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Surface micro-topography causes hot-spots of biogeochemical activity in a wetland system

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BACKGROUND

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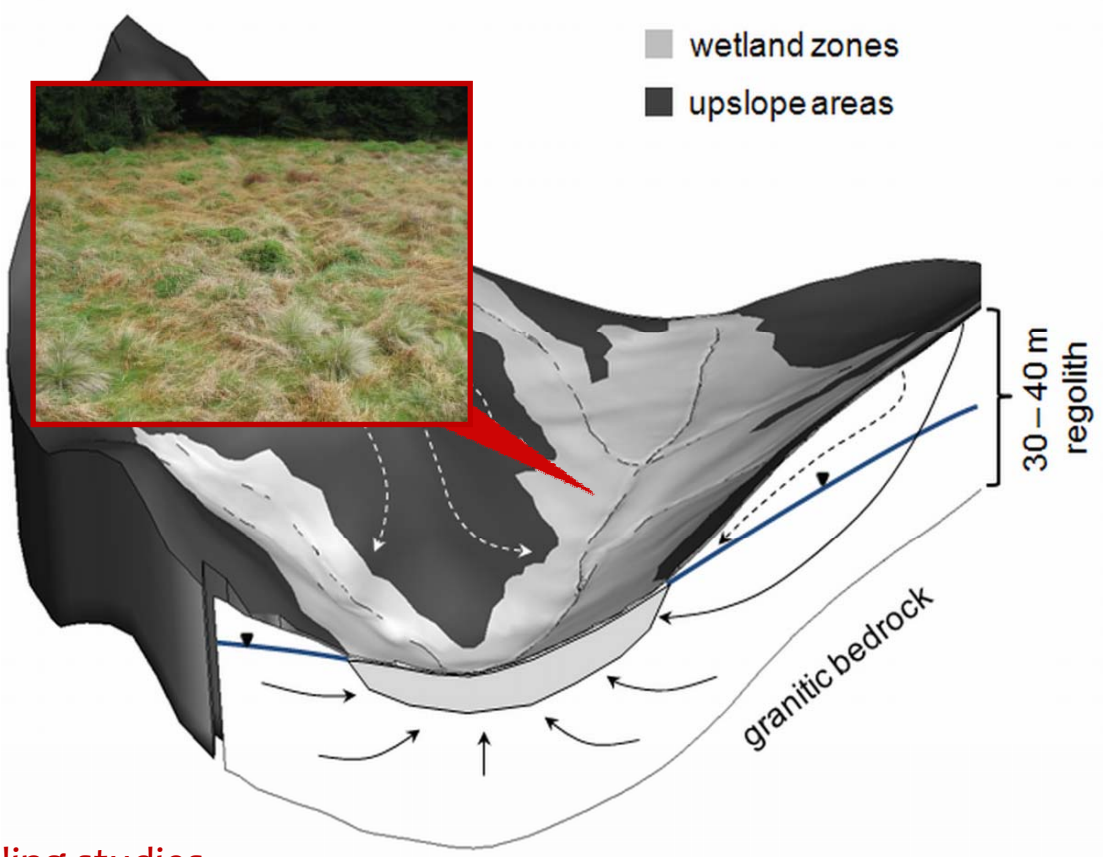
Lehstenbach Catchment:

- ~4.2 km²; located in North-Eastern Bavaria
- 1/3 of area: riparian wetlands
- areas control event runoff generation & water quality
- wetlands show pronounced micro-topographical structures (***hollow*** & ***hummock*** structures)



influence of micro-topography on

- ✓ runoff generation
- ✓ subsurface flow patterns
- ✓ biogeochemical settings

} modeling studies

SYNTHETIC WETLAND

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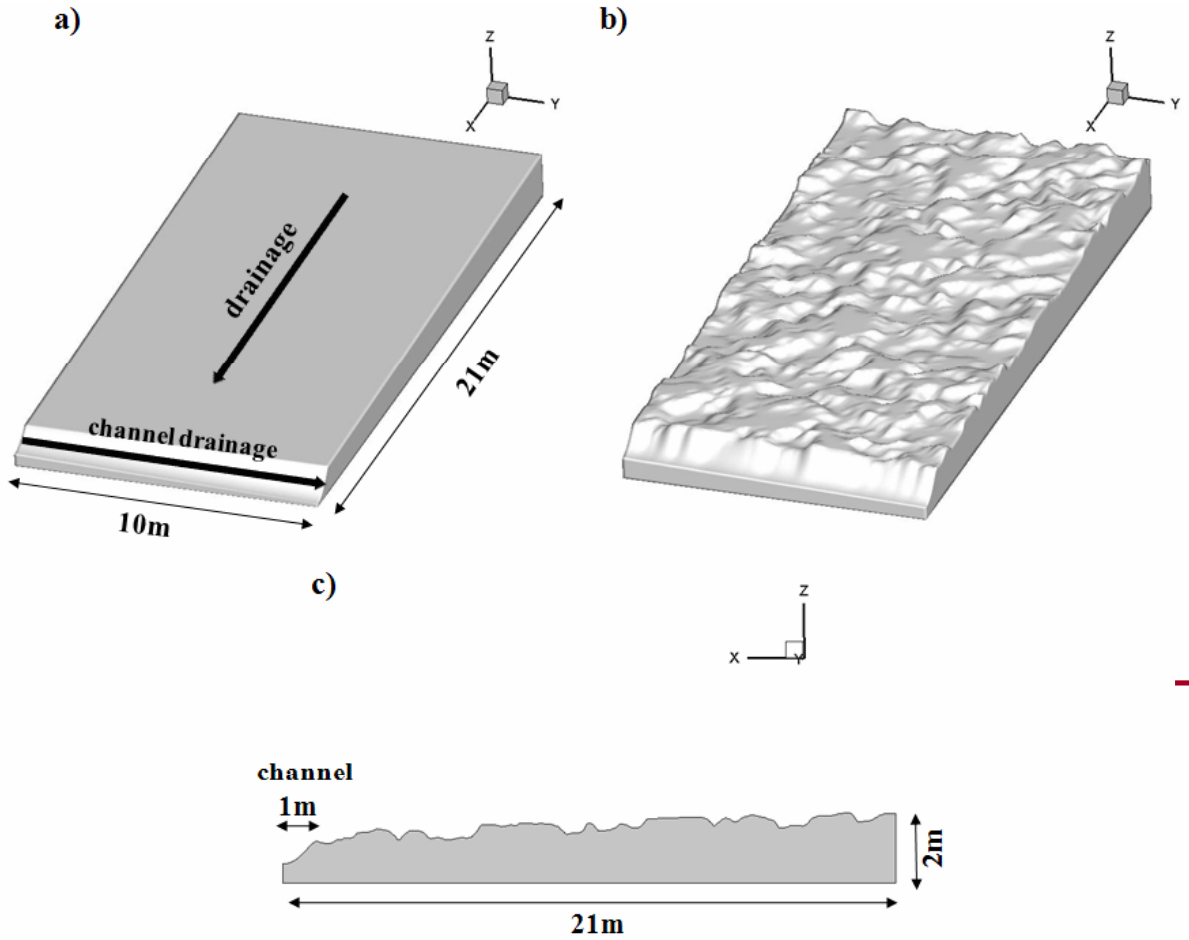

