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Davies Coupling in a Shallow-Water Model

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Motivation

High resolution NWP techniques:

- ★ **global model with variable resolution**

  ARPEGE 22 – 270 km

- ★ **low resolution driving model with nested high resolution LAM**

  DWD/GME → DWD/LM 60 km → 7 km

- ★ **combination of both methods**

  ARPEGE → ALADIN/LACE → ALADIN/SLOK

  25 km → 12 km → 7 km

WHY NESTED MODELS IMPROVE WEATHER - FORECAST

- the surface is more accurately characterized (orography, roughness, type of soil, vegetation, albedo …)
- more realistic parametrizations might be used, eventually some of the physical processes can be fully resolved in LAM
- own assimilation system $\Rightarrow$ better initial conditions (early phases of integration)

Shallow-water equations

- 1D system (Coriolis acceleration not considered)
- linearization around resting background

$$(g, H = const)$$

$$\frac{\partial u}{\partial t} = -g\frac{\partial h}{\partial x},$$

$$\frac{\partial h}{\partial t} = -H\frac{\partial u}{\partial x}$$

- forward-backward scheme
- centered finite differences

} DISCRETIZATION

Davies relaxation scheme

continuous formulation in **shallow-water system**

$$\frac{\partial u}{\partial t} = -g\frac{\partial h}{\partial x} - K(x)(u - u_{DM}),$$

$$\frac{\partial h}{\partial t} = -H\frac{\partial u}{\partial x} - K(x)(h - h_{DM}),$$

