

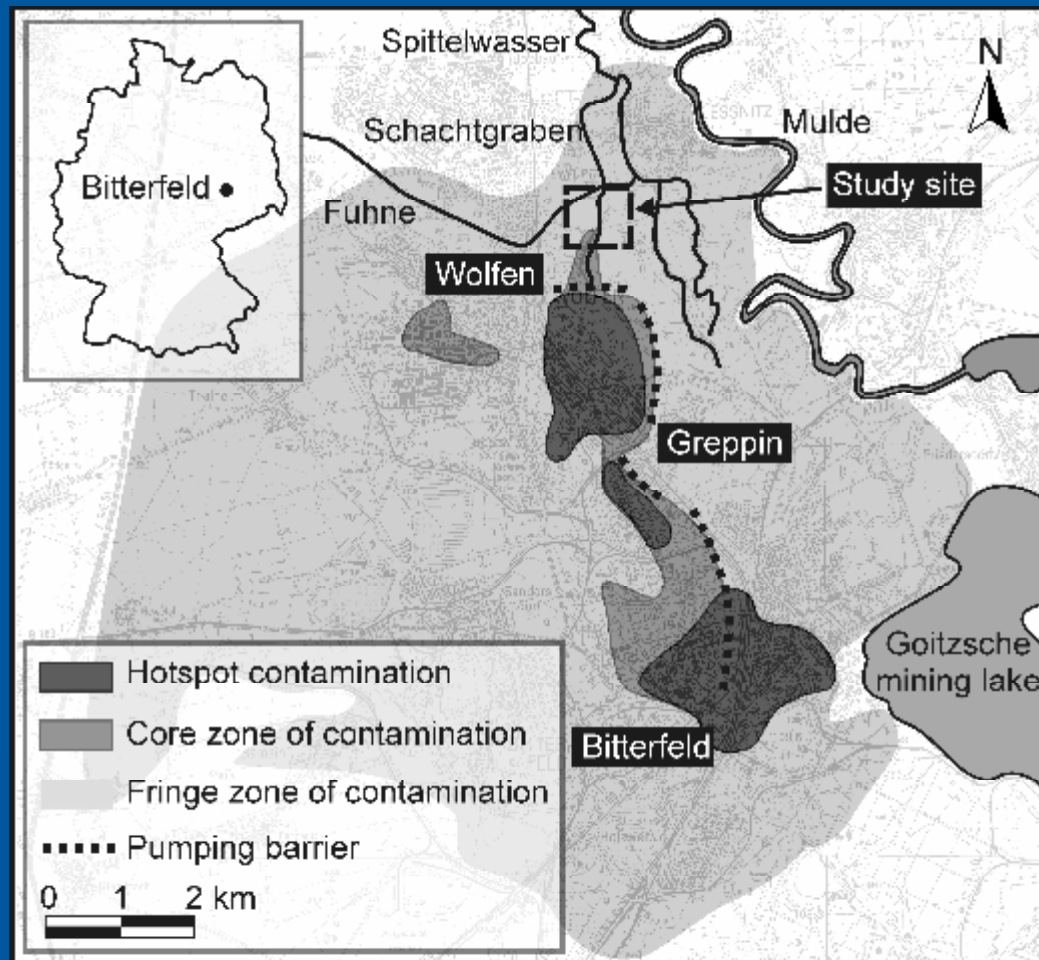


Groundwater – Surface Water Interactions at the Contaminated Mega-Site Bitterfeld, Germany