- *geostatistical generated micro-topography*
  - *indicator based geostatistics (TPROGS)*
- *numerical flow model (Hydreogeosphere):*
  - *variably saturated flow (3D Richards Eq.)*
  - *surface flow (diffusive wave approx.)*

→ *no (subsurface) material heterogeneity*

EVENT - RUNOFF GENERATION

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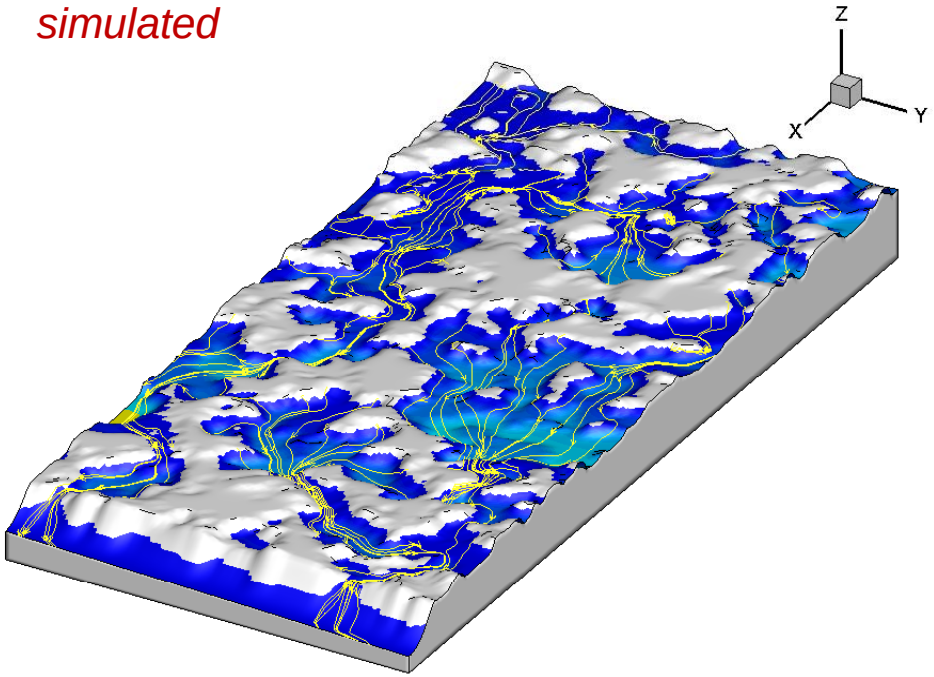
simulated



observed

high flow → formation of surface flow networks

Contents lists available at ScienceDirect

Advances in Water Resources

journal homepage: www.elsevier.com/ locate/advwatres

Effects of micro-topography on surface–subsurface exchange and runoff generation in a virtual riparian wetland — A modeling study

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SUBSURFACE FLOW PATTERNS

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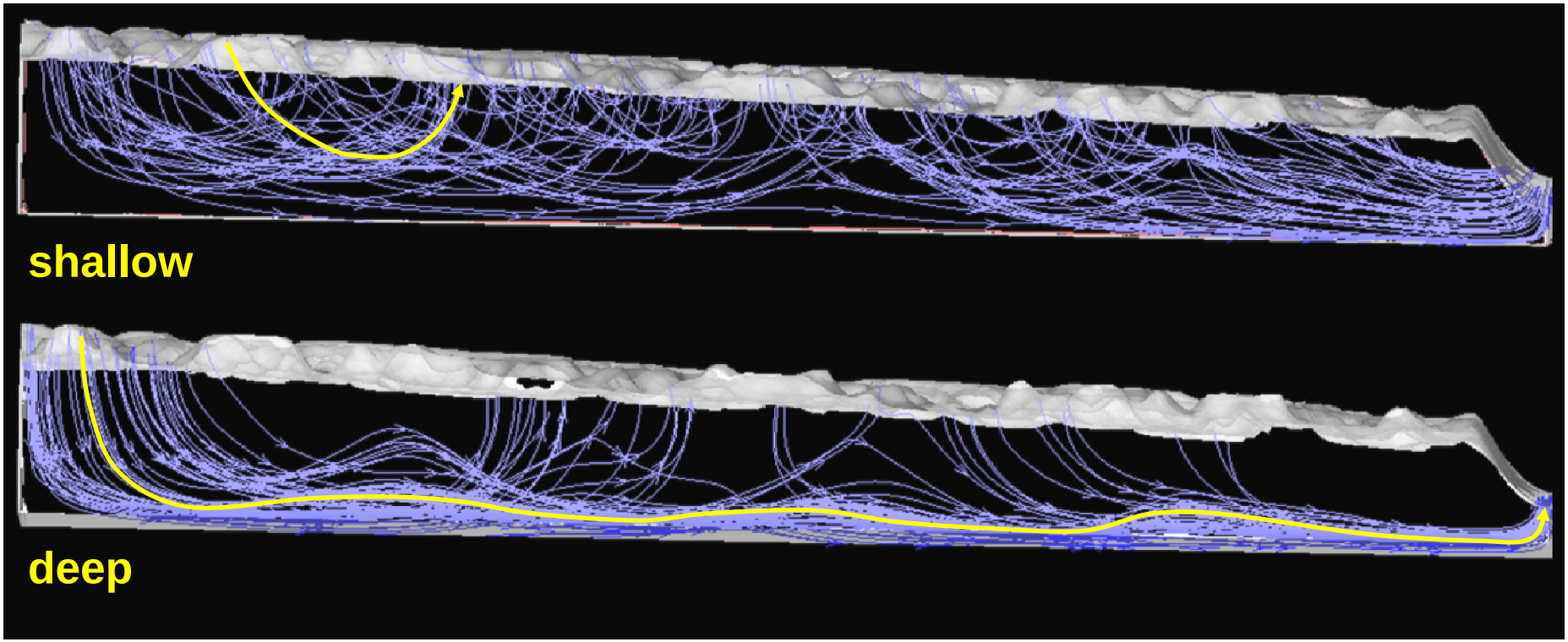

