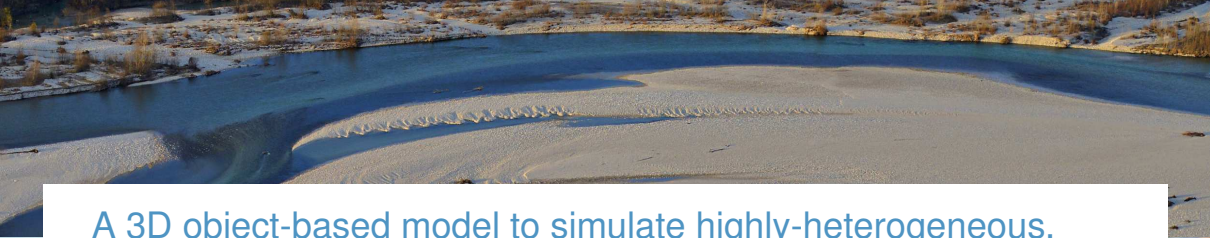

A 3D object-based model to simulate highly-heterogeneous, coarse, braided river deposits

Emanuel Huber[1], Jef Caers[1], Peter Huggenberger[2]

[1] Department of Geological Sciences, Stanford University
[2] Applied and Environmental Geology, University of Basel

Objectives

Motivations:

$\rightarrow$ Geologically realistic subsurface heterogeneity model

Objective:

$\rightarrow$ object-based model for coarse, braided river deposits

Coarse, braided river deposits:

- Highly heterogeneous in terms of hydraulic conductivity
- Important groundwater reservoirs worldwide

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- Important groundwater reservoirs worldwide

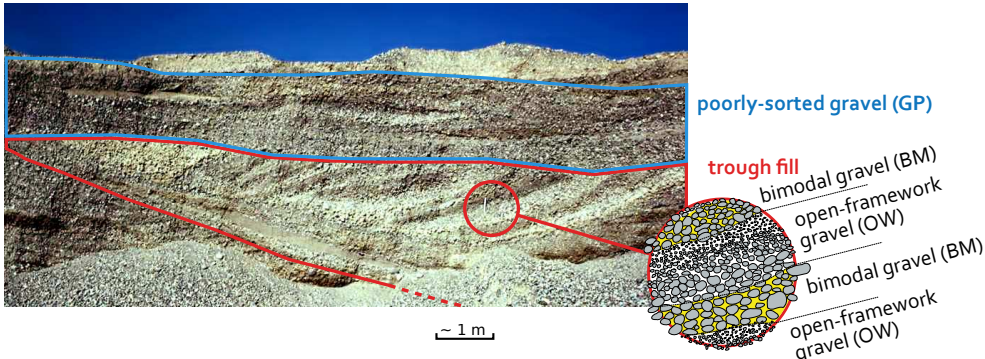
Method

Observations → conceptualisation → model formulation

Observation: ancient deposits

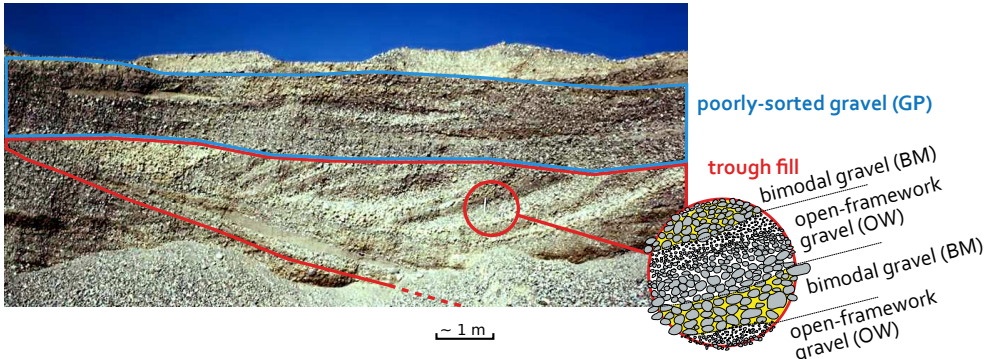
Gravel carry Northeast Switzerland

Observation: ancient deposits



- Spoon-shaped trough fills
  cross-bedding = layers of bimodal – open-framework gravel
- Horizontal/sub-horizontal layers of poorly sorted gravel
- Sand and open-framework lenses

