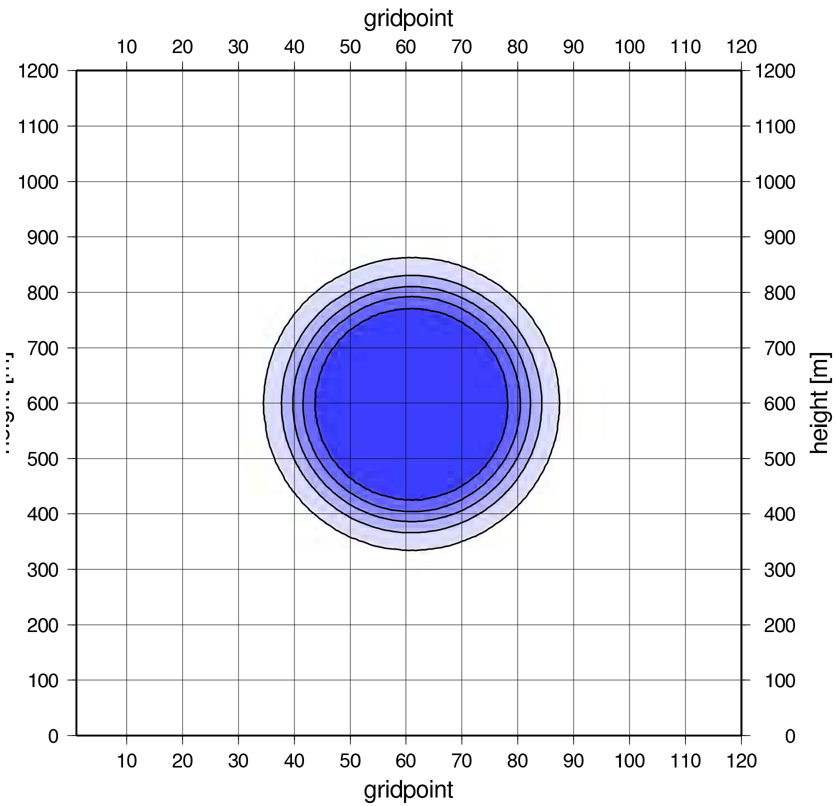


$\Delta x = 10\,\mathrm{m},\ t = 0\,\mathrm{s}$

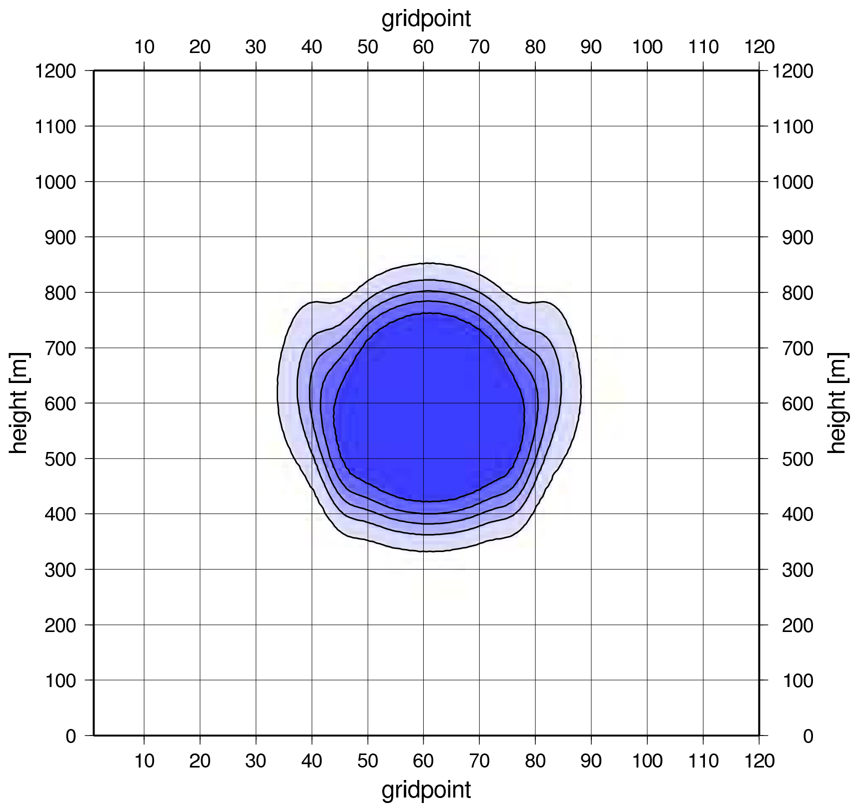
Toward the NH dynamics

Cold bubble test

non-hydrostatic



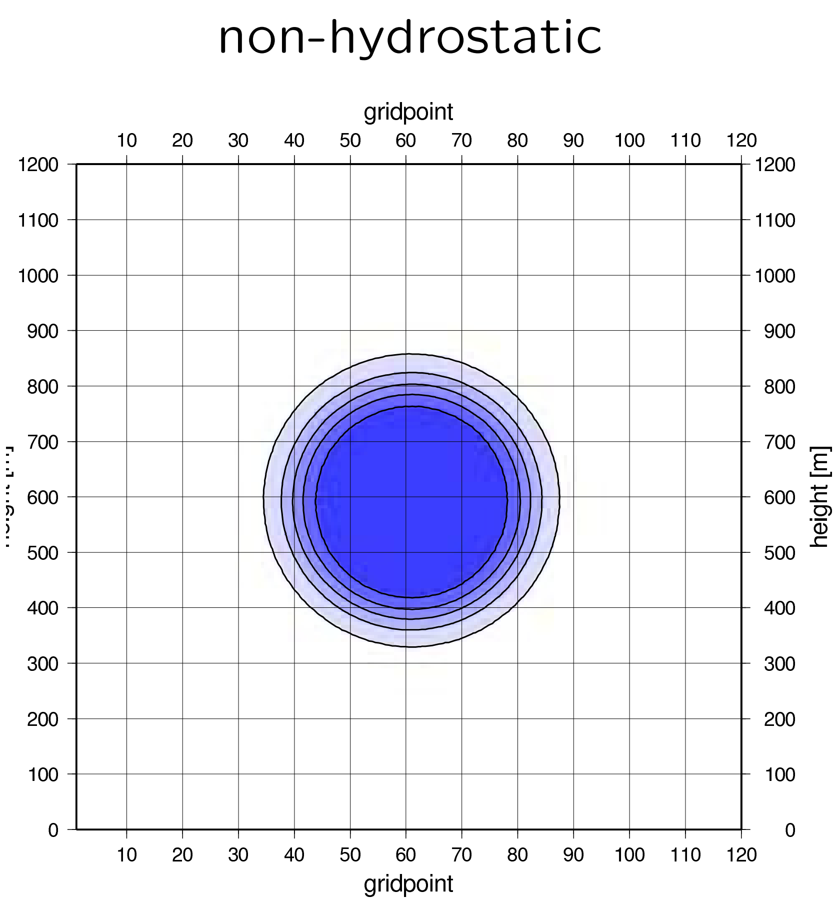
hydrostatic

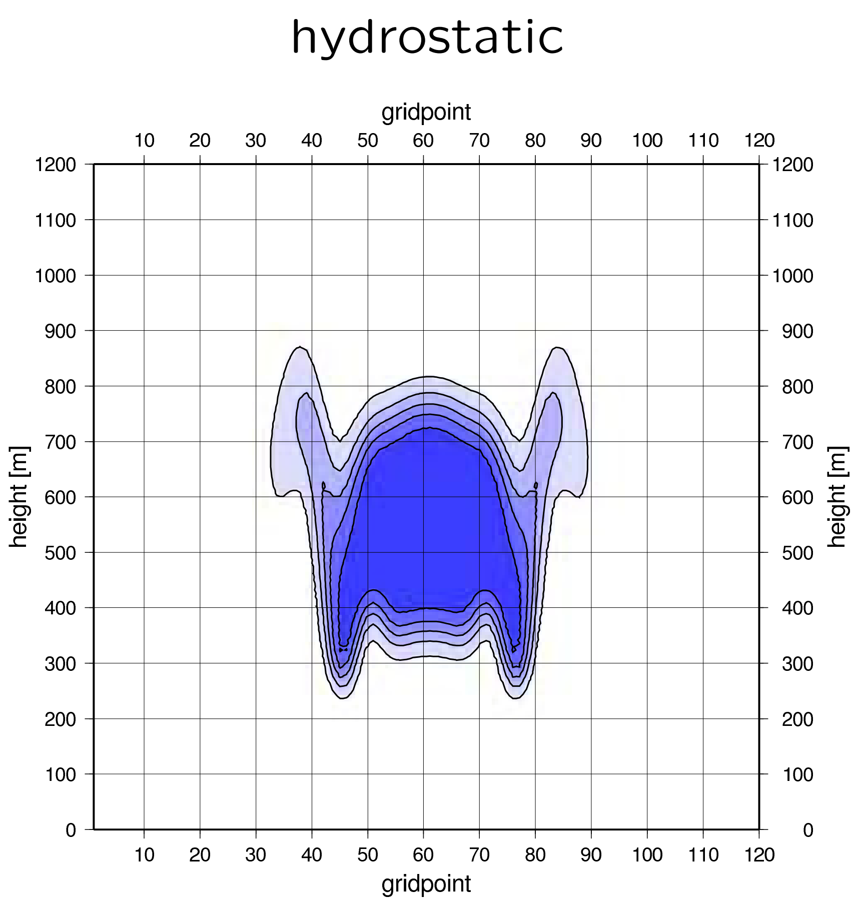


$\Delta x = 10\,\mathrm{m},\ t = 20\,\mathrm{s}$

Toward the NH dynamics

Cold bubble test



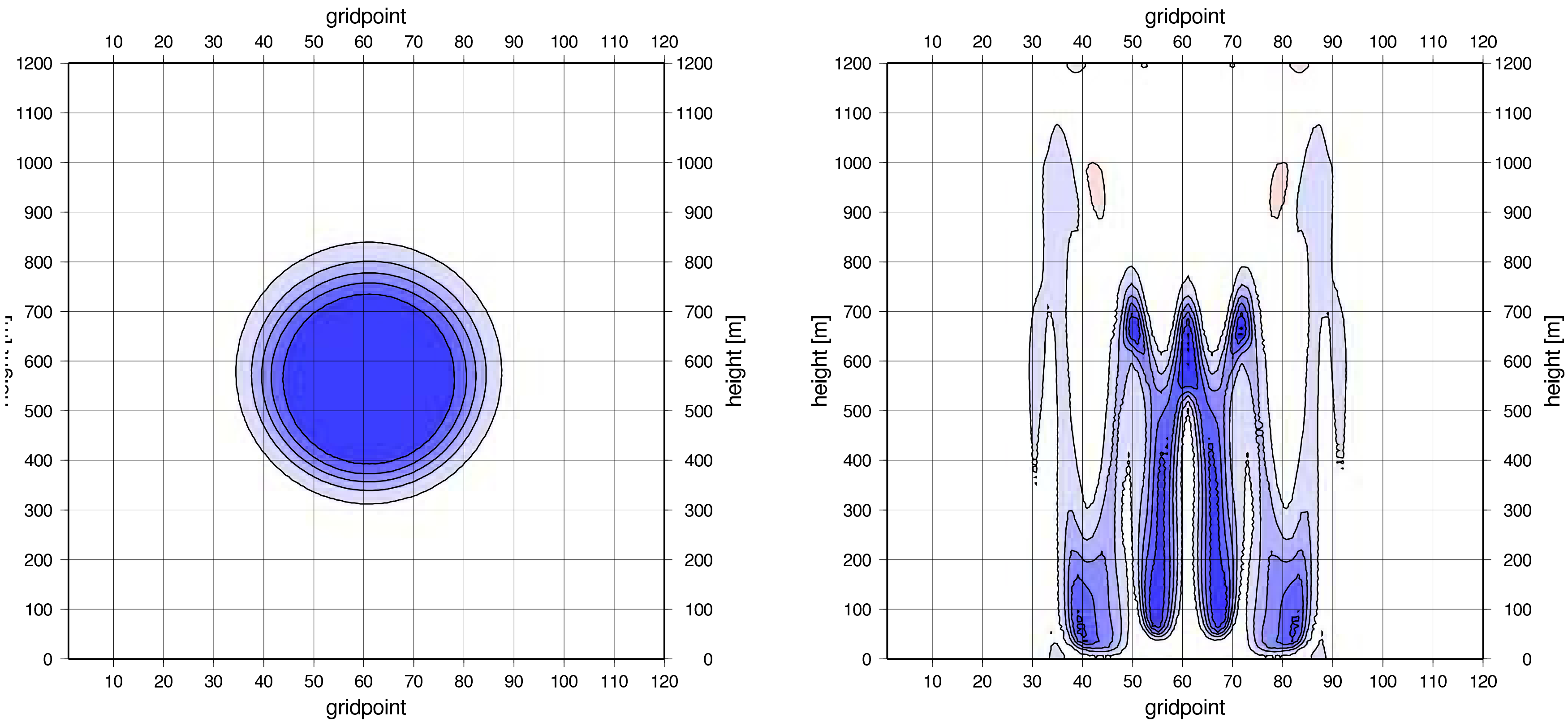


$\Delta x = 10\,\mathrm{m},\ t = 50\,\mathrm{s}$