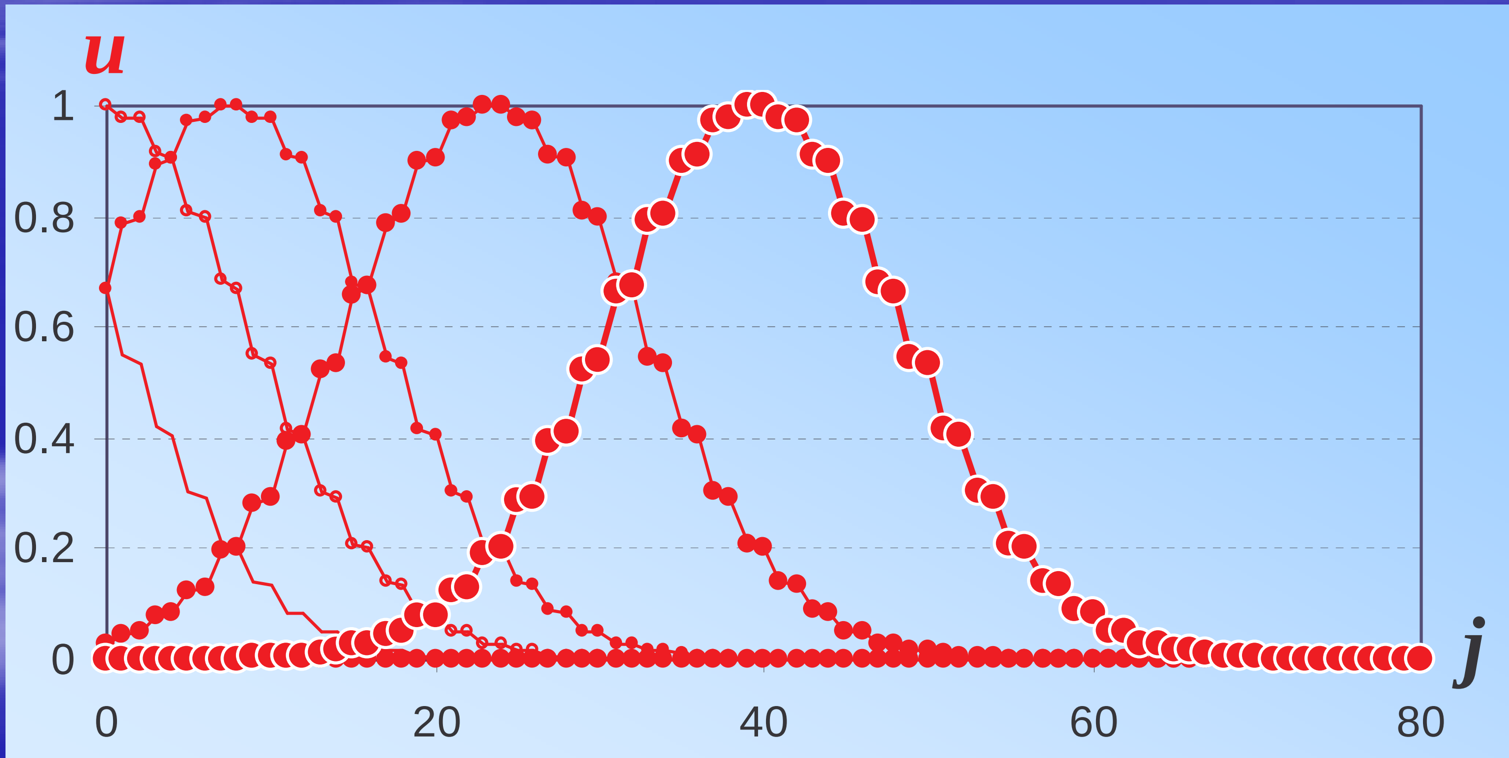
$$K(x) > 0$$

discrete formulation - general formalism:

$$X^{+} = (1-\beta)\cdot X^{+}_{LAM} + \beta \cdot X^{+}_{DM} \qquad X = \begin{pmatrix} u \\ h \end{pmatrix}$$