E. Kalbus, C. Schmidt, J.W. Molson, F. Reinstorf, M. Schirmer



BACKGROUND



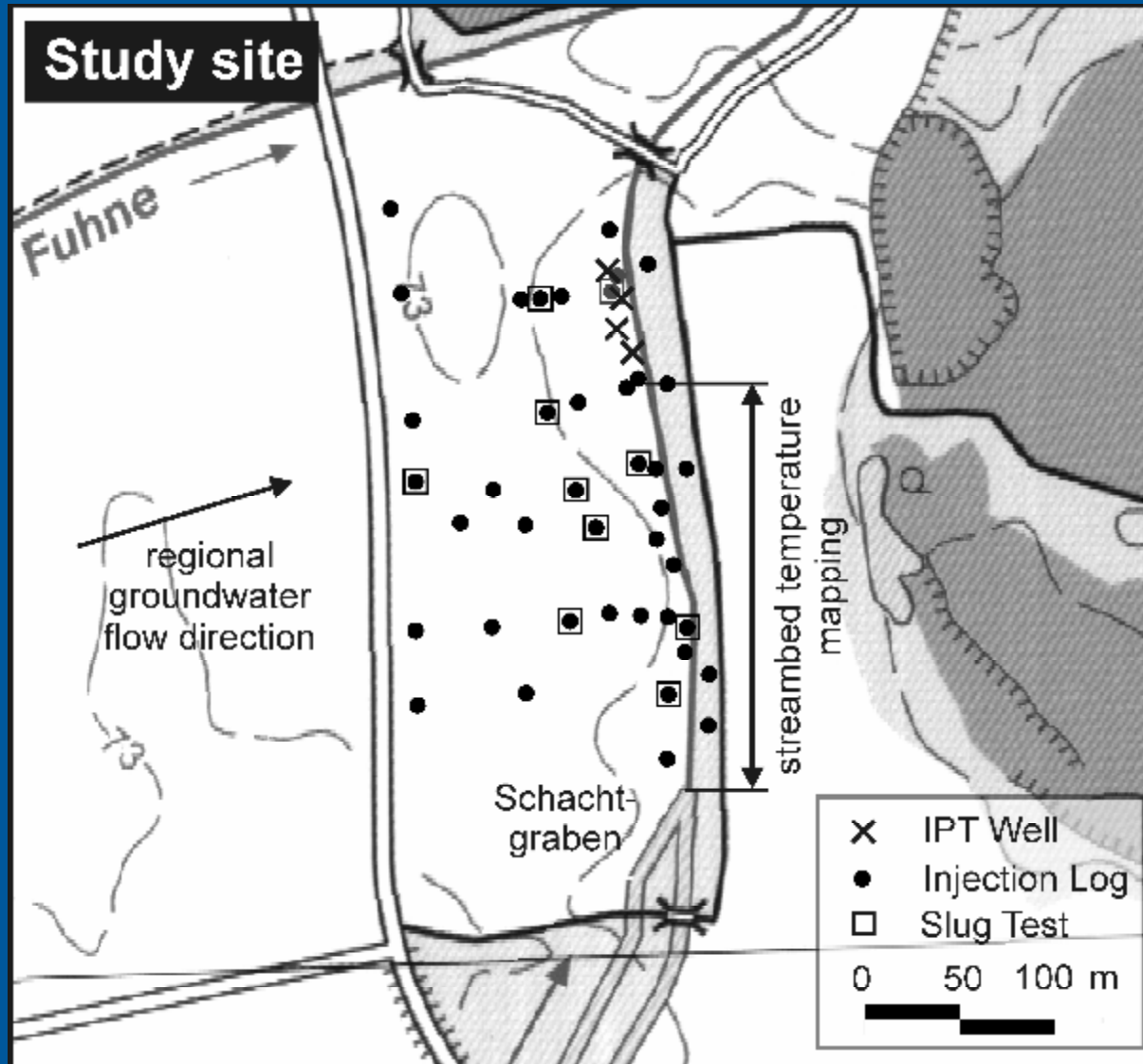
Objectives:

- § Quantification of contaminant mass fluxes
- § Spatial heterogeneity of water and solute fluxes

OUTLINE

- § Summary of field methods and flux calculations
- § Modelling study of the influence of subsurface heterogeneity on the patterns of groundwater discharge through the streambed