Toward the NH dynamics

Cold bubble test

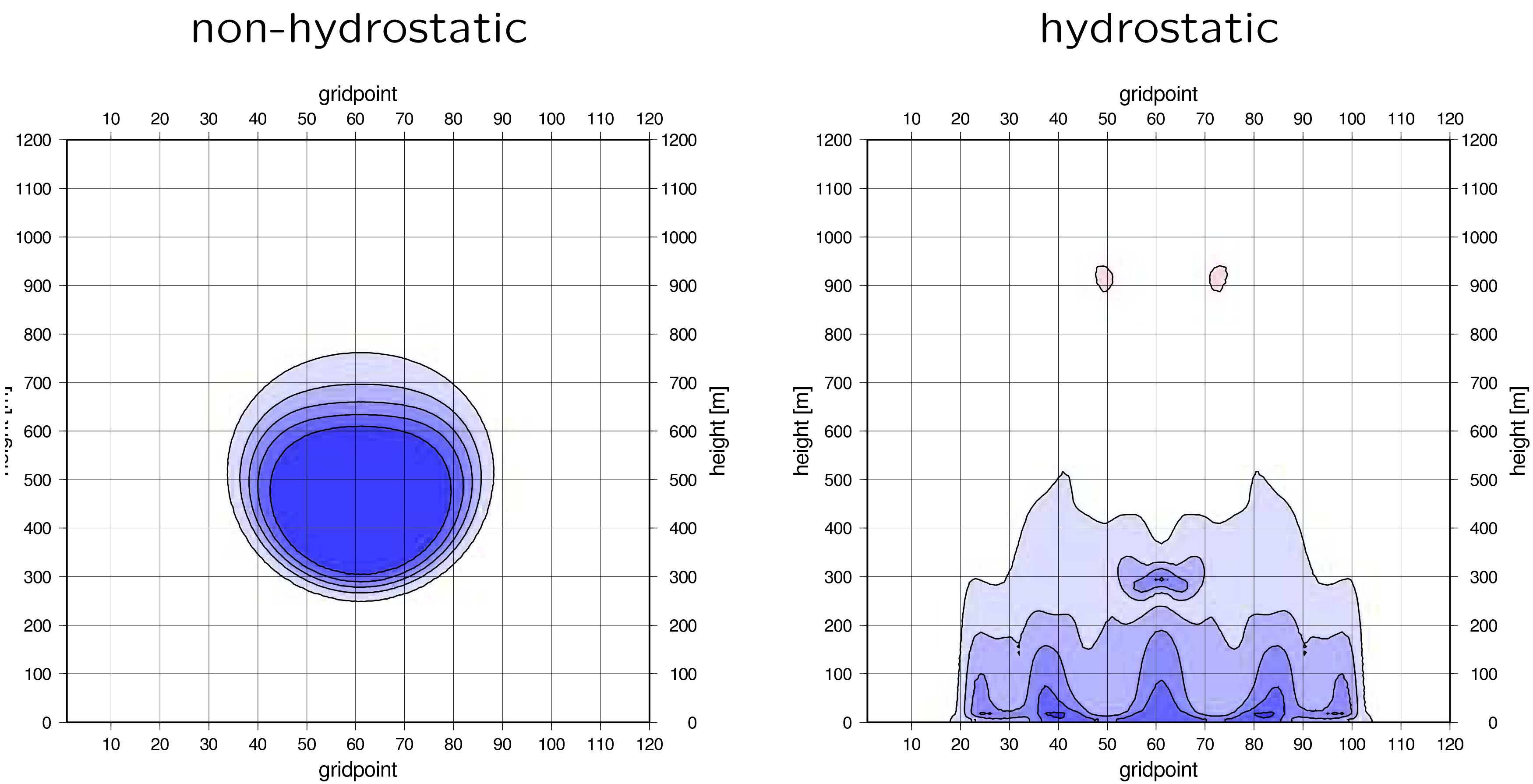
non-hydrostatic hydrostatic



$$\Delta x = 10\,\mathrm{m},\ t = 100\,\mathrm{s}$$

Toward the NH dynamics

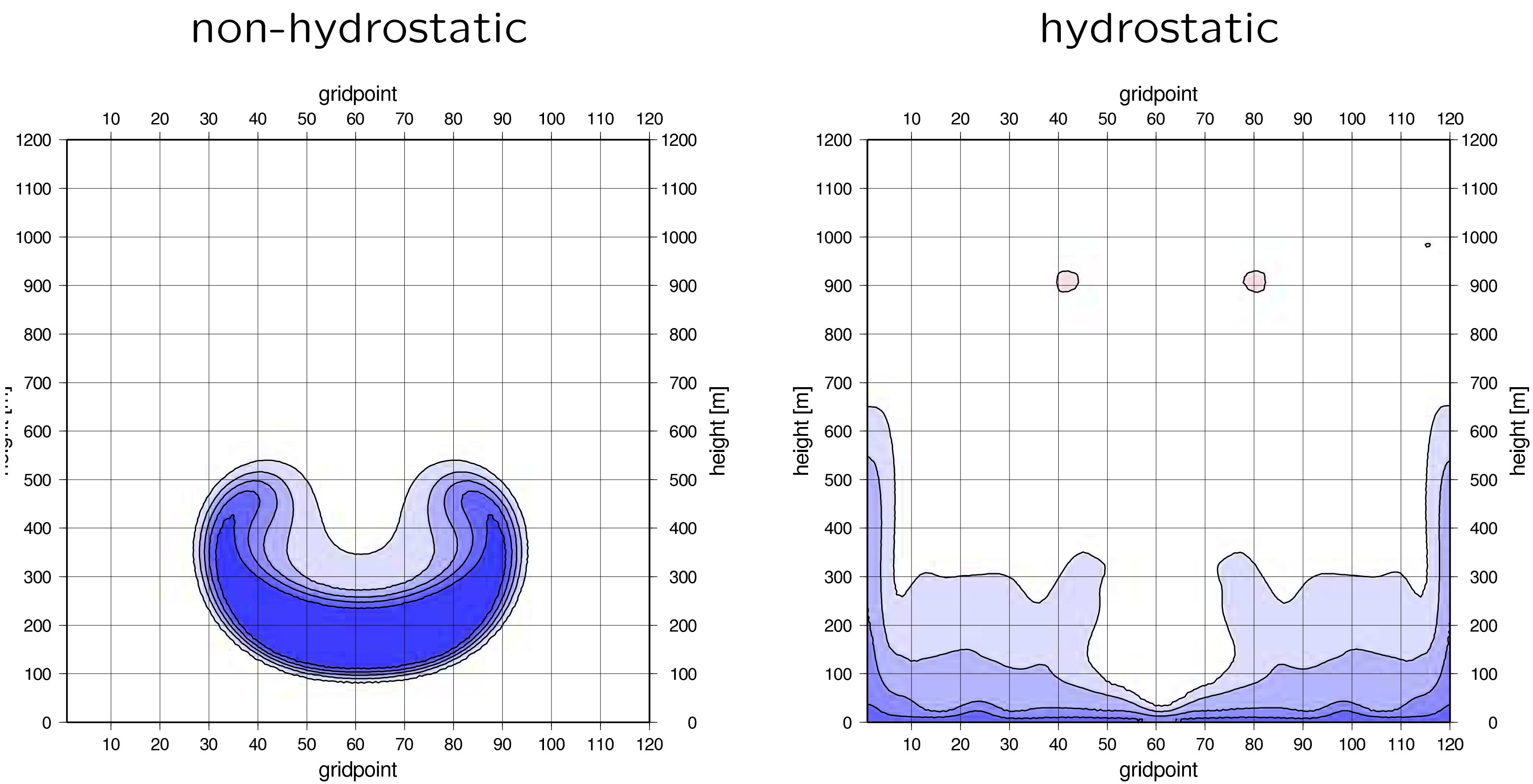
Cold bubble test



$$\Delta x = 10\,\mathrm{m},\ t = 200\,\mathrm{s}$$

Toward the NH dynamics

Cold bubble test

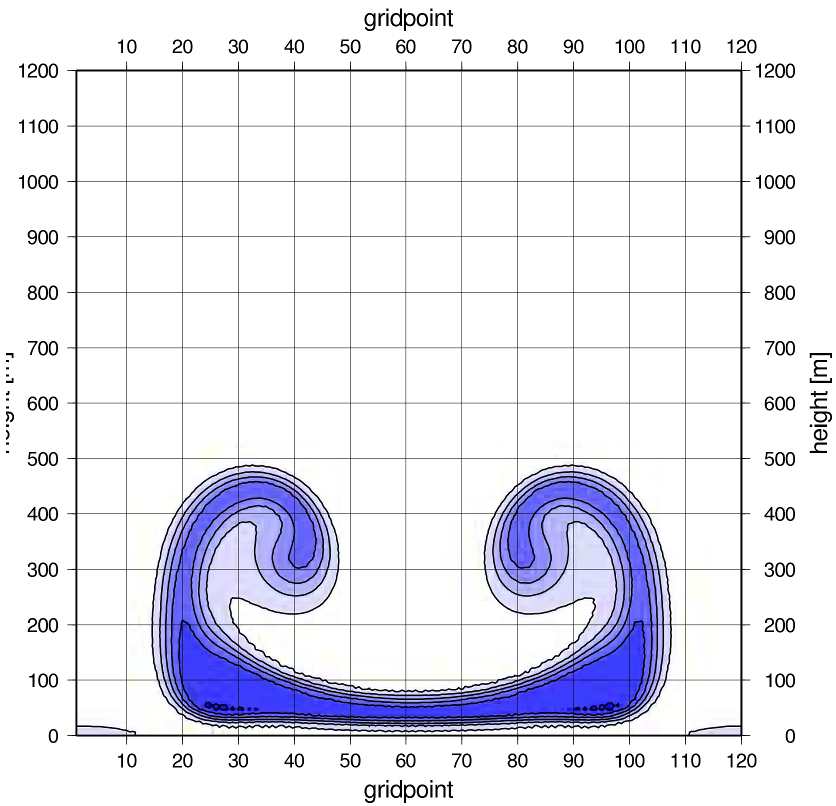


$\Delta x = 10\,\mathrm{m},\ t = 400\,\mathrm{s}$

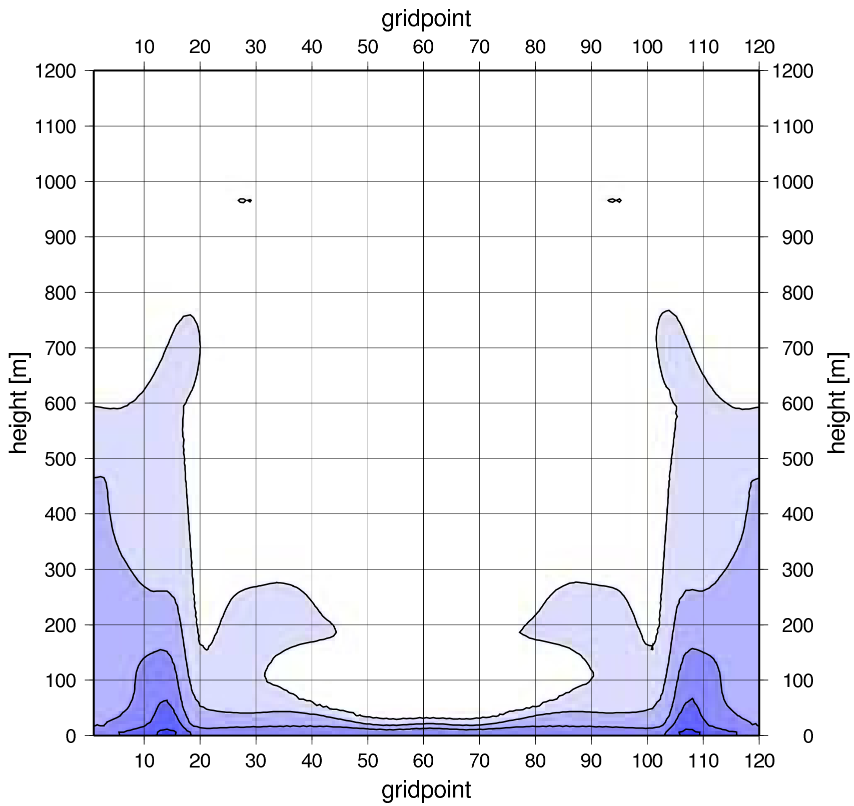
Toward the NH dynamics

