



British
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NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

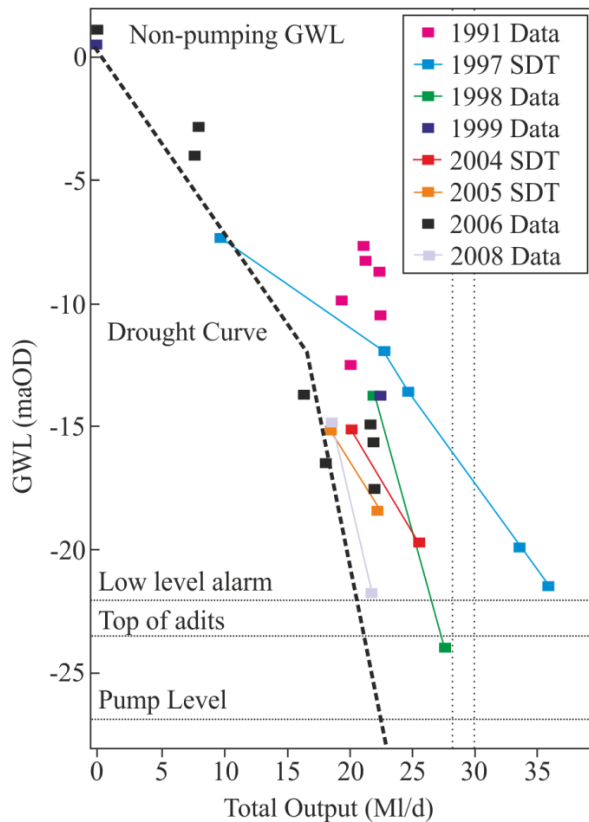
Multi-scale modelling of borehole yields for DO assessment in chalk aquifers

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London

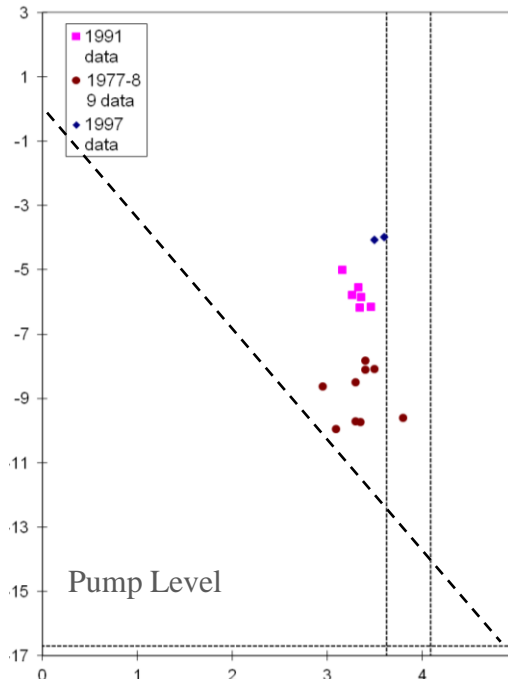


Deployable Output



Deployable Output

- **Reliable (sustainable) yield of a source**
- **Constrained by properties of aquifer and borehole**
- **Also constrained by the surrounding environment, licence conditions, water quality, and capacity of treatment plant/output mains**



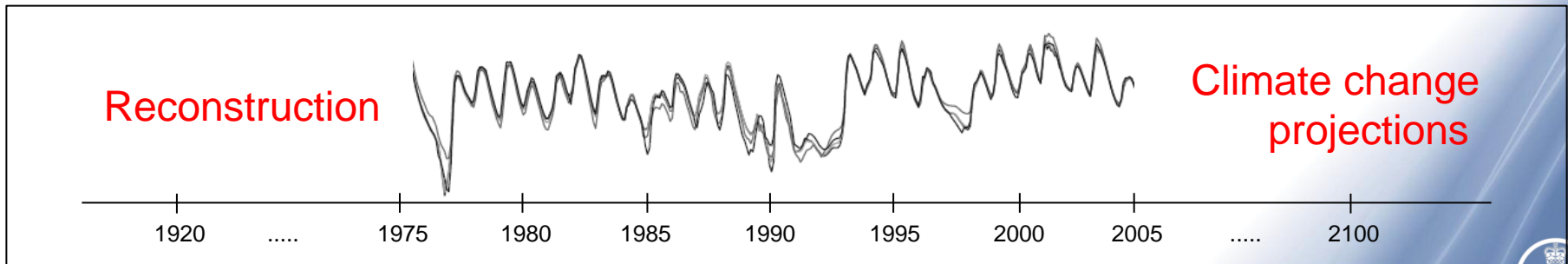
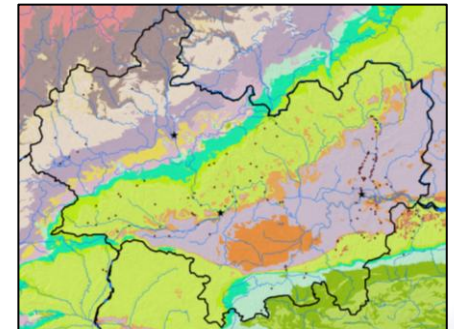
Limitations of current methodology:

