Efficient semi-implicit discretizations on terrain intersecting grids for high resolution atmospheric models

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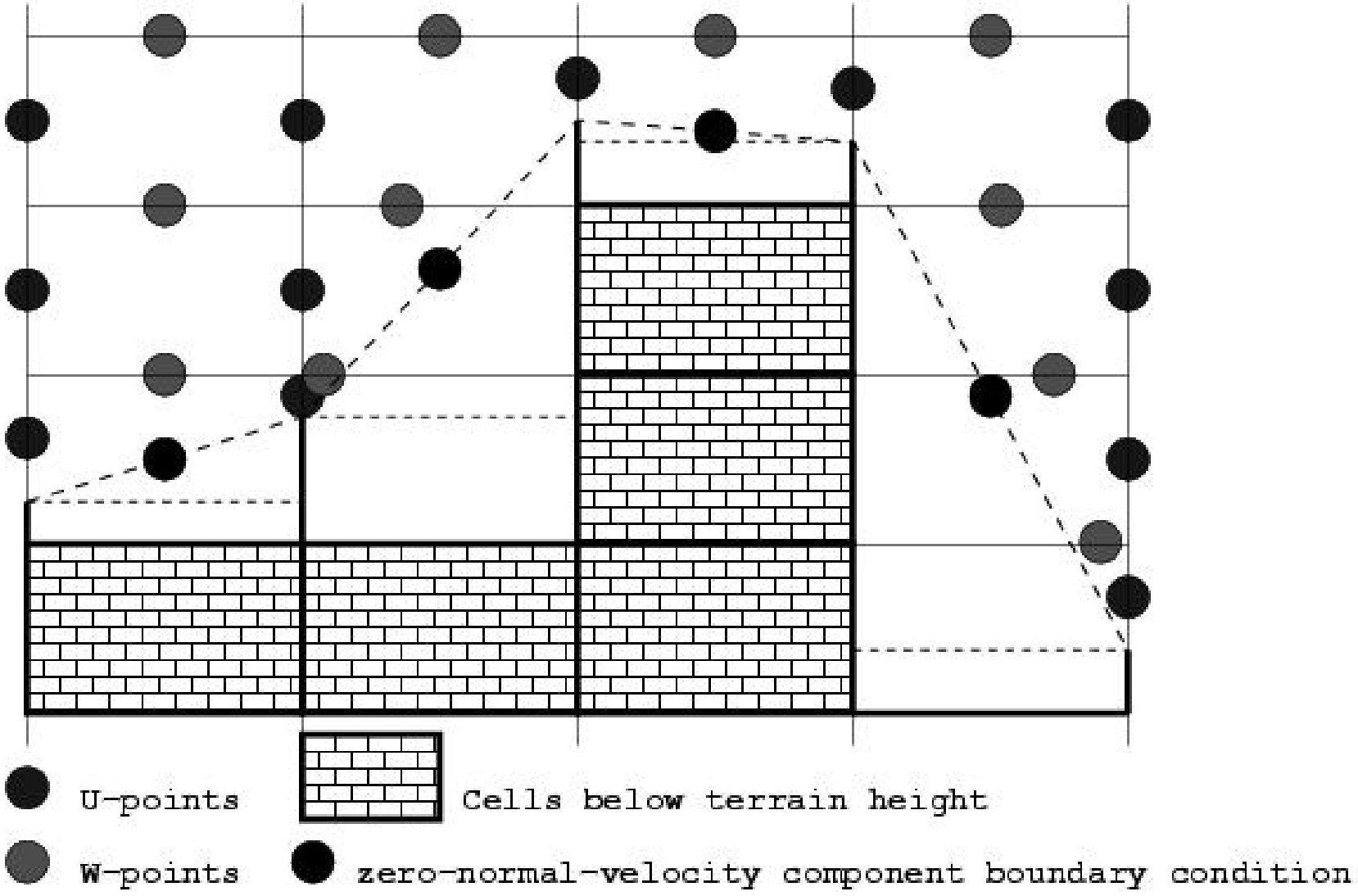
Outline of discretization approach