OVERVIEW OF FIELD OBSERVATIONS

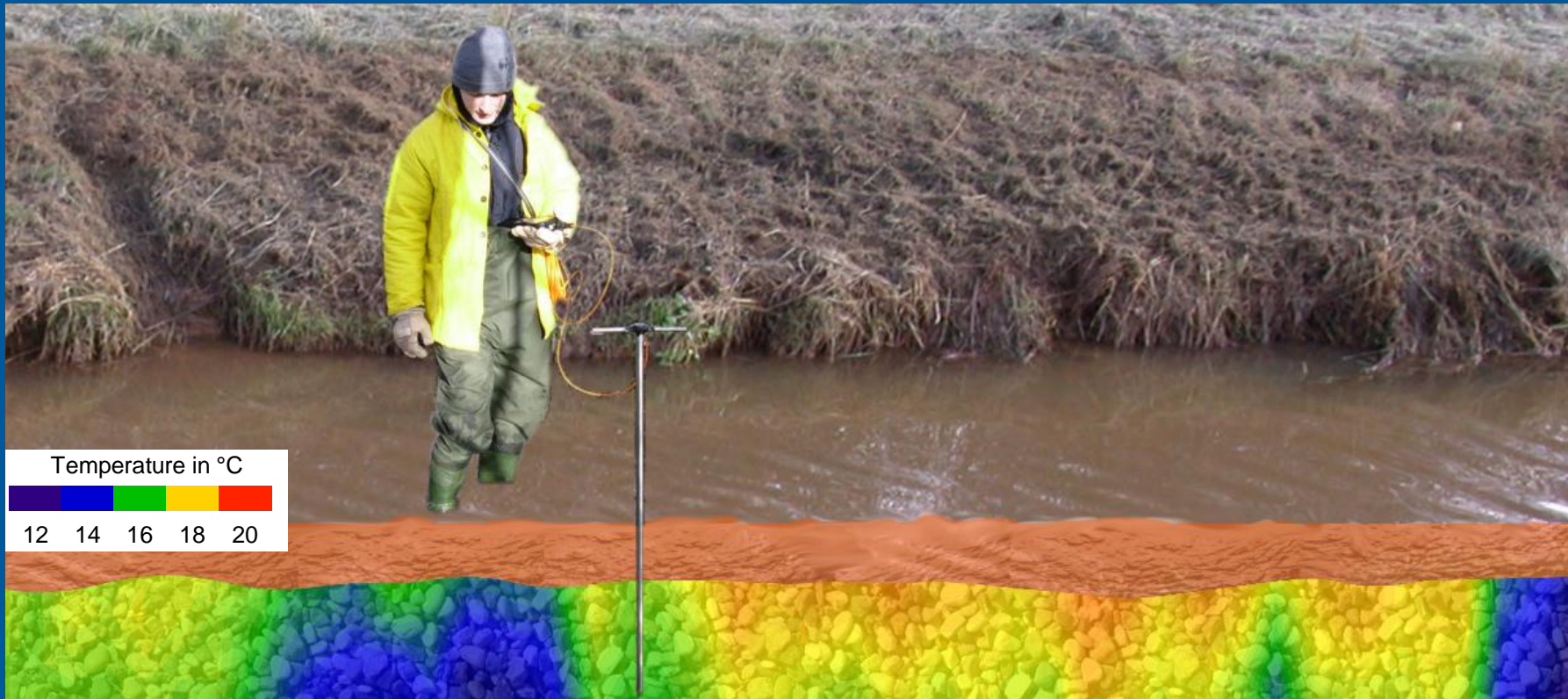


- § 4 IPT wells
- § 41 injection logs
- § 29 slug tests
- § 140 streambed temperature profiles



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STREAMBED TEMPERATURE MAPPING



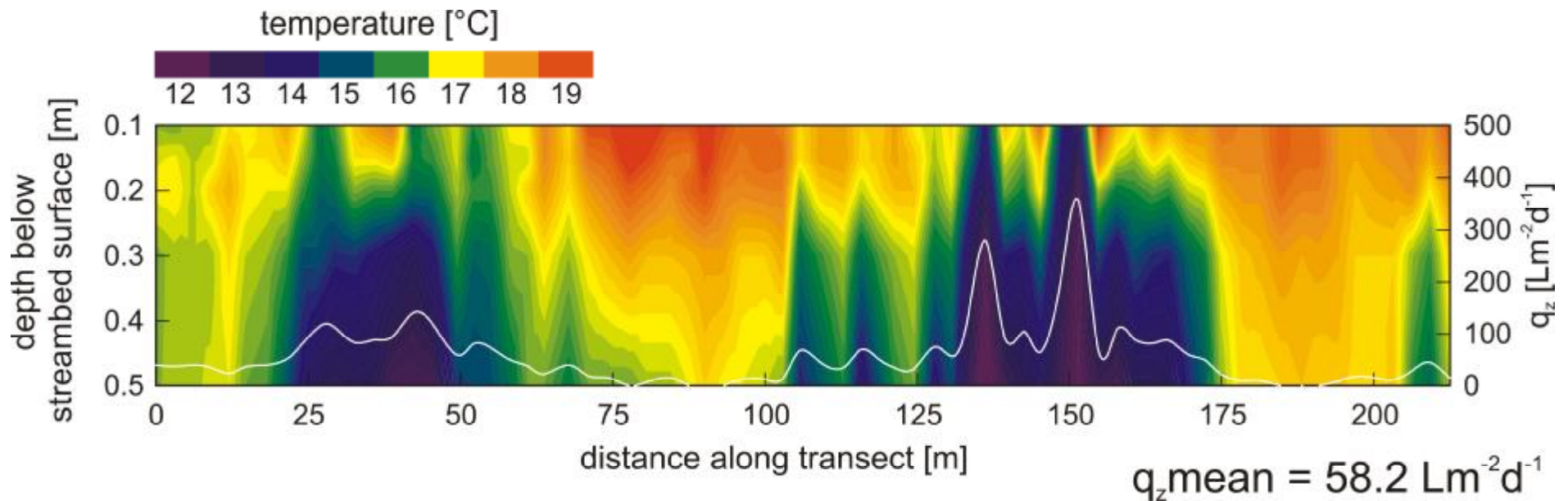
§ 2 longitudinal transects

§ spacing of ~ 3 m

§ simultaneously at 5 depth (0.1, 0.15, 0.2, 0.3, 0.5 m)