Cold bubble test

non-hydrostatic



hydrostatic



$\Delta x = 10\,\mathrm{m},\ t = 600\,\mathrm{s}$

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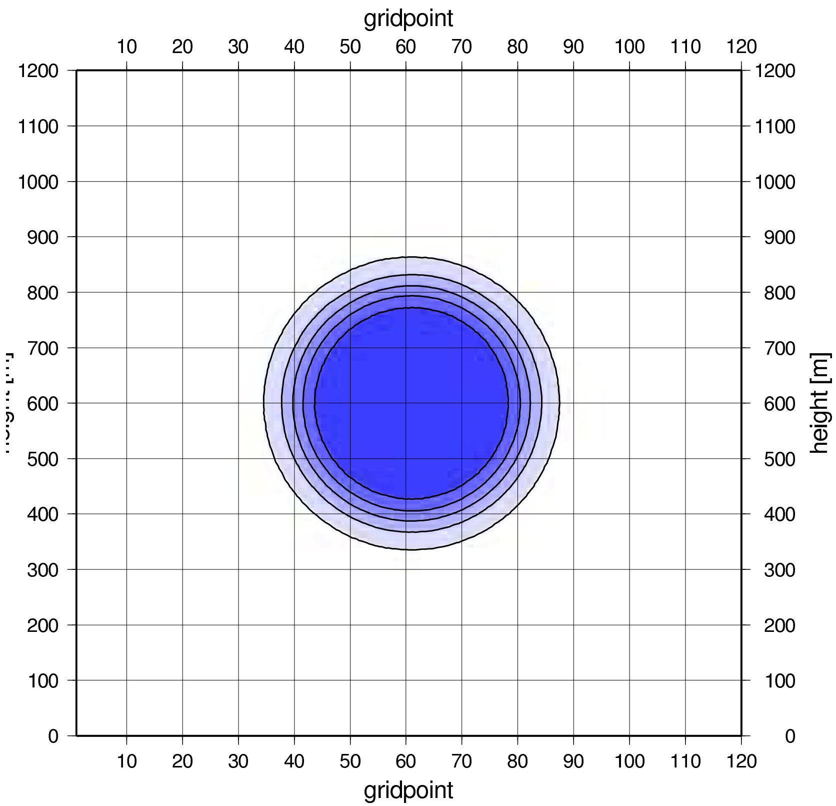
ALADIN

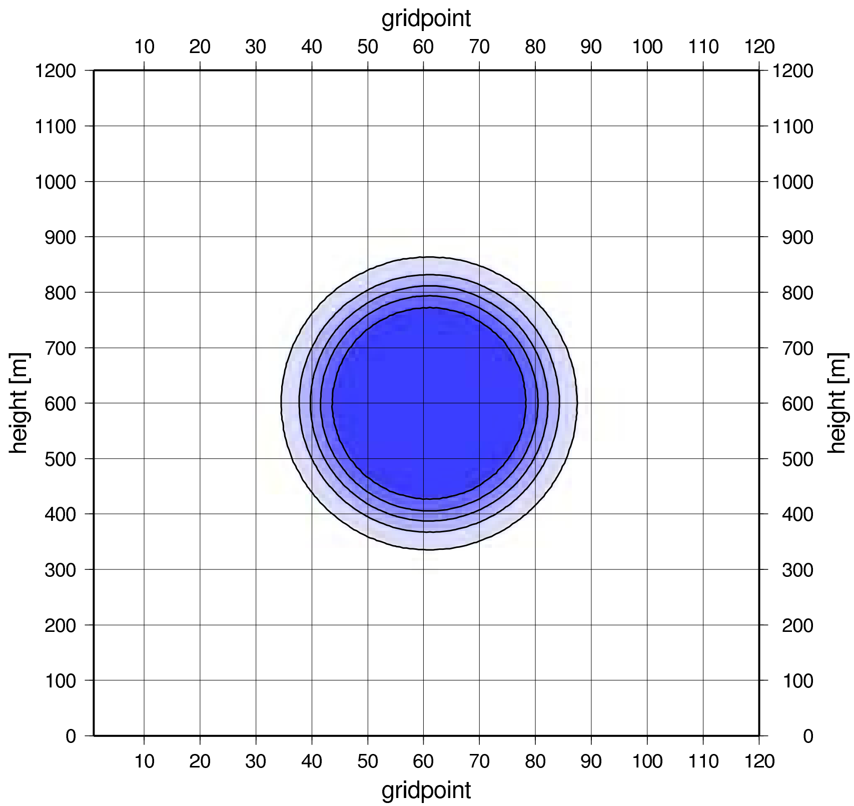
Toward the NH dynamics

Cold bubble test

non-hydrostatic



hydrostatic



$\Delta x = 1\,\mathrm{km},\ t = 0\,\mathrm{min}$

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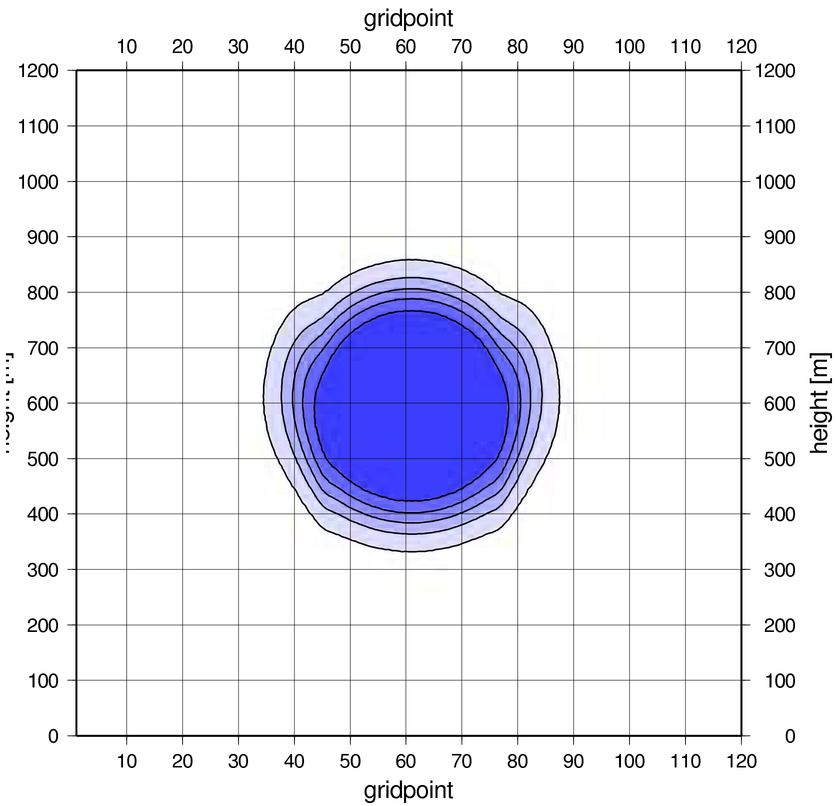
ALADIN

