Improving Groundwater Behaviour Prediction with AI

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10 November 2025

AI for Sustainability

PhD CDT

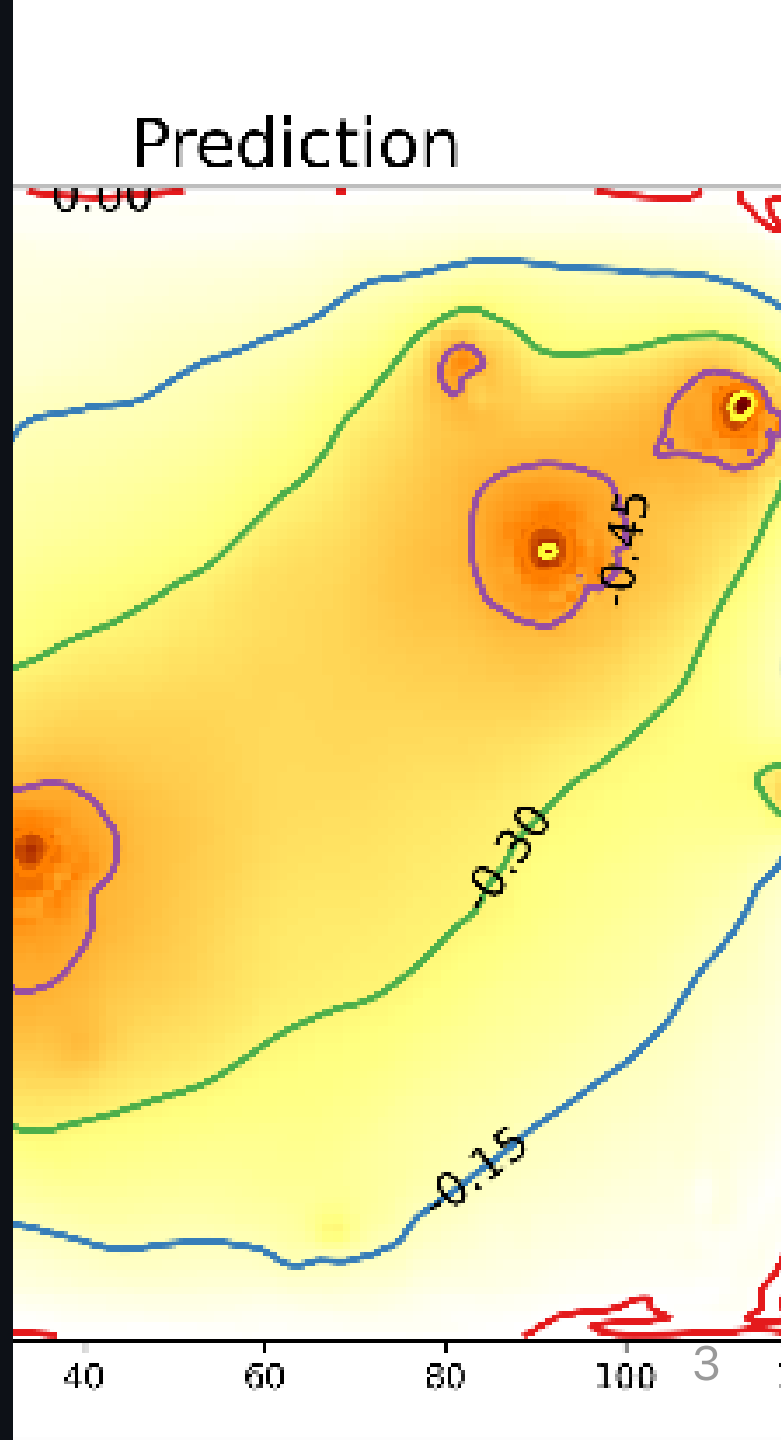
Motivation

- Water companies struggle to provide clean water in the UK & globally.
- Rainfall is not in short supply but may become seasonally concentrated.
- When groundwater abstraction is too high, river levels fall and fish die.
- Groundwater is difficult to model physically, and aquifers contain unknown geological discontinuities.
- Good water supplies promote health; poor water leads to disease and reduced life expectancy.
- AI processor cooling will drive further demand for water.

These points are also true outside the UK

Existing Research

- Groundwater has traditionally been modelled physically.
- The global standard is MODFLOW, developed over 40 years in Fortran.
- Groundwater aquifers have been modelled with ML since 2020 with a mixture of techniques. Examples include:
  - Feedforward Neural Networks
  - Recurrent Neural Networks (e.g. LSTM)
  - Hybrid models (e.g. CNN-LSTM)
  - Spatial-Temporal Graph Neural Networks (ST-GNN)
  - Physics-Informed Neural Networks (PINNs)
    These are research efforts and are not available across the water industry.



Research Opportunities in 2025

- Improve the models used to model groundwater, possibly by further combining previous approaches, e.g. Physics-Informed Spatial-Temporal Graph Neural Networks (PISTGNN).
  It's not clear whether ever-increasing sophistication is impactful.
- Add underground geological discontinuities, rivers, abstraction points and rainfall catchments to graphs. Increase scale to regional / national.
- Combine long-range rainfall forecasts, to permit present-day abstraction based on future replenishment.
- Provide an interpretable "grey-box" decision-support capability.
- Produce open-source software which is accessible to end users in the water industry.

Thank you

I have access to water data and hydrogeology experts in the UK.

I'm looking for research supervision within Southampton University, and validation of the research gaps identified.

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