CRC 1253 CATCHMENTS AS REACTORS
CAMPOS

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Where To Draw The Line?

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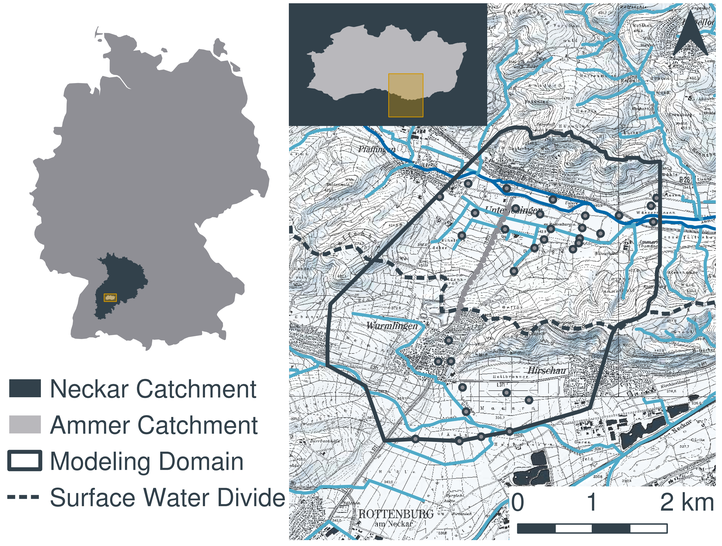
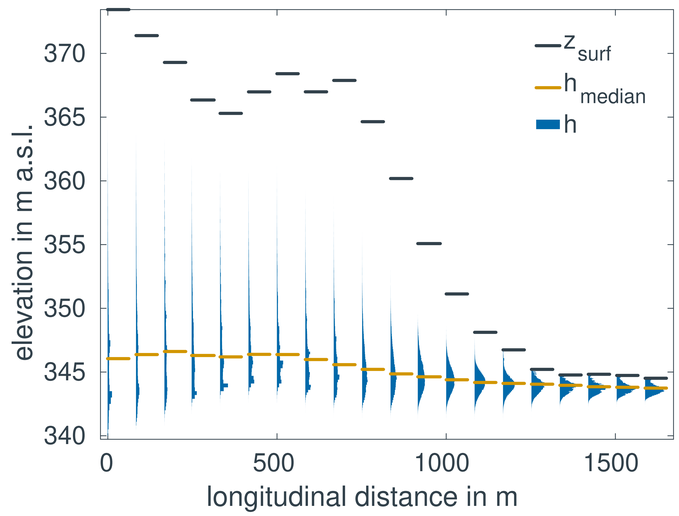
Problem
Delineation of Groundwater Divide



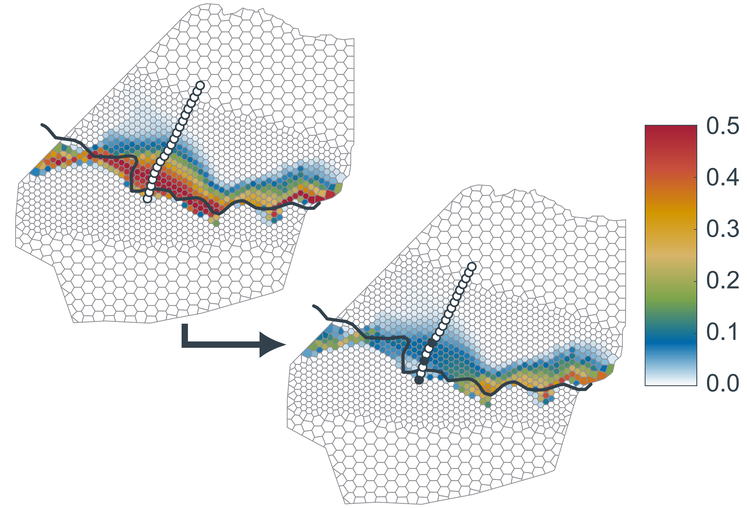
- groundwater divides are important
- proper delineation requires hydraulic **head measurements**
- piezometers are expensive
- goal: find **optimal** piezometer **placement strategy**

Approach
Novel Stochastic Framework



- ensemble flow **modeling**
- plausibility check
- **particle tracking** { Ammer → ◎ / Neckar → ◉ }
- optimal design routine
  - **PreDIA**
  - Bayesian averaging

Results
Measure in the Unknown Regions



- ⓘ place wells far from existing ones
- choose medium spacing
- best designs are non-trivial
- **uncertainty reduction** of > 50 %

Use the power of clicking/tapping!