Observation: ancient deposits



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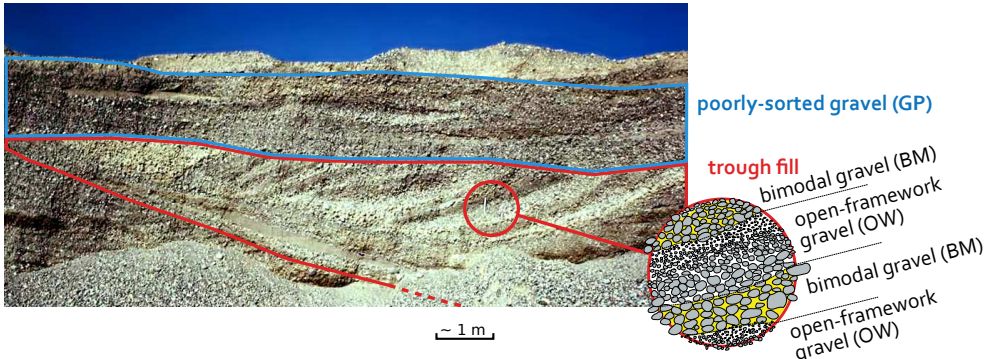

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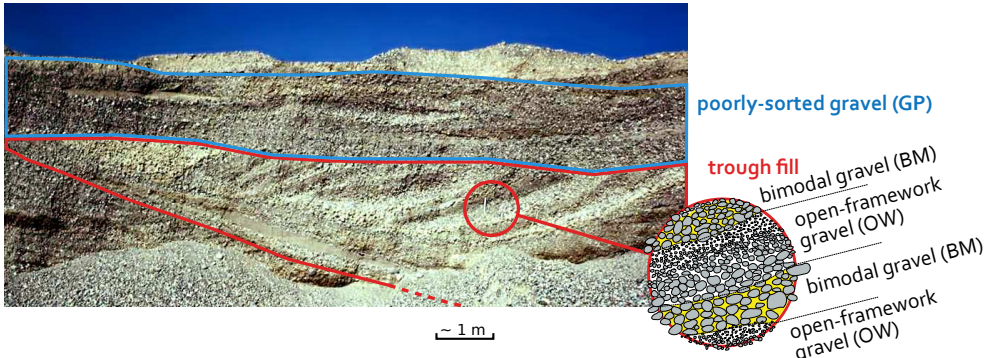

Hydraulic properties after Jussel et al. (1994)

	Poorly sorted gravel	Bimodal gravel	Open-framework gravel
Porosity	0.2	0.25	**0.35**
K_h	1.5×10^{-3} m/s	1.5×10^{-3} m/s	**1×10^{-1} m/s**
σ_{lnK}	0.5	0.1	0.1
K_h/K_v	6	1	1

Observation: geomorphology, key to dynamics

Depositional elements

- Trough fills ← scours at flow confluence
- Link to the topography of gravel sheets/unit bars
- Horizontal layers ← remnants of gravel sheets

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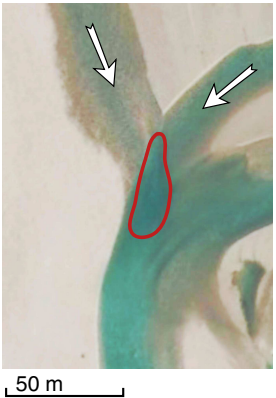

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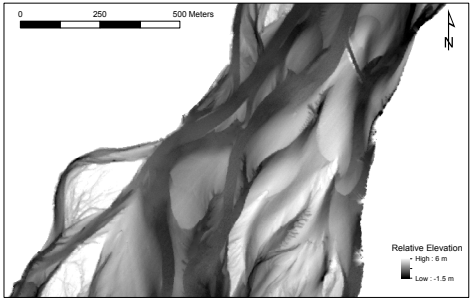

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Observation: geomorphology, key to dynamics

