University of BRISTOL

A coupled approach to model surface-subsurface interactions

Quantifying Aquifer ↔ River Fluxes: Modelling for Process and Management

12 March 2008

JP Renaud

Context

- Flooding and run-off generation
- Buffering of flood peaks by floodplains

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- Flooding and run-off generation
- Buffering of flood peaks by floodplains

- **Stewart et al. (1999)**
  - Showed that +/- 10% of flow in the river can be linked to floodplain processes

  - Model
    - 2D flood inundation model: TELEMAC-2D
    - Added diffuse source terms to account for infiltration
    - Other models are used there and then, inc. CHASM

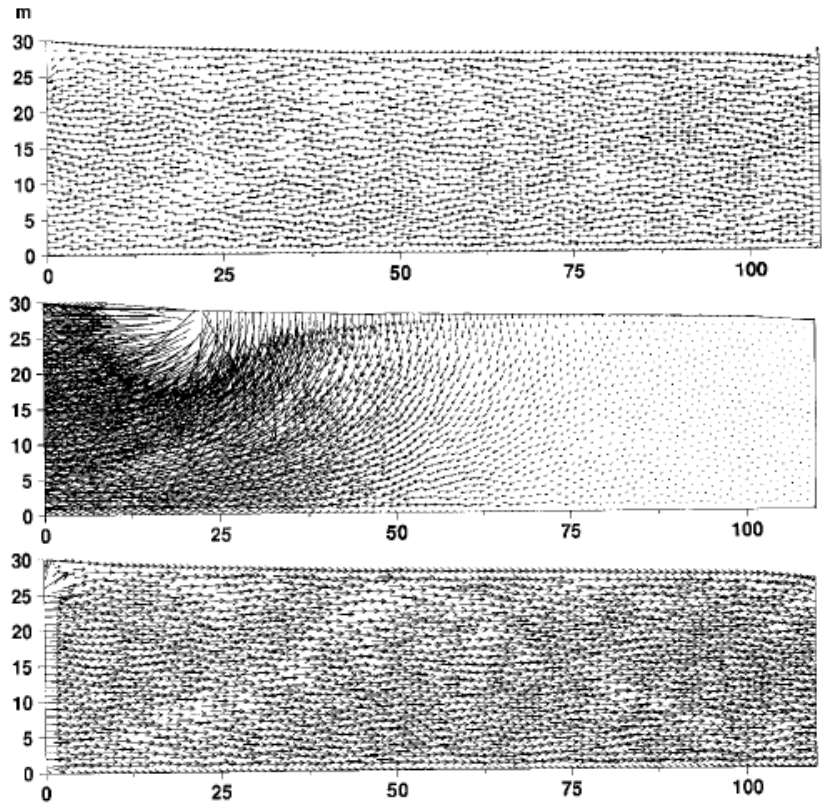
Context

- Flooding and run-off generation
- Buffering of flood peaks by floodplains

- **Bates et al. (2000)**
  - Illustrated the type of subsurface-surface interaction possible during flood events