coexisting flow systems (deep/shallow)
→ induced by micro-topography

SUBSURFACE RESIDENCE TIMES

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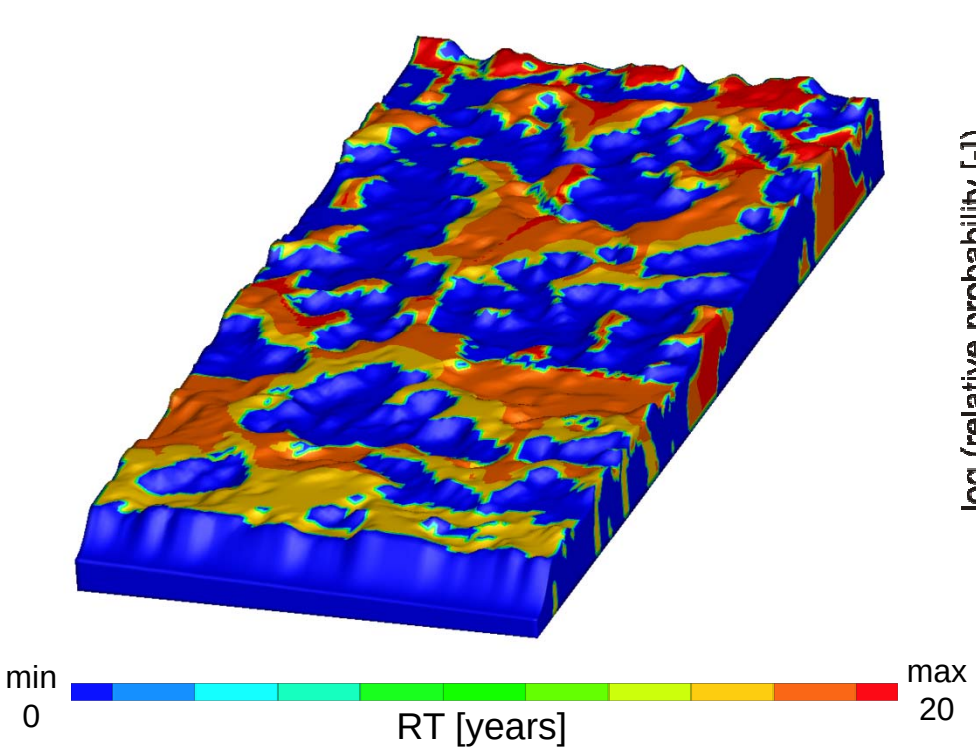

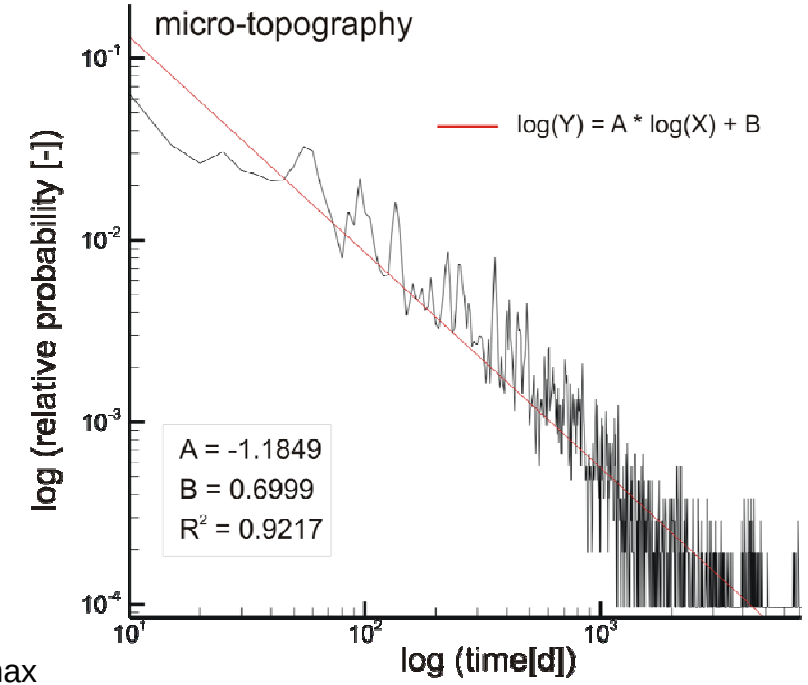

micro-topography → power law distributed RT
→ significance for biogeochemistry???