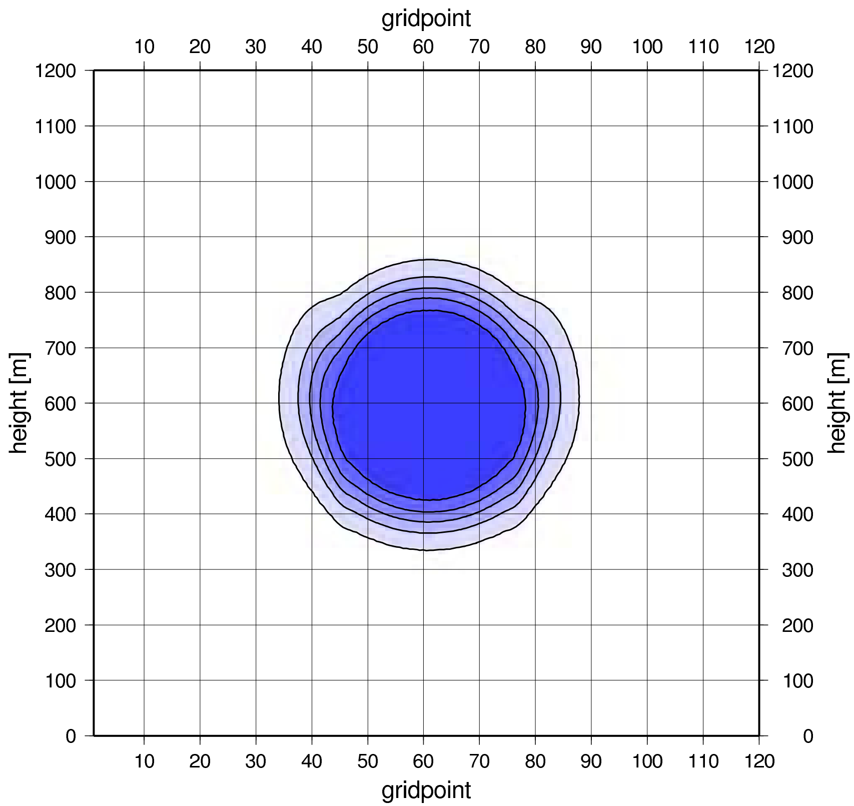
Toward the NH dynamics

Cold bubble test

non-hydrostatic



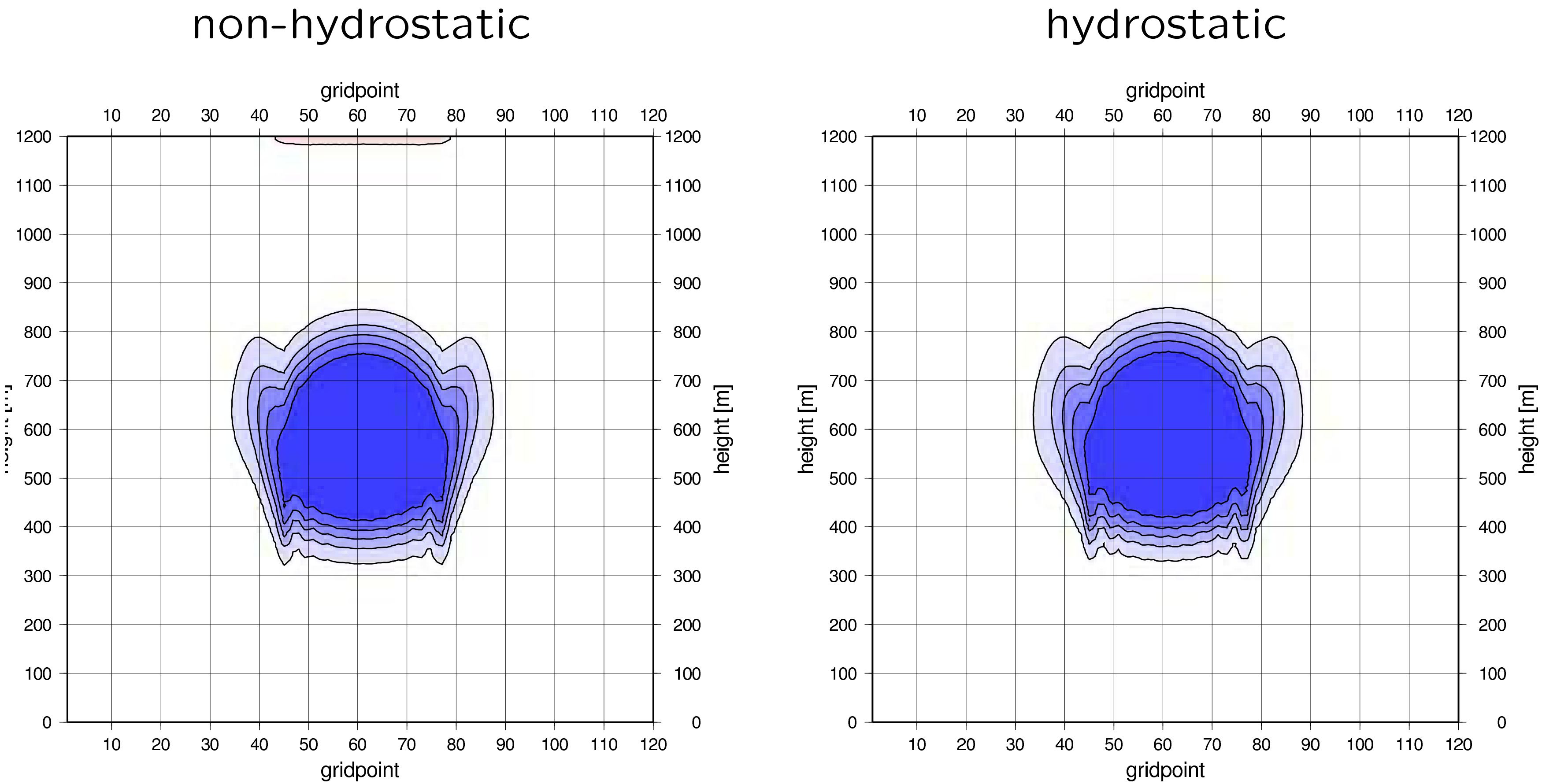
hydrostatic



$\Delta x = 1\,\mathrm{km},\ t = 20\,\mathrm{min}$

Toward the NH dynamics

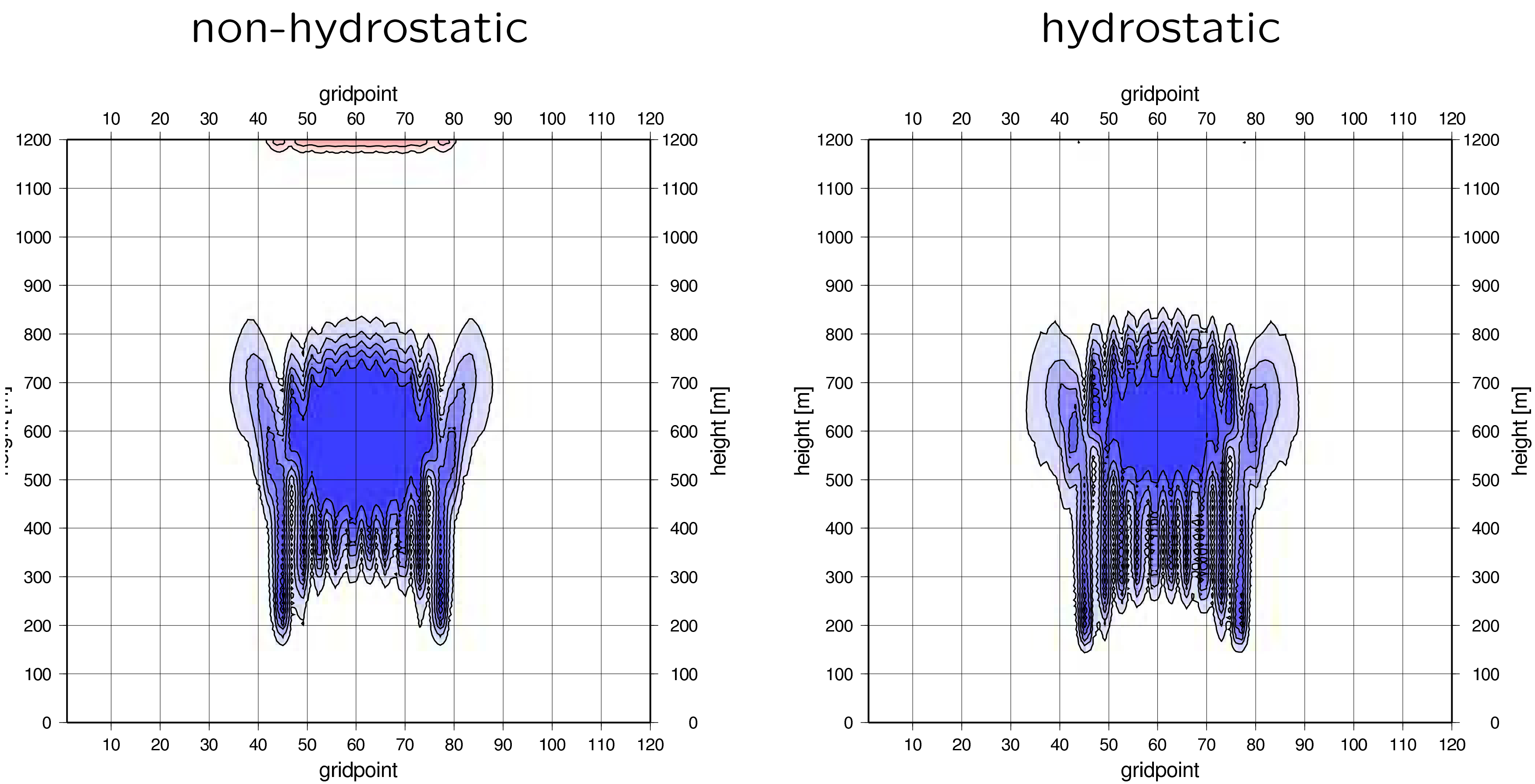
Cold bubble test



$\Delta x = 1\,\mathrm{km},\ t = 40\,\mathrm{min}$

Toward the NH dynamics

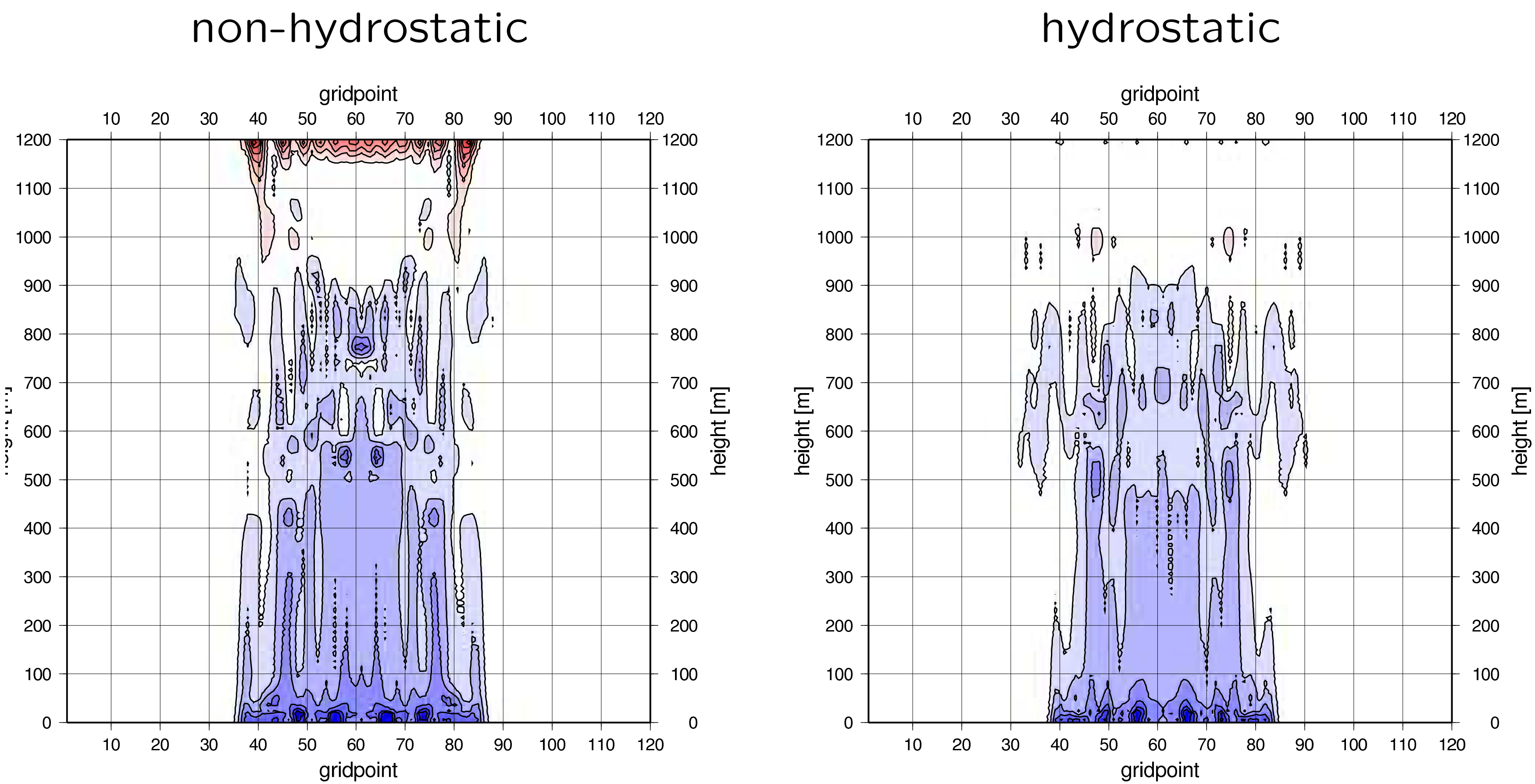
Cold bubble test



$\Delta x = 1\,\mathrm{km},\ t = 1\,\mathrm{h}$

Toward the NH dynamics

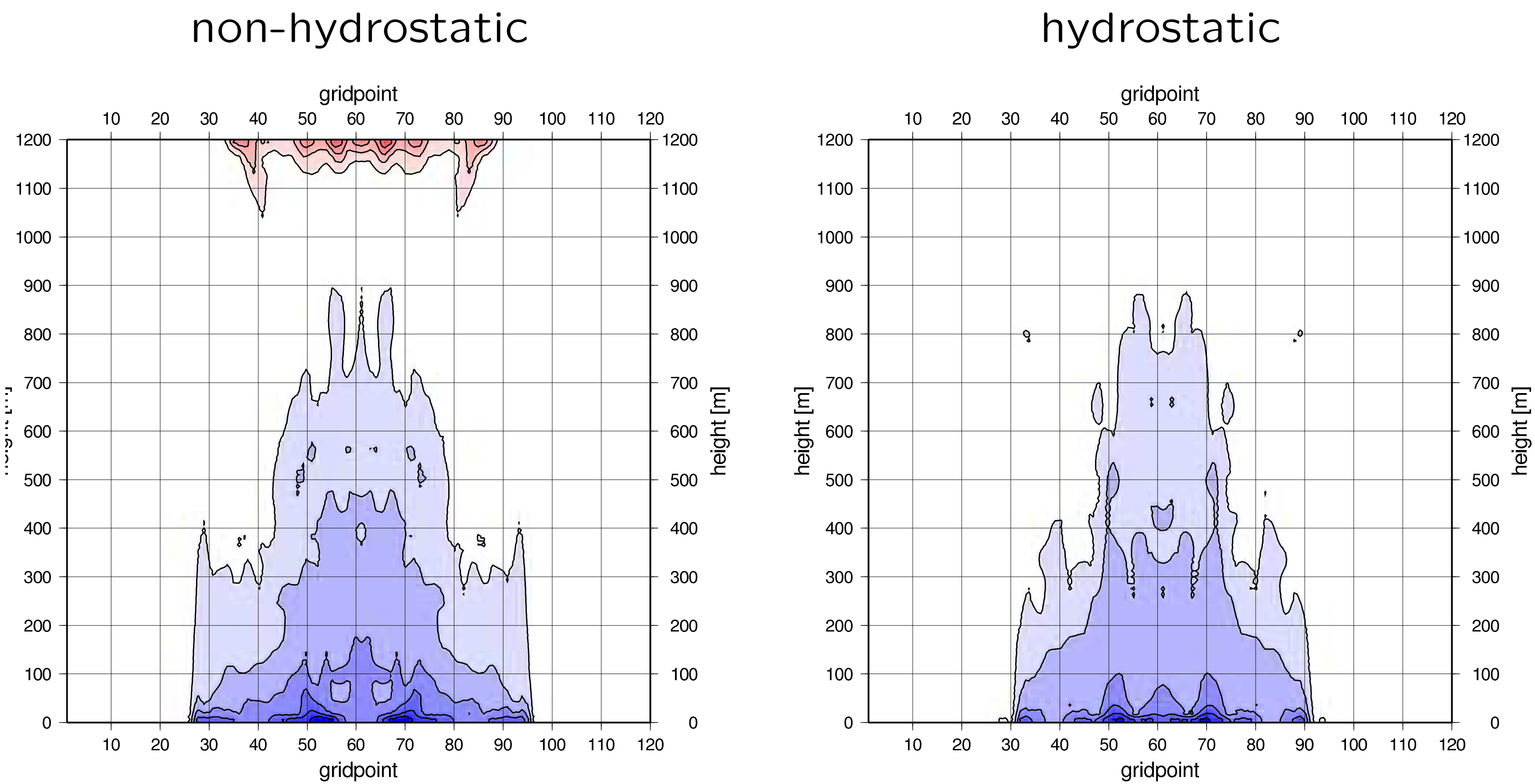
Cold bubble test



$\Delta x = 1\,\mathrm{km},\ t = 2\,\mathrm{h}$