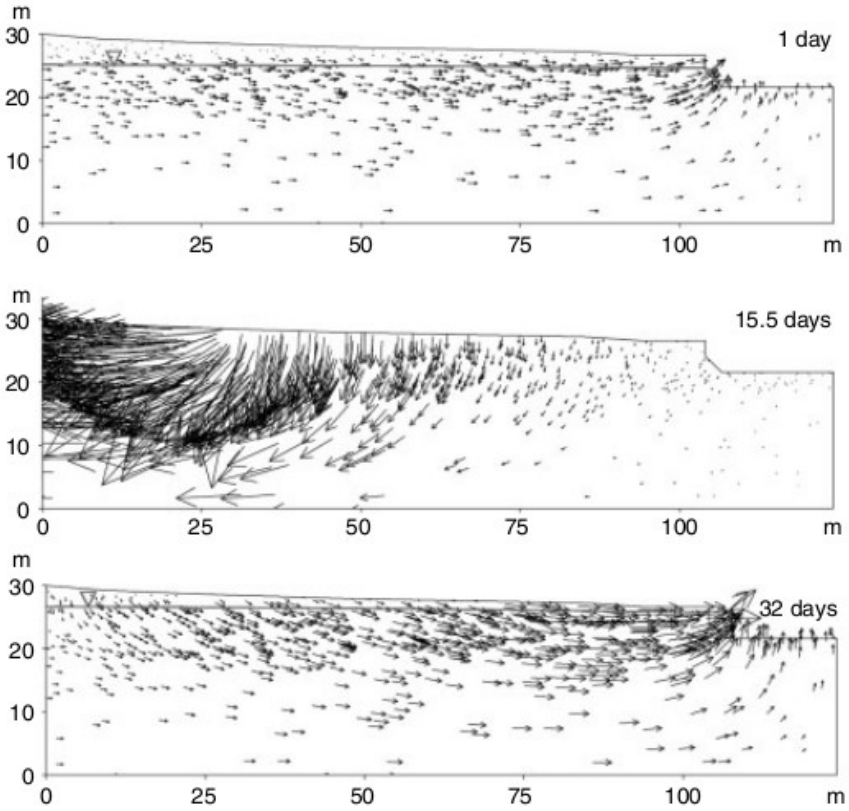
  - Model:
    - 2D (vertical slice) groundwater model: ESTEL-2D

2D mixing?



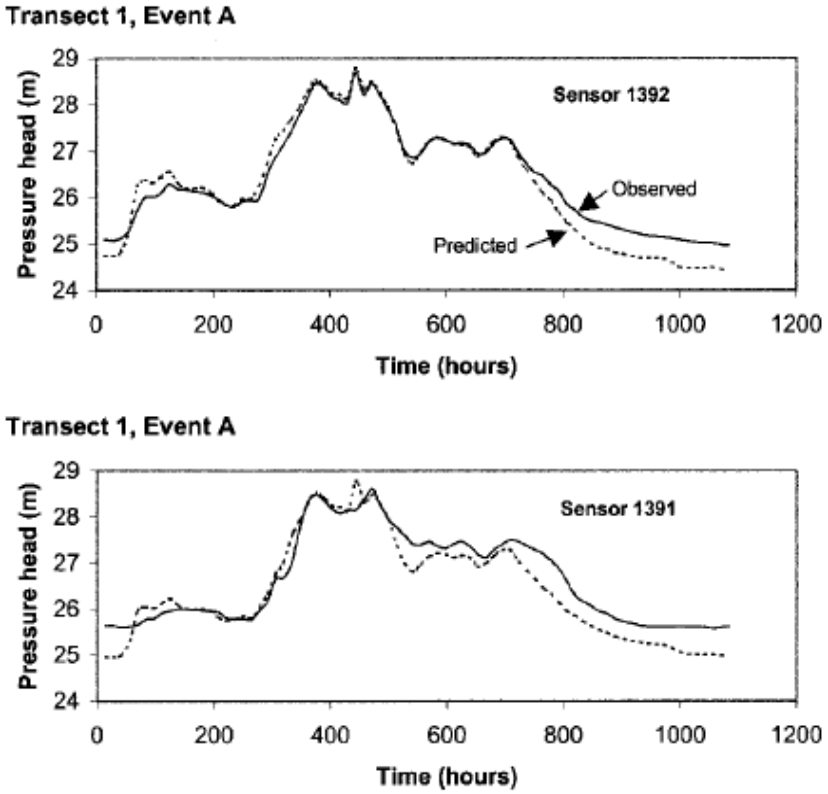
From Bates et al (2000)

2D mixing?



From Cloke et al (2003)

2D mixing?