COUPLING HYDROLOGY & BIOGEOCHEMISTRY

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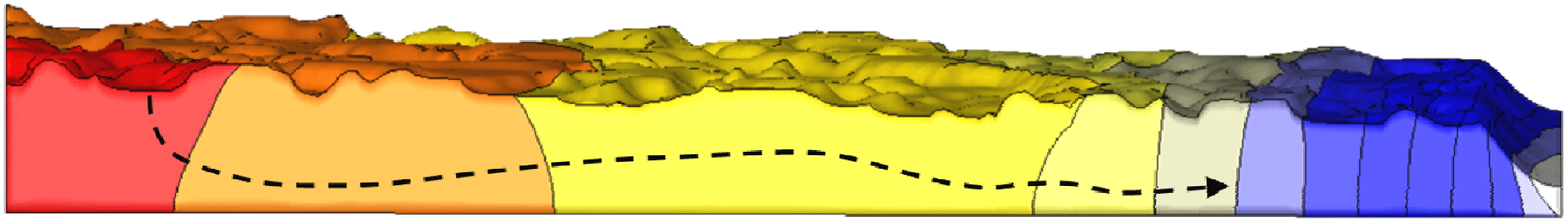
3D transient head field



particle tracking

infiltration

aerob. respiration

denitrification

Fe-reduction

SO_4-reduction

nitrification

Fe II oxidation

sulfid oxidation

exfiltration

reduction	oxidation

→*wetland typical redox processes represented in PhreeqC*

Subsurface Flow Paths

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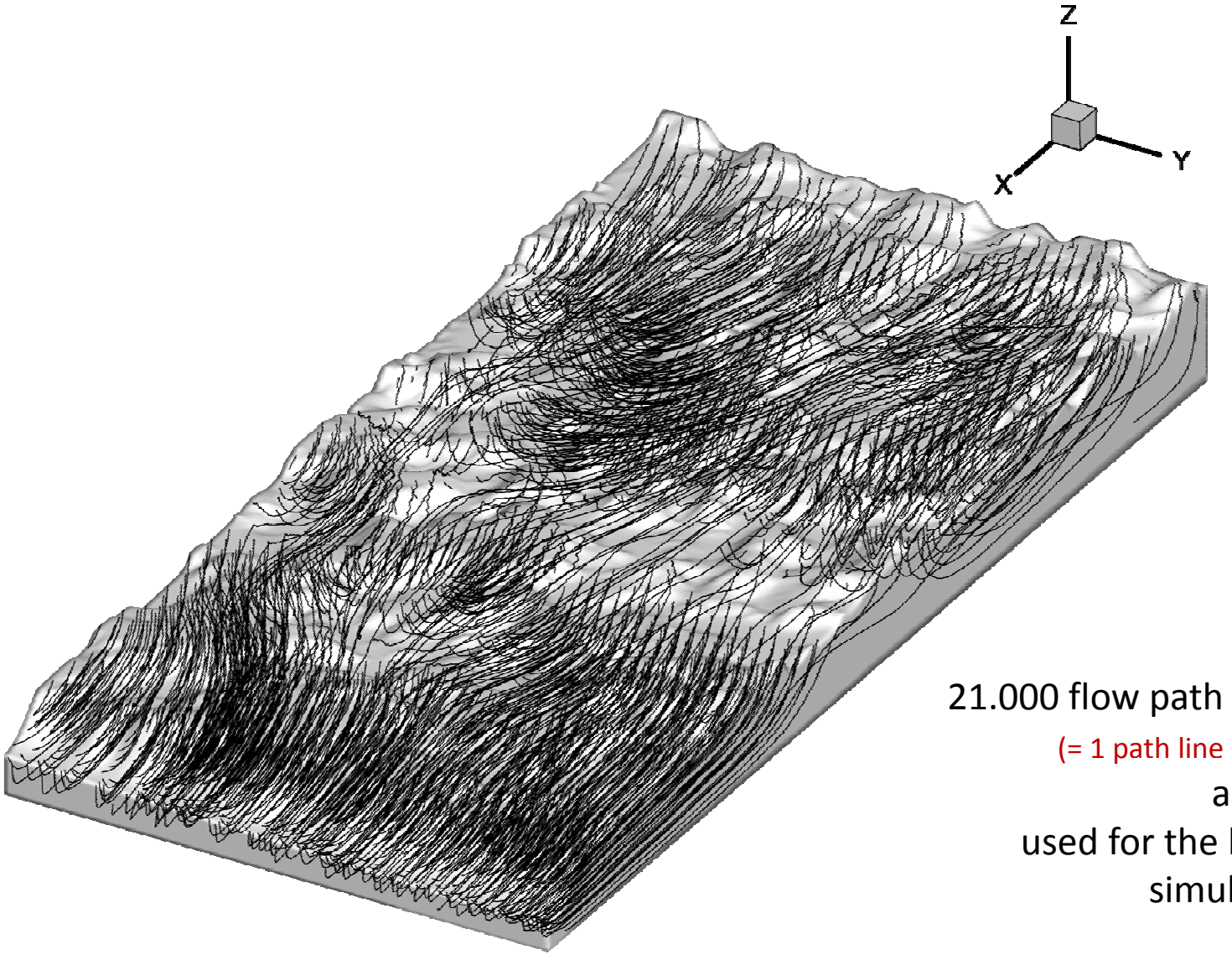