(L.B., JCP 2000)

- **Semi-implicit, semi-lagrangian two time level discretization of the Euler equations**
- **Finite volume discretization of the divergence**
- **Horizontal C grid, vertical Charney Phillips**
- **Improved interpolation at the boundary for SL advection, RBF interpolators (joint work with G.Rosatti, University of Trento)**

Computational grid

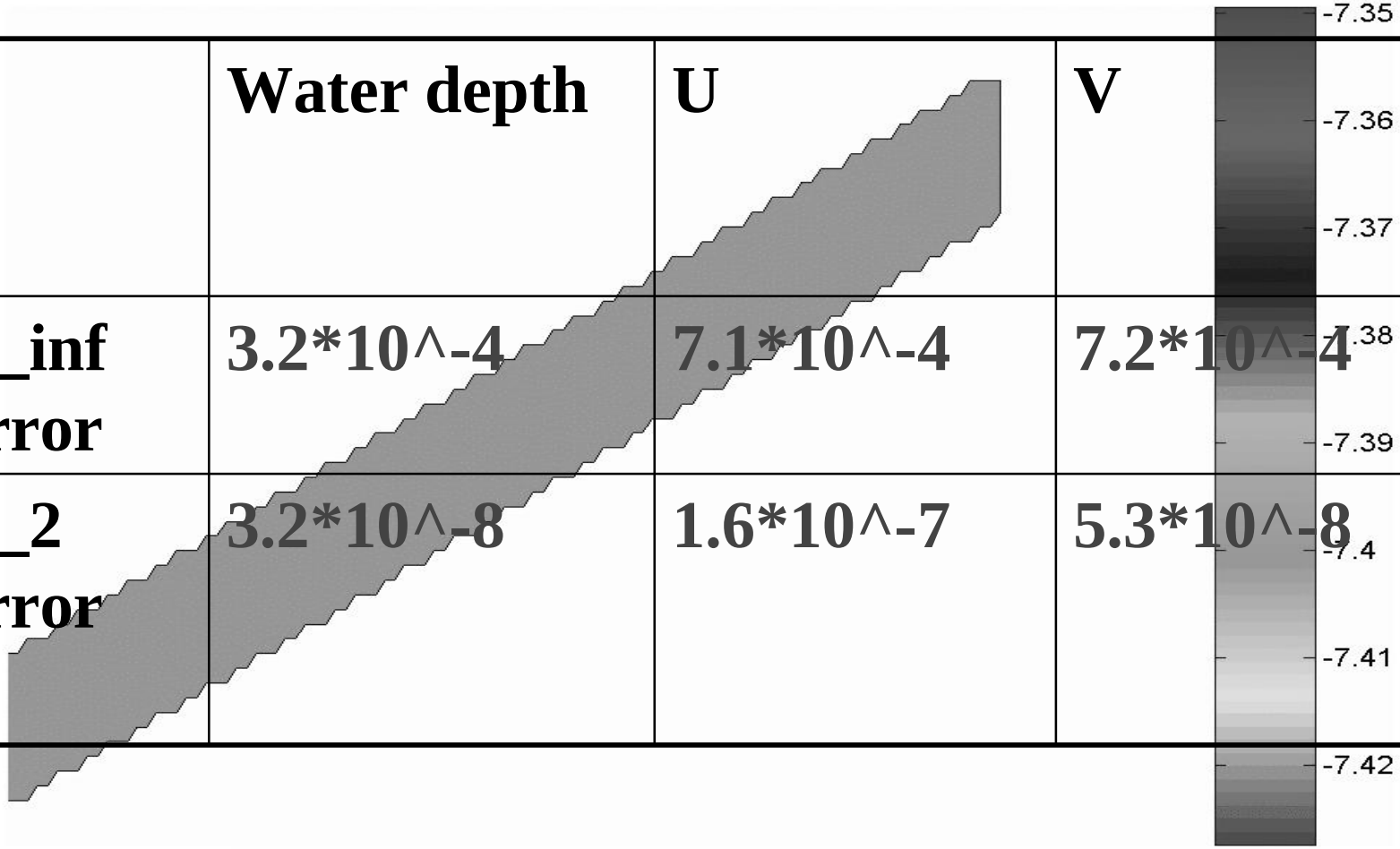


The solver

