H-box methods for Zero-width, Overtoppable Barrier in 1D/2D Shallow Water Equations

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Defining terms

- Shallow Water Equations:

$$\frac{\partial h}{\partial t} + \frac{\partial}{\partial x}(hu) + \frac{\partial}{\partial y}(hv) = 0,$$

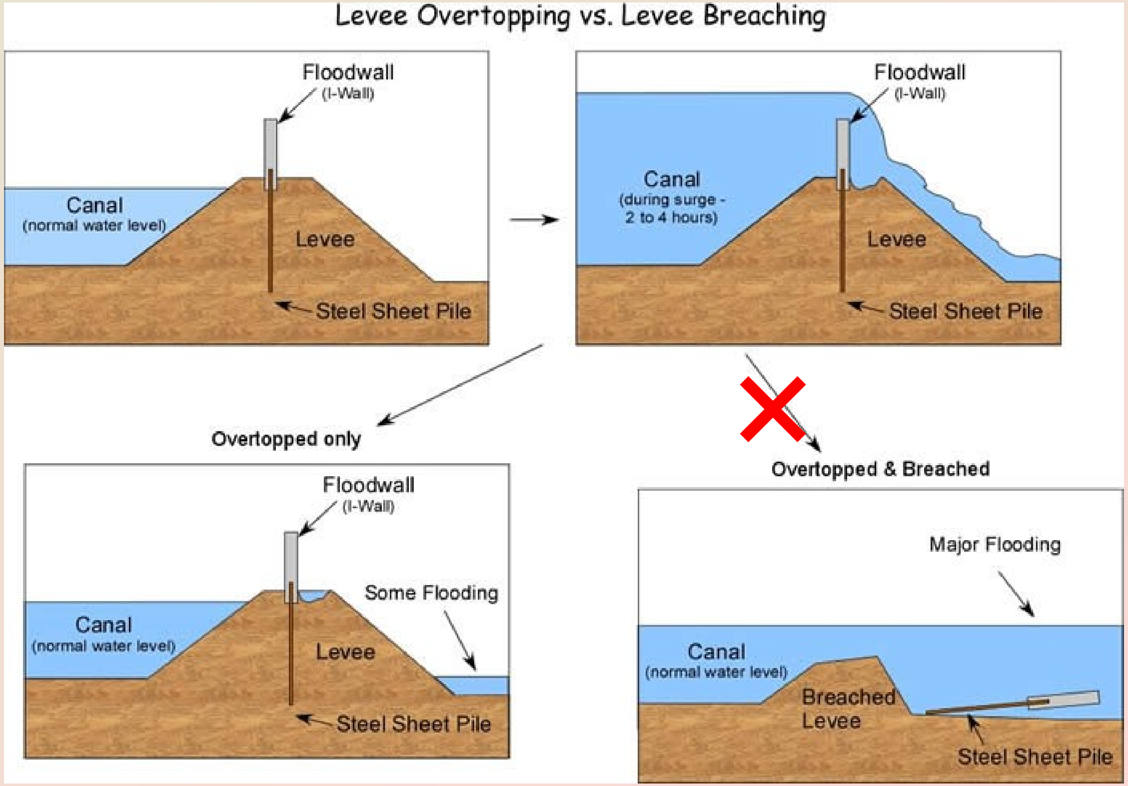
$$\frac{\partial}{\partial t}(hu) + \frac{\partial}{\partial x}(hu^2 + \frac{1}{2}gh^2) + \frac{\partial}{\partial y}(huv) = -gh\frac{\partial b}{\partial x},$$

$$\frac{\partial}{\partial t}(hv) + \frac{\partial}{\partial x}(huv) + \frac{\partial}{\partial y}(\frac{1}{2}gh^2 + hv^2) = -gh\frac{\partial b}{\partial y},$$

- “Zero-width” barrier:

Defining terms

- "Overtoppable" barrier:

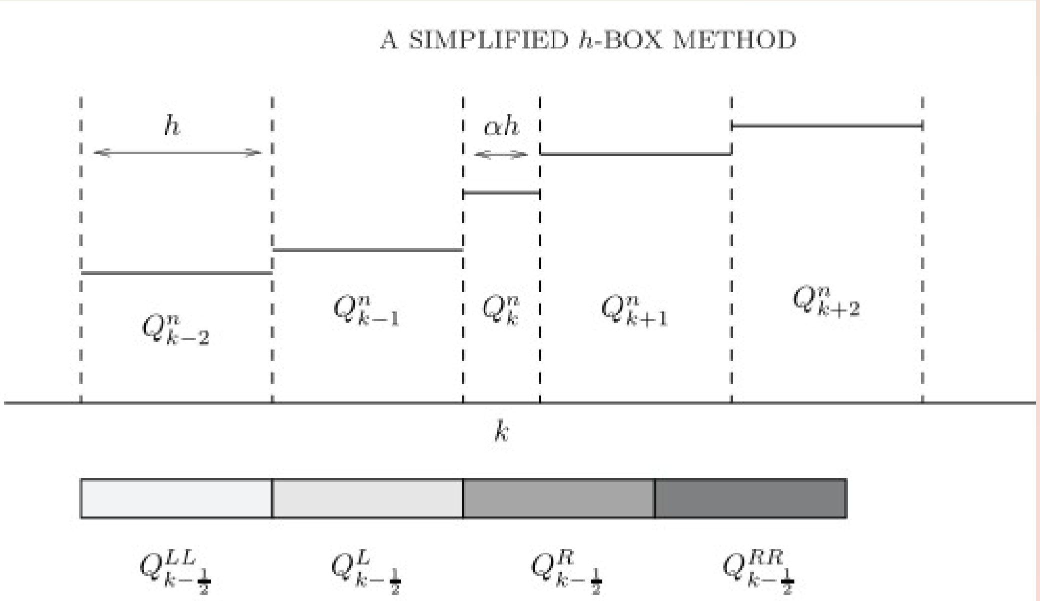


(diagram from Stephen Nelson at Tulane University)

