KTH ROYAL INSTITUTE OF TECHNOLOGY

Transport Processes in Geosphere-Biosphere Interface

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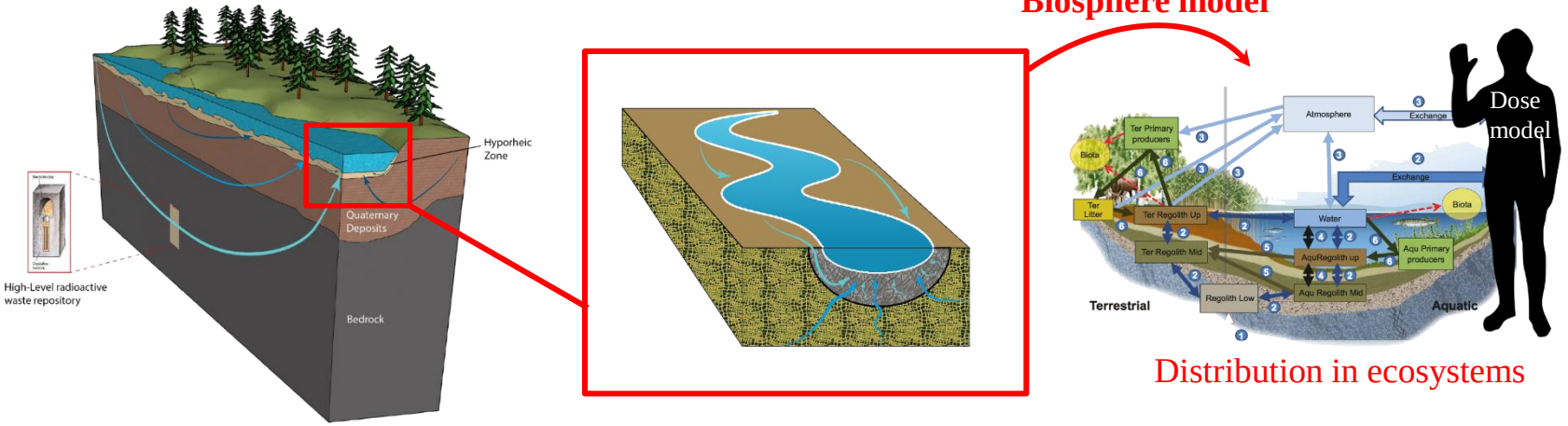
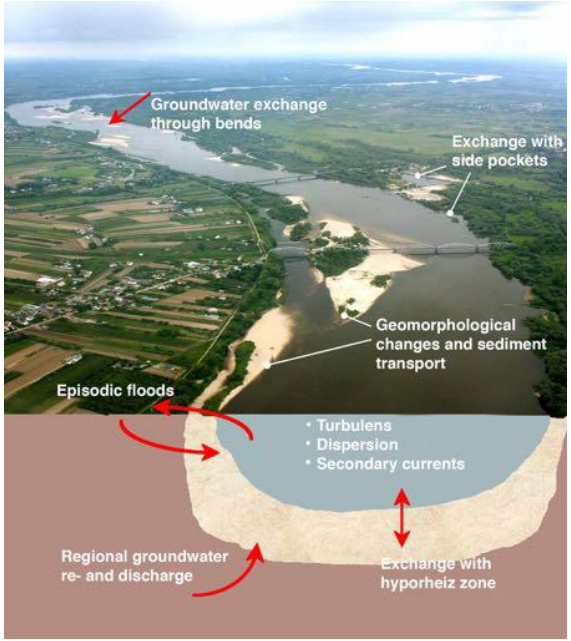
Introduction

- Radioactive waste management due to the increase of radioactive waste generation
- Recognized option: Deep, stable geological disposal repository (KBS3)
- Evaluation of impact of radioactive contamination leakage from deep repository into biosphere
- Regional groundwater: the main component in radio nuclide transfer among biosphere compartments
- Hyporheic fluxes influences the magnitude, direction of the groundwater flow near the streambed as well as and fragmentation of deep groundwater upwelling zones



Hyporheic Fluxes

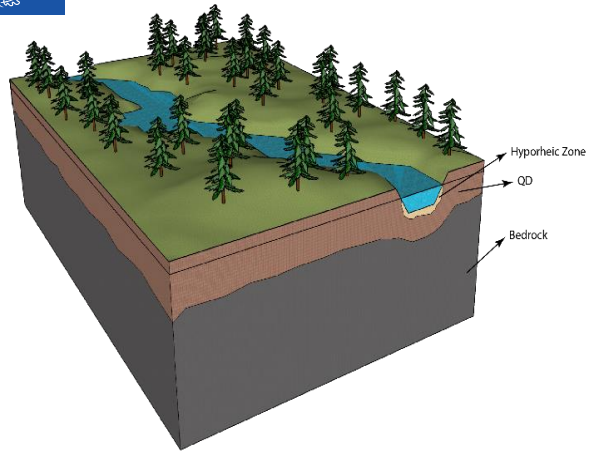
- Hyporheic flow is a shallow groundwater flow driven by the pressure variation along the stream bed
- Groundwater and hyporheic fluxes influence on each other characteristics:
  - ***Velocity***
  - ***Direction of fluxes***
  - ***Travel time***
  - ***Travel length***
  - ***Discharge zones***

