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Fleur Loveridge
Nick Woodman
William Powrie

**When does
a fracture matter
for a borehole
heat exchanger ?**

**Engineering and the Environment
The University of Southampton**

GSHPA technical seminar
Leeds, 24 May 2018

Intro

$$\text{Apparent thermal conductivity} = \text{Effective thermal conductivity} + \text{Darcy velocity} * \text{dispersivity tensor} * \text{heat capacity of fluid}$$

(Sauty *et al.*, 1982)

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Groundwater

Uncertainty

Sensitivity

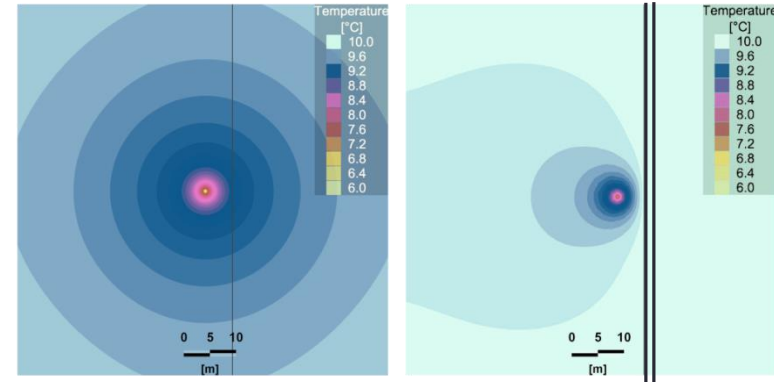
Conclusion



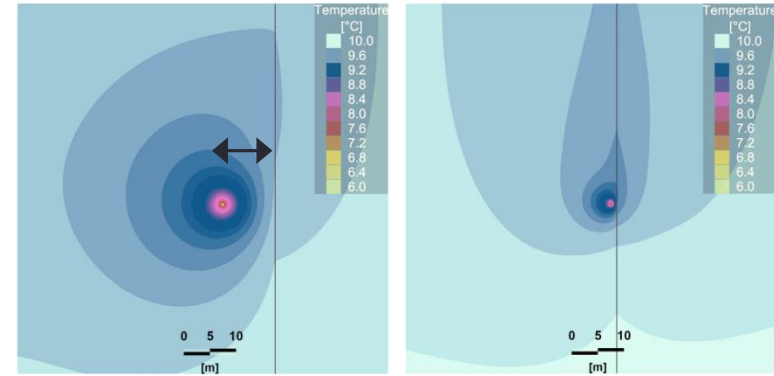
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Dehkordi *et al.*, 2015

Fracture aperture



Fracture distance



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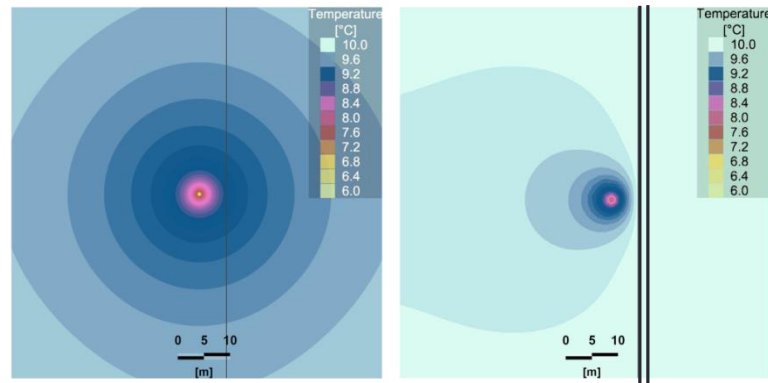
Fracture in
impermeable
matrix



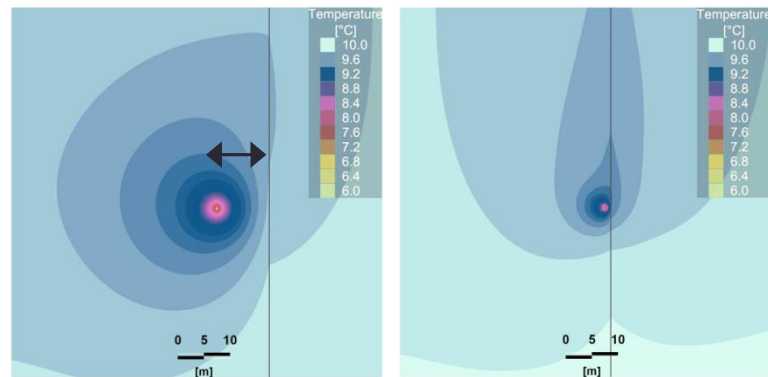
↑ apparent
thermal
conductivity

Dehkordi *et al.*, 2015

Fracture aperture



Fracture distance



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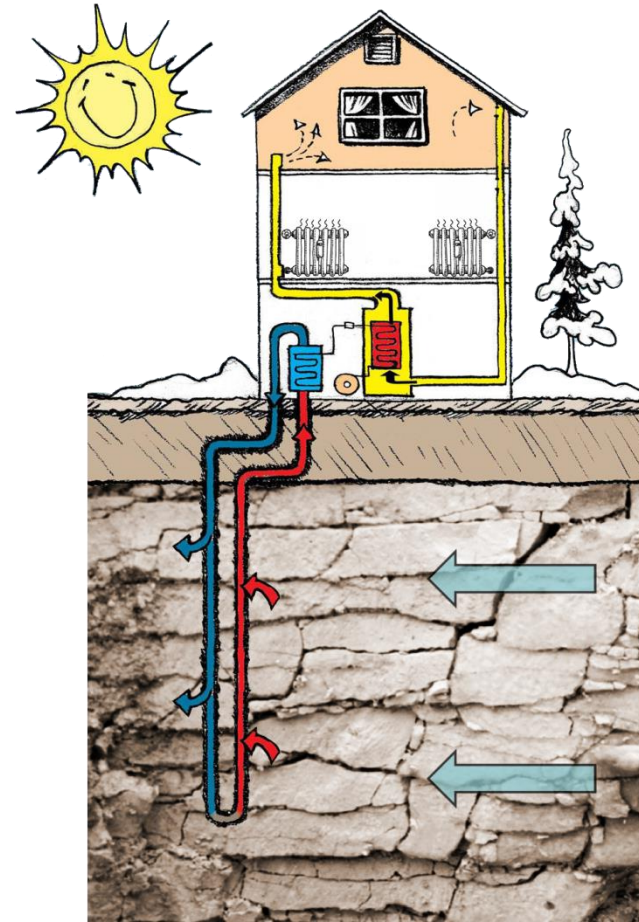
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fracture influence