From Bates et al (2000)

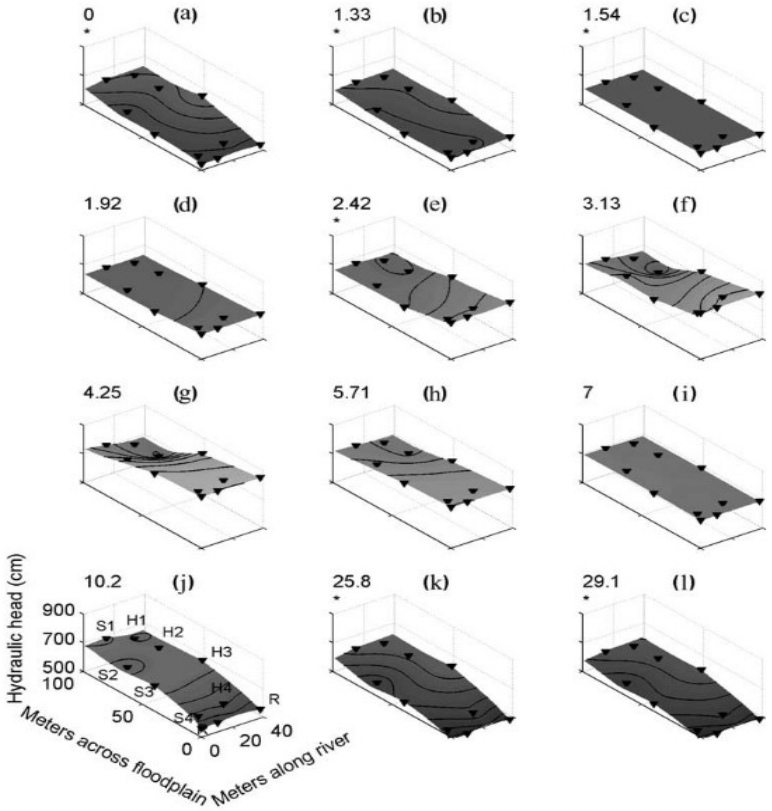
Context

- Flooding and run-off generation
- Buffering of flood peaks by floodplains

- **Jung et al. (2004)**
  - Showed that the main direction of flow changes direction during the flood event.

  - Model:
    - None, simple maps of water table

3D mixing?



From Jung et al (2004)

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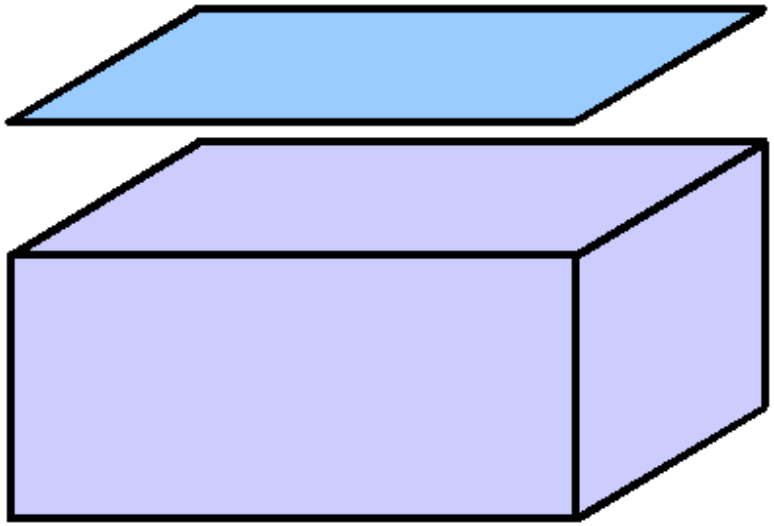
- Flooding and run-off generation
- Buffering of flood peaks by floodplains
- [Flooding by rising water table behind levees]

- Floodplains as chemical buffer zones
- Runoff generation (“old” and “new” water...)