Depositional elements

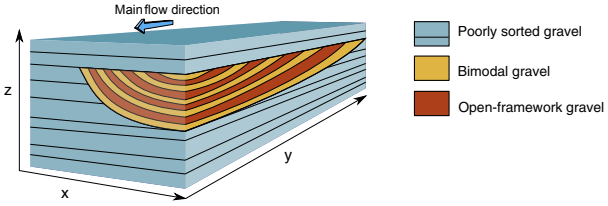
- Trough fills $\leftarrow$ scours at flow confluence
- Link to the topography of gravel sheets/unit bars
- Horizontal layers $\leftarrow$ remnants of gravel sheets

Preservation potential

The deeper the depositional element, the higher the chance to be preserved in the geological records.

Conceptualisation

Structure



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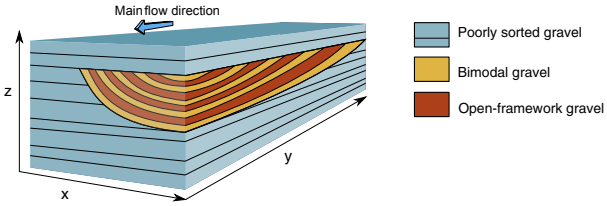
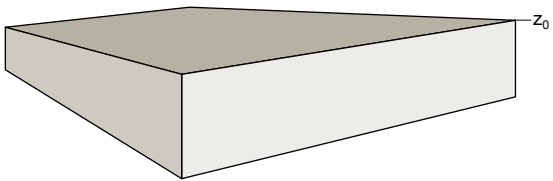


Dynamics



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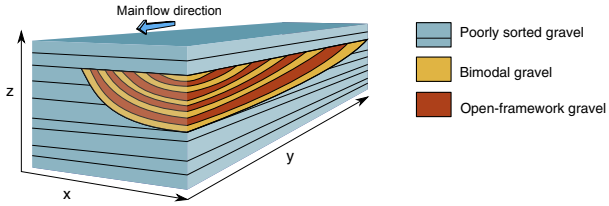

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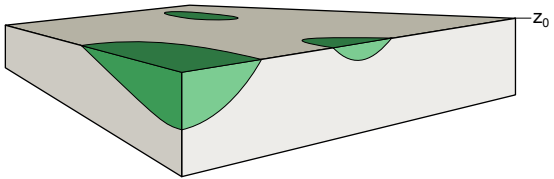

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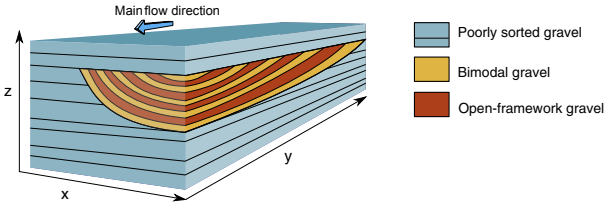

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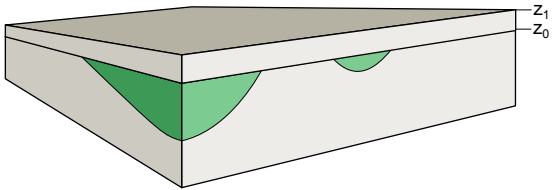

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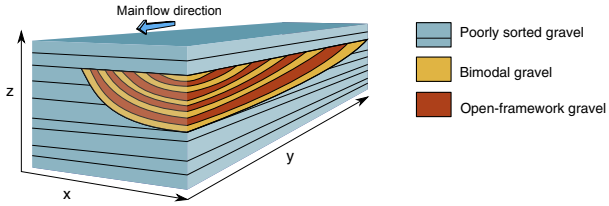

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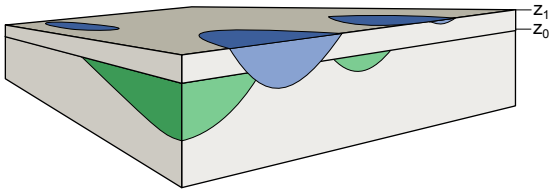