groundwater & uncertainty

effective parameters



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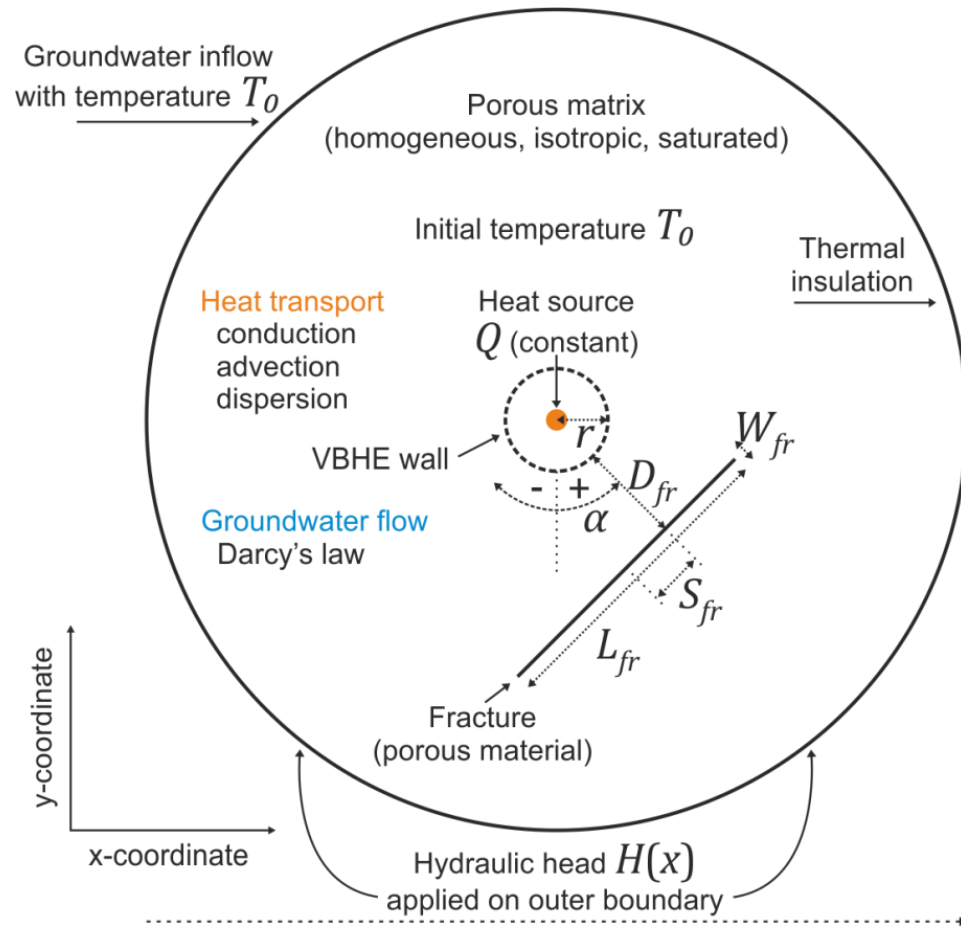
Groundwater

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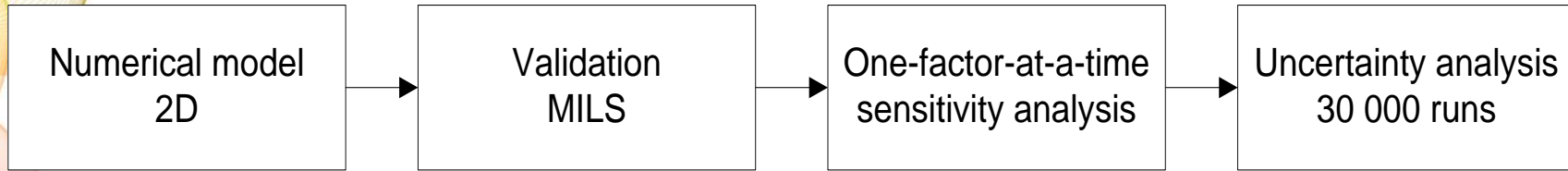
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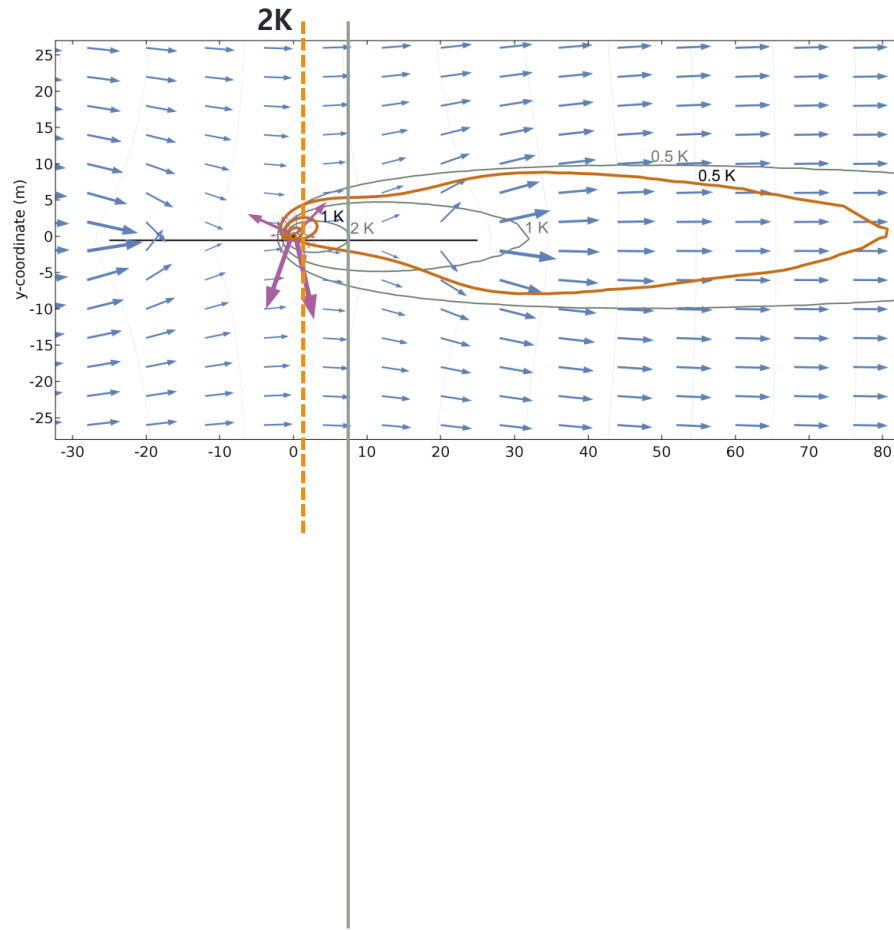
Conclusion