21.000 flow path lines were isolated

(= 1 path line per surface node)

and

used for the biogeochmical simulations

Sulfate – Reduction: $SO_4^{2-} + C_{org} \rightarrow S^{2-}$

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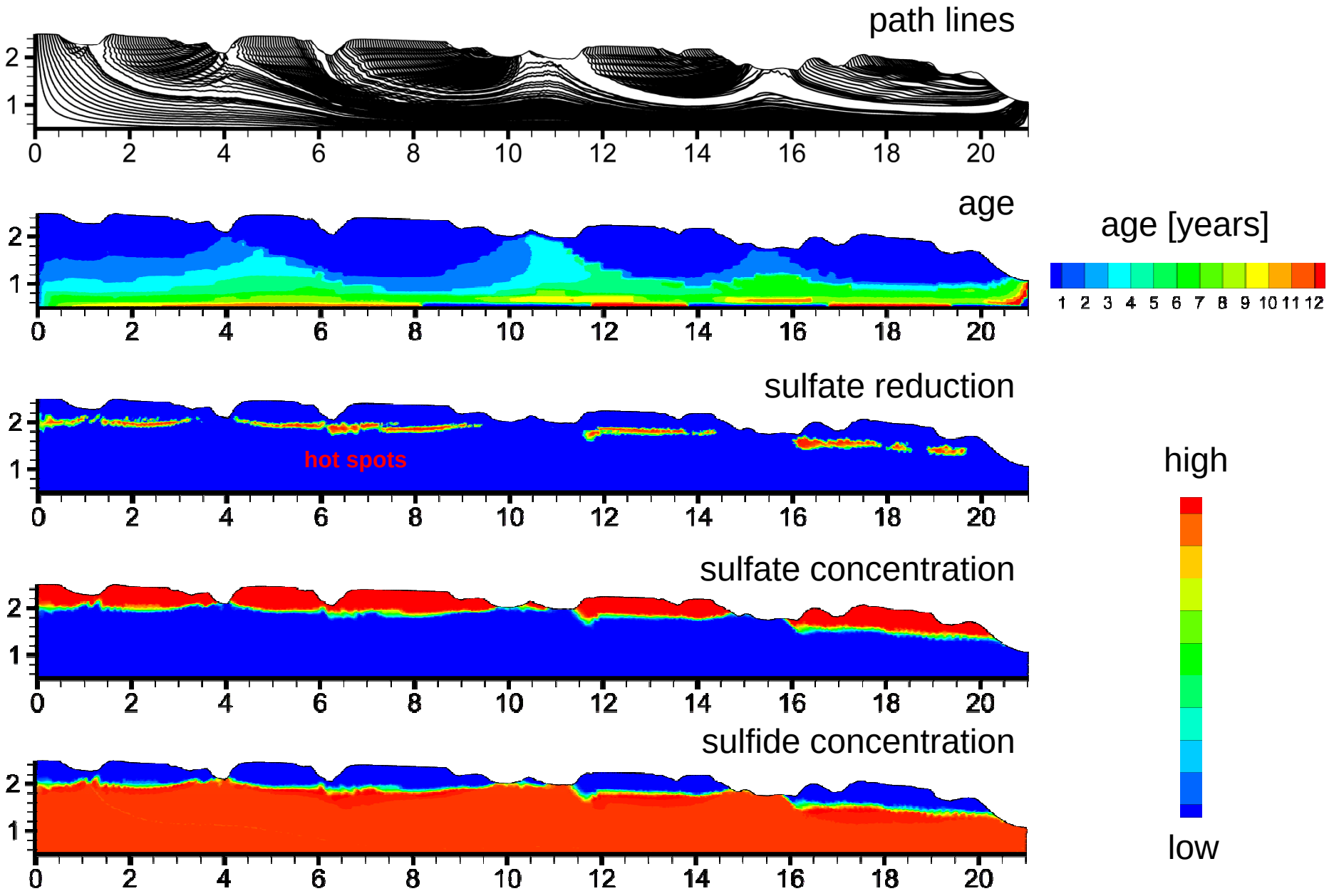