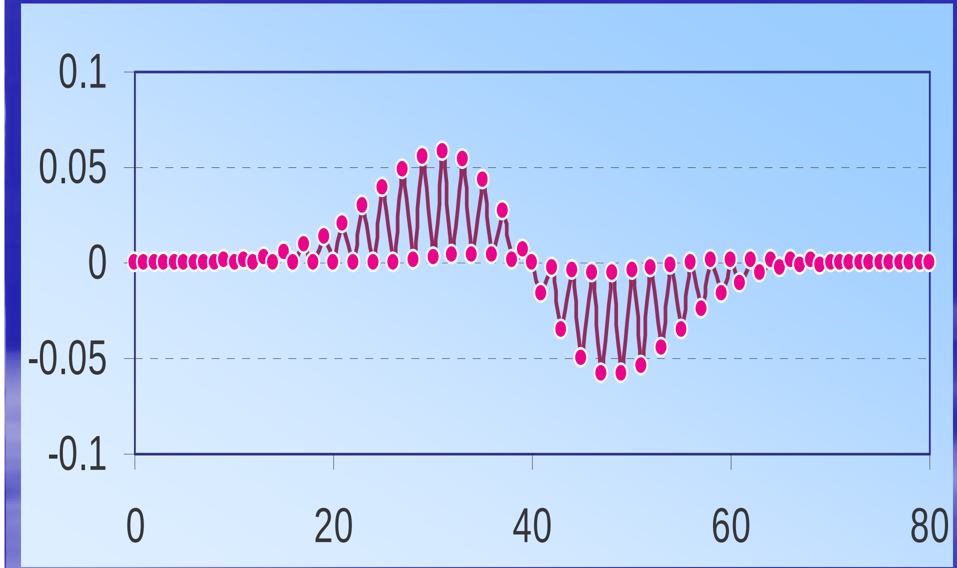
PROPERTIES OF DAVIES RELAXATION SCHEME

Input of the wave from the driving model