Workflow



Example

Distance 0.5 m



after 30 years

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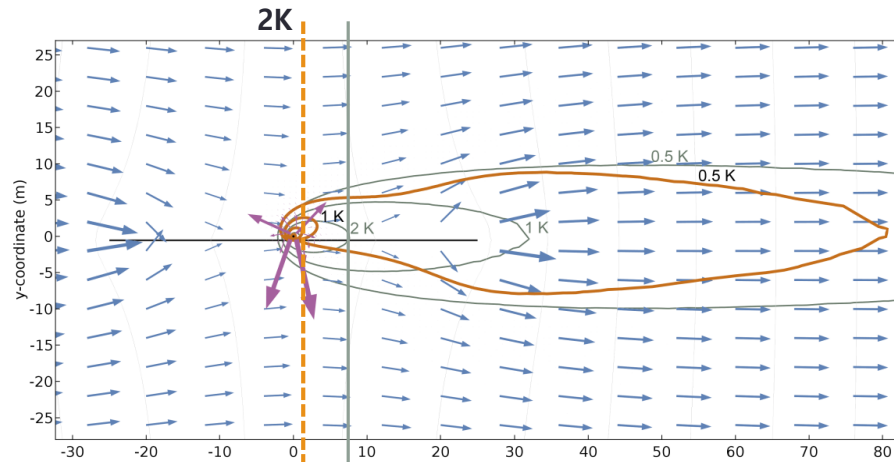
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Conclusion