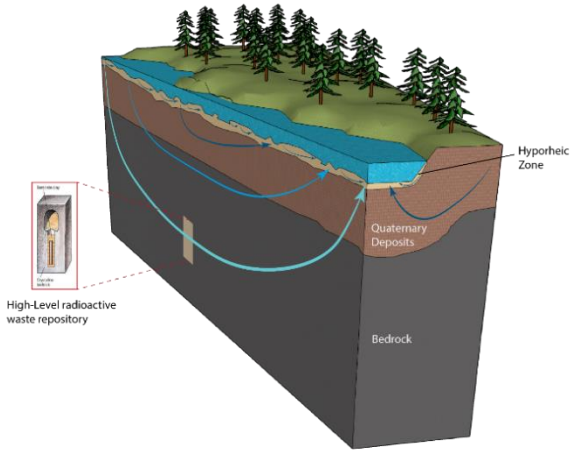


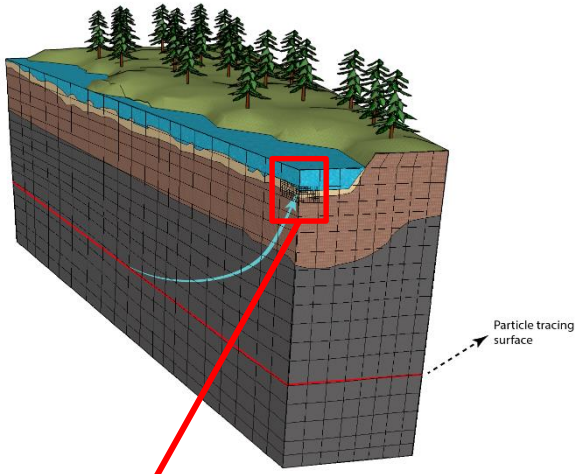
Aims and Objectives

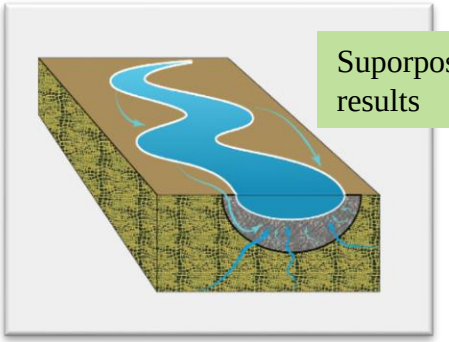
- Deriving support for biosphere models:
  - *calculate the reaction rate coefficient (1/T)*
  - *determine the patchiness of the groundwater at the topography surface*
- To find the discharge points of deep groundwater at the ground surface
  - *Finding the impact of hyporheic fluxes on groundwater flow paths (velocity & direction)*

Coceptual Methodology









Suporpositioning results

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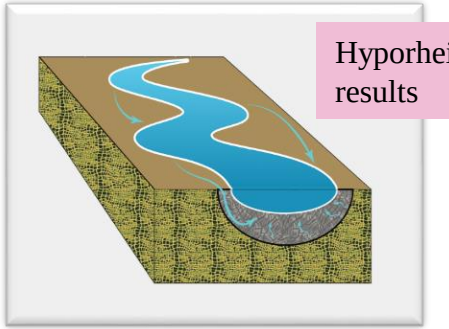

Hyporheic Scale results

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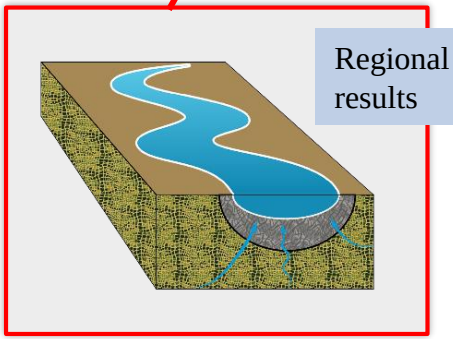
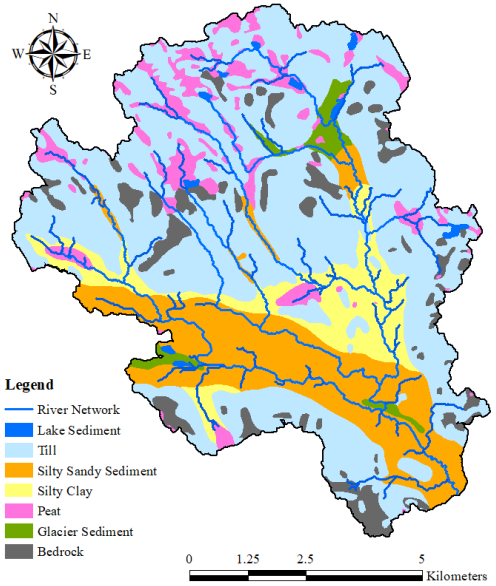