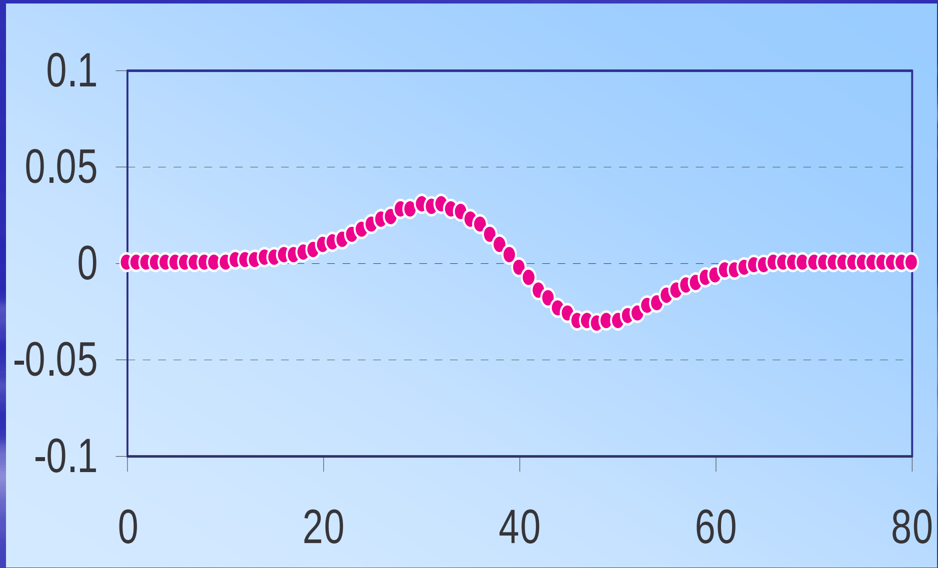


Difference between numerical and analytical solution

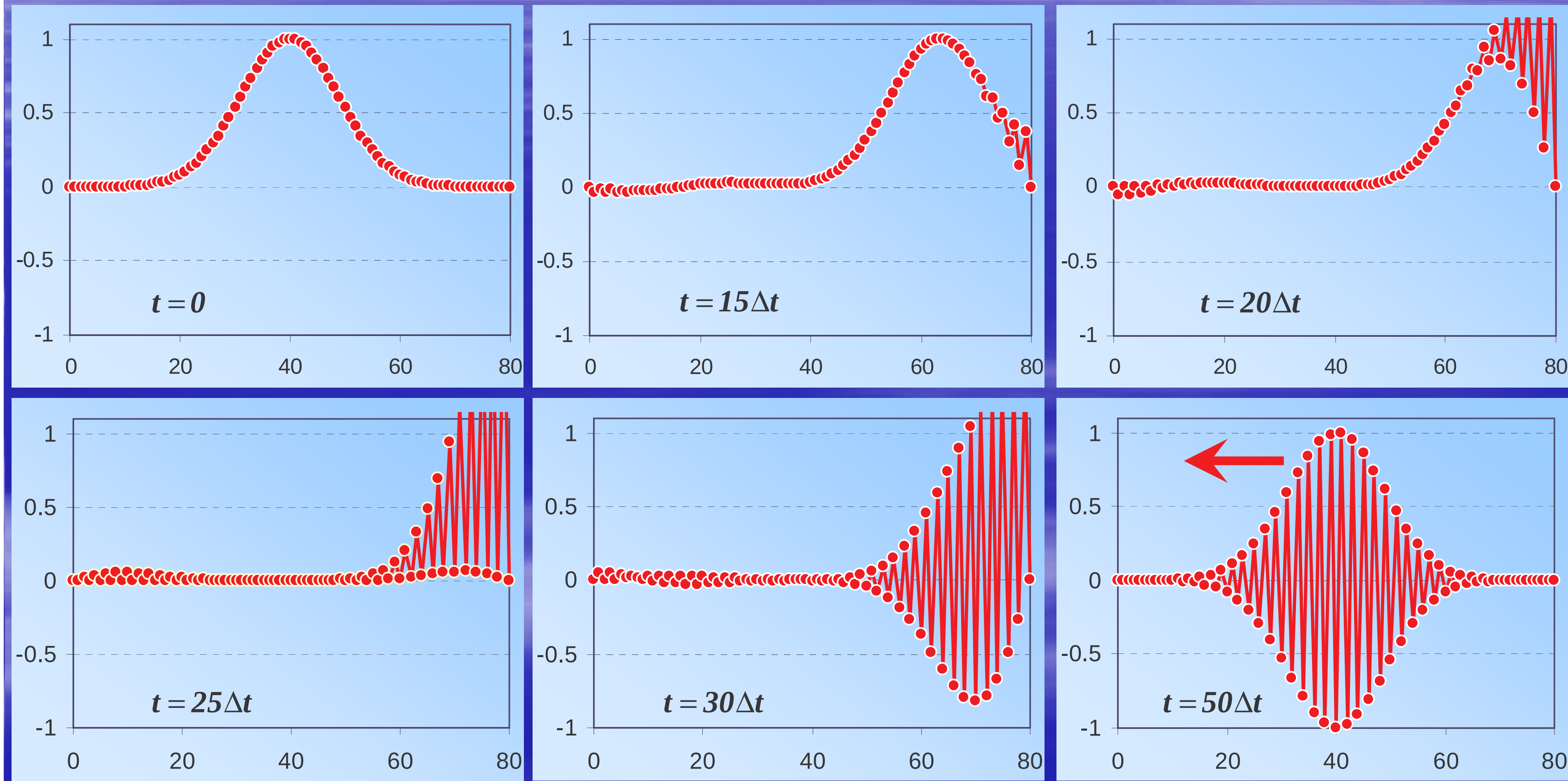
(no relaxation)