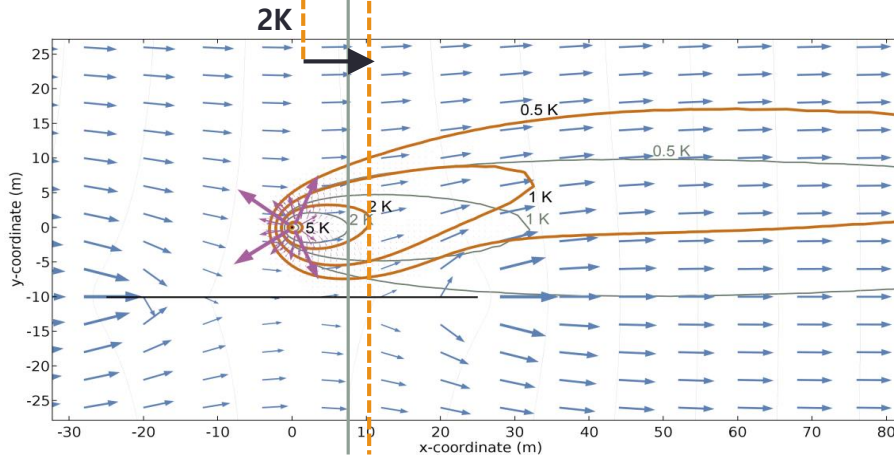
Example

Distance 0.5 m



after 30 years

Distance 10 m



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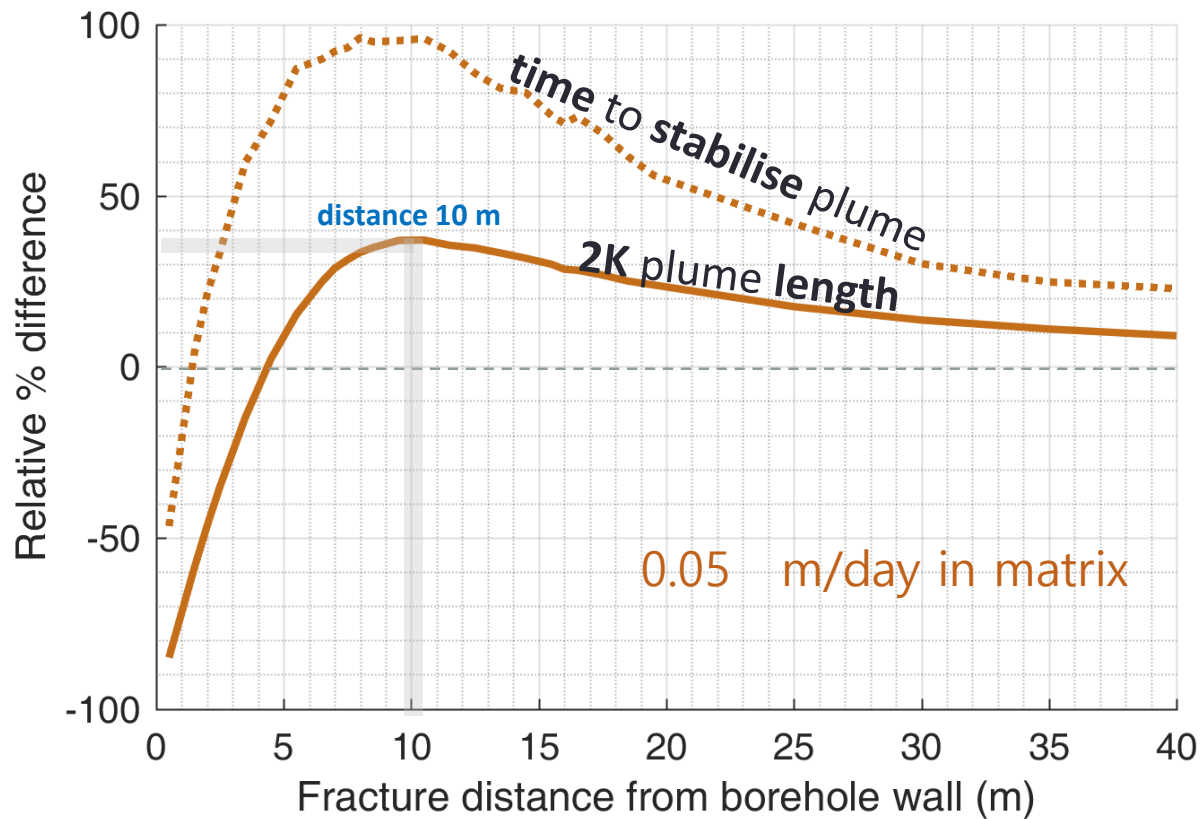
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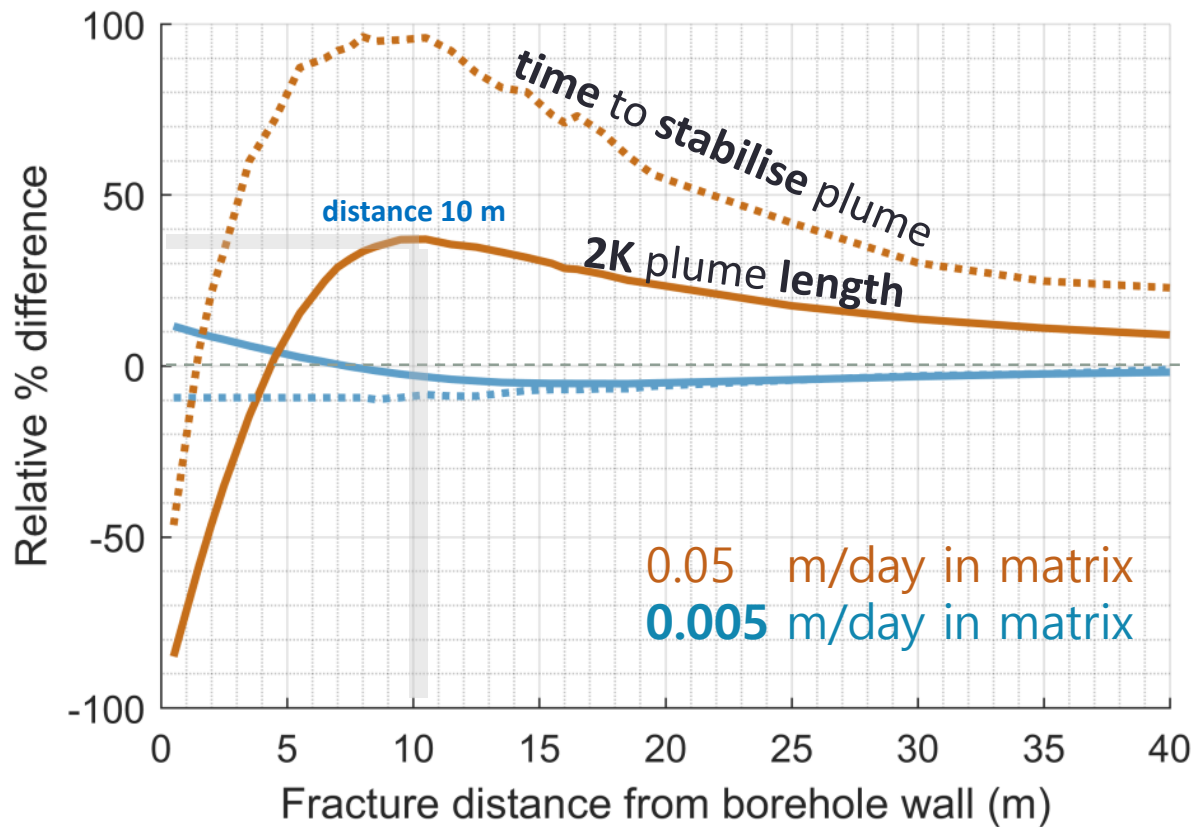