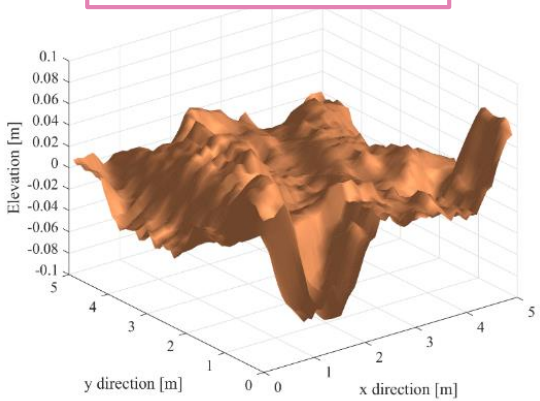
Regional Scale results

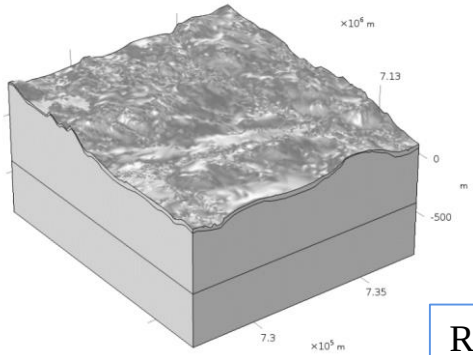
Modeling Strategy

- Catchment study: Krycklan catchment (near the city of Umeå)
- Two separate models: regional and streambed scales
- Regional scale: numerical modeling
  - Boundary condition (landscape control/recharge control)
- Streambed scale: exact solution
- Applying Superposition