Defining terms

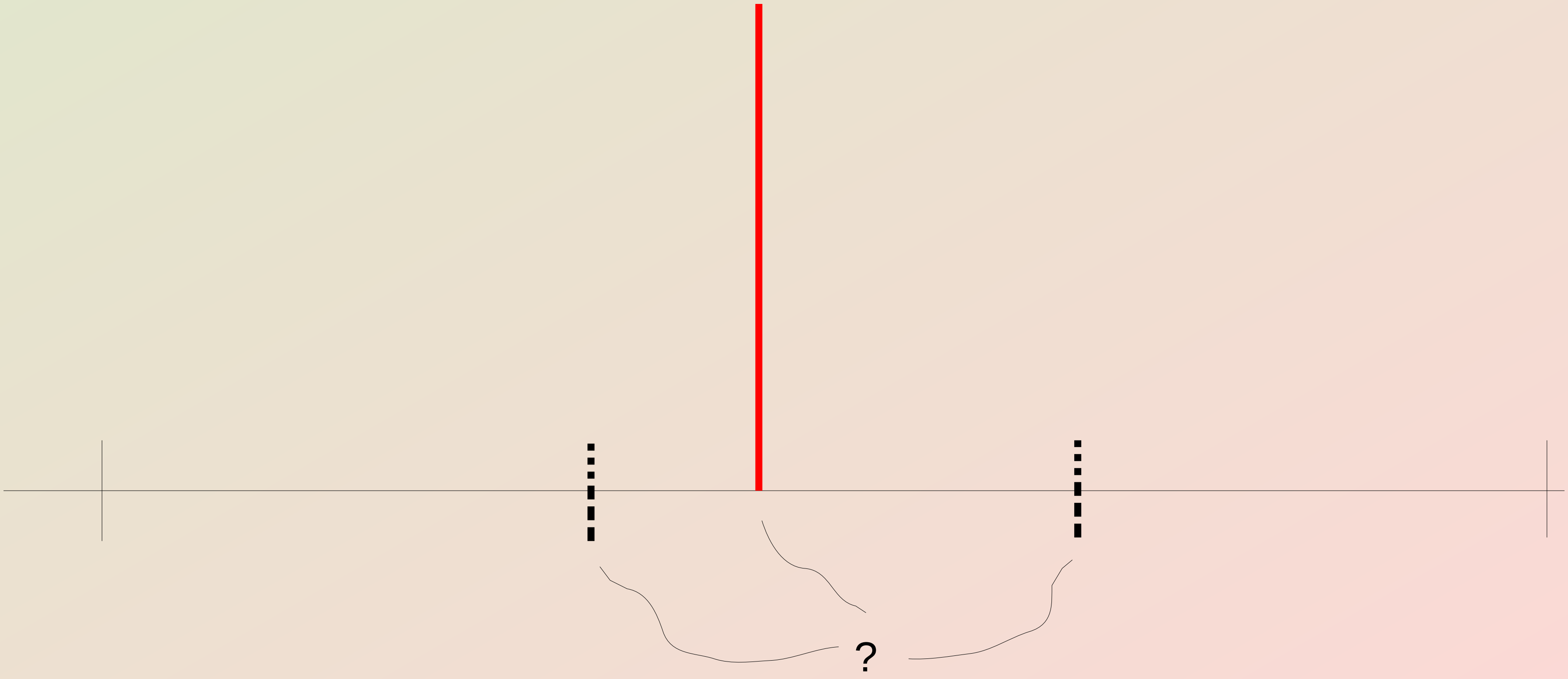
- H-box methods:

Have been used for non-overtoppable solid boundaries

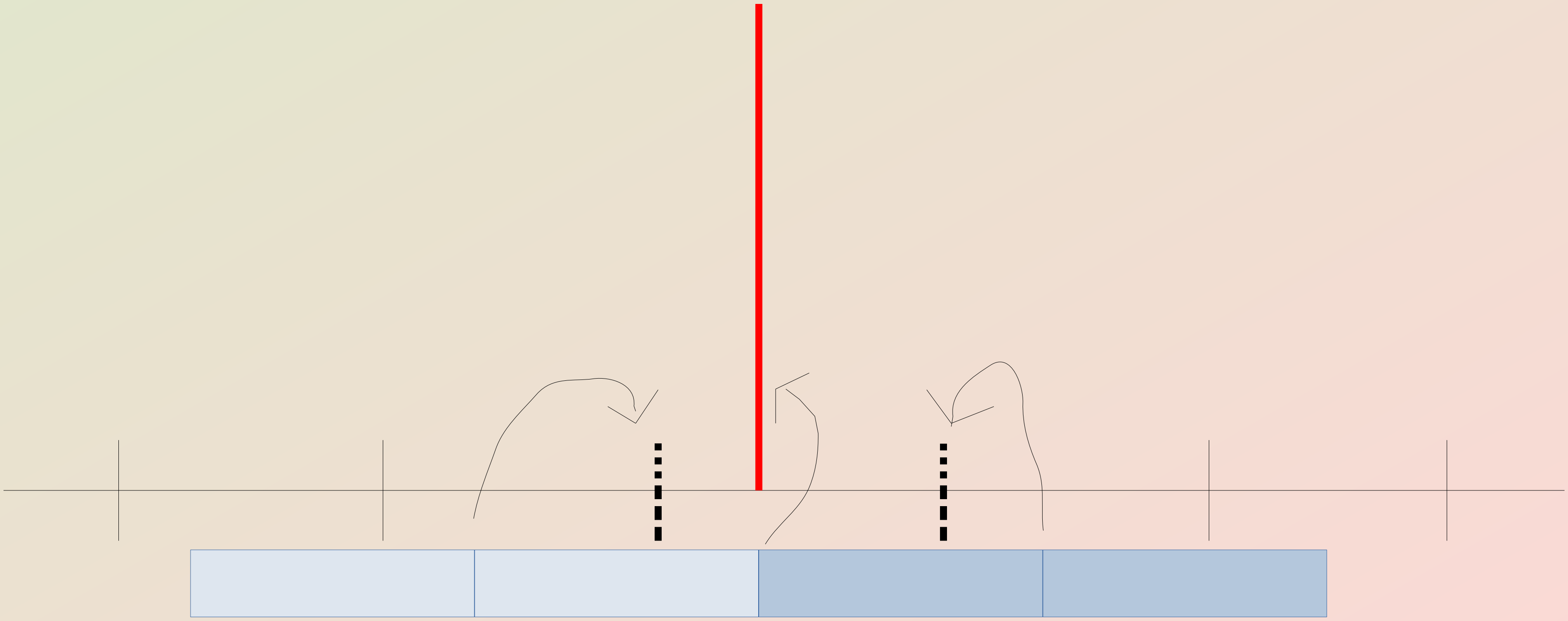


(from “A Simplified h-Box method”, by Marsha Berger, Christiane Helzel)