Methodology

- Coupled model

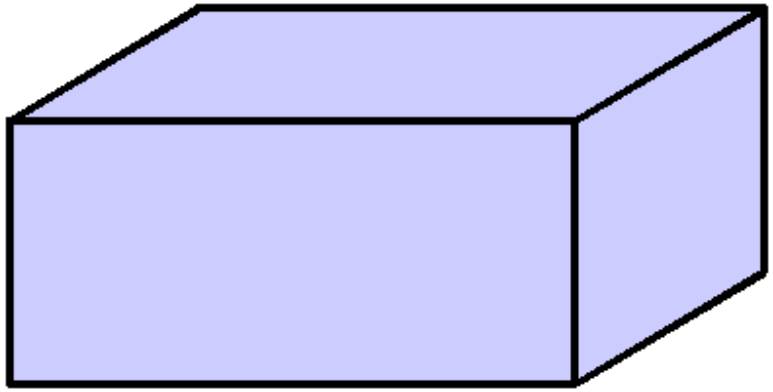


Methodology

- Groundwater flow

ESTEL-3D

Richards equation
3D unstructured
grid of tetrahedrons



Methodology

- Surface flow

TELEMAC-2D

Shallow Water
Depth average

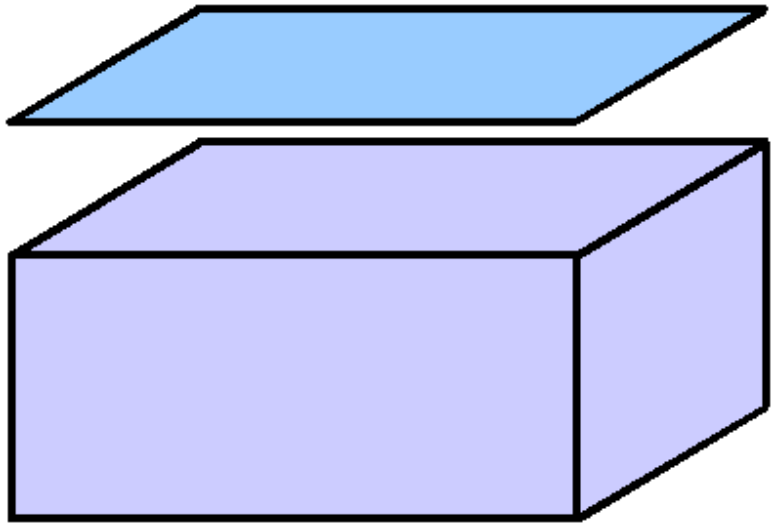
2D unstructured
grid of triangles

Methodology

- Coupled model

- 2D water depth in river used as boundary condition for the 3D model
- Flux from 3D model used as a source term in 2D model

- Iterative algorithm



Exchanges of water

- Source term is used in TELEMAC-2D

$$\frac{\partial h}{\partial t} + \nabla\left(h\,\mathbf{u}\right) = q$$

Exchanges of water

- Source term is used in TELEMAC-2D

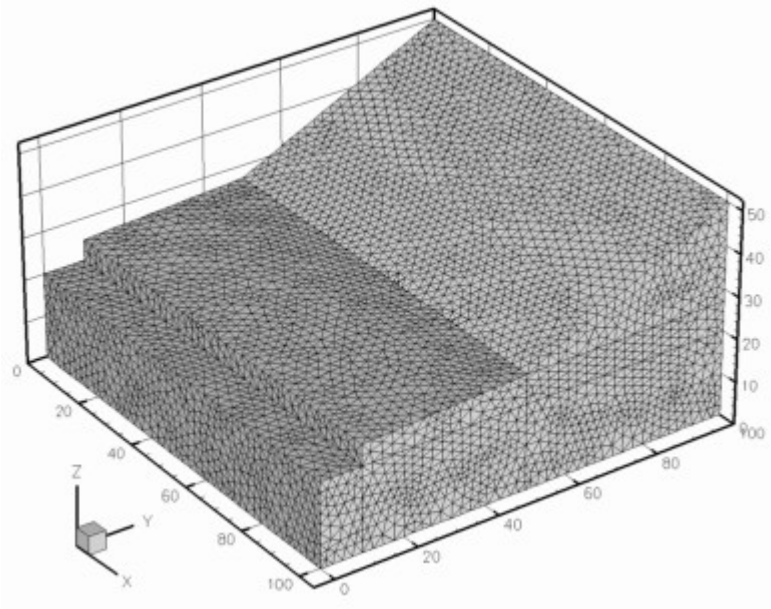
$$\frac{\partial h}{\partial t} + \nabla\left(h\,\mathbf{u}\right) = q$$