Streambed Model

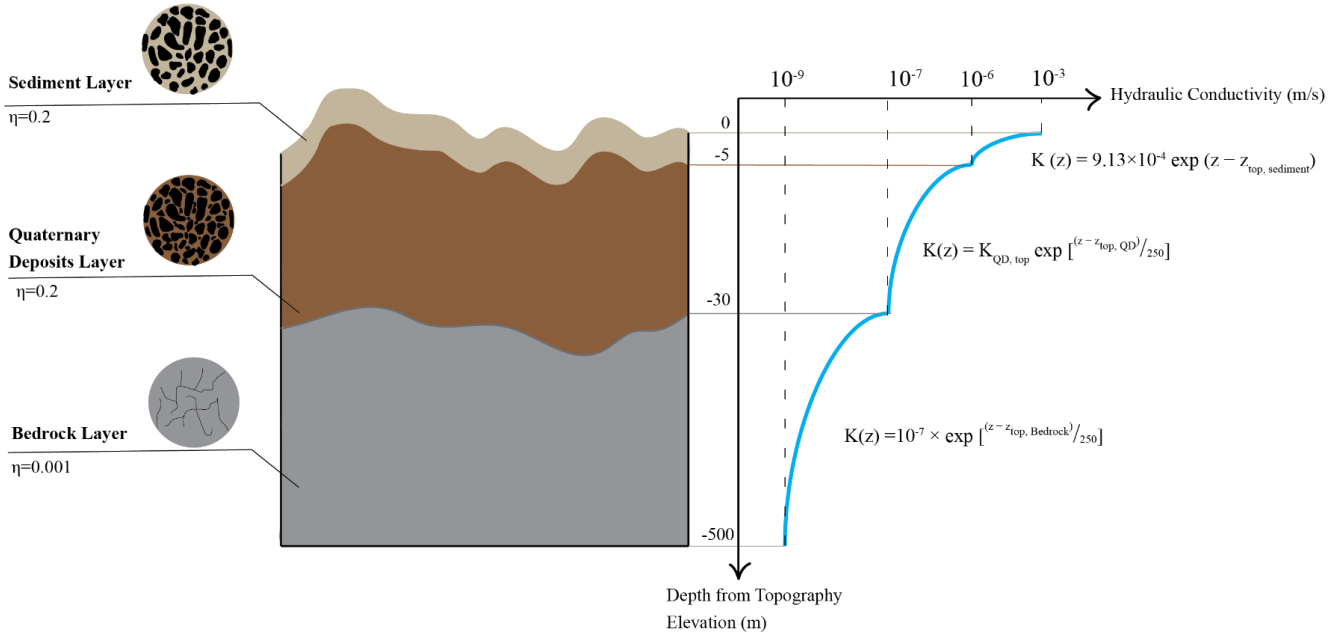




Regional Model

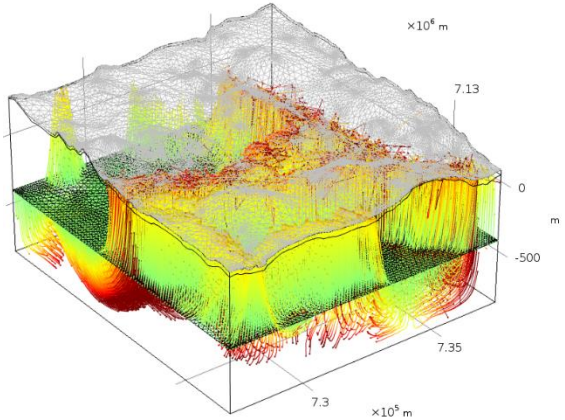
Regional Scale Modeling

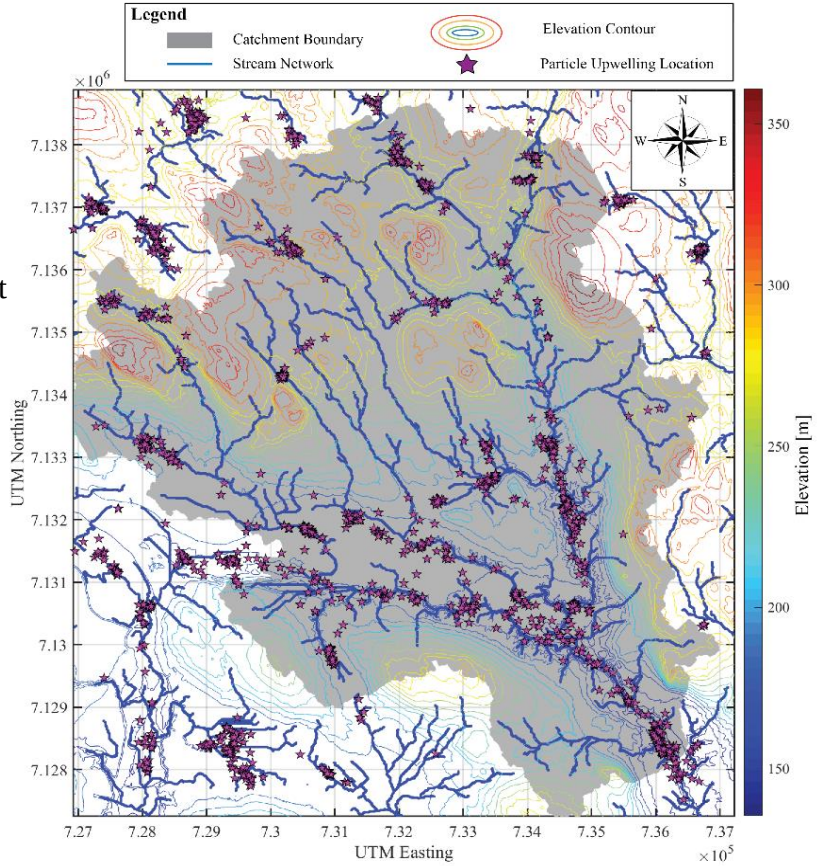
- Three horizontal layers : streambed sediment, Quaternary Deposits, and the bedrock
  - (streambed sediment defines as the top five meters of Quaternary deposits depth from the topography surface)