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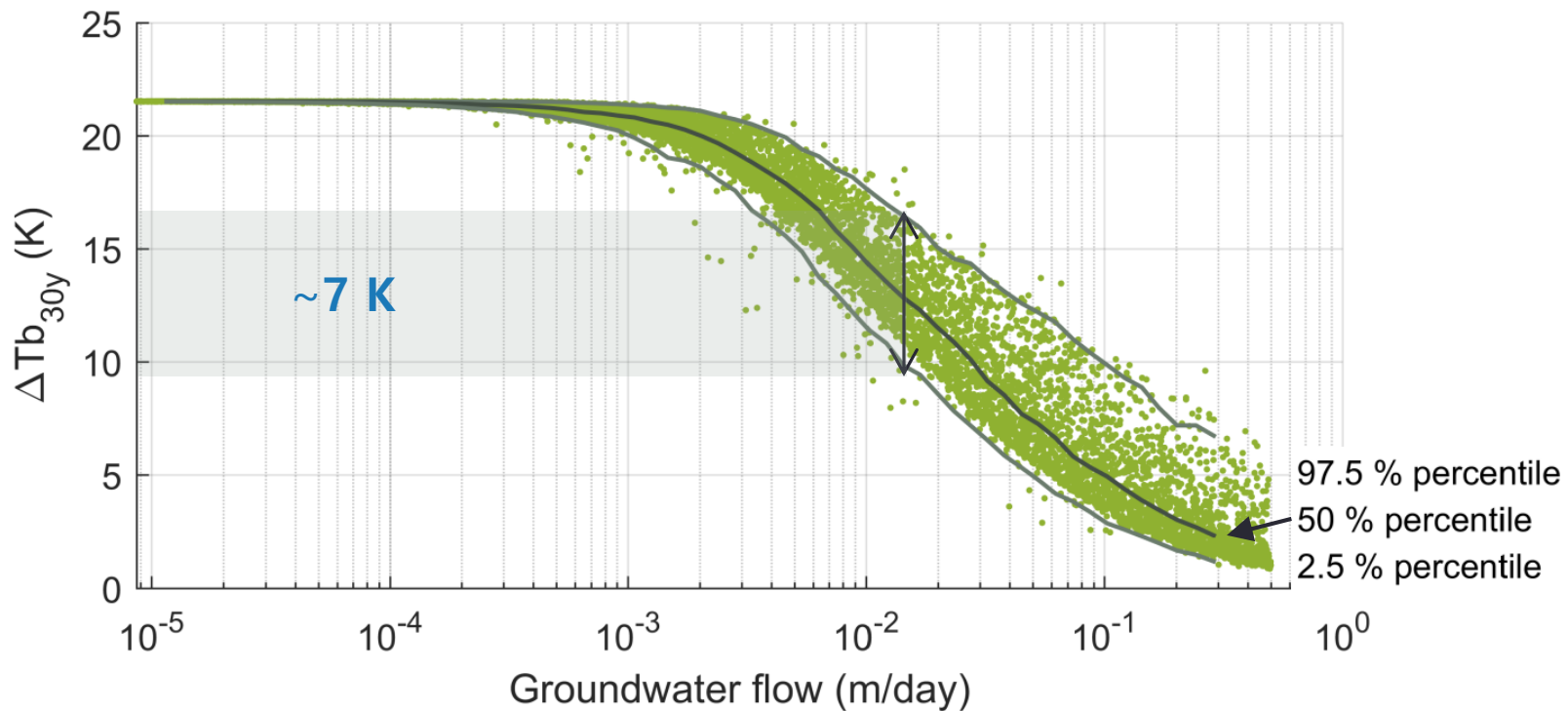
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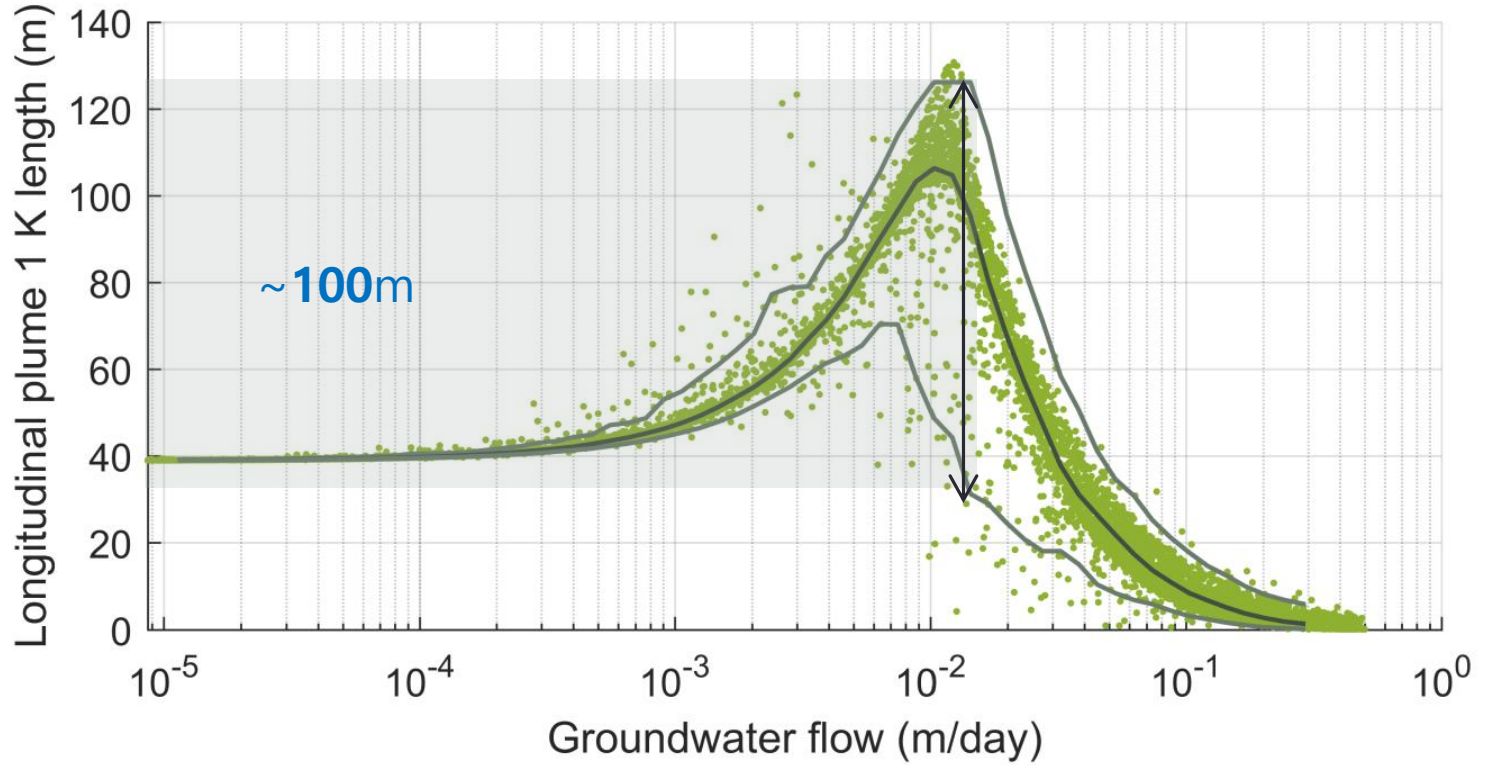
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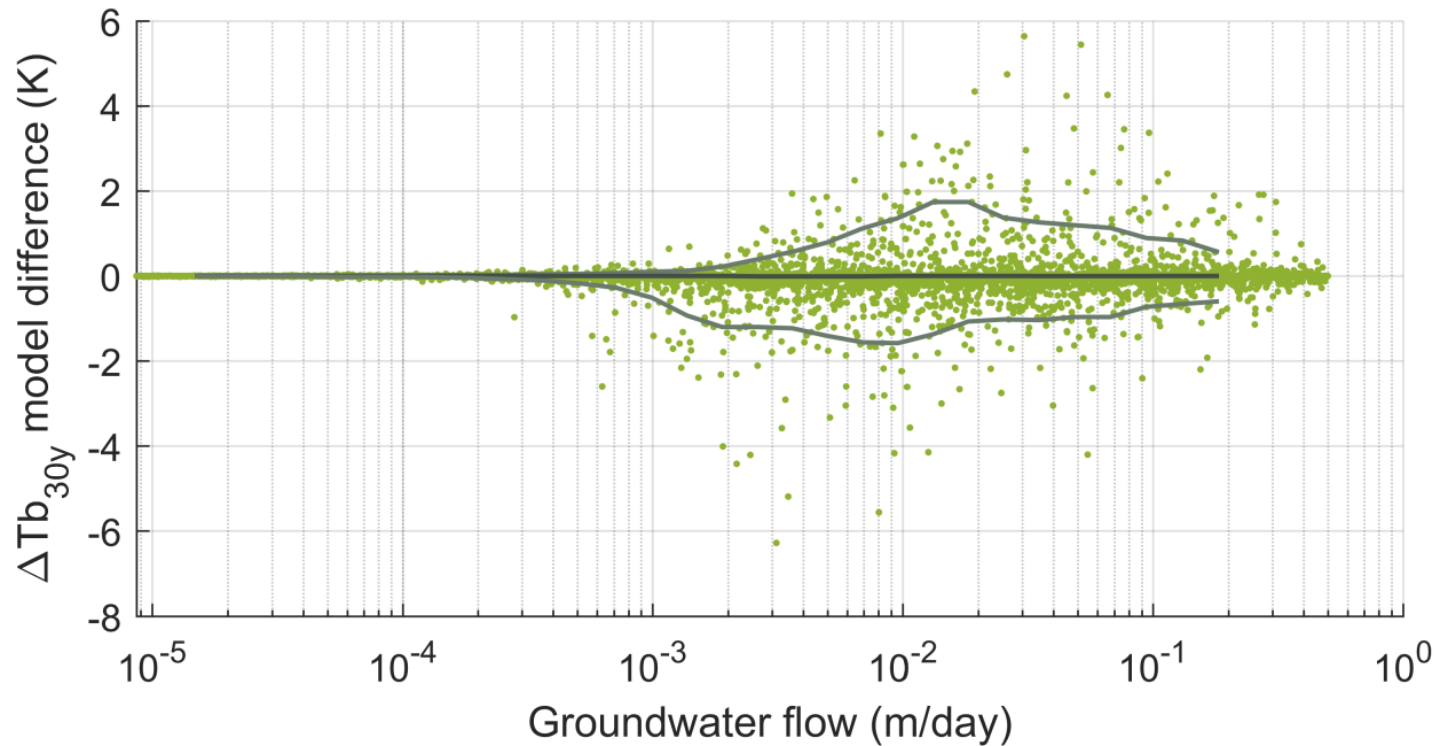
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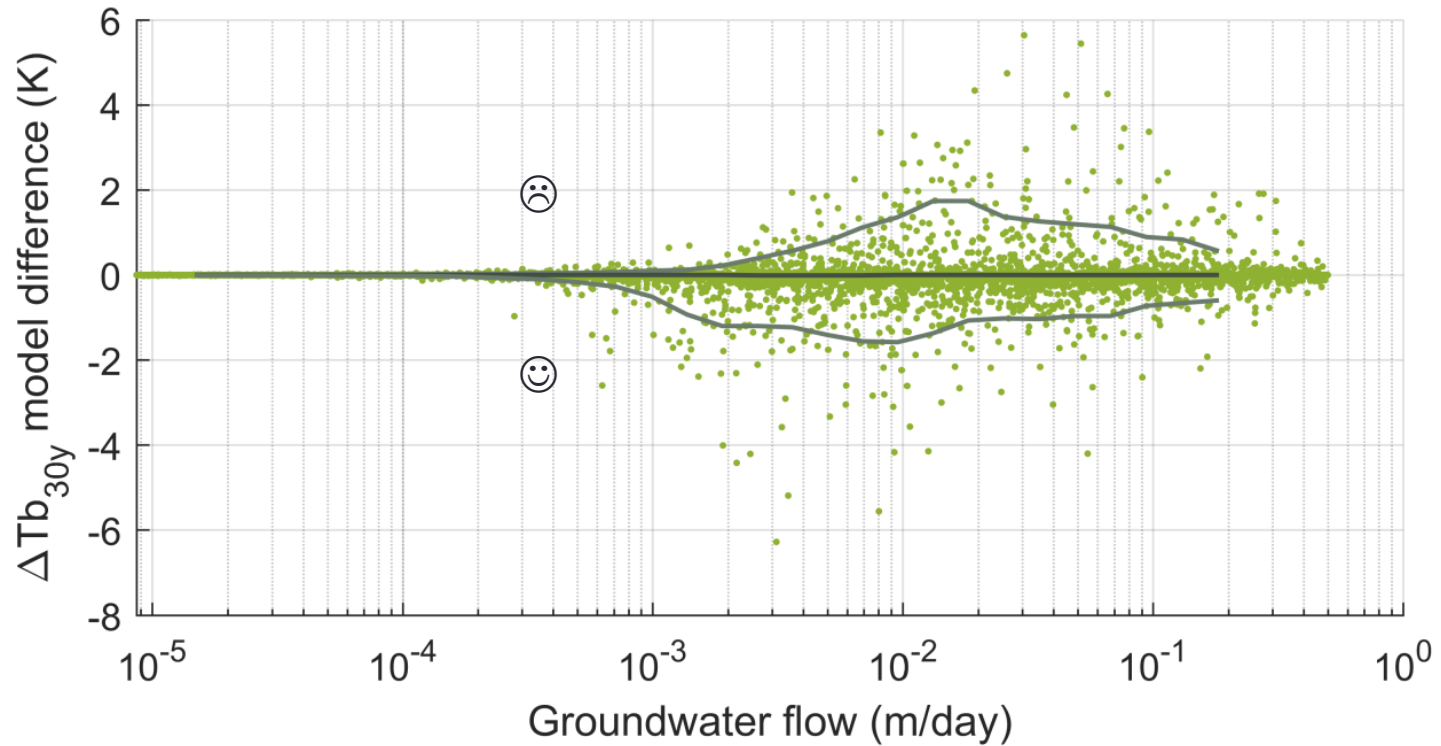