Sulfide – Oxidation: $S^{2-} + O_2 \rightarrow SO_4^{2-}$

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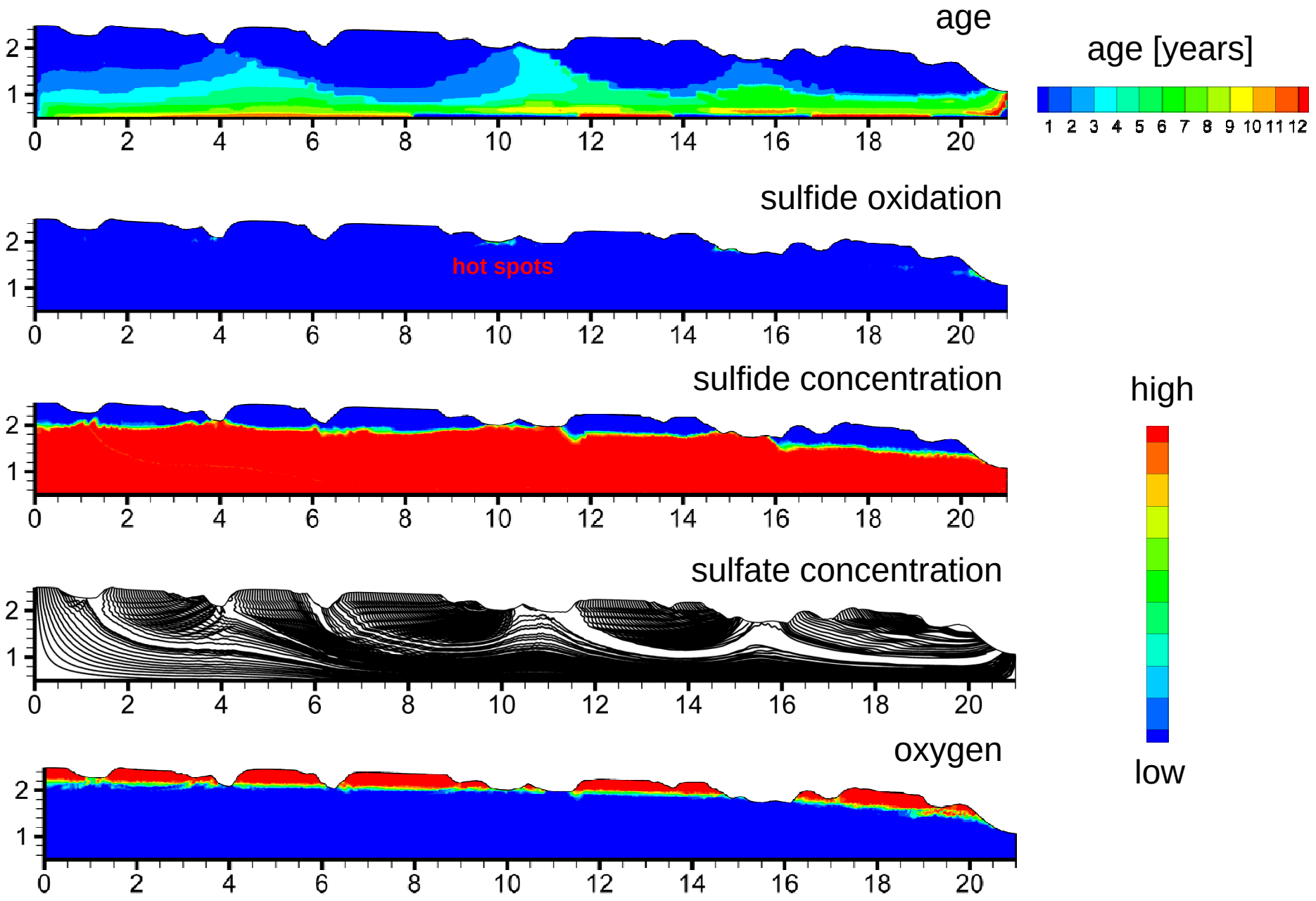
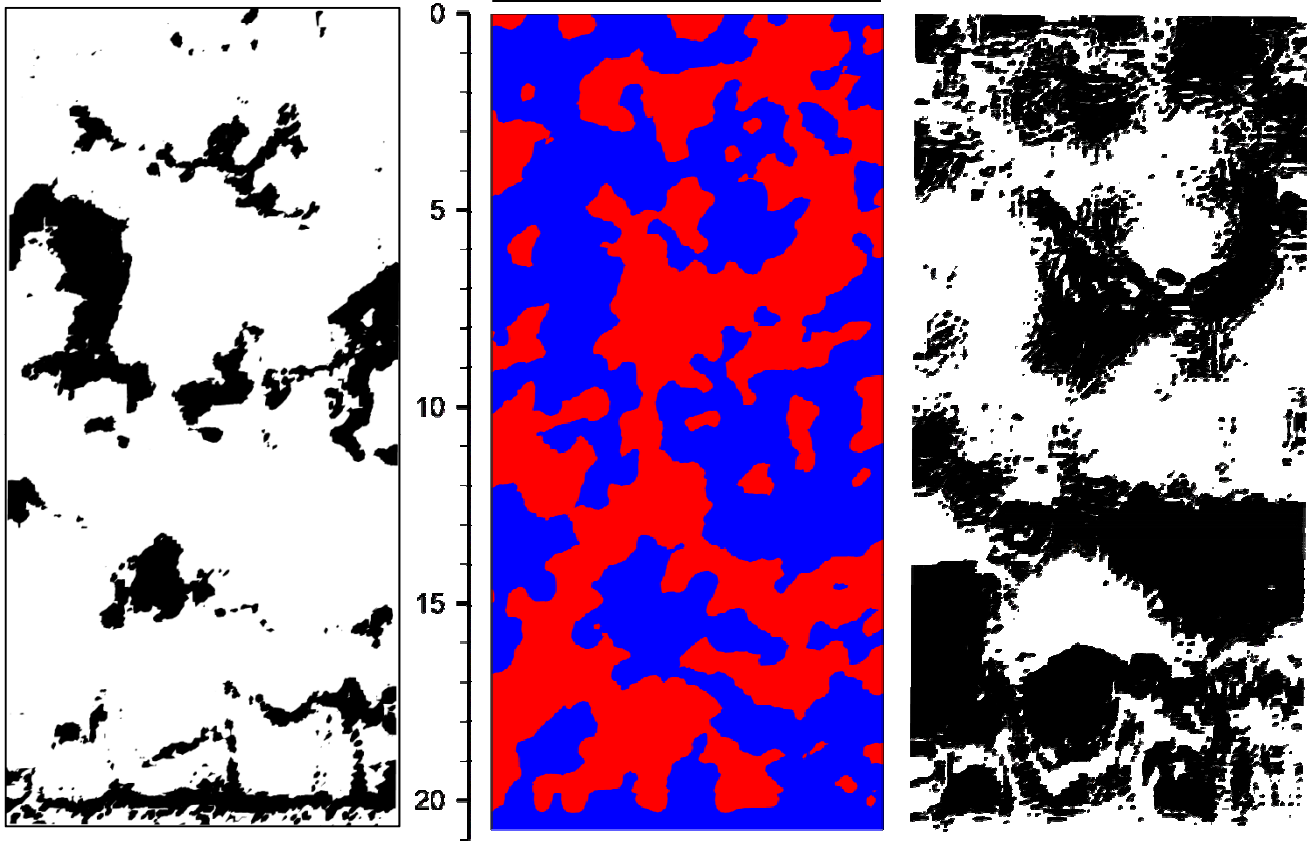


oxidation



reduction

hollows

hummock - structures

hot spots
process activity

→*hot spots below depressions*

→*hot spots below hummocks*

Fe(II)-Profiles:

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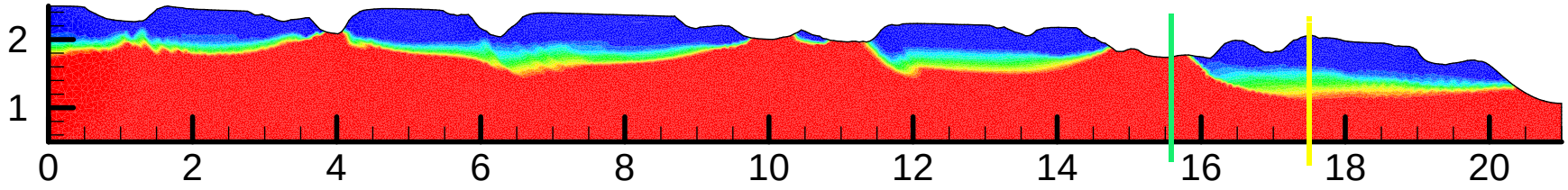