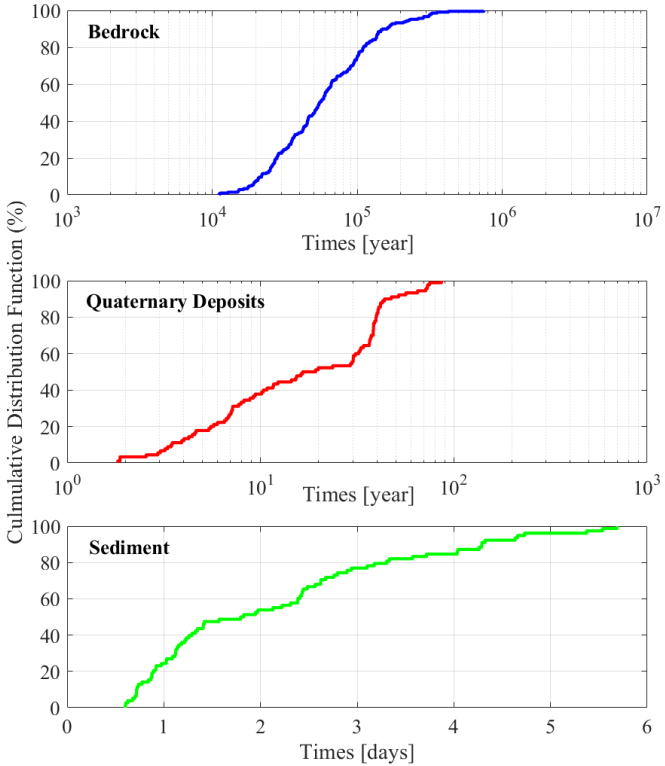
Particle Tracing

- 10000 inert particles (grid of 100 × 100) released
  - from a flat horizontal surface located approximately at 500 m depth from the minimum topography elevation
- 2094 discharge points
  - ❑ 1287 discharge points within the catchment
  - ❑ 807 discharge points out of the catchment