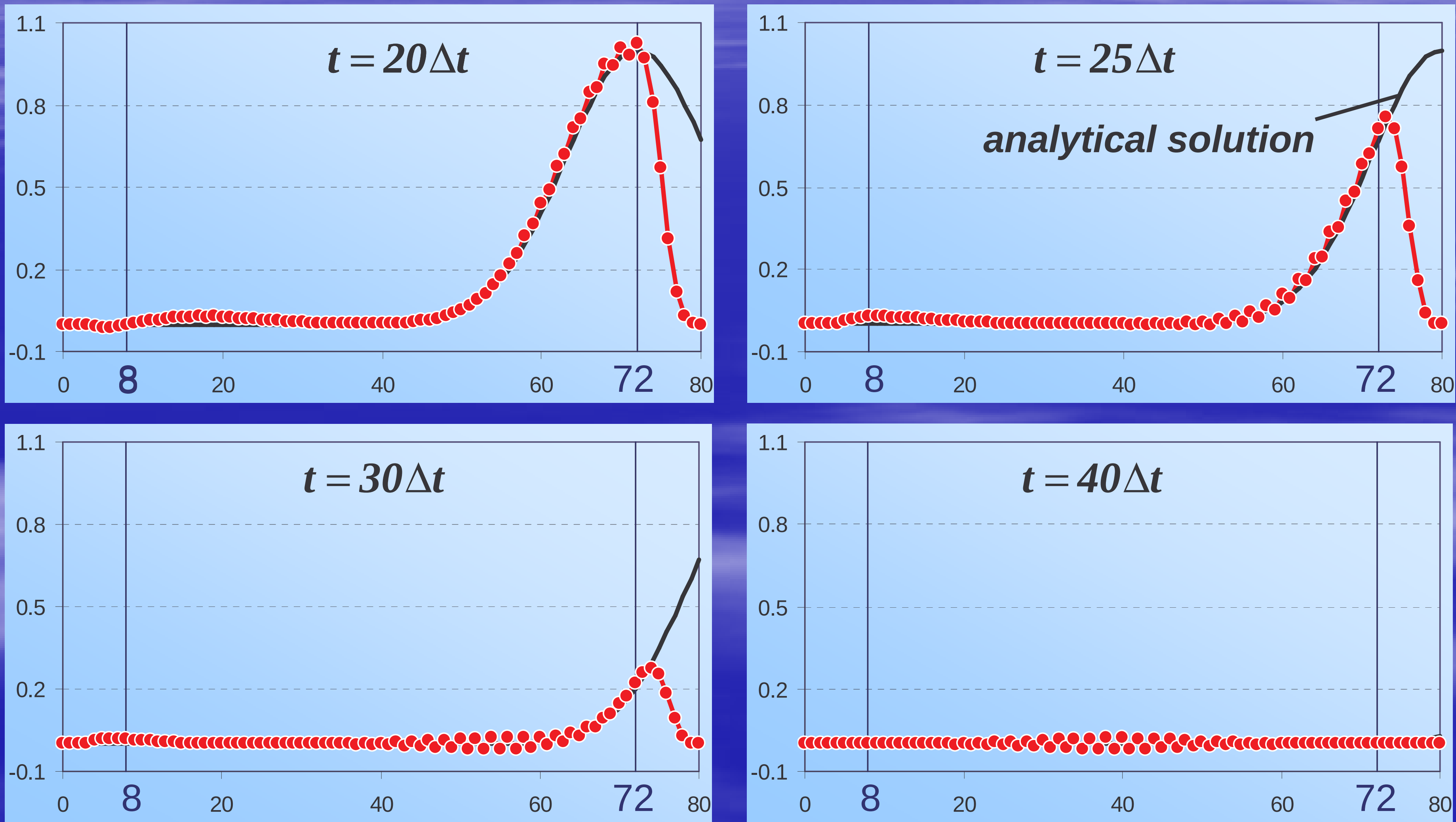
8-point relaxation zone



Outcome of the wave, which is not represented in driving model



8-point relaxation zone



Minimalization of the reflection

- ***weight function***
- ***width of the relaxation zone***

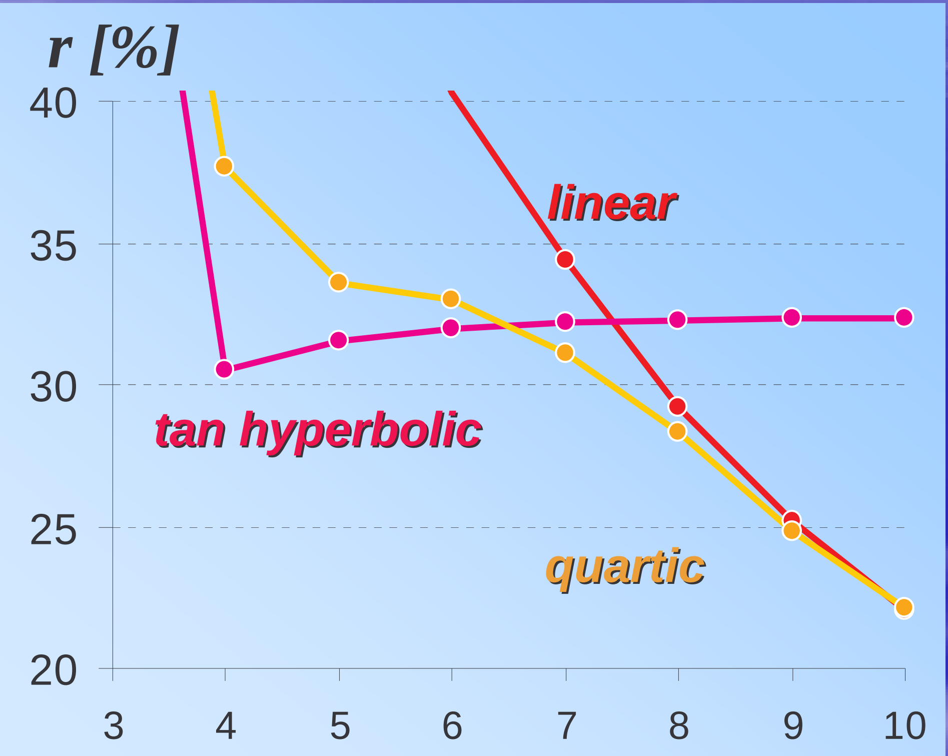
- **the velocity of the wave (4 different velocities satisfying CFL stability criterion)**