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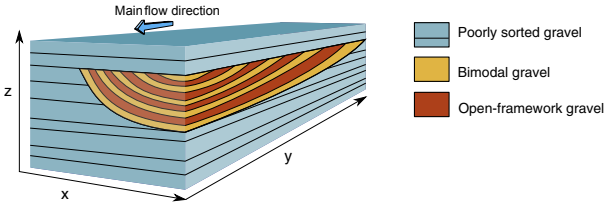

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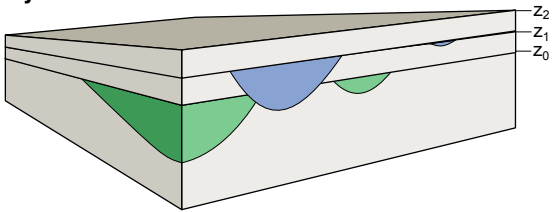

Model formulation: object-based model

Object definition:

- Trough fills = truncated ellipsoids
  $\rightarrow \mathcal{E} = x, y, z, \theta, l, w, h, r$
- cross-bedding: truncated ellipsoids
  $\rightarrow$ thickness bedding, position
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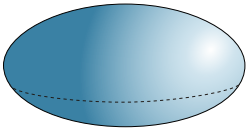

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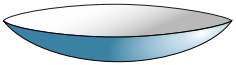

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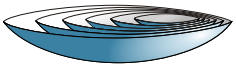

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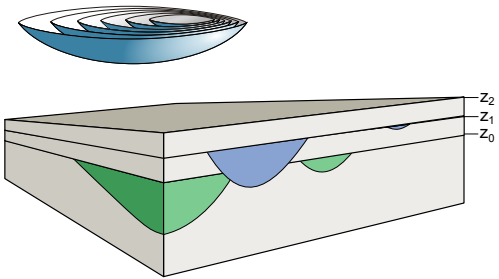

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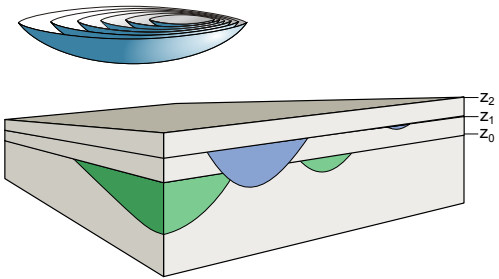

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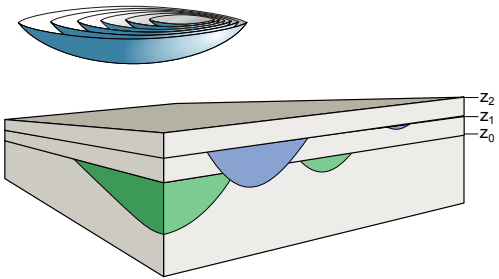

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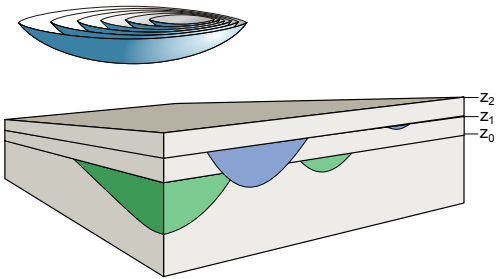

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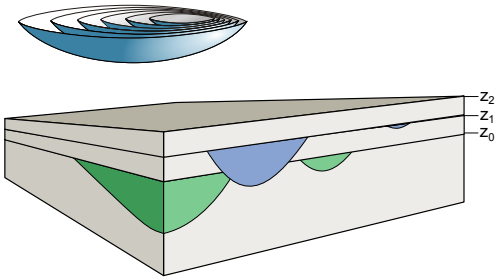
Model = object parameters
Vertical section algebraically computed