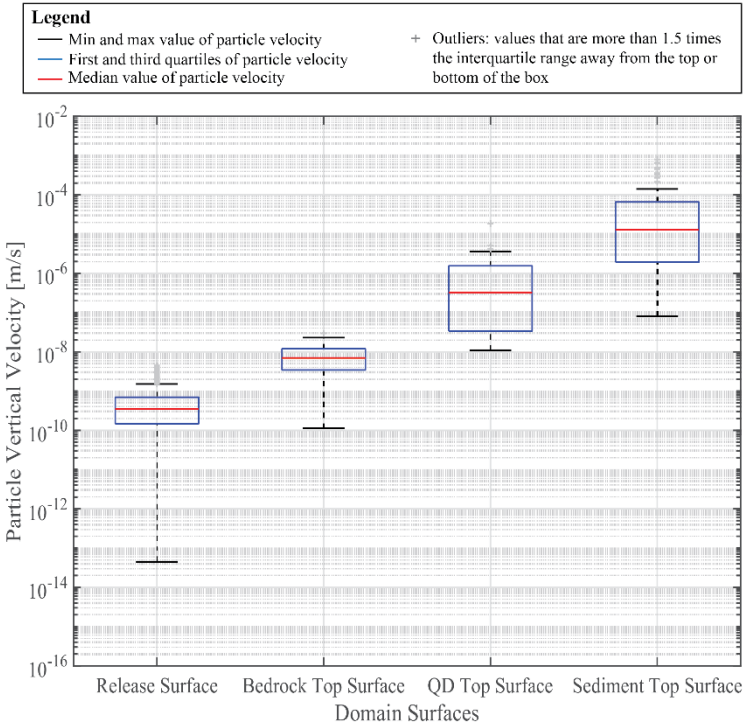




Regional Model Results



Particles travel time in each layer



Particles vertical velocity on layers' top surface

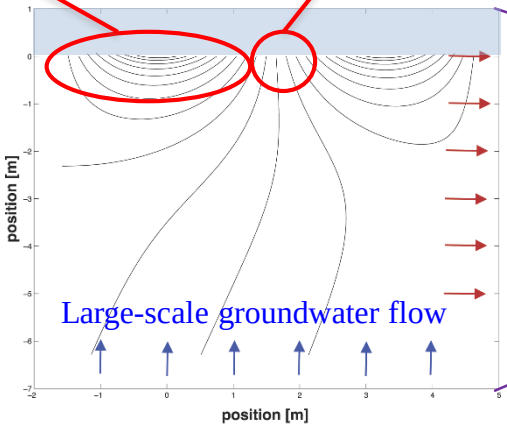
Streambed Scale Modeling

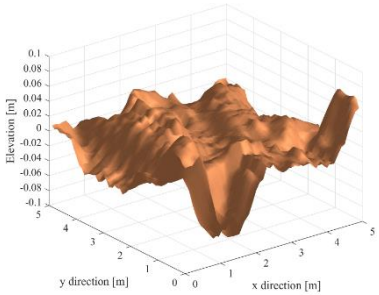
Isolated, hyporheic flow

Upwelling groundwater

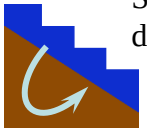
Stream

Below stream; Hyporheic zone



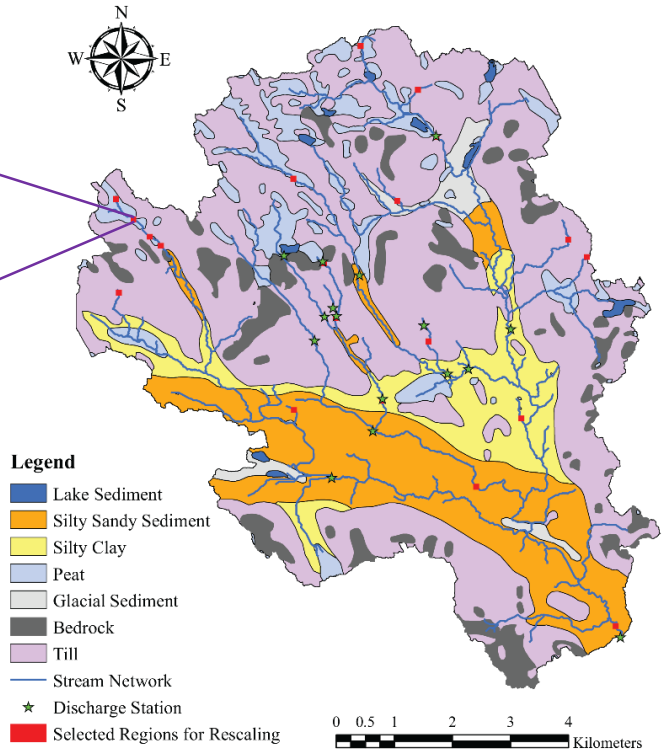


Drives hyporheic flows



Static head driven

Dynamic head driven



Streambed Scale

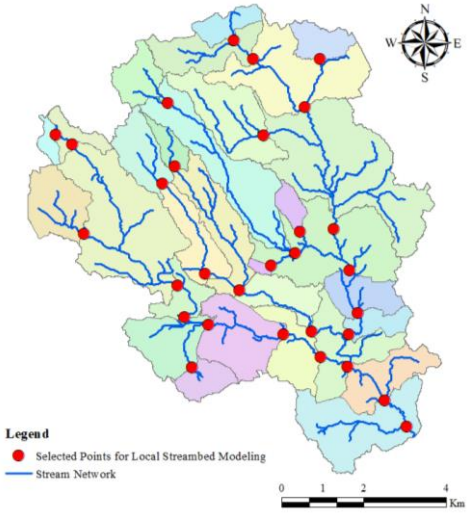
Hydrostatic Damping Factor

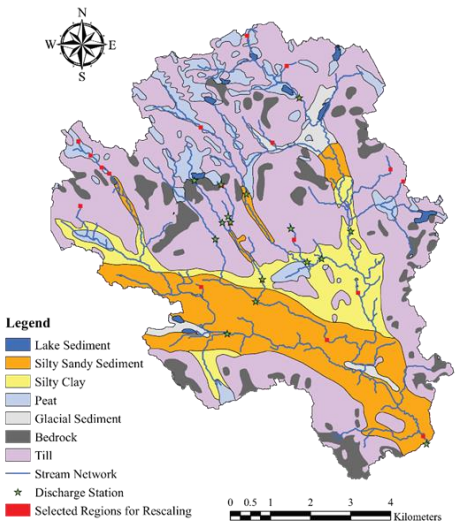
Depth Decaying Function

$$H_S(x,y,z) = \sum_{j=1}^{N}\sum_{i=1}^{N}\left[\left(\frac{h_m}{\sigma_{S,B}\sqrt{2}}\right) + C_{damp}(\lambda_i)\right](A)_{i,j}\sin(k_i x)\cos(k_j y) \times e^{\left(-\frac{c}{2}+\sqrt{\frac{c^2}{4}+\alpha\left(k_x^2+k_y^2\right)}\right)z}$$