§ total of 140 profiles

TEMPERATURE DISTRIBUTION AND GROUND-WATER FLUX THROUGH THE STREAMBED



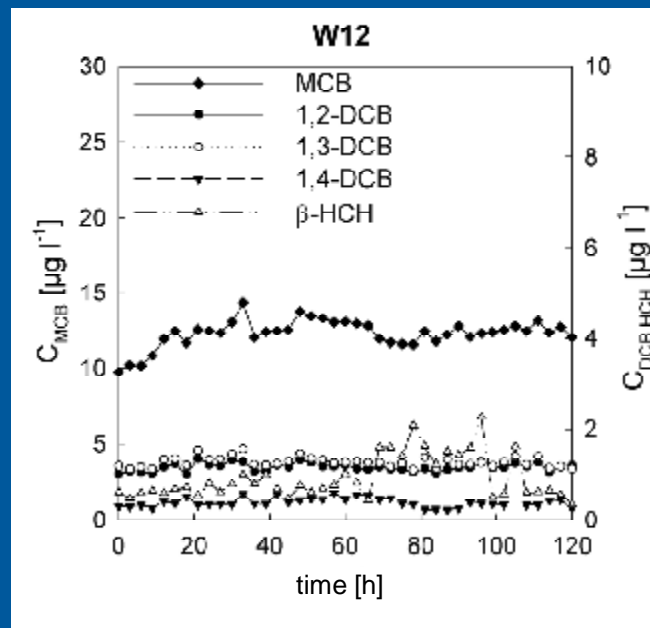
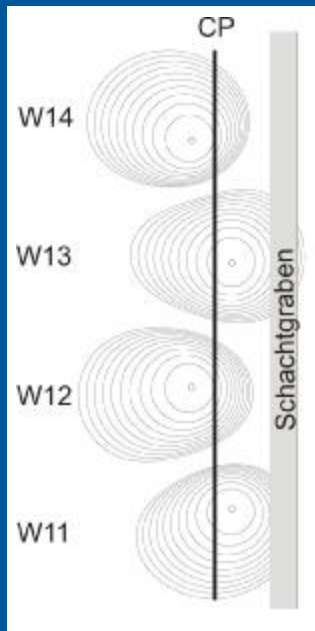
Schmidt et al., HESS 2006

$$\sigma^2 q_z = 4295, \text{ SD } 65$$

$$\sigma^2 T_{50} = 2.9, \text{ SD } 1.7$$

CONTAMINANT CONCENTRATIONS AND MASS FLUXES

Integral Pumping Tests (Bayer-Raich et al. WRR 2006)



$$J = C_{av} * q_z$$

	C_{av} [$\mu\text{g L}^{-1}$]	J_m [$\mu\text{g m}^{-2} \text{d}^{-1}$]	J_{max} [$\mu\text{g m}^{-2} \text{d}^{-1}$]
MCB	12.61	733.9	5737.6
1,2-DCB	1.33	77.4	605.2
1,3-DCB	1.38	80.3	627.9
1,4-DCB	0.49	28.5	223.0
β -HCH	0.99	57.6	450.5

$$q_{z,m} = 58.2 \text{ L m}^{-2} \text{ d}^{-1}$$

$$q_{z,max} = 455 \text{ L m}^{-2} \text{ d}^{-1}$$

§ 4 wells

§ 5 days of simultaneous pumping

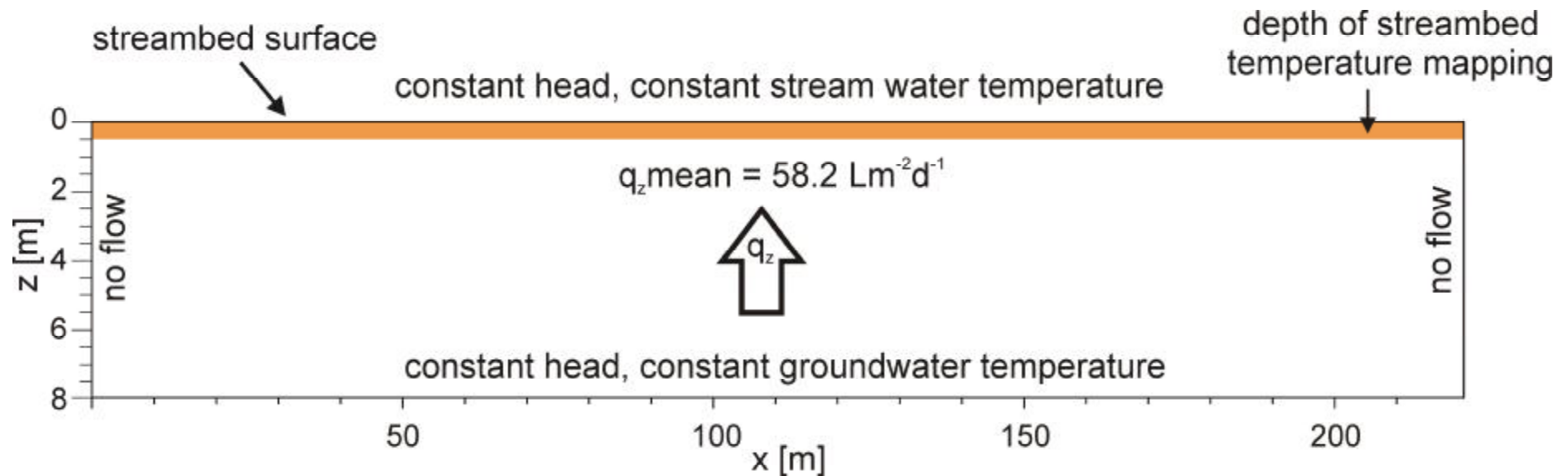
§ sampling every 3 hours

à concentration time series

MODELLING STUDY

§ HEATFLOW (Molson et al., WRR 1992)