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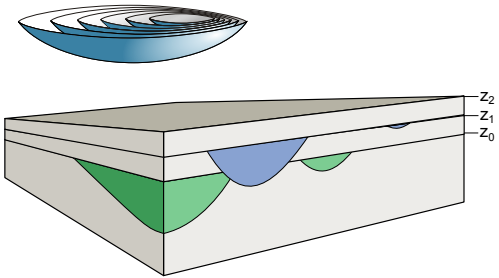
R-package: CBRDM
(Coarse Braided River Deposit Model)



github.com/emanuelhuber/CBRDM

Braided river dynamics

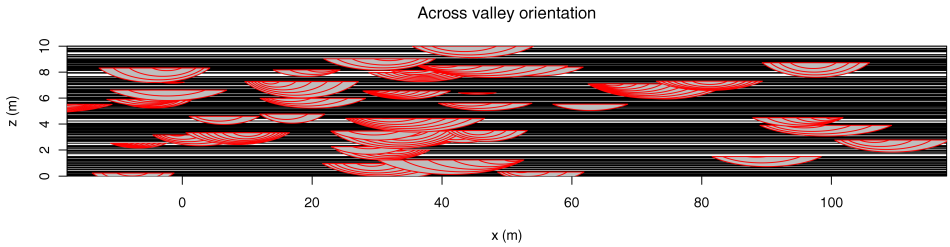
Simulations of two braided river dynamics:

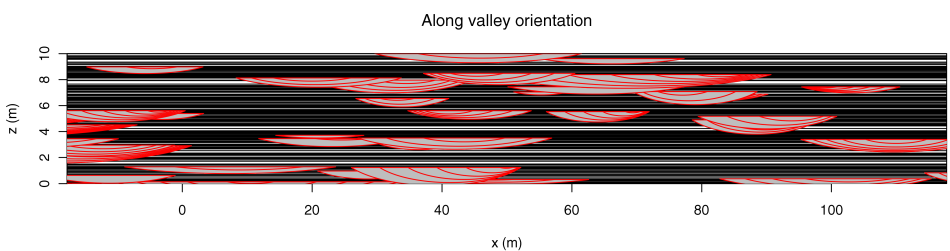
- High sediment deposition rate (5 cm/event)
- Low sediment deposition rate (0.5 cm/event)

$\Rightarrow$ Impact on subsurface heterogeneity & subsurface flow

Braided river dynamics

High sediment deposition rate: 5 $cm/$event





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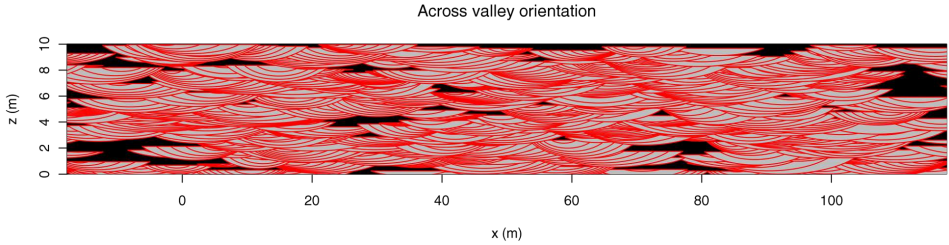
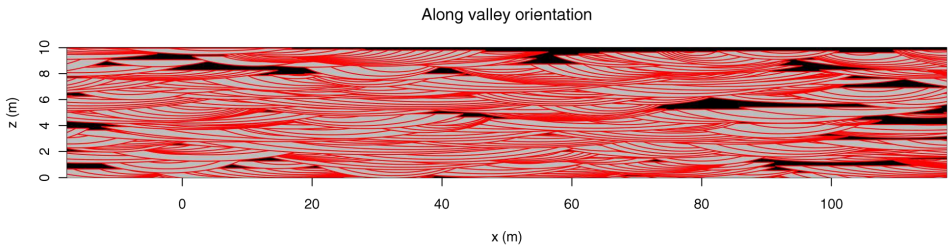
Braided river dynamics

Low sediment deposition rate: 0.5 $cm/$event





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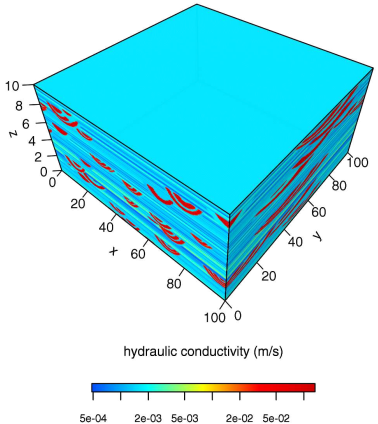
Braided river dynamics & subsurface heterogeneity