Dynamic Contribution

Topography Fluctuation



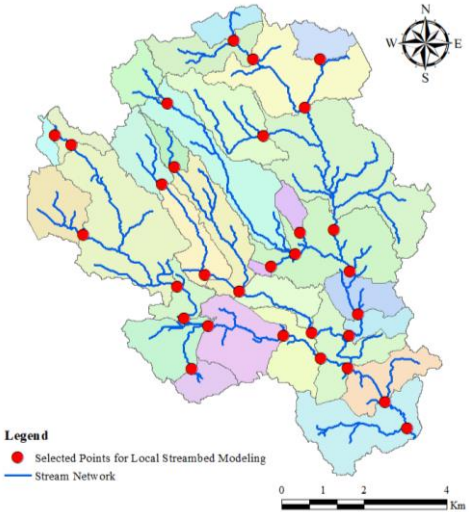


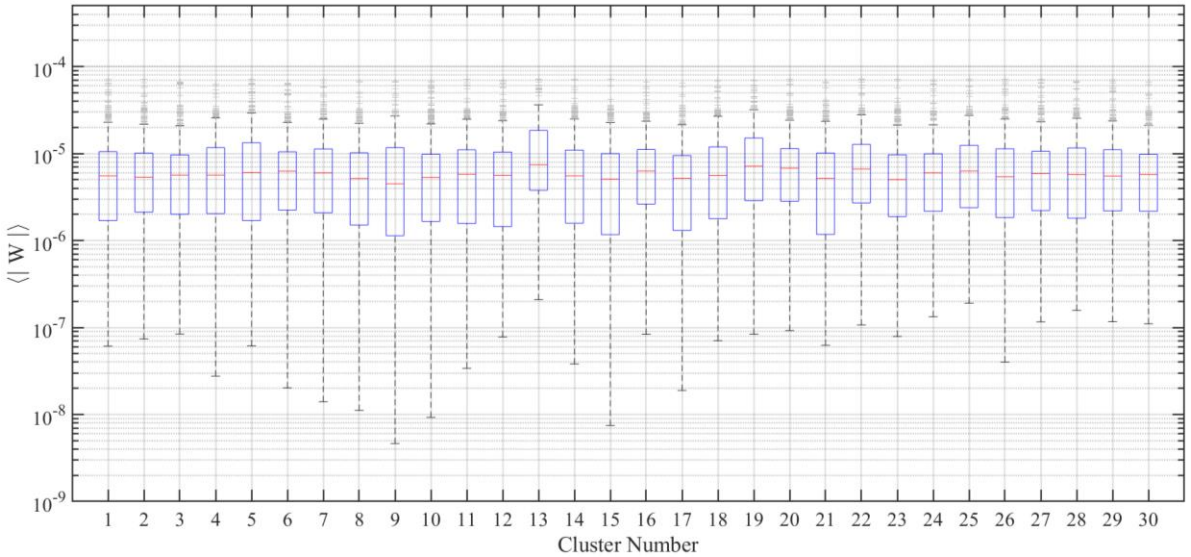
Monte Carlo simulation is used to generalize the results of our study

- **Dynamic contribution**: **indirectly** used in Monte Carlo
- **Hydro static damping factor**: **directly** used in Monte Carlo **unifrom distribution**
- **Topography Fluctuation**: **directly** used in Monte Carlo (choosing one of the 20 topography in a uniform distribution)

Streambed Scale Results

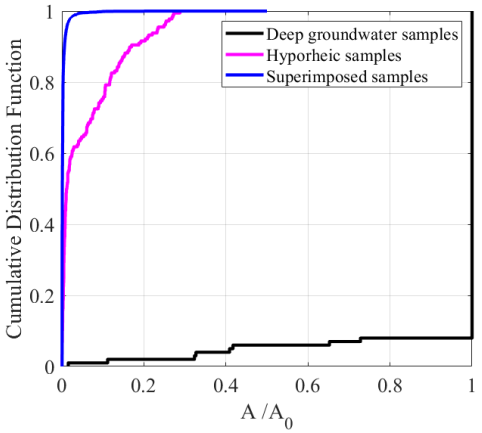
- 400 samples in Monte Carlo simulation
  - Explanation:
    400 samples means 30×400=12000 (30 dynamic contribution and 400 samples)