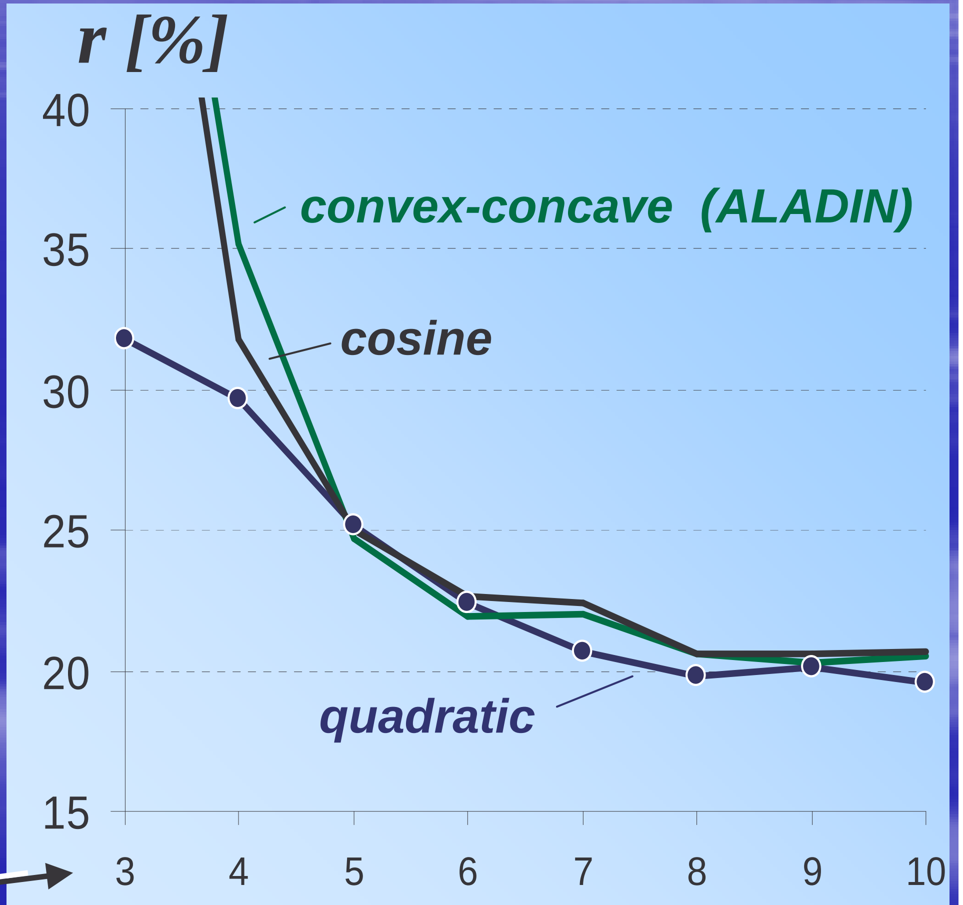
(simulation of dispersive system)