§ 2D model of streambed and connected aquifer



§ stochastically generated K fields (FGEN, Robin et al., WRR 1993)

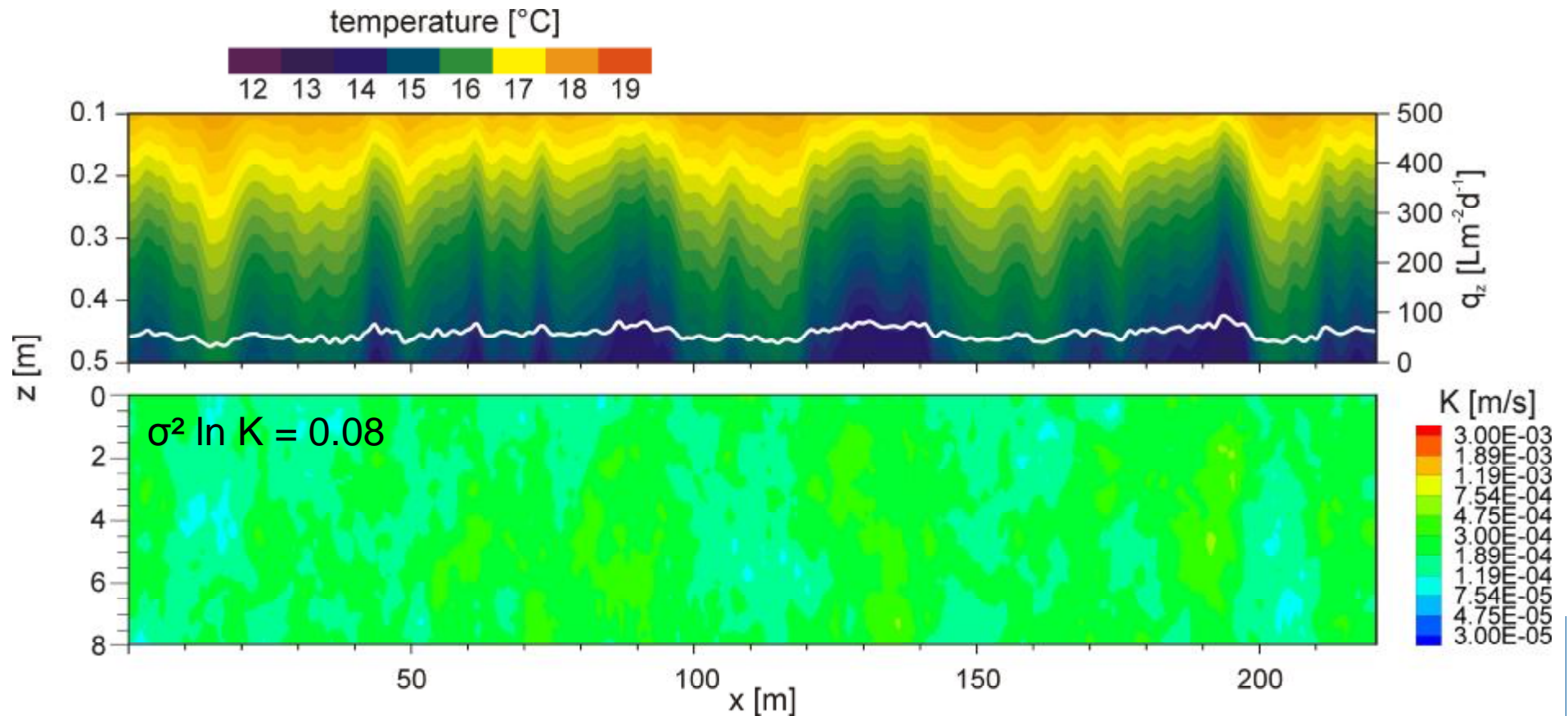
à mean and variance of $\ln K$, correlation lengths in each direction