- Boundary condition (Dirichlet) is used in ESTEL-3D

$$\frac{\partial \theta(h)}{\partial t} + \nabla.\left(k_r(h)\mathbf{K_s}\nabla\left(h+z\right)\right) = 0$$

Current state of development

- Works well on small test cases



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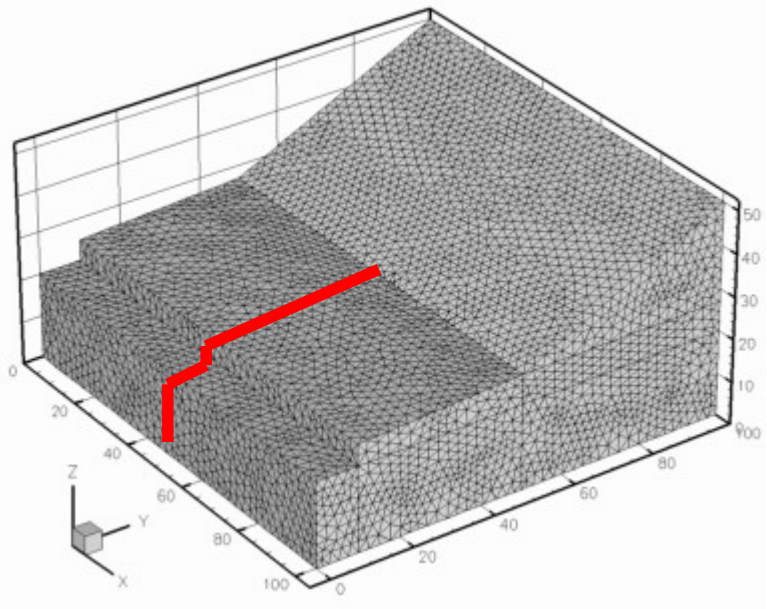