High sediment deposition rate: 5 *cm*/event



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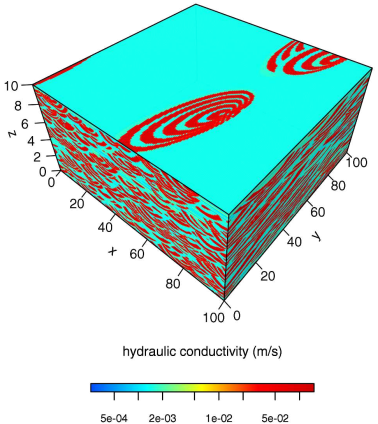

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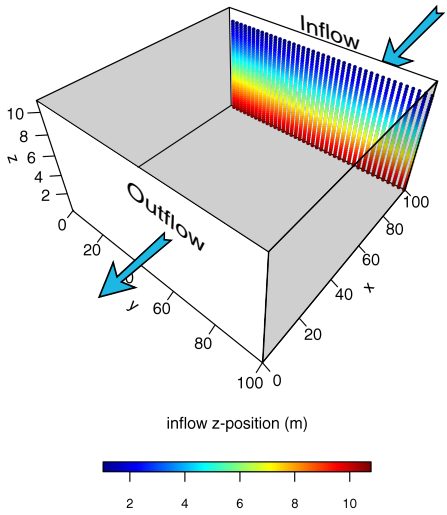
Braided river dynamics & subsurface flow field



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Braided river dynamics & subsurface flow field

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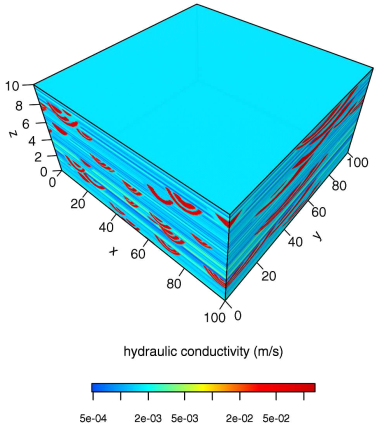

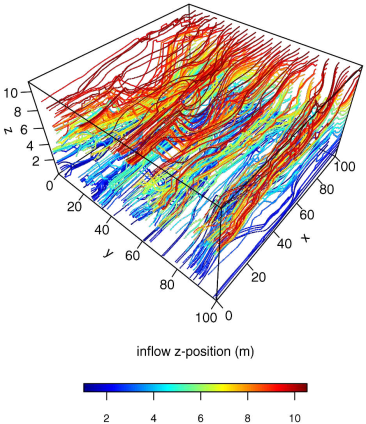

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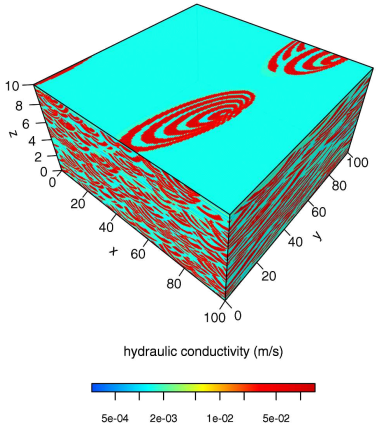

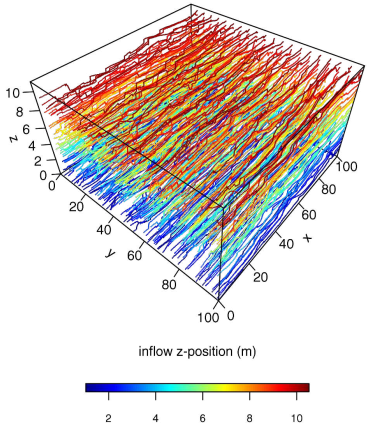

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Conclusion

Take home message:

- Subsurface structure
- Object-based model
- Impact on the subsurface flow

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Future research:

- Link sedimentology - geomorphology
- Parameter inference based on geophysical data