§ K data obtained from 41 injection logs and 29 slug tests

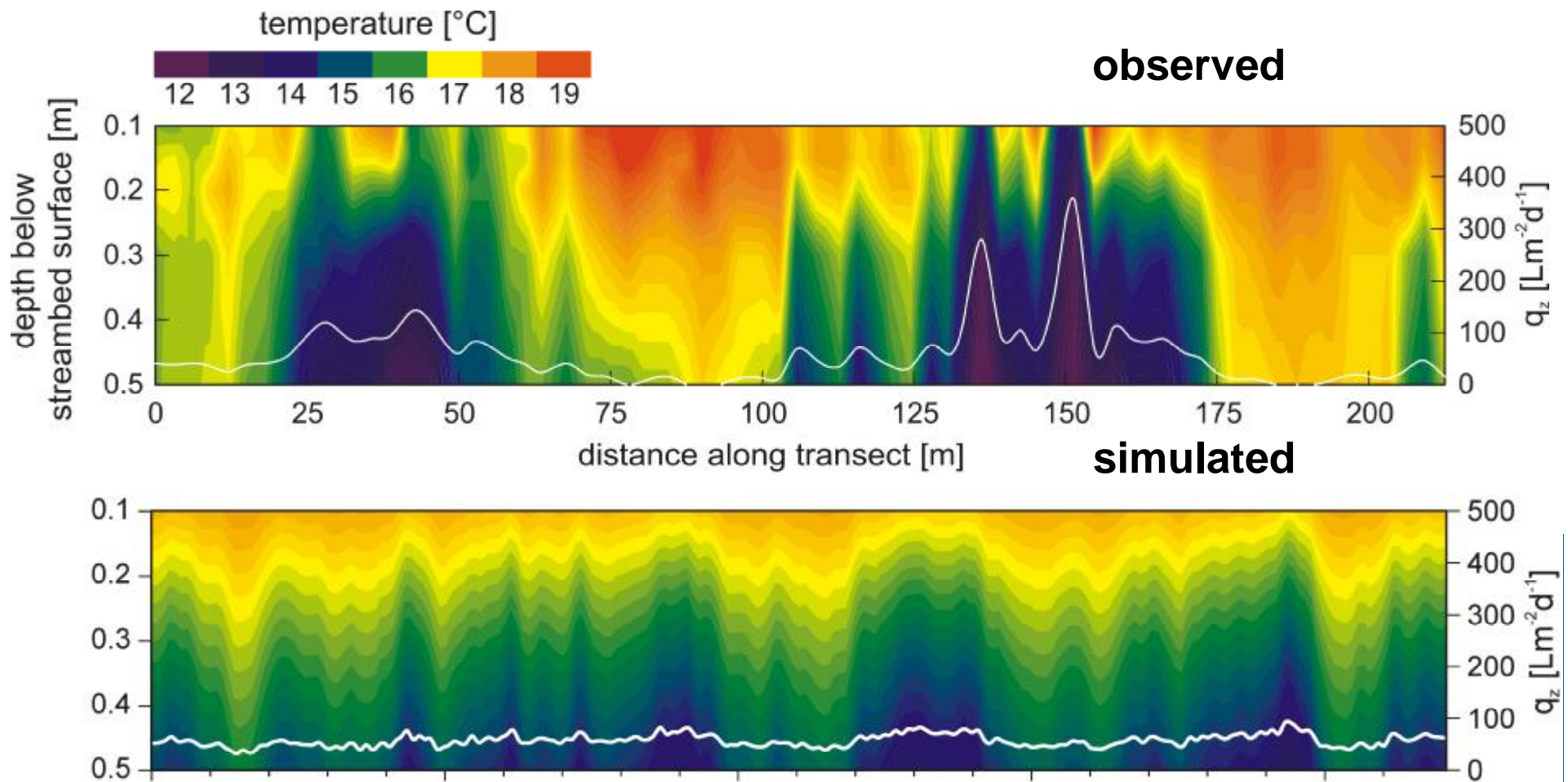


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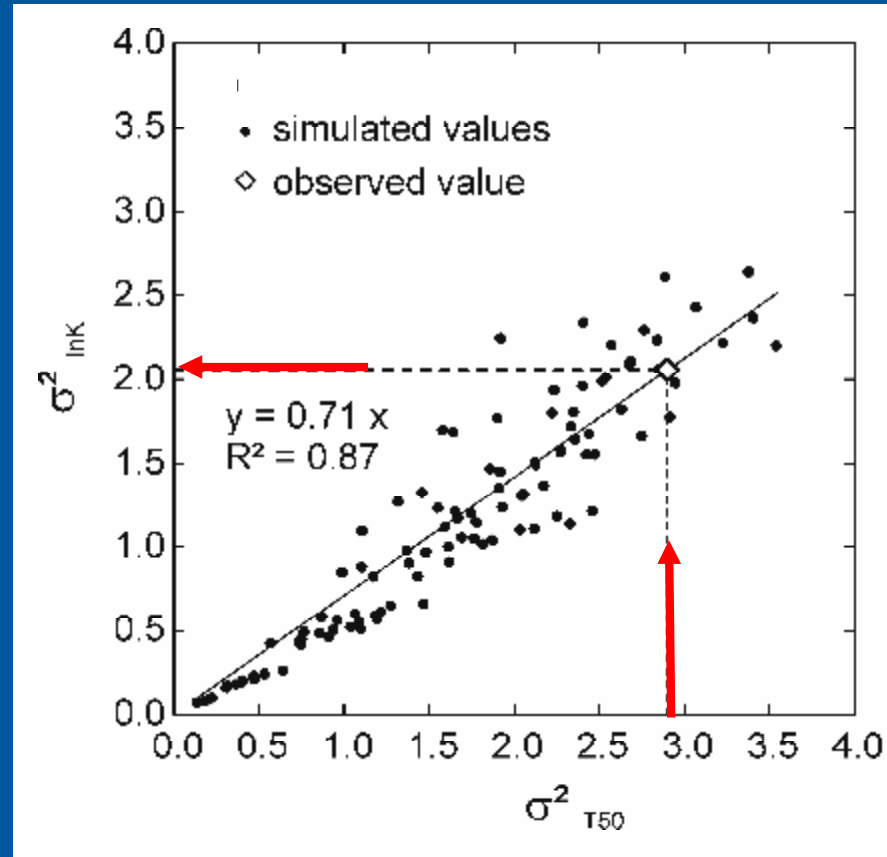
FIRST MODELLING RESULT