Toward the NH dynamics

Cold bubble test



$\Delta x = 1\,\mathrm{km},\ t = 4\,\mathrm{h}$

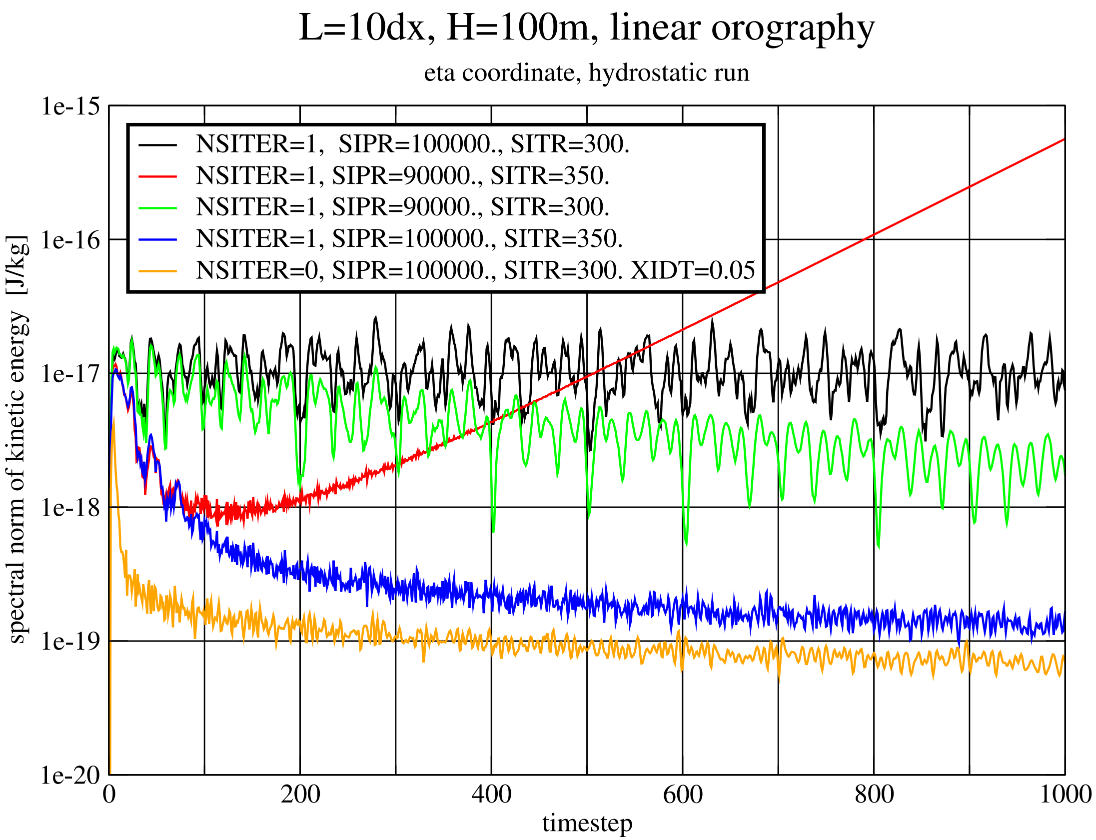
Toward the NH dynamics

Parallel suite ALADIN/CE, Δx=9 km, L43

- Identify eventual problems of NH dyn.
- Learn about the systematic extra value of the NH (for that scales)
- DA and LBC field are the same (hydrostatic)
- Comparable model settings (geometry, physics, timestep organization,. . .)
- Dynamics as close as possible to the hydrostatic reference
  - Horizontal diffusion, LBC coupling (two extra variables)
  - SI background (T^*, π^*)
  - vertical discretization