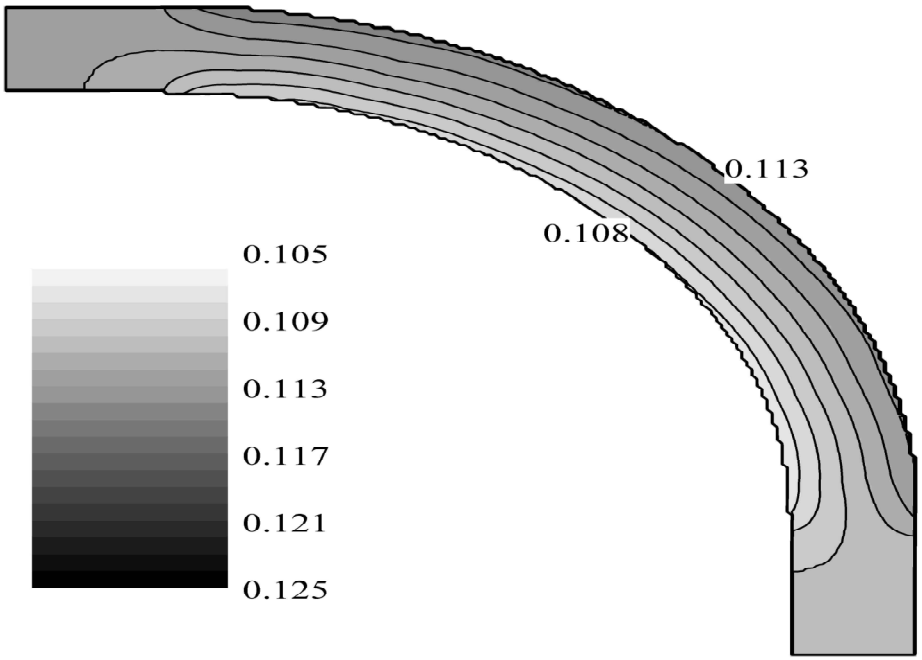
- **Weakly nonlinear system Ax+f(x)=b: fixed point iteration with PCG as linear kernel**
- **Convergence of nonlinear iterations**
- **Linear part A: symmetric and well conditioned independently of orography**
- **Block tridiagonal preconditioning with linear operators of vertical discretization**
- **Fully MPI-parallel and portable code**
- **Next: domain decomposition preconditioners**