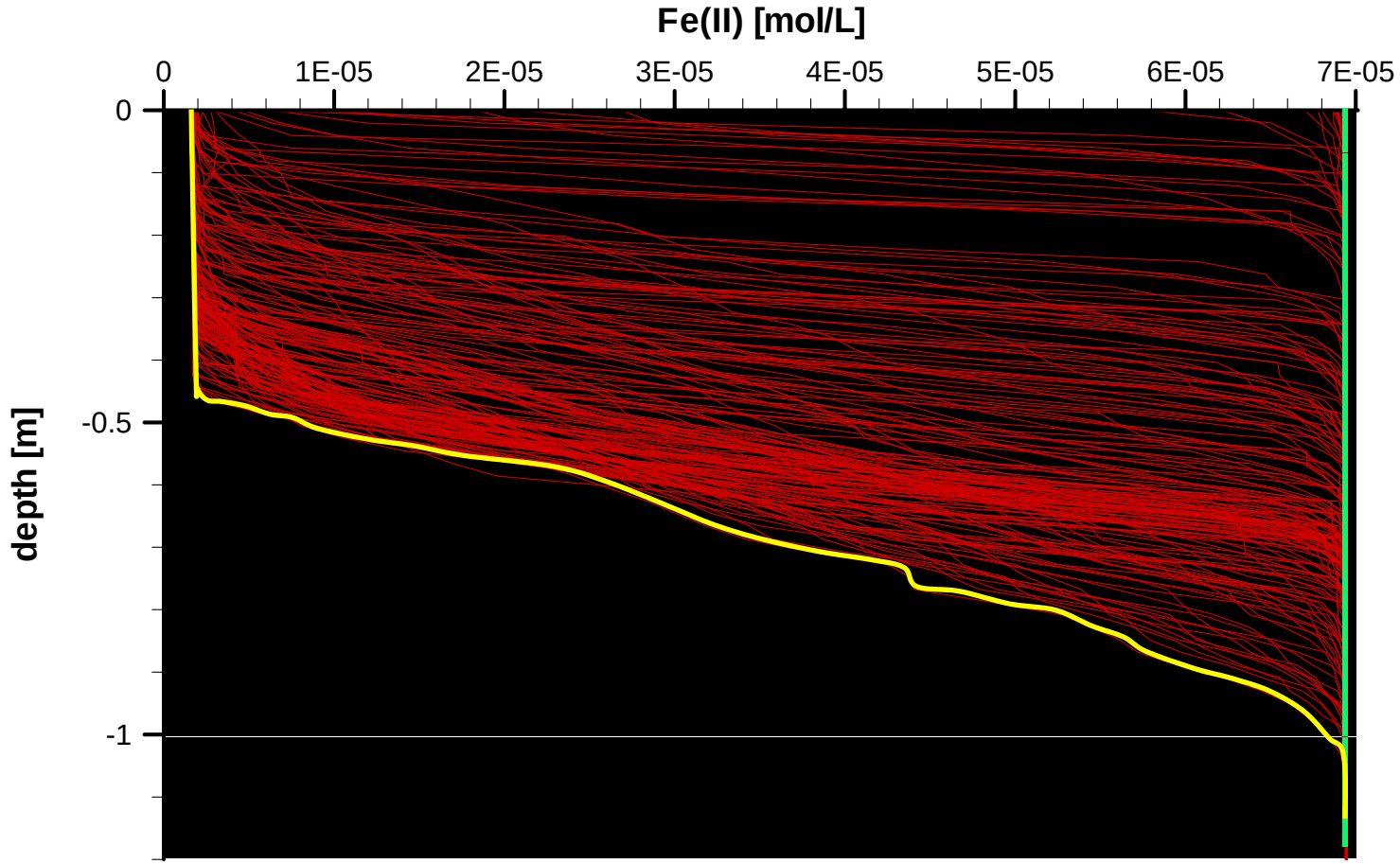

Fe(II)-Profiles:

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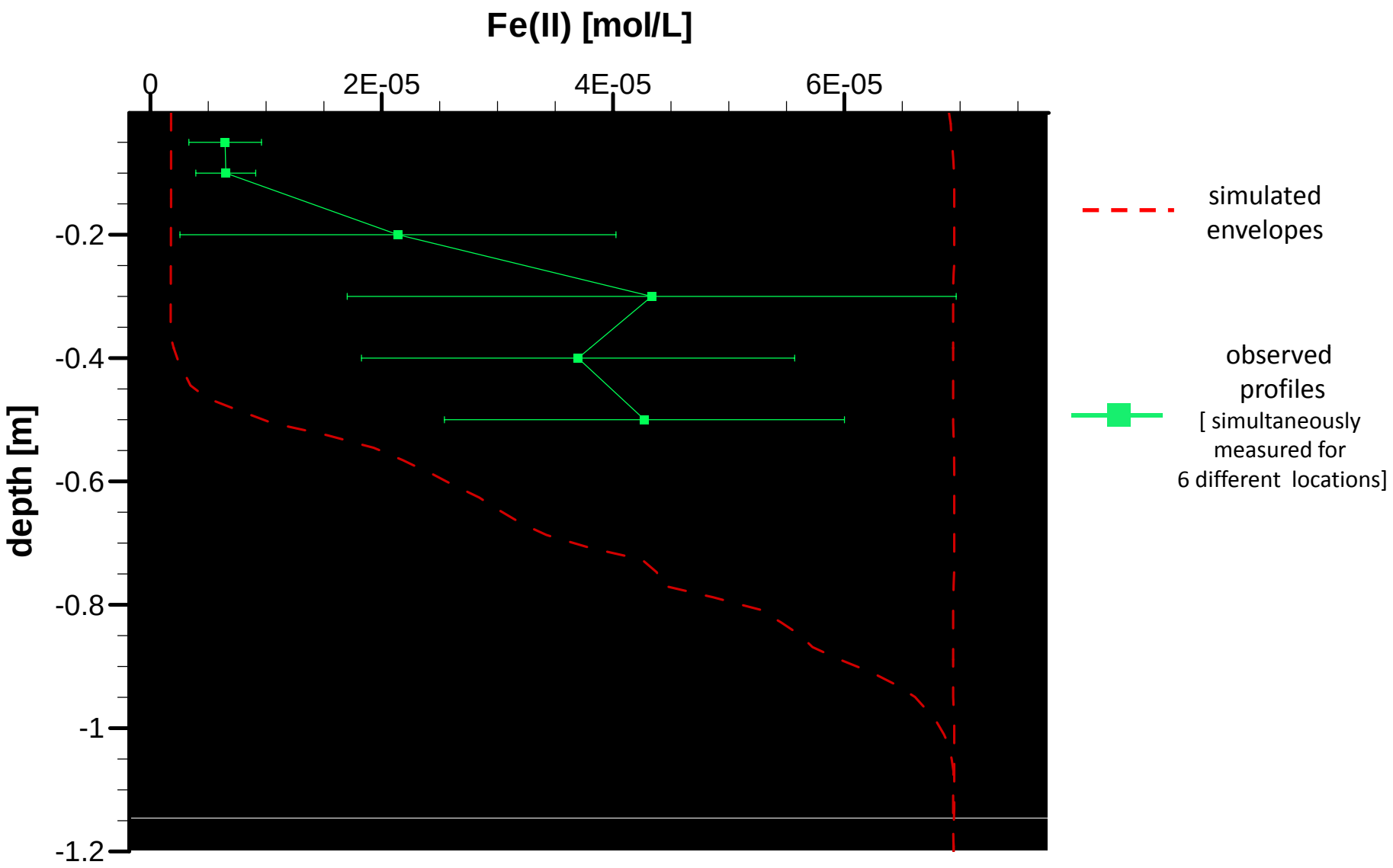

Nitrate & Sulfate - Profiles:

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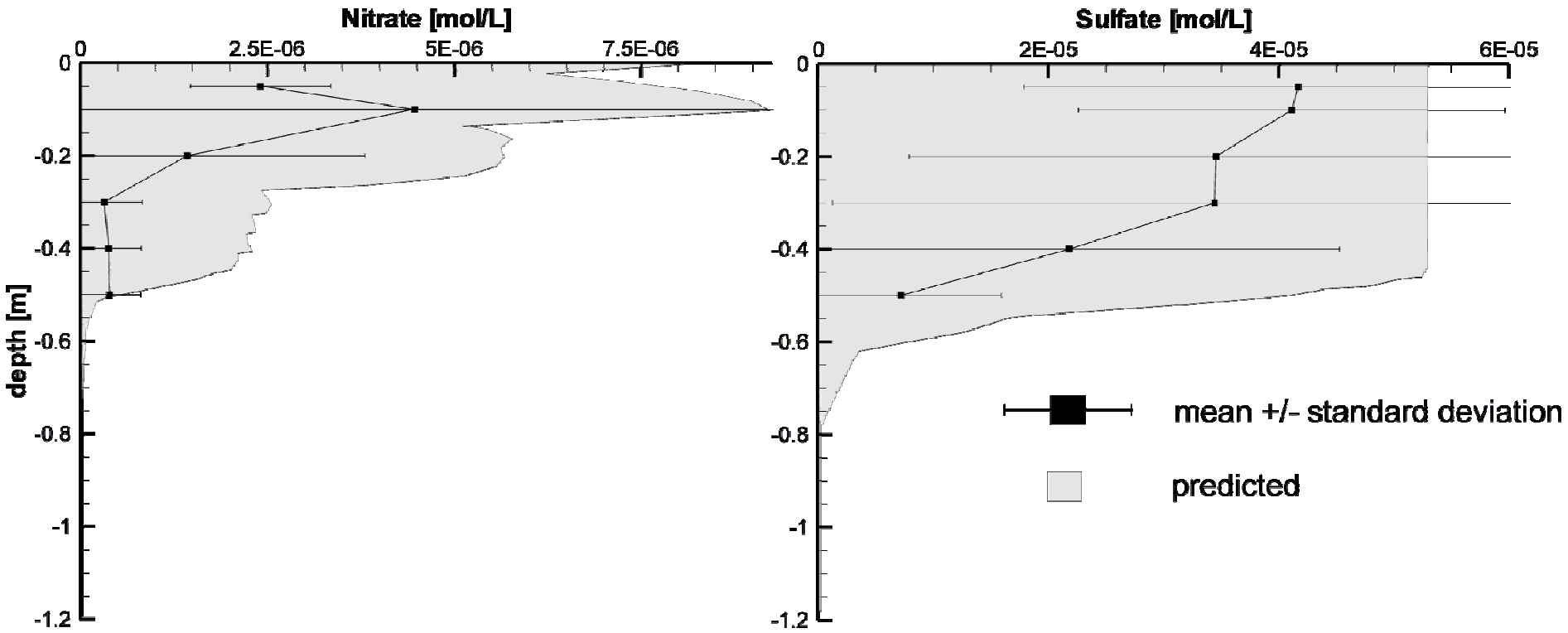

→ *field variations can be approximated*

SUMMARY

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heterogenous biogeochemistry → complex subsurface flow induced by superficial micro-relief

→*heterogeneous biogeochemical settings can be generated for homogenous soil material*

Hot Spots

reduction → *prefrential formation*

infiltration zones below hummocks

oxidation →

upwelling/exfiltration zones below hollows

Thank you for your attention