- **Availability and quality of operational data**
- **Vertical heterogeneity?**
- **Interference?**
- **Climate change?**

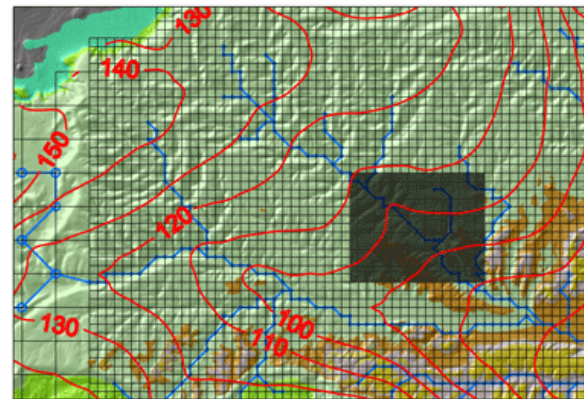
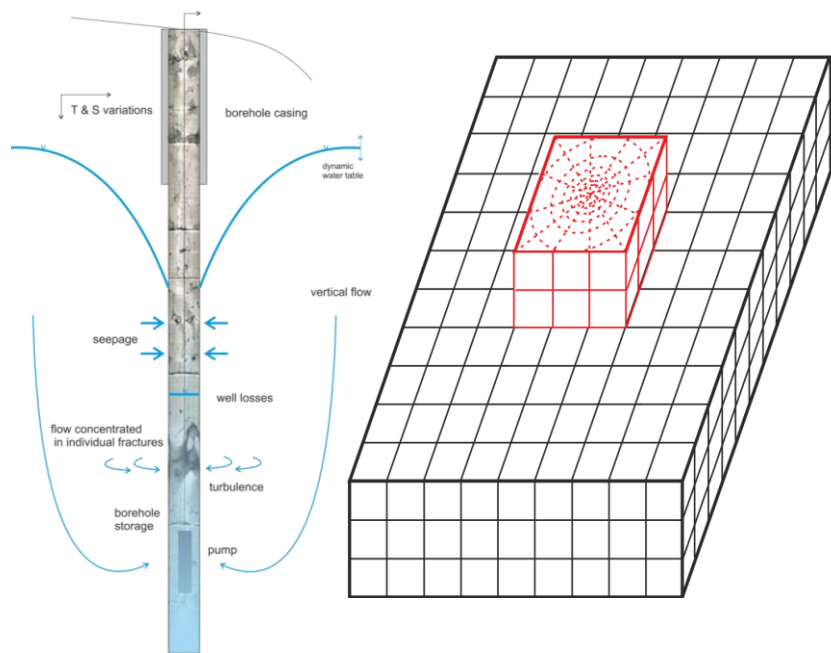
Modelling Sustainable Yield

AIM: Develop a modelling tool to address limitations of the current methodology

- **Availability and quality of operational data**
 - **Reconstruct operational GWLs during historic droughts**
- **Vertical heterogeneity**
 - **Represent non-linear processes at borehole scale**
- **Interference**
 - **Represent abstraction borehole in regional context**
- **Climate change**
 - **Apply scenarios to assess impact**



Multi-scale Groundwater Modelling



SPIDERR Flow Model

Coupled radial-cartesian GW model for simulating abstraction boreholes within regional GW models