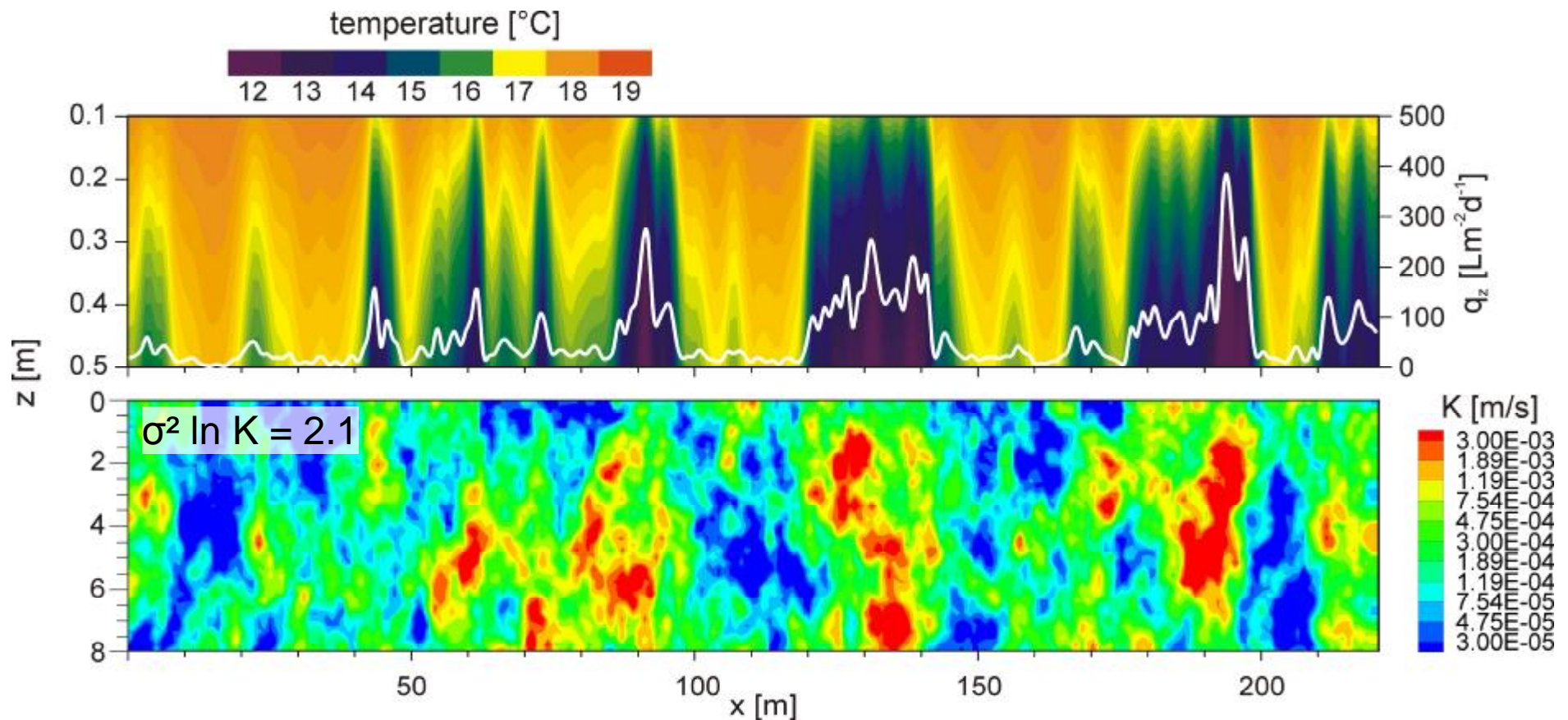
FIRST MODELLING RESULTS – OBSERVED VS. SIMULATED



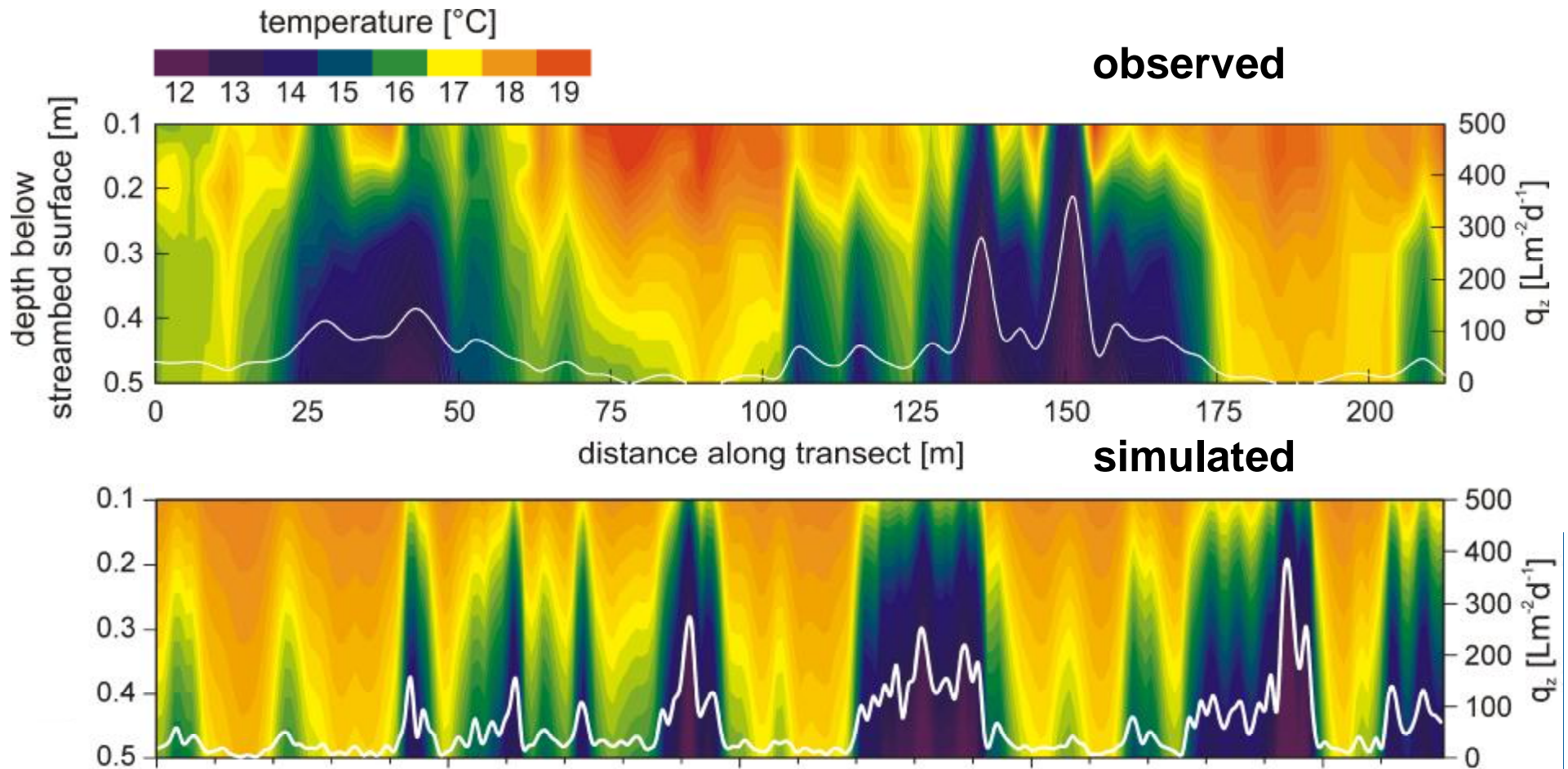
VARIANCE OF T VS. VARIANCE OF K



MODELLING RESULTS – ADJUSTED VARIANCE OF K



ADJUSTED VARIANCE – OBSERVED VS. SIMULATED



SUMMARY AND CONCLUSIONS

- § Spatial pattern of groundwater-stream interactions was determined from streambed temperature measurements
- § Contaminant concentrations from IPT and groundwater fluxes from STM → spatial heterogeneity of contaminant mass fluxes from aquifer to stream
- § Thermal modelling of stream-aquifer system

- Distribution of streambed temperatures relates to the heterogeneity of the aquifer
- Temperature observations can be a helpful supplement to traditional subsurface exploration techniques
- Heat can be a useful tool explore interactions between groundwater and surface water



This work was supported by the European Union FP6 Integrated Project AquaTerra (Project no. 505428) under the thematic priority "Sustainable Development, Global Change and Ecosystems".

Thank you for
your attention!

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edda.kalbus@ufz.de