Applications to open channel flow: straight channel

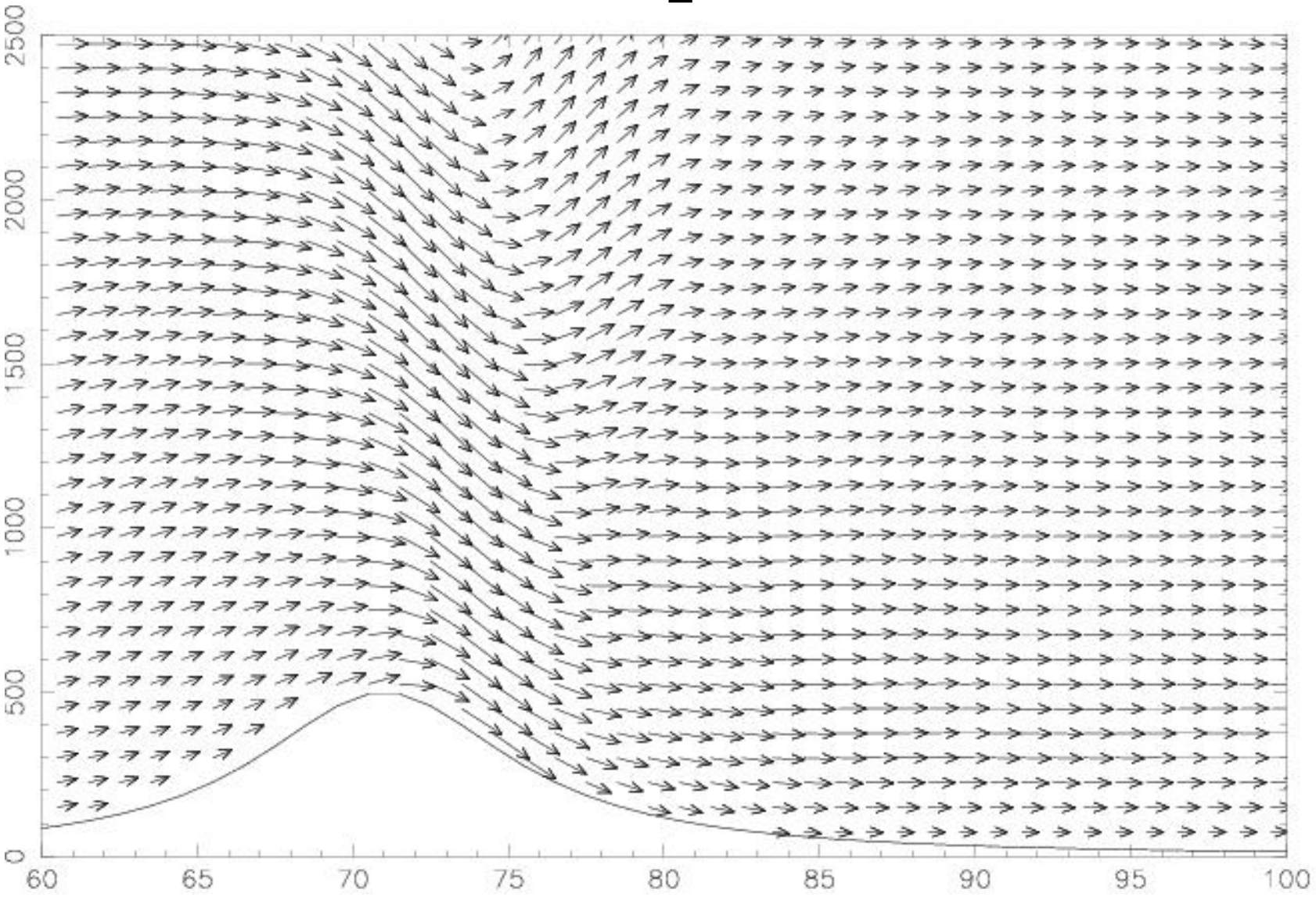
	Water depth	U	V
L_inf error	3.2*10^-4	7.1*10^-4	7.2*10^-4
L_2 error	3.2*10^-8	1.6*10^-7	5.3*10^-8