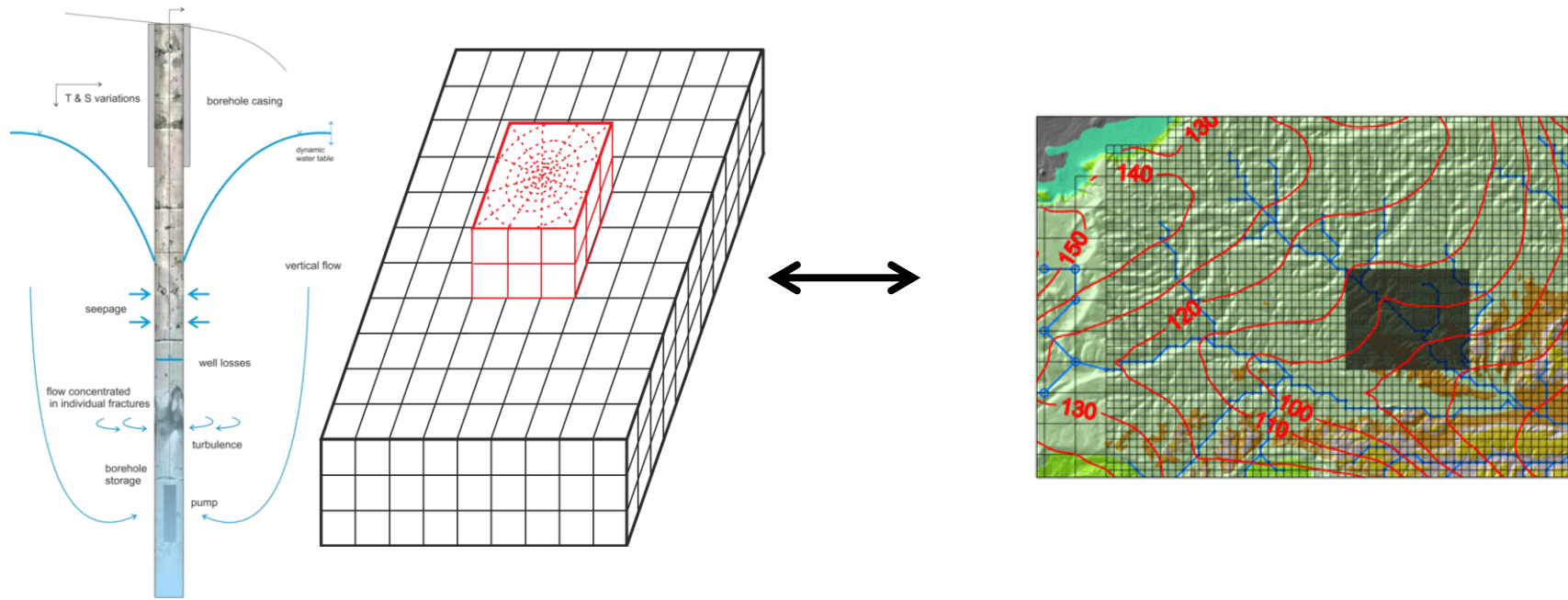


OpenMI

ZOOMQ3D

Regional GW modelling code

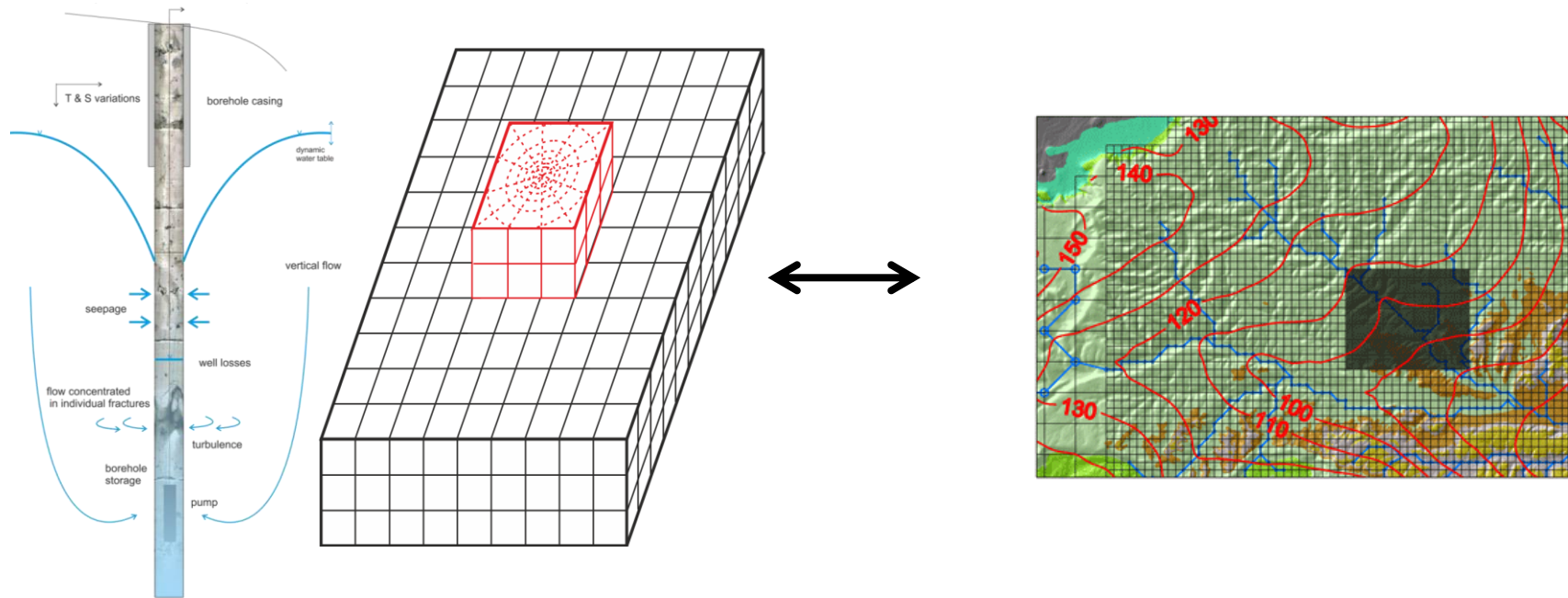
Multi-scale Groundwater Modelling



SPIDERR Flow Model: Radial Model

- Finite difference approximation
- Darcy-Forchheimer (non-linear flow)
- Logarithmic radial node spacing
- Vertical layering
- Vertical & horizontal heterogeneity
- Partially or fully penetrating borehole