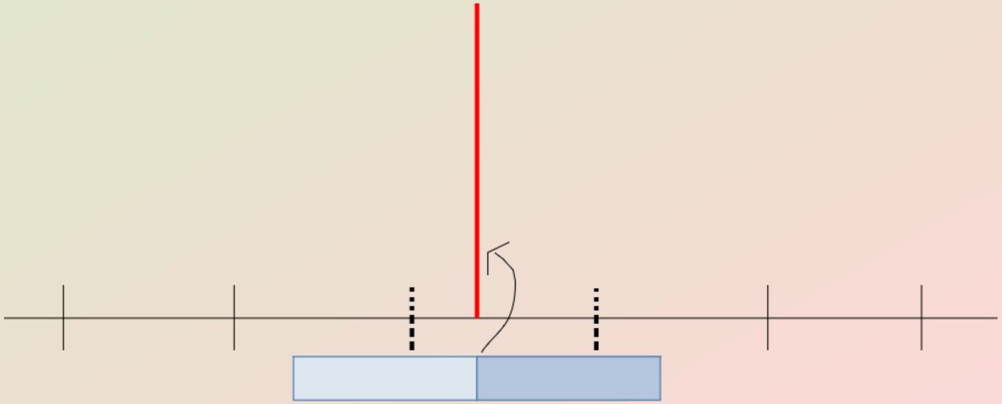
Issues in 1D

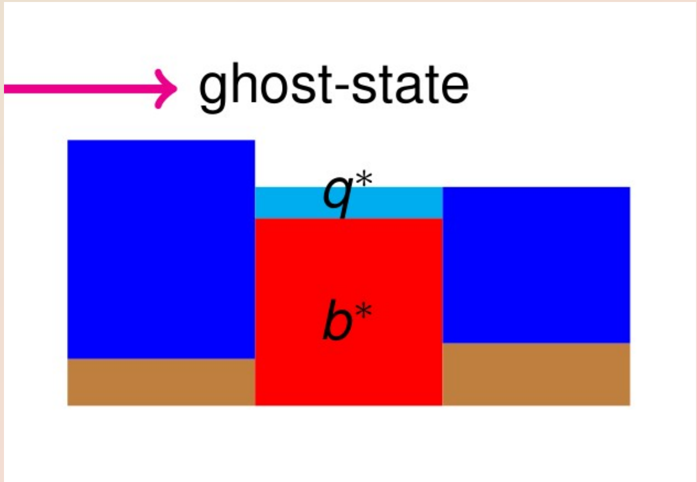


Solution

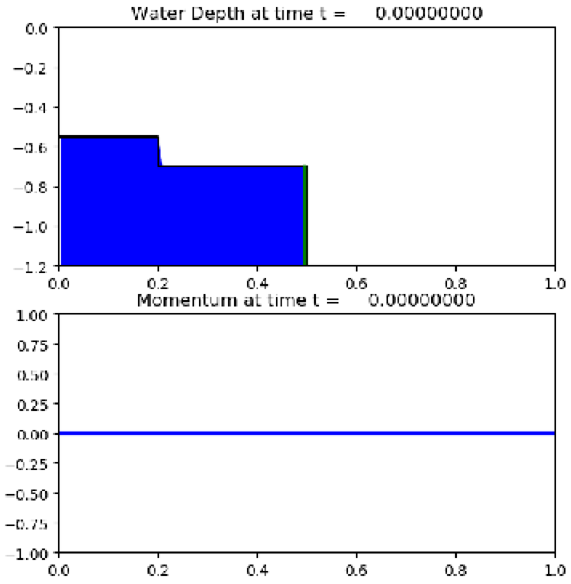


Solution



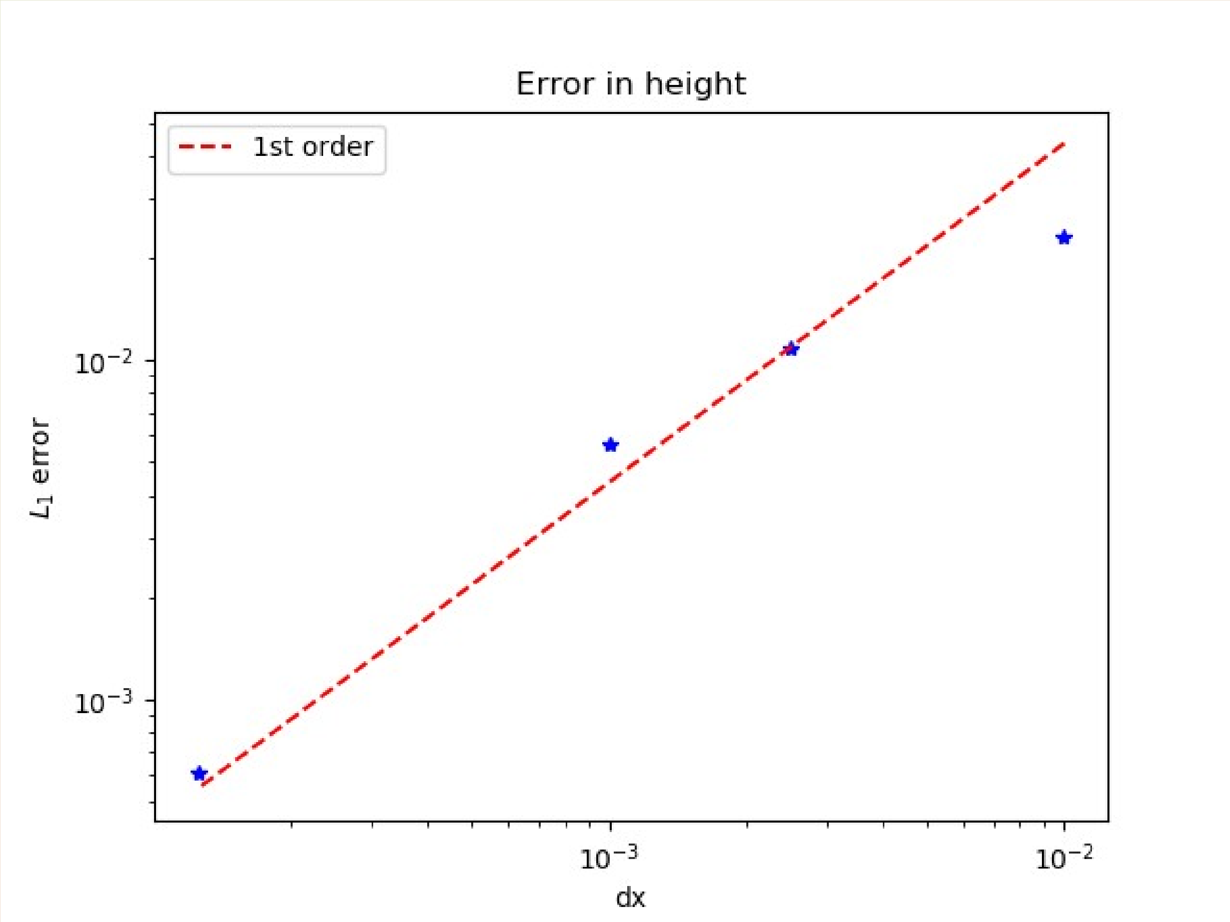


Results

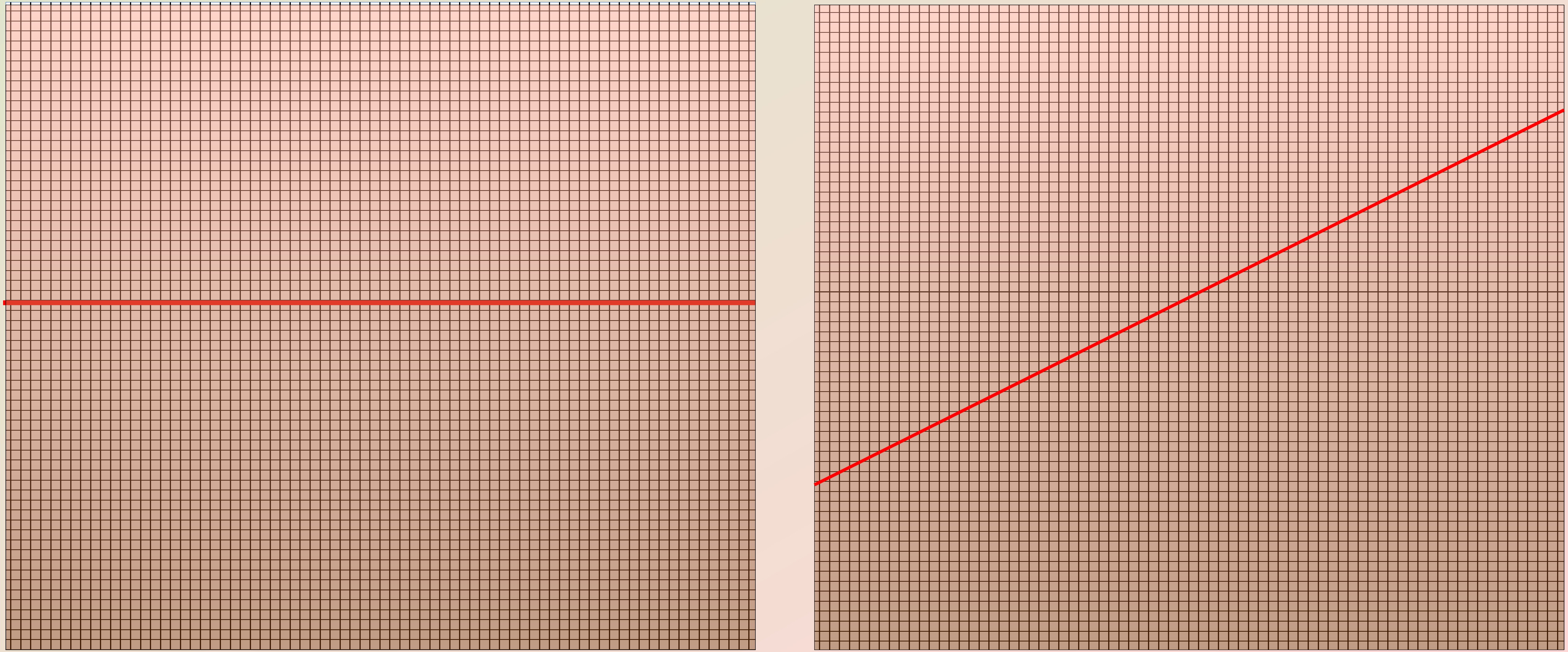