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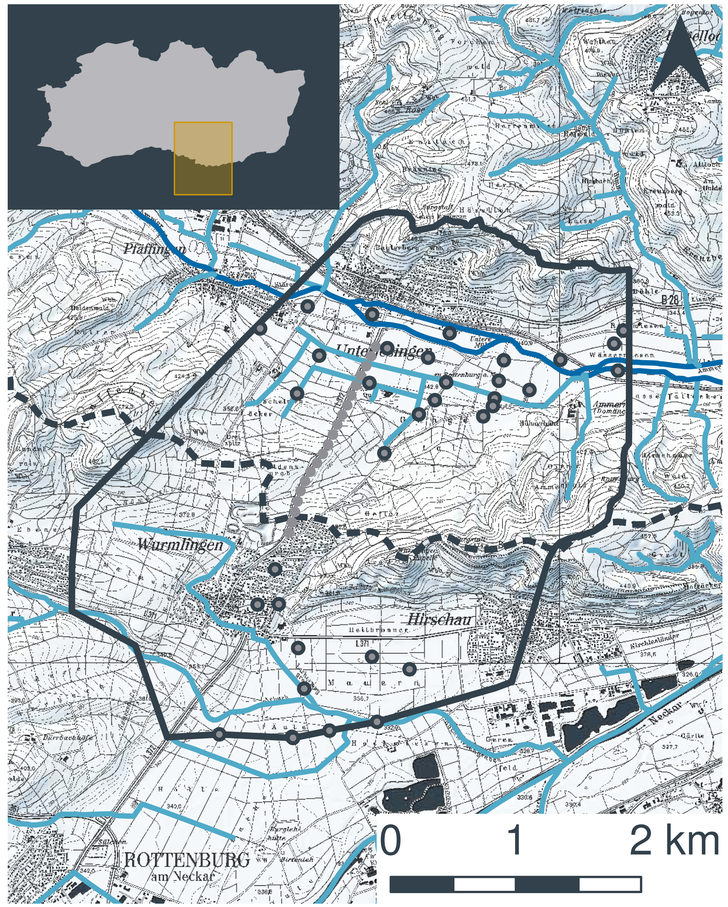
Problem



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Delineation of Groundwater Divide

- groundwater divides…
  - separate different groundwater bodies
  - determine **contaminant fate**
  - need to be known for catchment water balances
  - can be used as model boundaries

→ are imporant

- proper delineation…
  - is often difficult
  - cannot be derived from surface water divide (depending on hydrogeological setting)
  - needs a **calibrated subsurface flow model**

→ requires hydraulic head measurements

- piezometers…
  - must be permitted
  - require **drilling** holes
  - need well installation
  - have to be maintained

→ are expensive

- goal
  - maximize gained information
  - minimize number of piezometers

→ find **optimal** piezometer **placement strategy**

figure on the left

- example
- south-west Germany (Ammer/Neckar valley)
- dashed line: surface water divide
- solid line: modelling domain
- dots with edge: present wells
- dots without edge: new well points

→ what combination of three well points is best to derive the groundwater divide?

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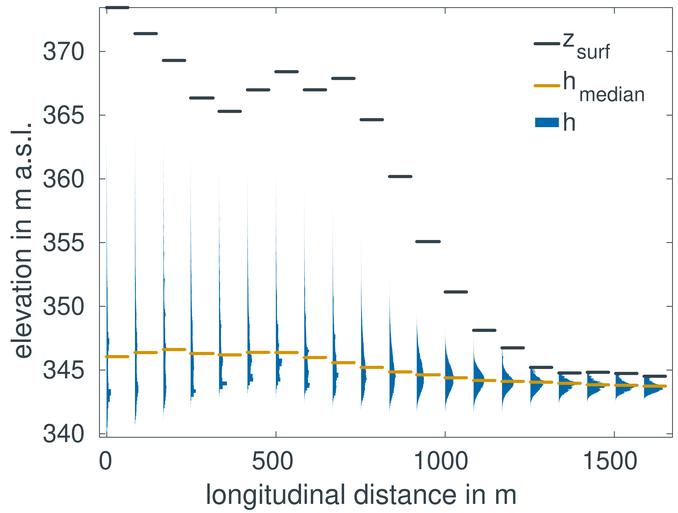
Approach