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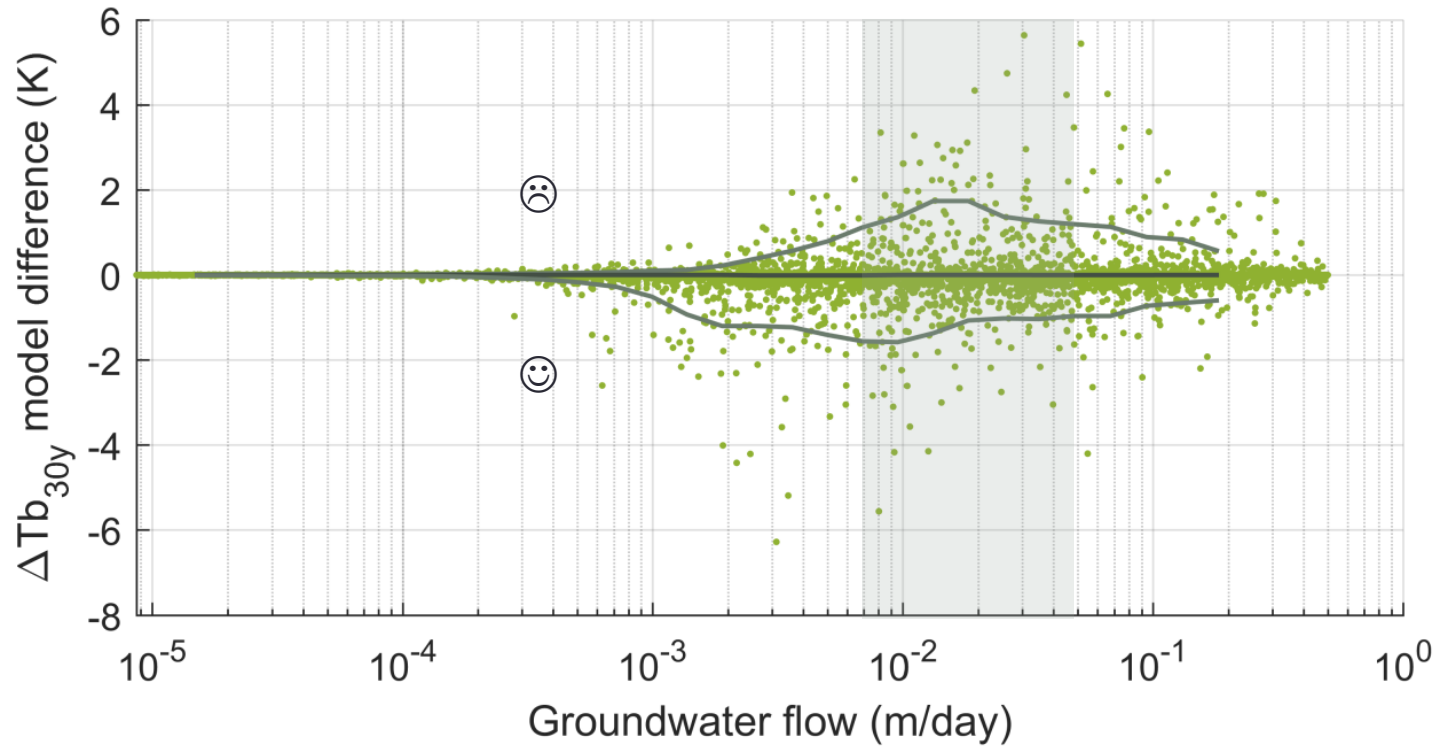
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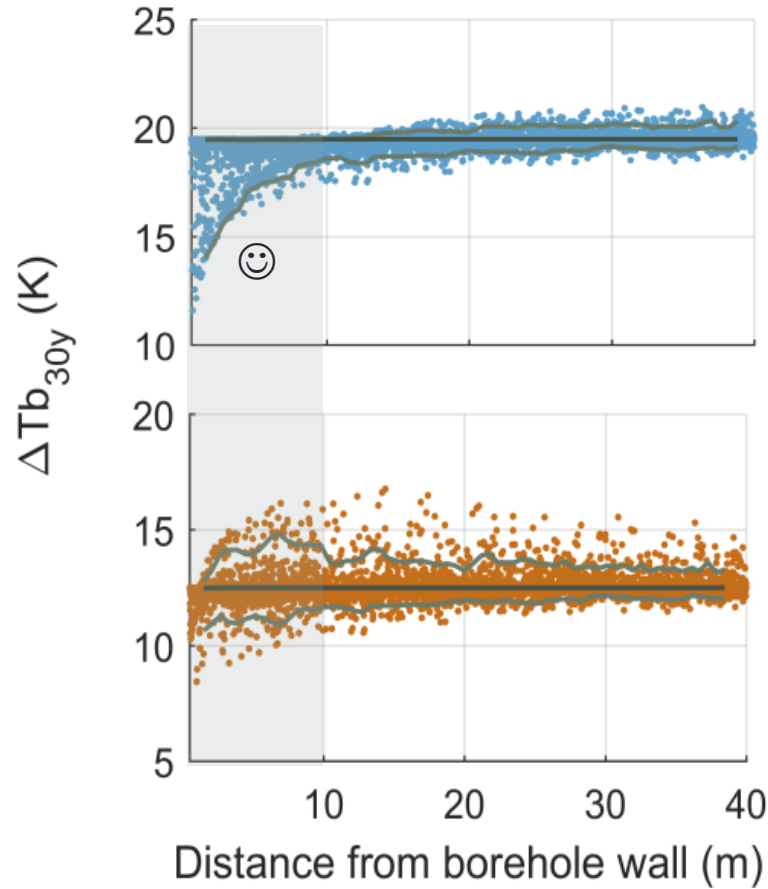
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0.005 m/day in matrix