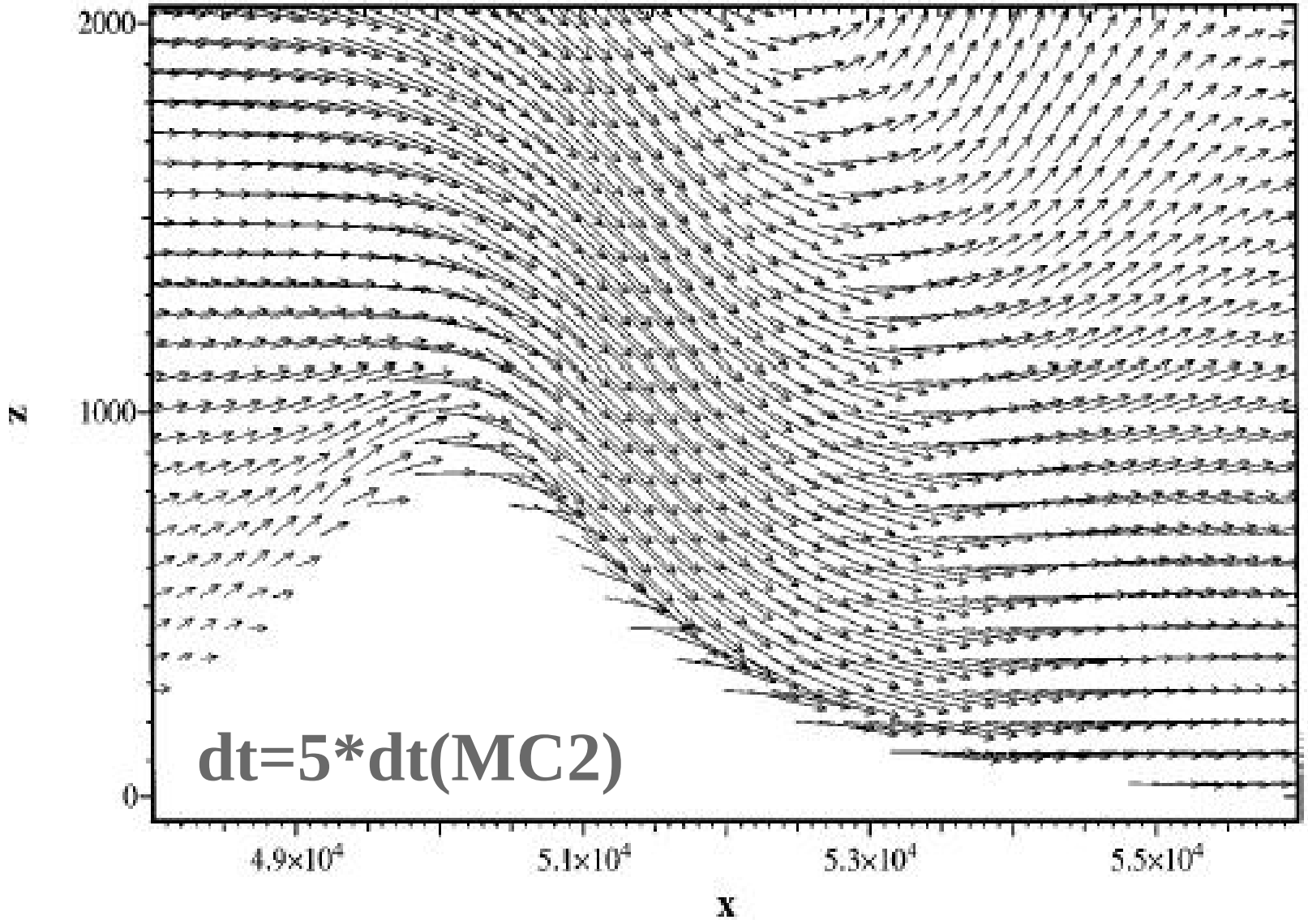
Applications to open channel flow: curved channel