Water Depth at time t = 0.00000000
Momentum at time t = 0.00000000

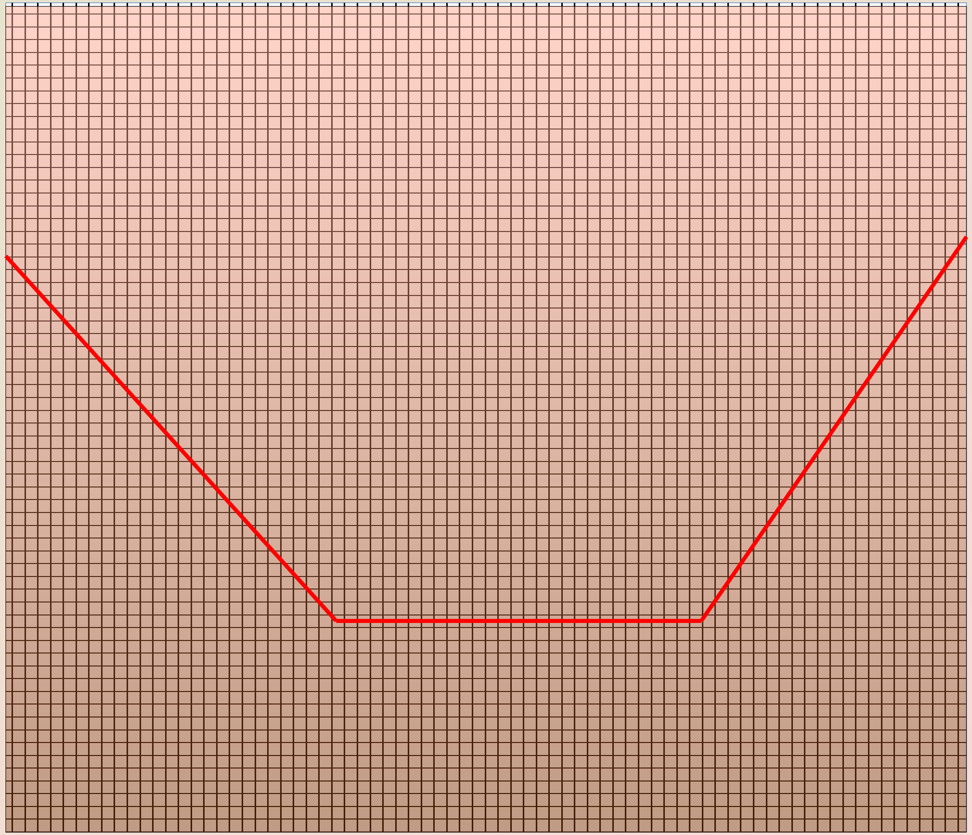
Results in 1D



2D Setup



2D Setup



Easy case: Vertical / Horizontal Barrers

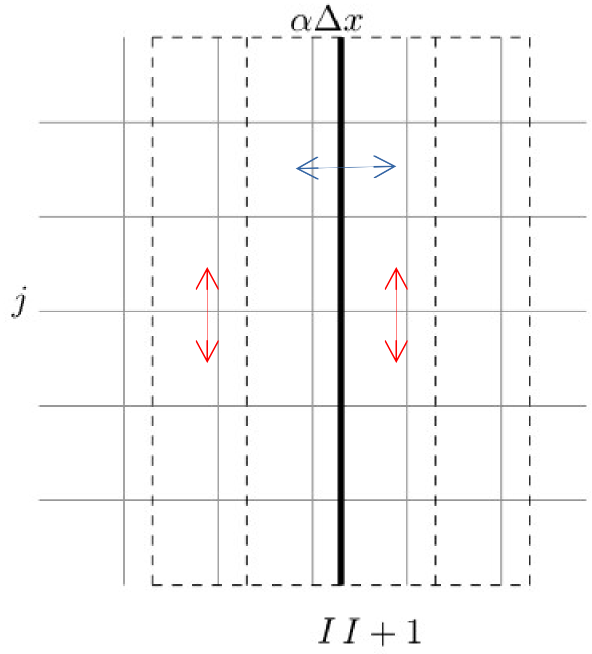