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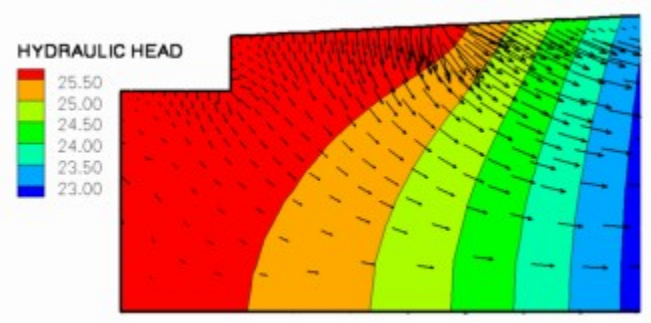
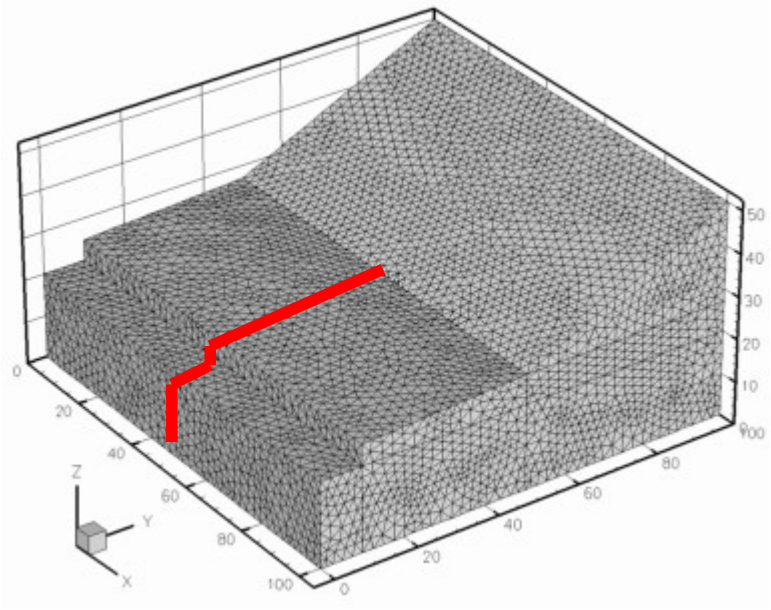
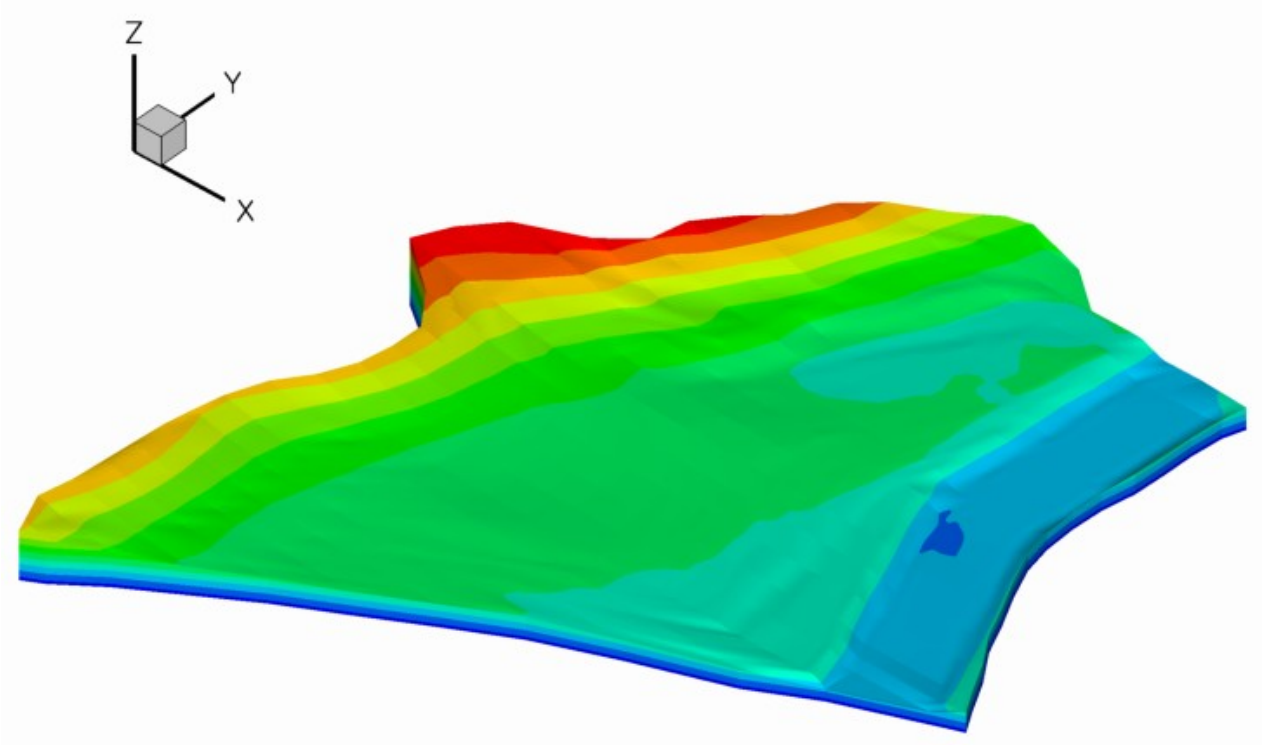




Moving towards real applications



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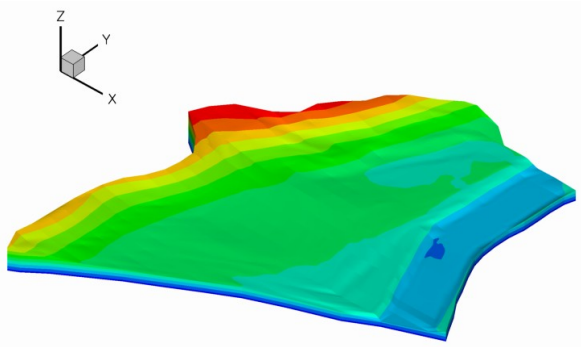

- Hitting a brick wall...

- CPU requirements are big
- 3D domain is huge in terms of the number of elements
- Try to run in “parallel” on a “super”-computer