0.05 m/day in matrix

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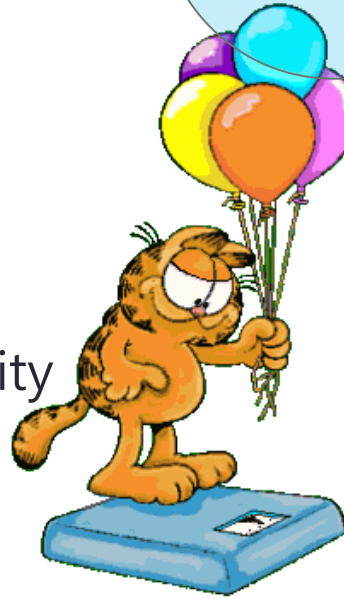
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**Apparent
thermal
conductivity**



Slow local
groundwater
flow

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**Apparent
thermal
conductivity**



Slow local
groundwater
flow

**Fast local
groundwater
flow**

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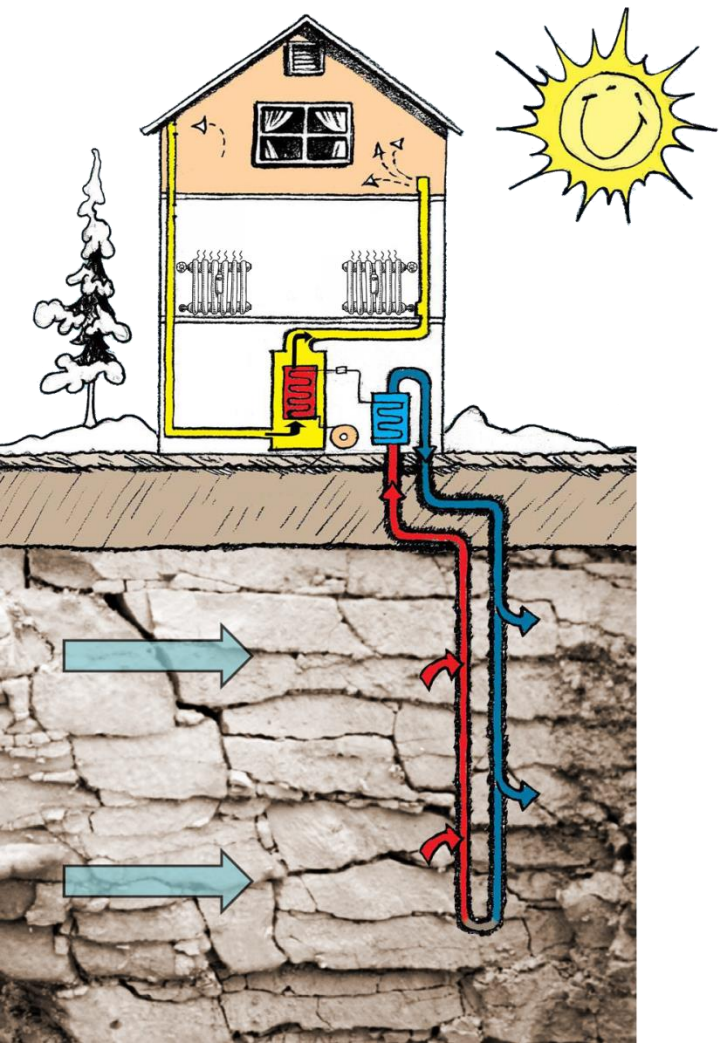
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Thank you
Questions & advice welcome

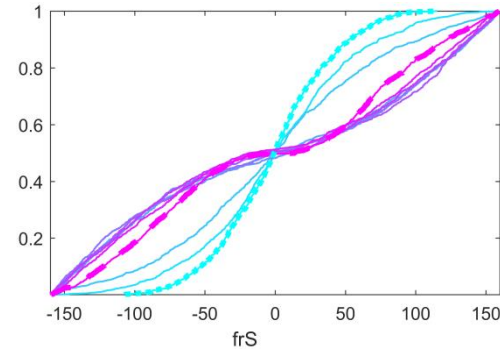
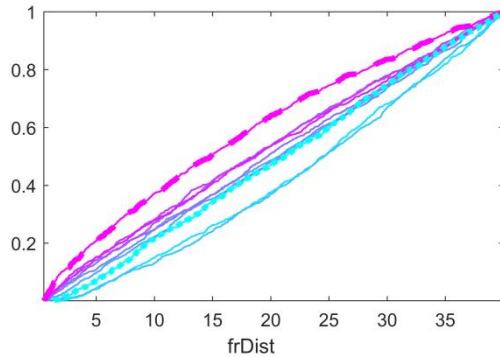
Oleksandra Pedchenko
Engineering and the Environment
University of Southampton
oop1g10@soton.ac.uk



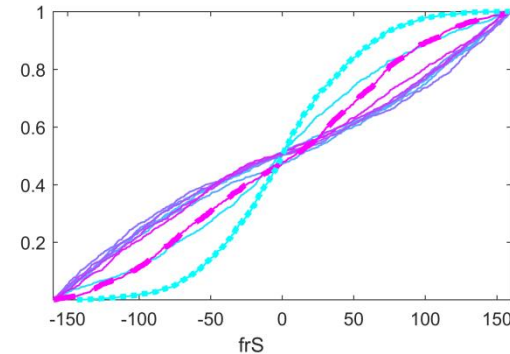
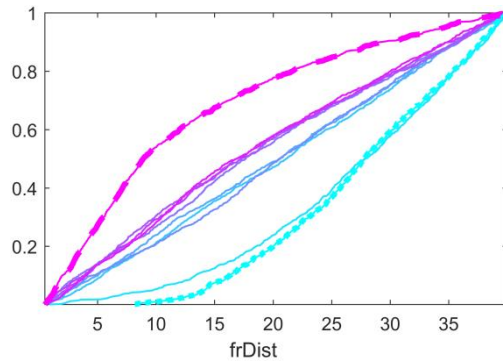
The image features decorative wavy lines in the corners. In the top right, there are overlapping, semi-transparent waves in shades of purple, red, and orange. In the bottom left, there are similar waves in shades of green, yellow, and red. The central text is set against a plain white background.