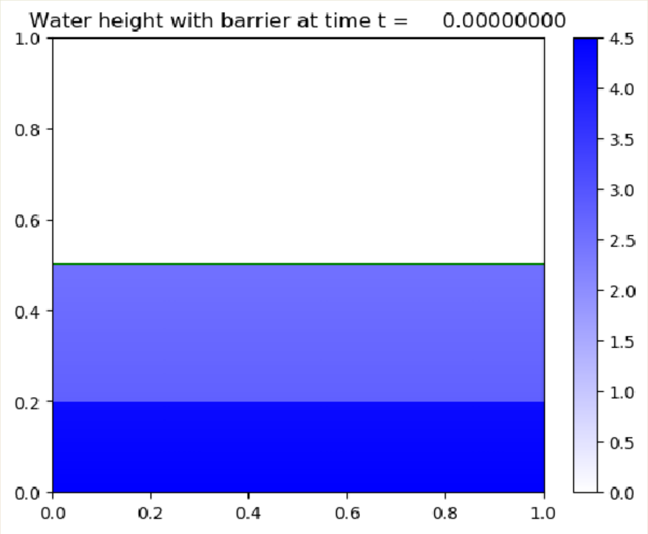
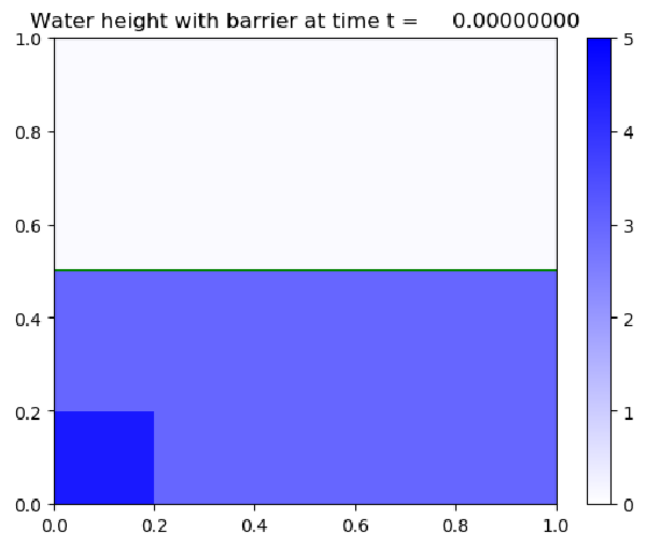


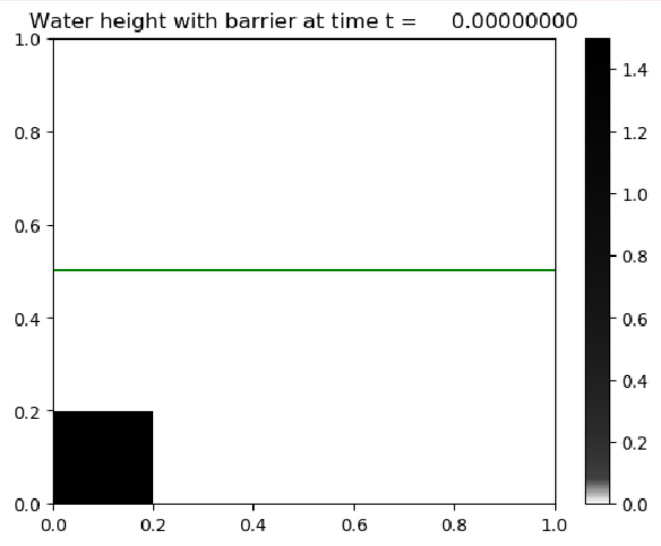
Figure 1: Grid of $\Delta x = \Delta y$ with vertical barrier thickened, with the h-boxes dashed