- **wave-length** $\{10\Delta x, 20\Delta x, 40\Delta x\}$

Choosing the weight function

testing criterion - critical reflection coefficient *r*

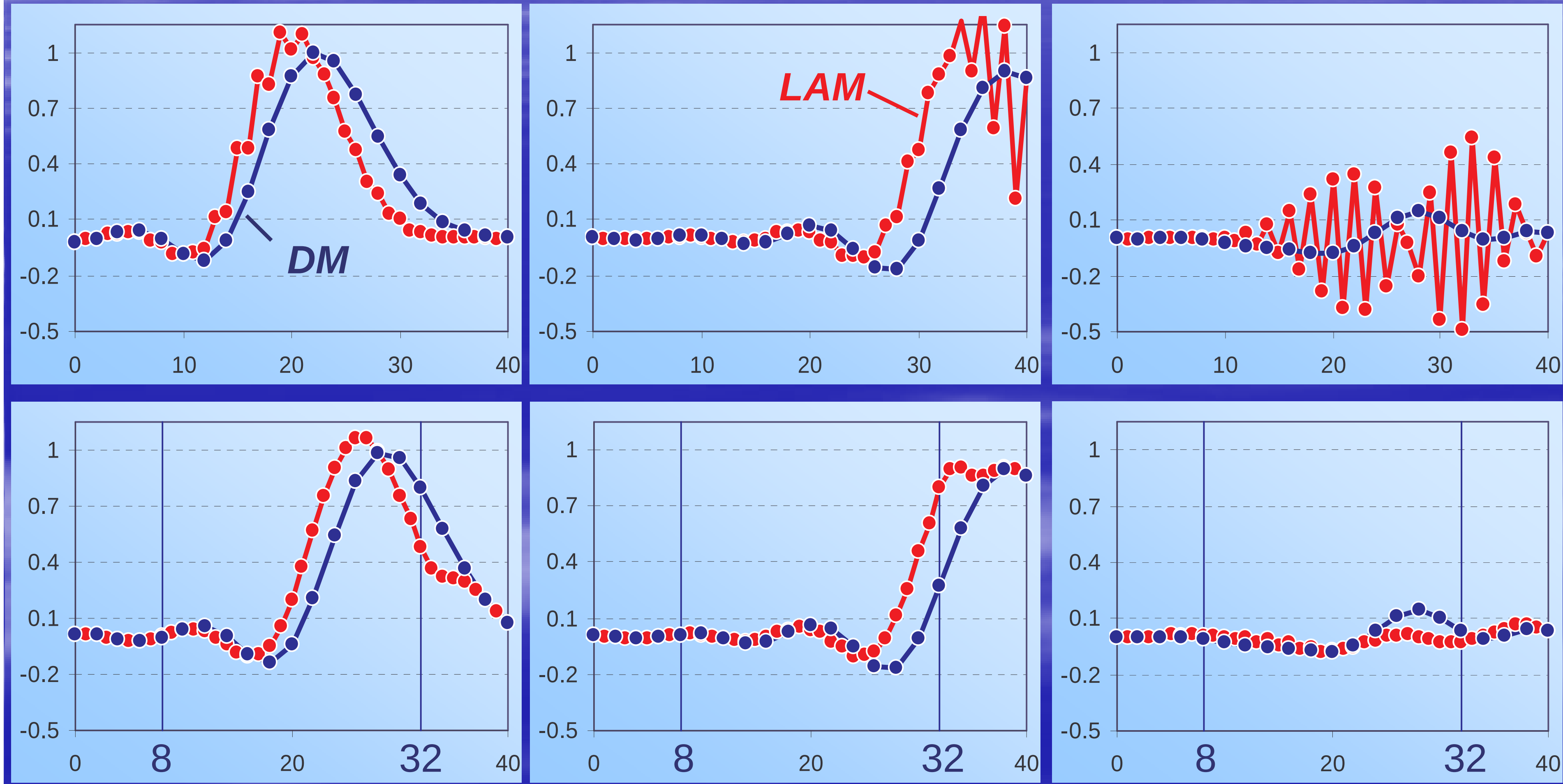




number of points in relaxation zone

$$H_{LAM} = 0.81\, H_{DM} \qquad (c_{LAM} = 0.9\, c_{DM})$$

(more accurate representation of surface)



DM-driving model LAM-limited area model