Toward the NH dynamics

Impact of the SI background



2D model, time evolution of KE

Toward the NH dynamics

Vertical discretization

	HYD	NH
`NDLNPR=0`	yes	-
`NDLNPR=1`	yes	yes
VFE	yes	*not yet*

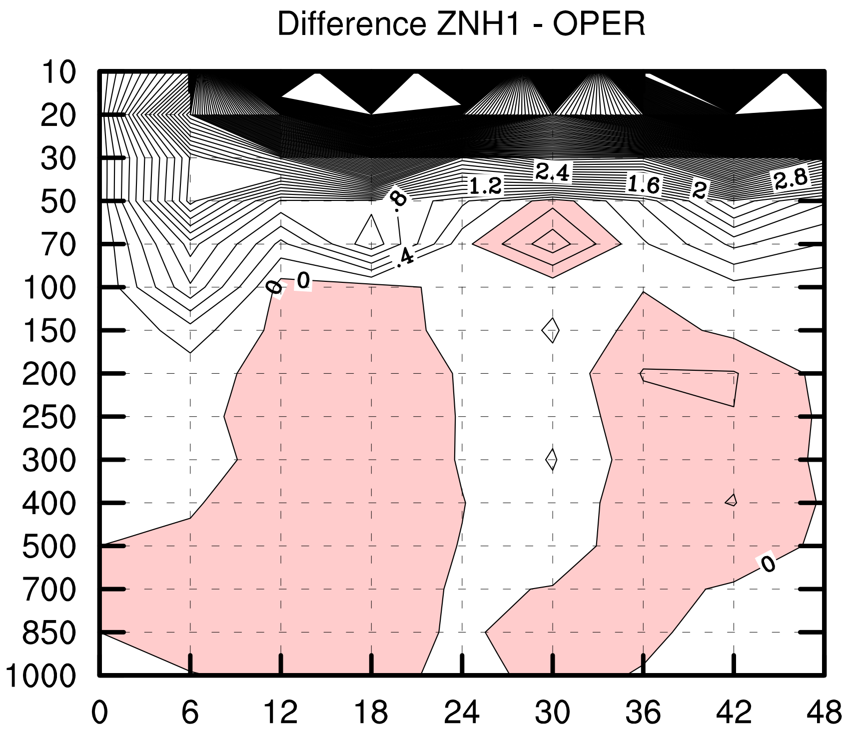
$$\texttt{NDLNPR} = 0: \quad \delta_l = \frac{\delta\pi_l}{\pi_l} = \delta \ln \pi_l = \ln\left(\frac{\pi_{\tilde{l}}}{\pi_{\tilde{l}-1}}\right)$$

$$\texttt{NDLNPR} = 1: \quad \delta_l = \frac{\delta\pi_l}{\pi_l} = \frac{\pi_{\tilde{l}} - \pi_{\tilde{l}-1}}{\sqrt{\pi_{\tilde{l}}\pi_{\tilde{l}-1}}}$$

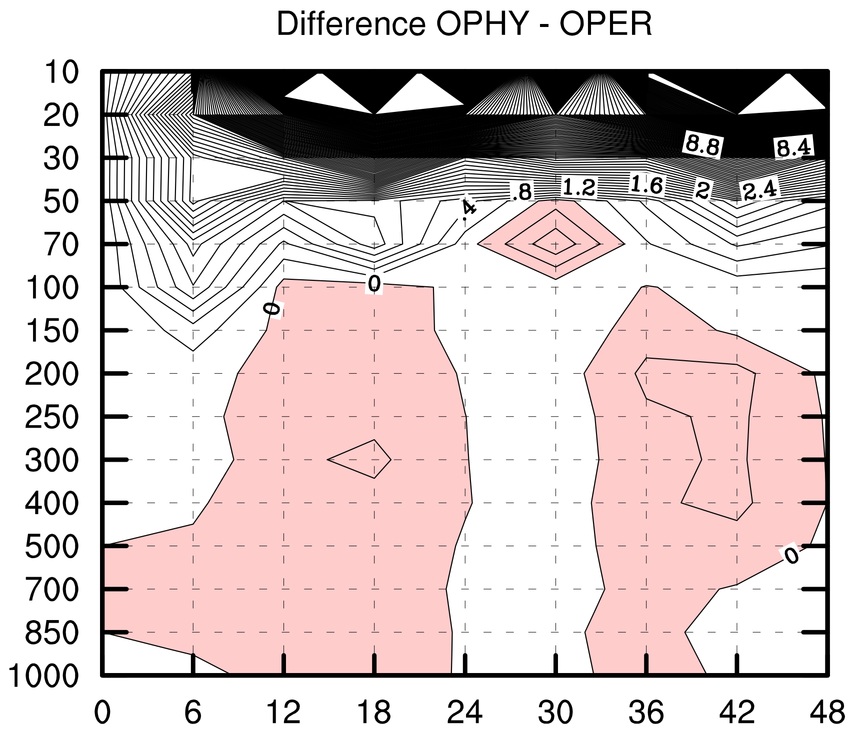
Toward the NH dynamics

Vertical discretization (II.)

rmse of geopotential height



default NH versus default hydr.

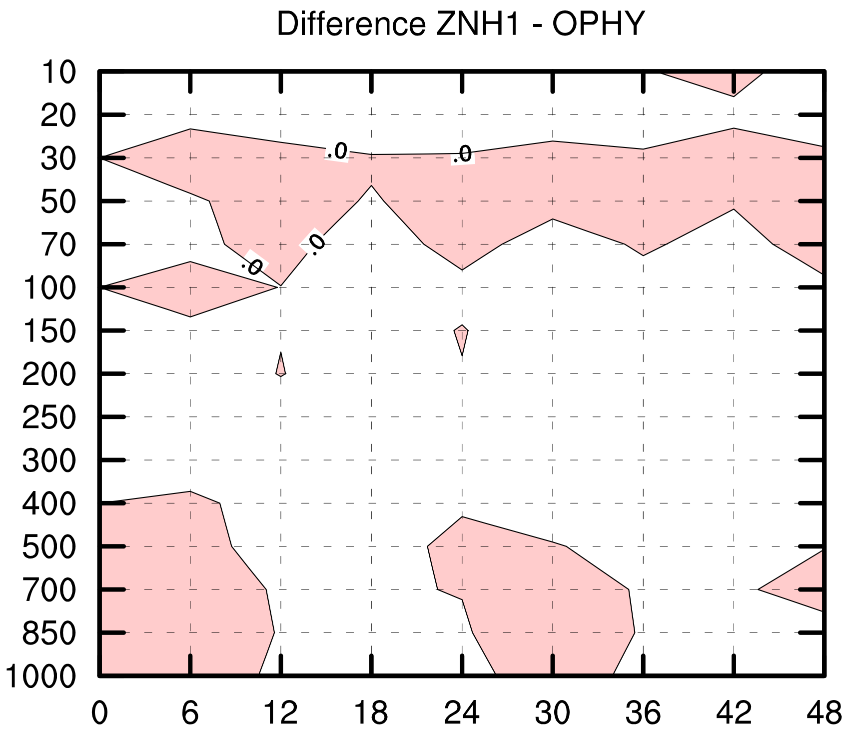


hydr. `NDLNPR`=1 vs. `NDLNPR`=0

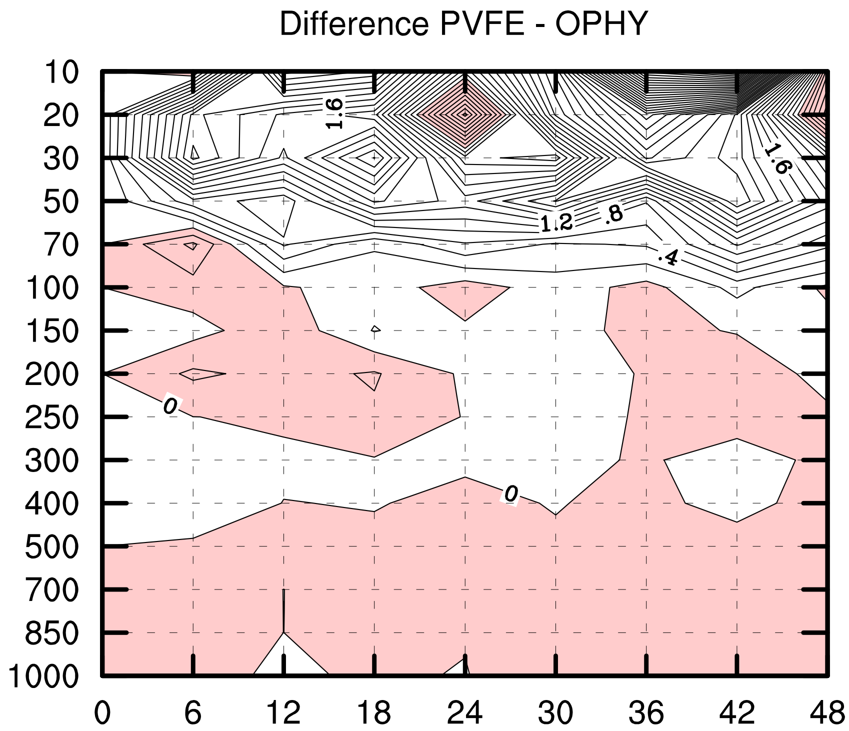
Toward the NH dynamics

Vertical discretization (II.)

rmse of geopotential height



NH versus hydr. (`NDLNPR`=1)



VFE vs. `NDLNPR`=1 (both hydr.)