Results for easy case

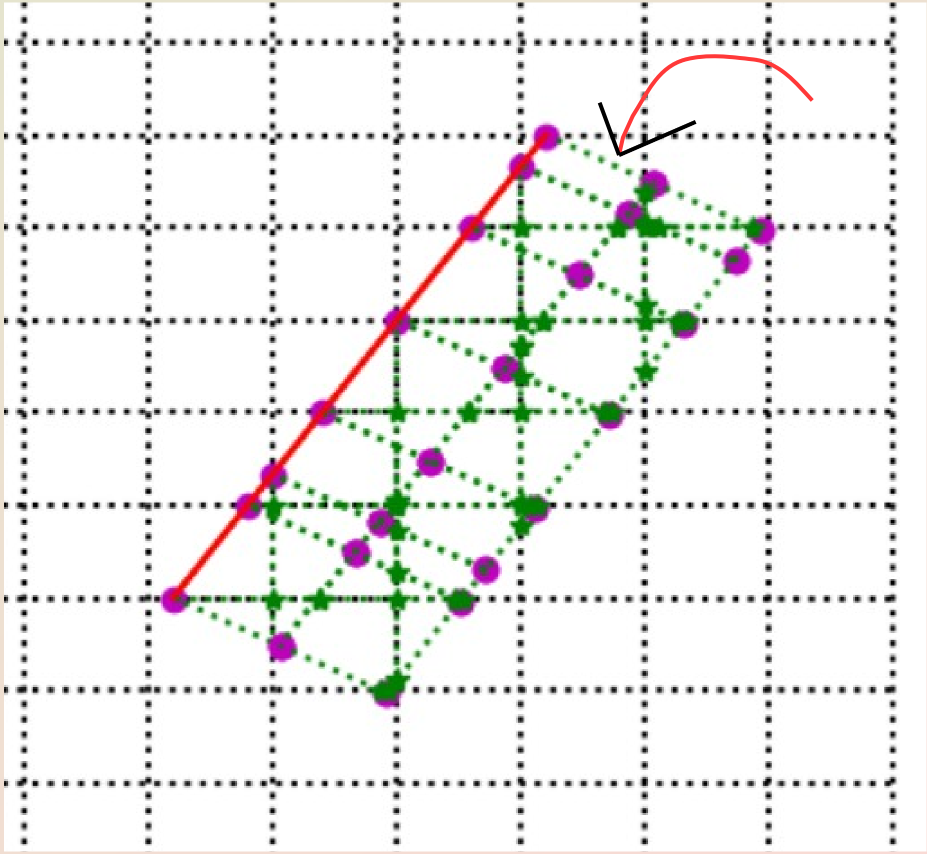
- (1) Planar wave inundation, (2) oblique wave, (3) oblique inundation