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Novel Stochastic Framework

- stochastic modeling
  - three-dimensional
  - subsurface flow (Richards equation)
  - steady state
  - vary parameters, geometries, boundary conditions
  - take **virtual measurements** at all potential new locations

➜ ensemble of realizations

- prefiltering
  - validate model realizations
  - compare against **plausibility criteria**
  - if implausible ➜ reject

➜ ensemble of plausible realizations

- particle tracking
  - for each realization
  - initiate particles at surface
  - move along **advective velocities**
  - keep track of outlet locations

➜ maps of particle fate

- Preposterior Data Impact Assessor
  - PreDIA: Leube et. al. (2012); *Bayesian assessment of the expected data impact on prediction confidence in optimal sampling design*; Water Resources Research 48, W02501; doi:10.1029/2010WR010137
  - optimal experimental design tool
  - makes use of **Bayesian averaging**
  - estimates uncertainty reduction… due to new measurements
  - metric: integrated probability of particle fate misclassification

➜ can rank piezometer configurations

figure on the left

- ensemble of virtual head observations
- all twenty potential locations
- 50 000 realizations

➜ partly large uncertainties

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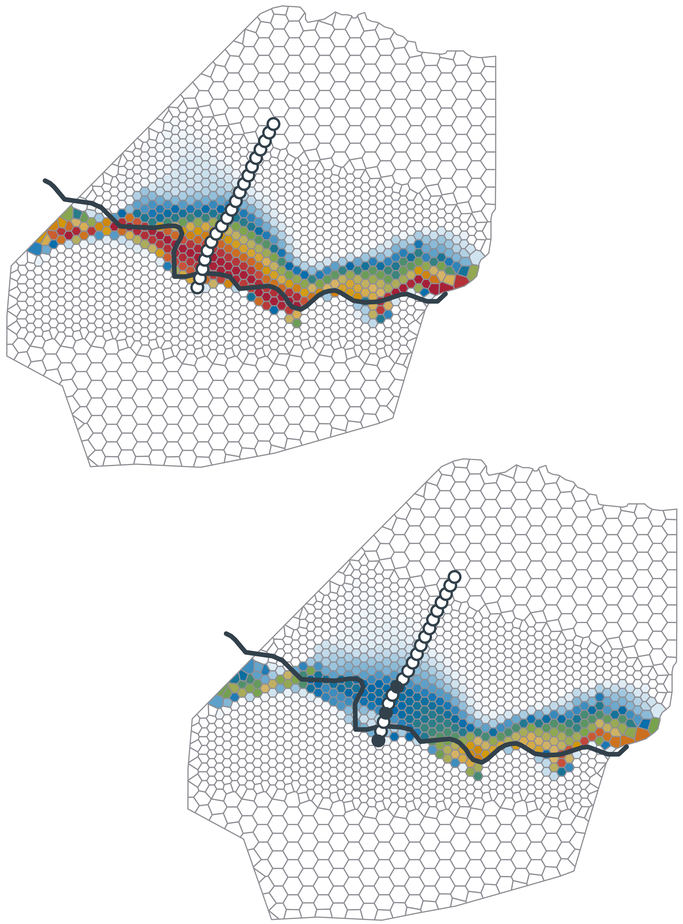
Results



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Measure in the Unknown Regions

- piezometers far **away from existing wells** perform better
- **medium spacing** (≈ 100 m) is preferred
- optimal designs are better than equidistant ones
- more piezometers ➜ more information

figure on the left

- maps of particle fate misclassification
- top: prior to analysis
- bottom: with three additional wells (black dots)

- **uncertainty** in groundwater divide **can be reduced**
- … especially close to the new wells

submitted to **Frontiers in Earth Science**

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