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Toward the NH dynamics

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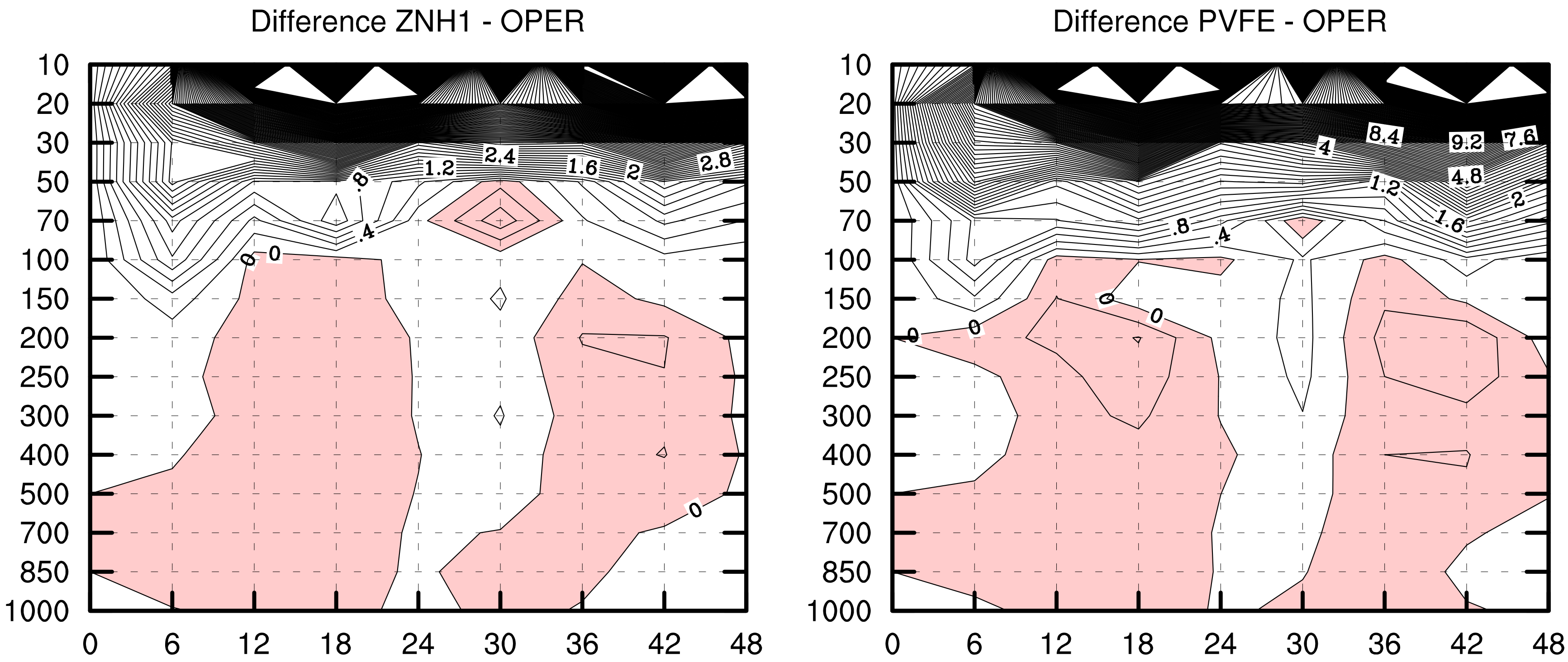
rmse of geopotential height



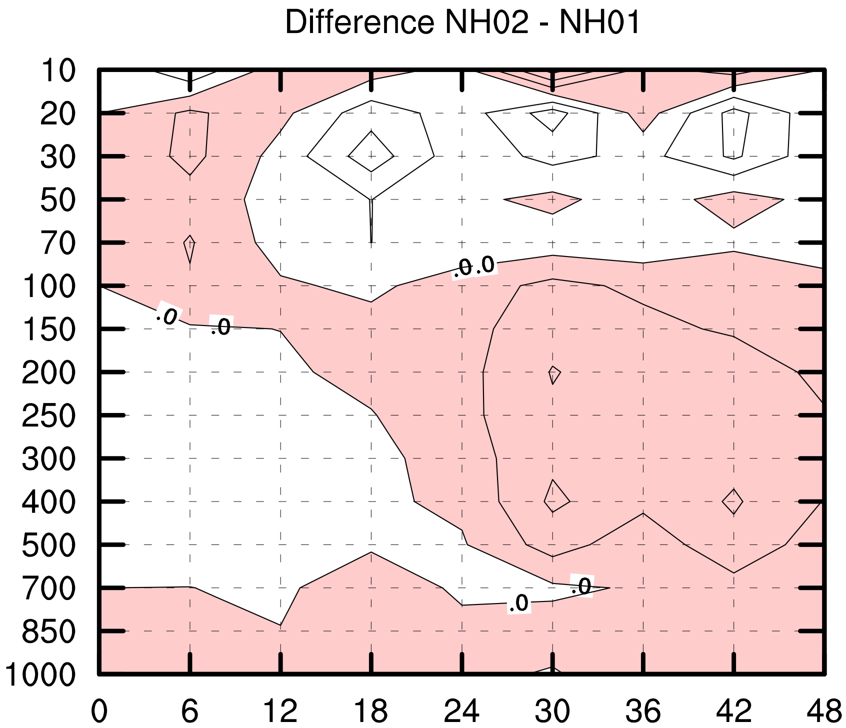
default NH versus def. hydr. hydr. VFE vs. def. hydr.

⇒ Higher sophistication of vertical discretization has potential to improve result, especially when provided by sufficient vertical resolution.

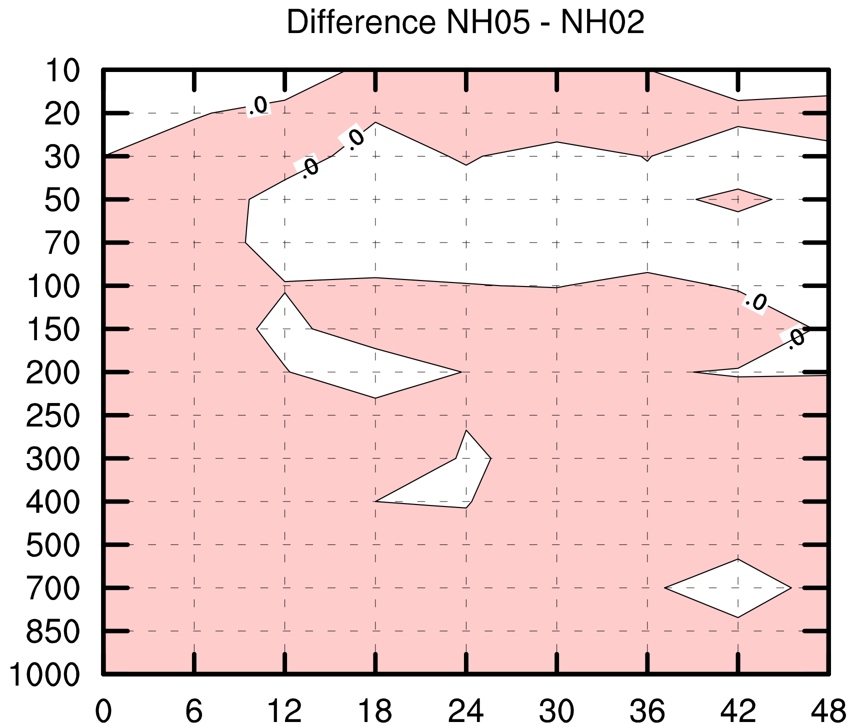
Toward the NH dynamics

ICI versus SI scheme

rmse of geopotential height



NSITER = 1 vs. NSITER = 0

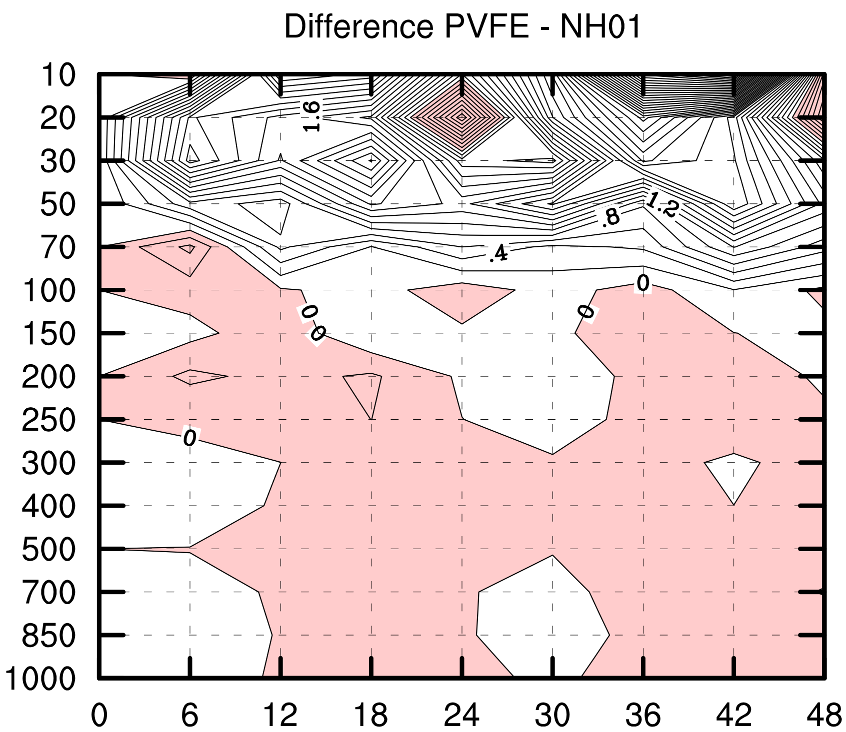


NSITER = 3 vs. NSITER = 1

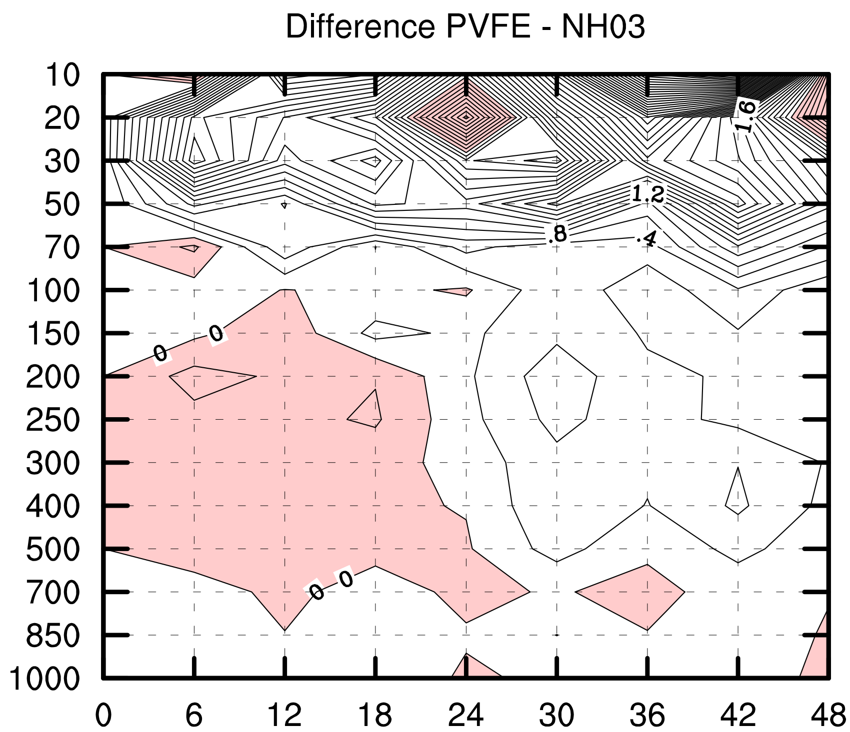
Toward the NH dynamics

ICI versus SI scheme (II.)

rmse of geopotential height



VFE (hydr.) vs. HN (`NSITER` = 0)