Q&A supplements

Sensitivity



0.05 m/day



0.005 m/day

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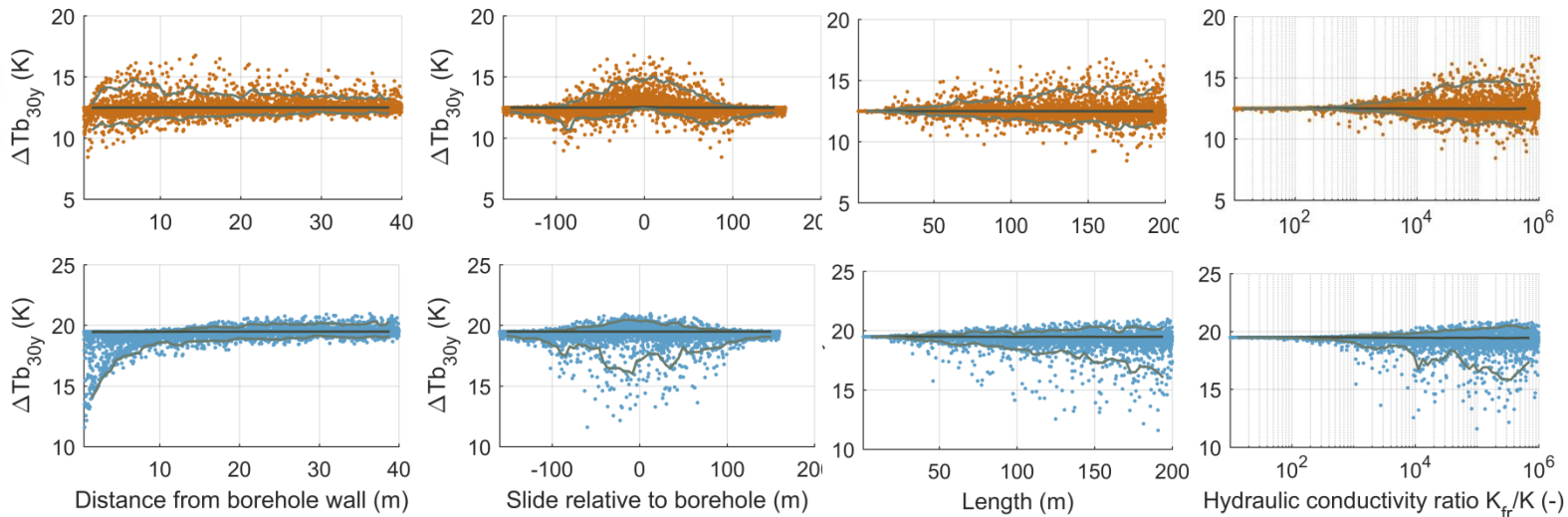
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0.05 m/day in matrix



0.005 m/day in matrix

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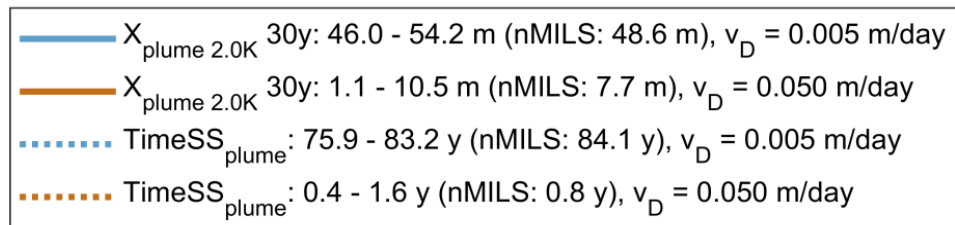
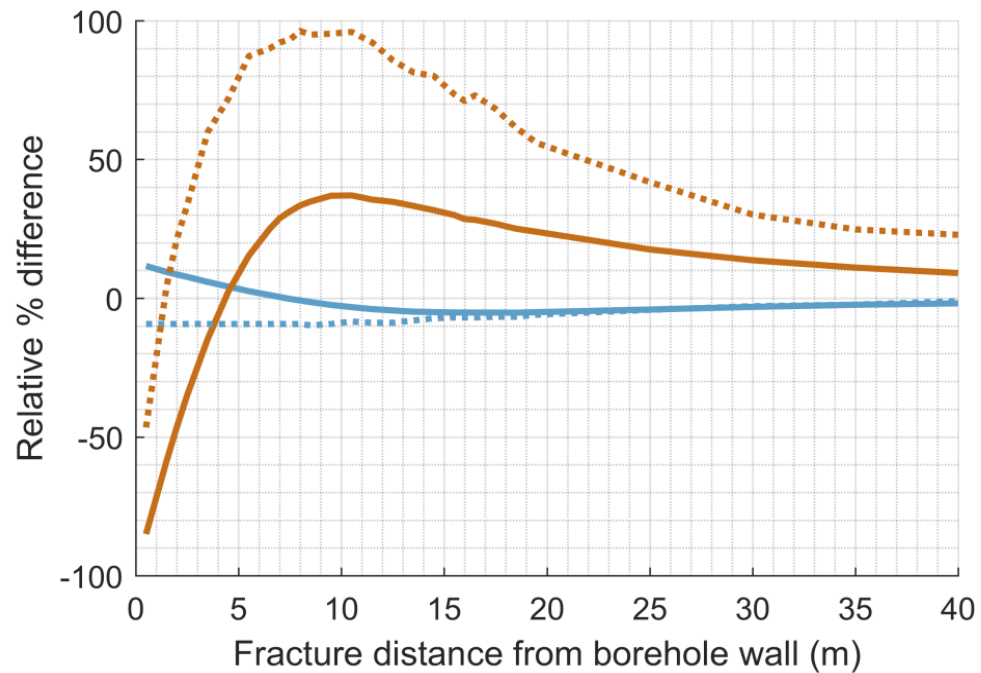
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Apparent thermal conductivity

$$\lambda_a = \lambda_A + \alpha \gamma_F |v|$$

heat capacity of fluid

effective thermal conductivity of porous medium

dispersivity tensor

Darcy velocity

(Sauty et al 1982)

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