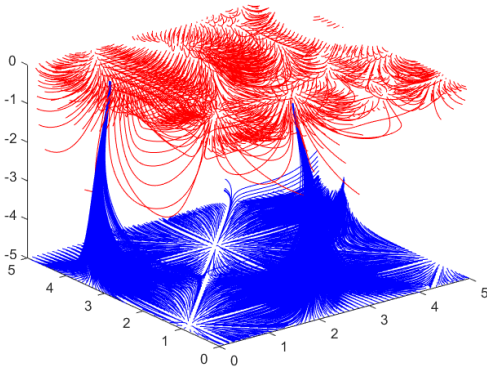


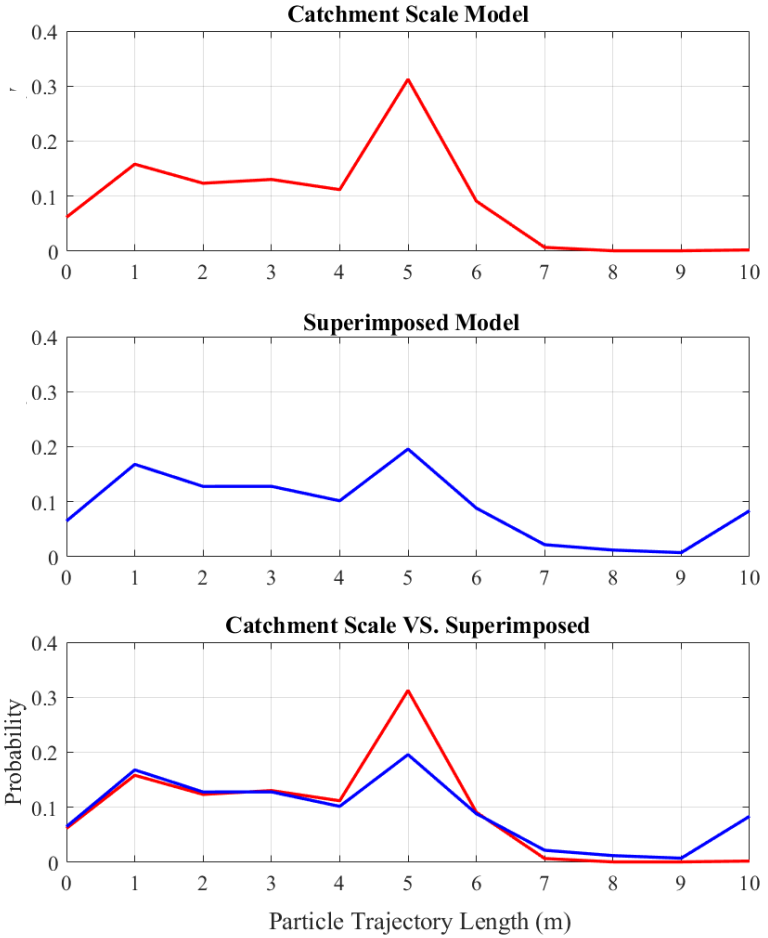


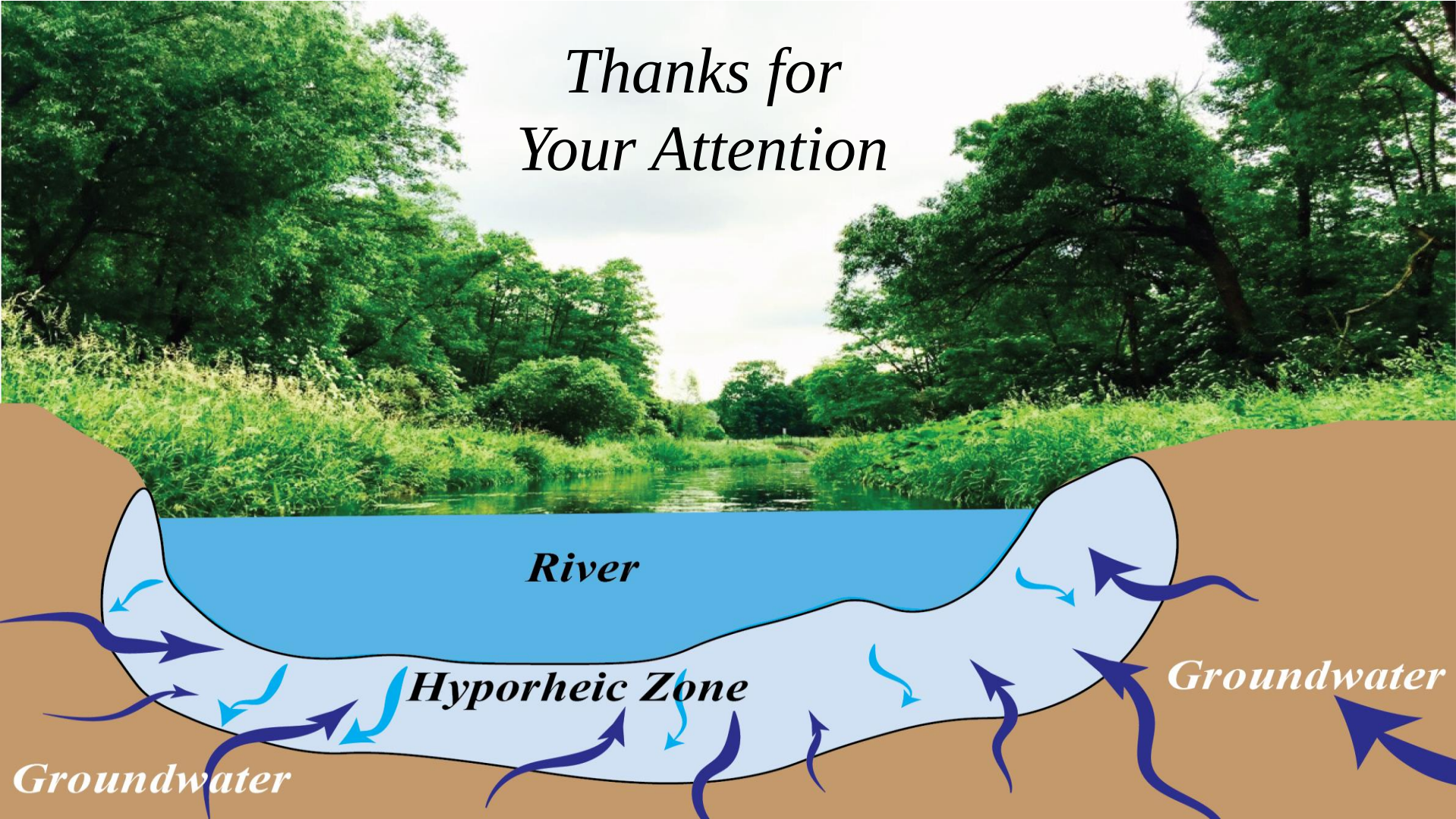
Superpositioning

- Hypoorheic fluxes Significantly change the patchiness of GW
- Deep GW is supressed due to hyporheic flow: leads to pin hole behaviour emergence
- Travel length and travel time of deep GW particles increase in superimposed model








Thanks for
Your Attention
River
Hyporheic Zone
Groundwater
Groundwater