2D Gallus-Klemp lee wave test case



2D nonlinear, nonhydrostatic test



Comparison with terrain following semi-implicit LM

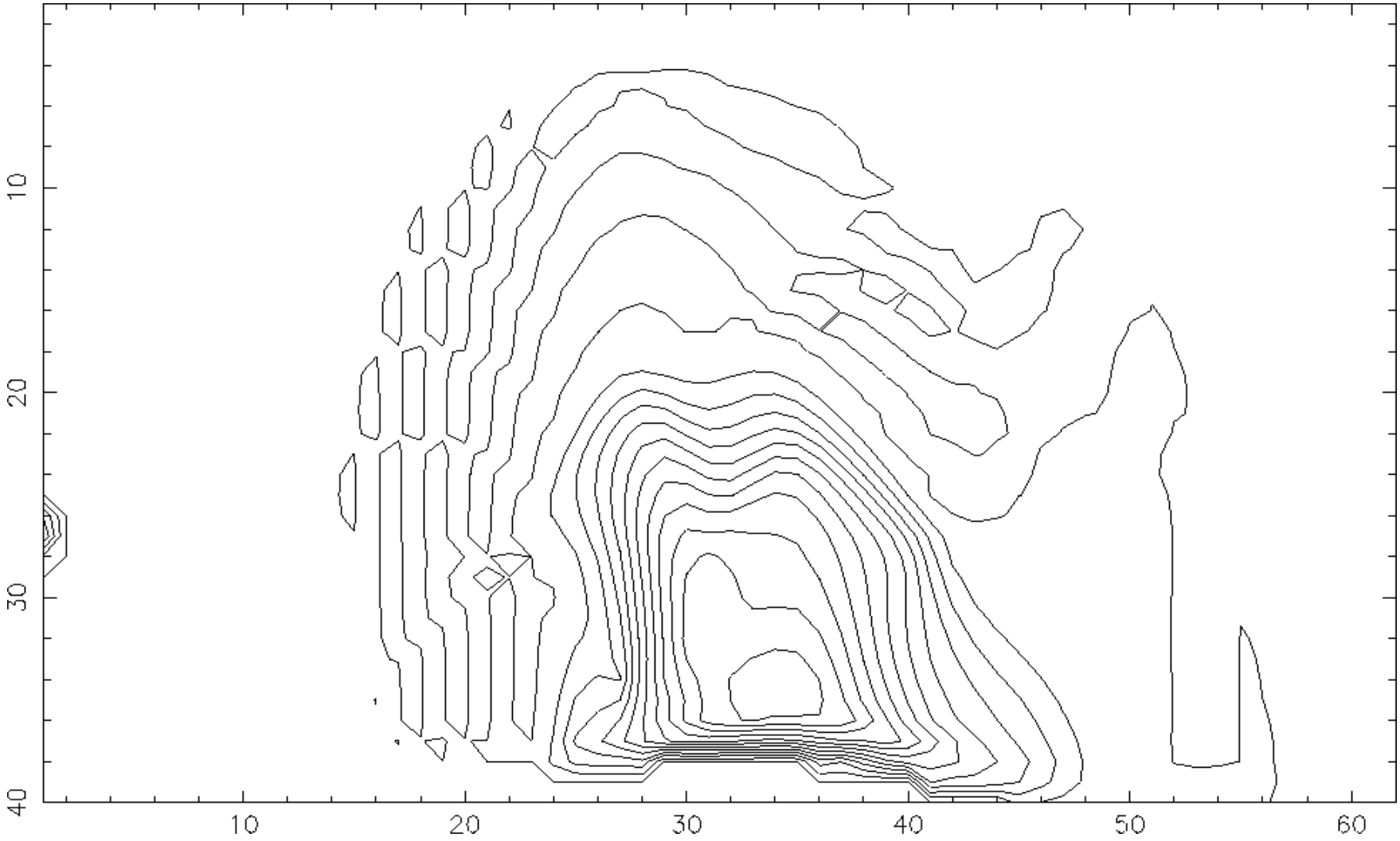
- **Difficulty of a fair comparison (different stopping criteria and implementation details)**
- **Slower convergence of iterative solver for terrain following semi-implicit**

	Residual 1% of initial value	Residual 0.1% of initial value	Residual 0.01% of initial value
SI iterations	**6**	**21**	**50**
SIZ iterations	**8**	**17**	**21**

Parallel run with 36 processors (3D lee wave test)

	Total CPU time for 1 hour	CPU time solver	COMM time solver	Fastest /slowest ratio
SE	88.95 s	45.03 s	11.95 s	1.4 s
SIZ	56.40 s	26.16 s	5.12 s	1.03 s

Setup of fair tests for efficiency comparison



Parallel run with 16 processors (3D cold bubble test)

	Total CPU time for 1 hour	CPU time solver	COMM time solver	CPU time advection	COMM time advection	Fastest /slowest ratio
SE	328 s	91 s	13.4 s	156 s	40.8 s	1.07
SIZ	207 s	119 s	13.4 s	65.4 s	7.4 s	1.02

Development plans

- **ARPA-SMR: development of a full SI-SL NWP model in the framework of the COSMO consortium adapting the LokalModell physics**

- **MPI: test tube for numerical methods to be used in ICON, the new global nonhydrostatic dynamical core**