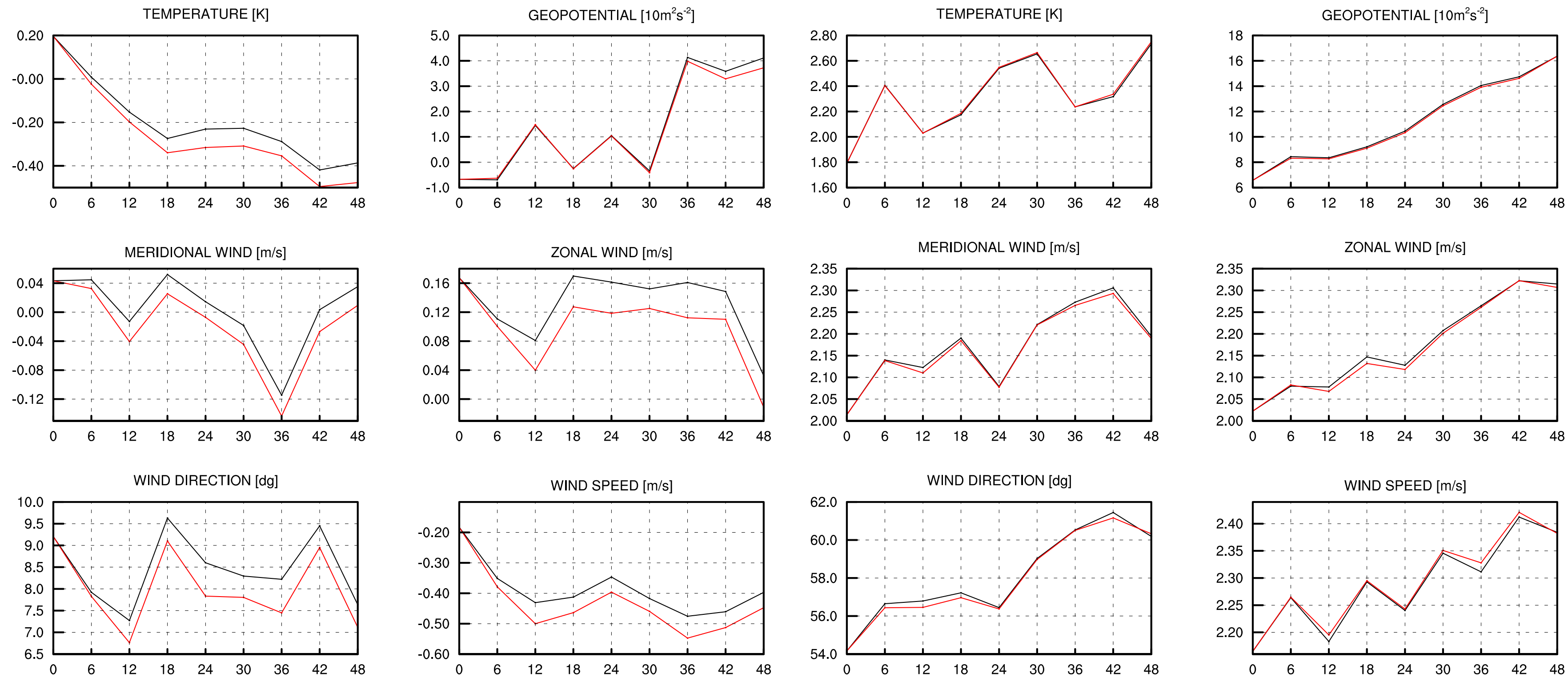


VFE (hydr.) vs. NH (`NSITER` = 1)

Toward the NH dynamics

ICI versus SI scheme (III.)

Surface parameters (`NSITER`=1 vs. `NSITER`=0)



bias rmse

Toward the NH dynamics

Summary (for LAM, Δx=9 km, L43)

- NH vs. hydrostatic
  - more variability of wind in PBL (better bias, worse stde)
  - otherwise no significant signal at all

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Toward the NH dynamics

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- GP-w option (`LGVADW`)
  - no significant signal at all

Toward the NH dynamics

Conclusions

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configuration	CPU increase (NEC-SX6, OpenMP)
hydr. `NDLNPR`=0	1.
hydr. `NDLNPR`=1	1.
hydr. VFE	1.15
NH SI	1.08
NH ICI (`NSITER`=1)	1.52
NH ICI, GP-w (`NSITER`=1)	1.49
NH ICI (`NSITER`=3)	2.32

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- To be repeated with Δx=4.5km, L87

Pressure gradient term

PG scheme of Simmons & Jiabin (1990)

The present form:

$$\nabla\Phi + RT\nabla(\ln p)$$

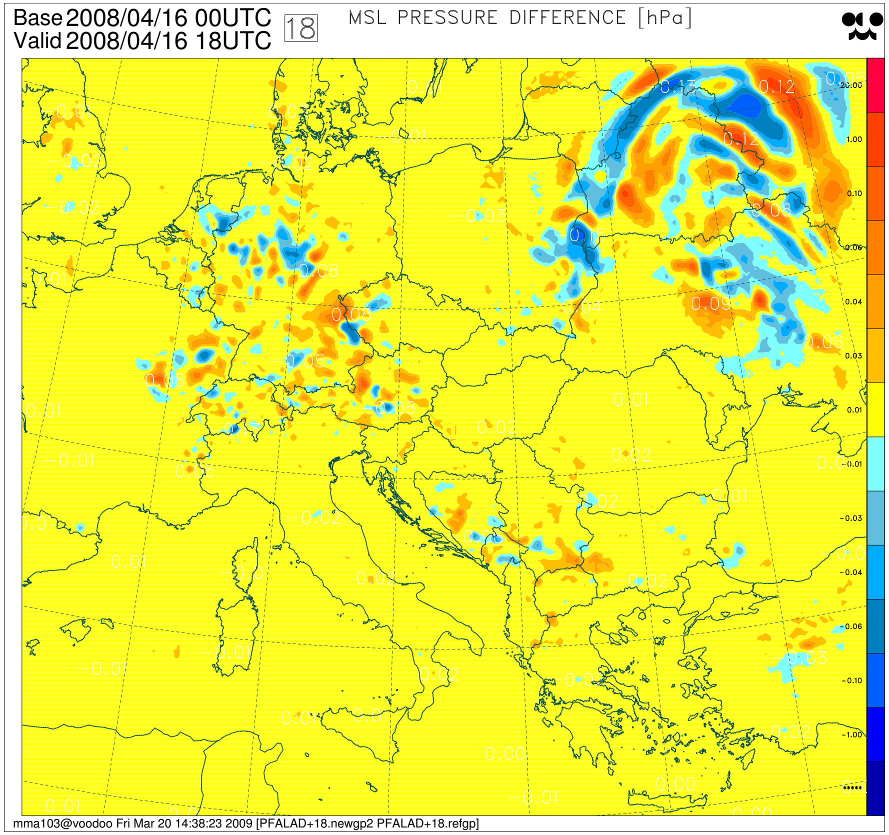
is replaced by:

$$\nabla\tilde{\Phi} + R_d\tilde{T}\nabla(\ln p)$$

with
$$\tilde{T} = T_v - T_0\,(p/p_0)^\alpha$$
$$\tilde{\Phi} = \Phi_s + \frac{R_d T_0}{\alpha}\,(p/p_0)^\alpha + \int_p^{p_s}\frac{R_d\tilde{T}}{p}dp$$

Pressure gradient term

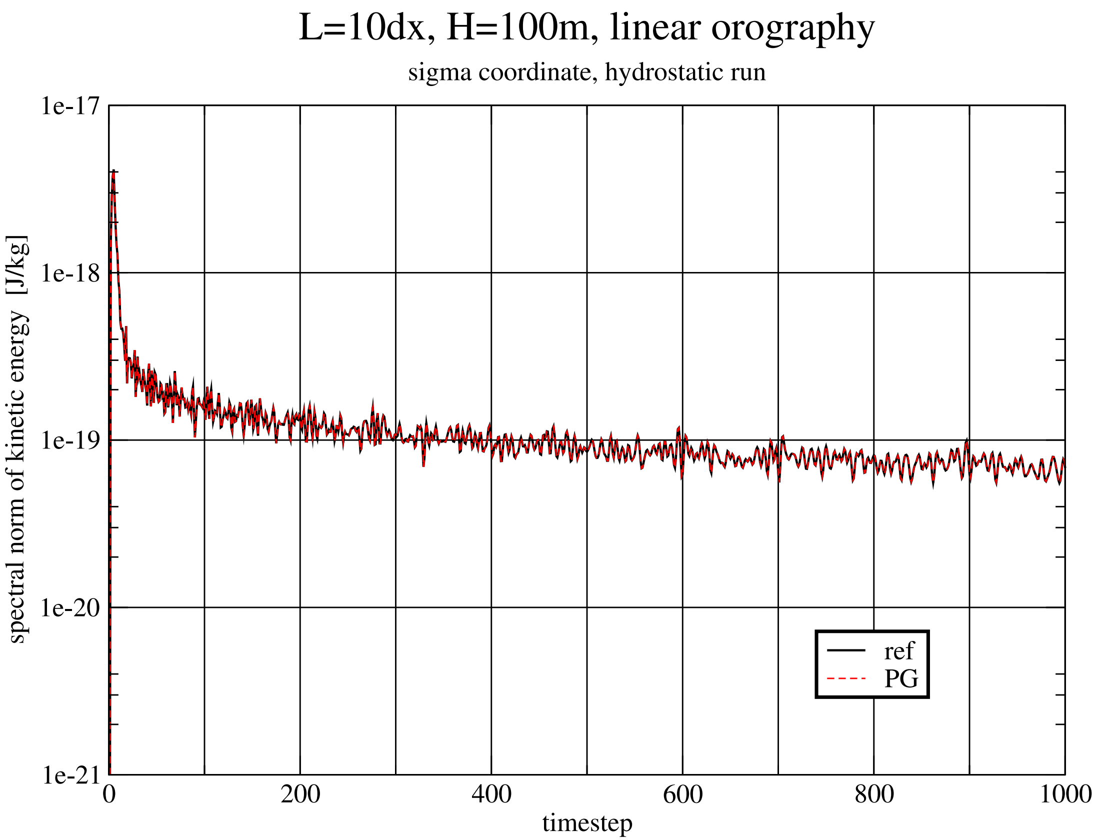
First preliminary results (Δx=9km)



PG scheme - ref scheme

Pressure gradient computation

Tests in 2D (HYD)



Still too easy for the pressure gradient term. . .

Other development

- Rotated Mercator projection (including TL/AD)
- More OpenMP for LAM (enabled MPI-OpenMP, intelligent scheduling,. . .)
- Optimization of SL interpolations
- Separation of SL quantities to be interpolated (DDH & 3D turb)
- Fully elastic projection of heat
- Boyd’s technique for bi-periodicity of LAM