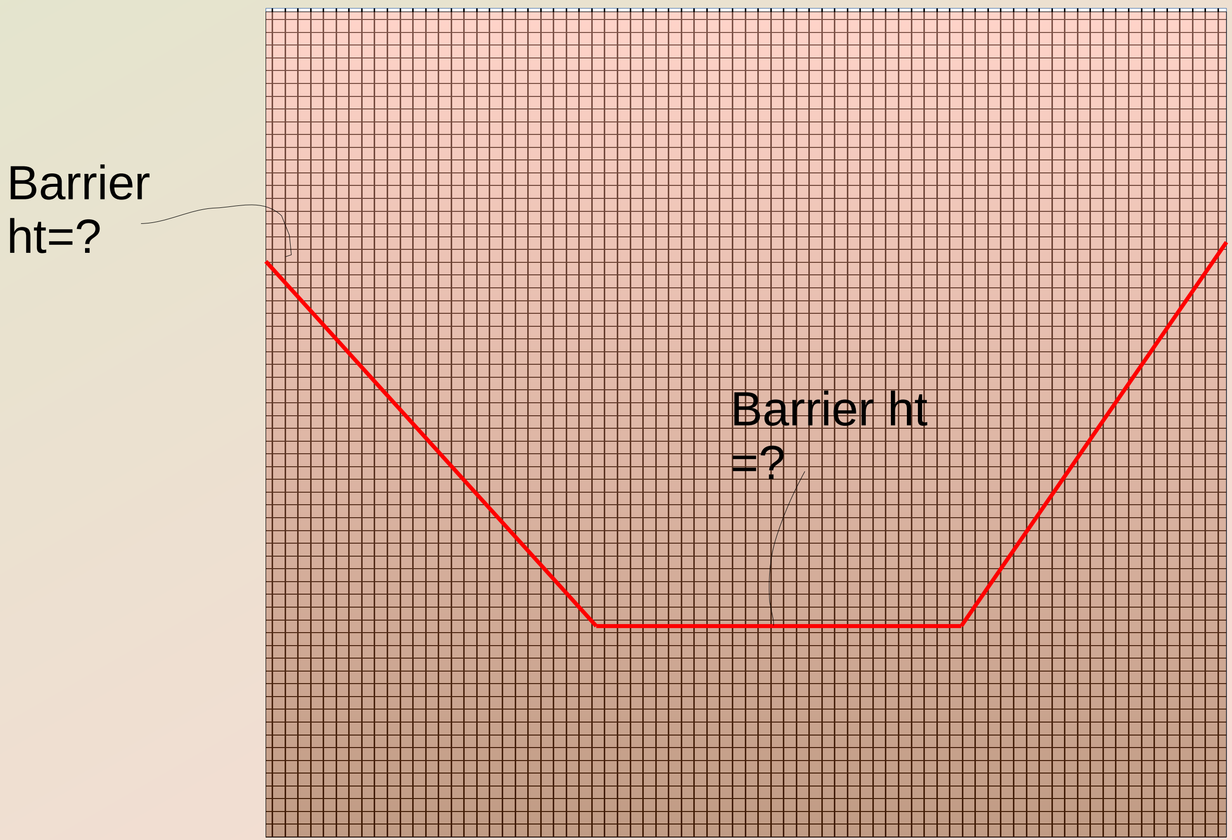




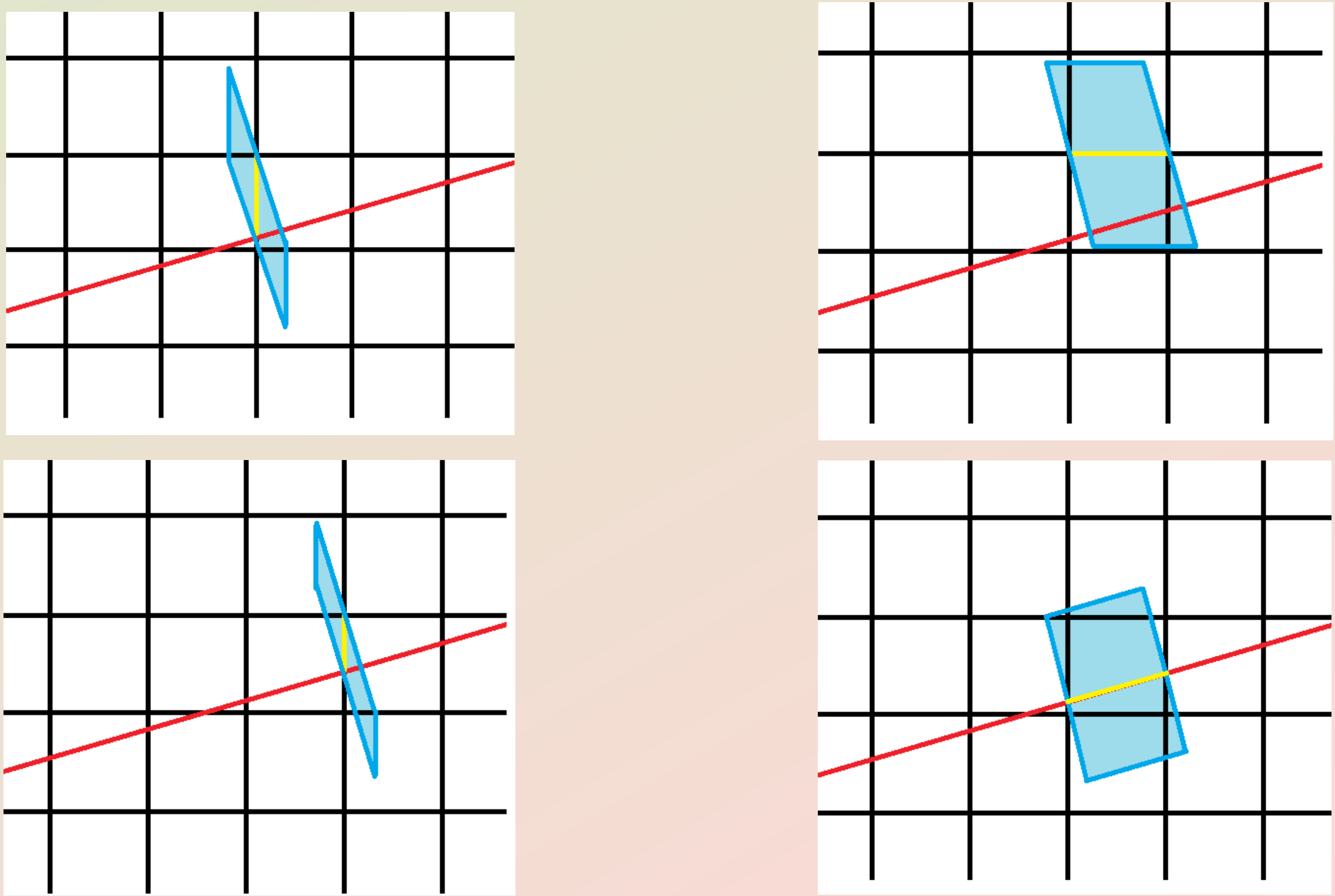
Issues in 2D: angles



Issues in 2D: barrier vs. bathymetry



Possible Solution/Issue

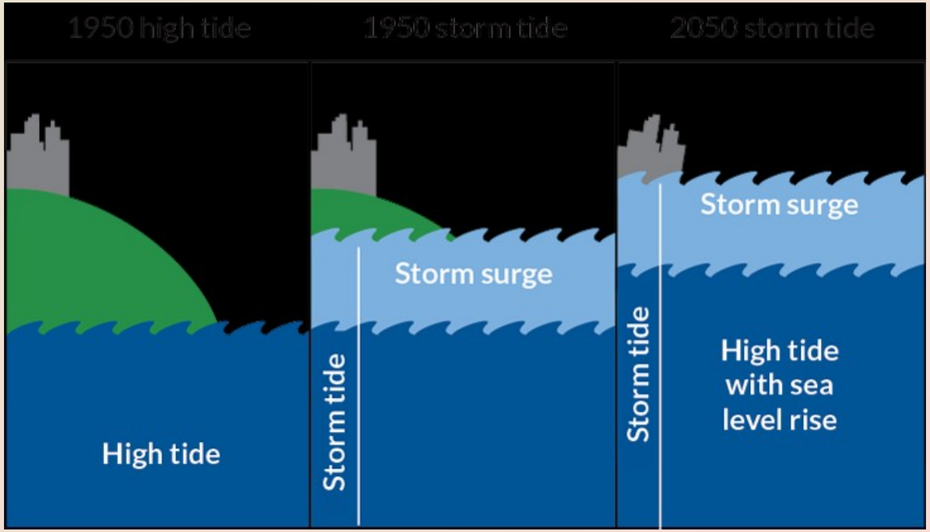


TO DO

- Barrier geometry pre-calculation
- Set appropriate “crossing” h-box values
- Rotate fluctuations to physical grid directions
- Update small and affected cells appropriately

Lesson

- Lk 21:25



Credit: *ScienceNews*