- Borehole storage
- Borehole casing & screening
- Seepage face development

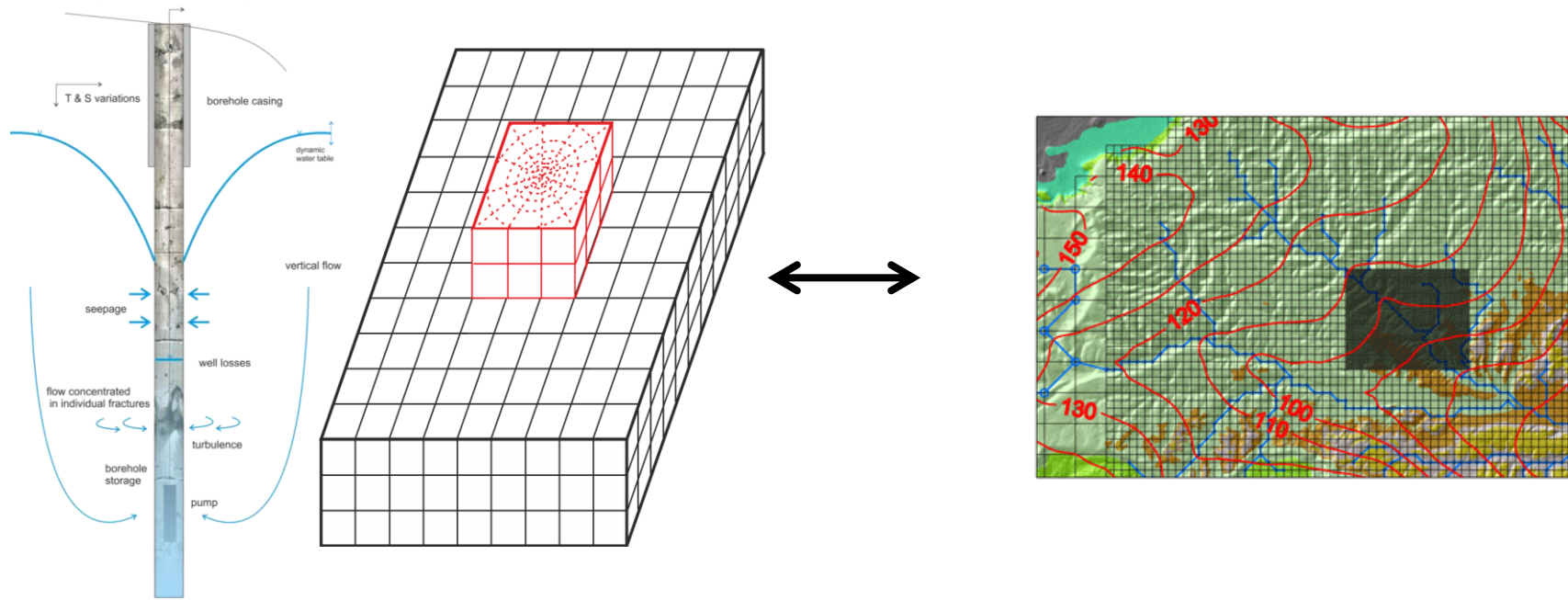
Multi-scale Groundwater Modelling



SPIDERR Flow Model: Radial-Cartesian Coupling

- Hybrid radial-Cartesian method applied in petroleum reservoir models
- Limitations of grid construction
- BUT**
- Quick, simple & user friendly

Multi-scale Groundwater Modelling

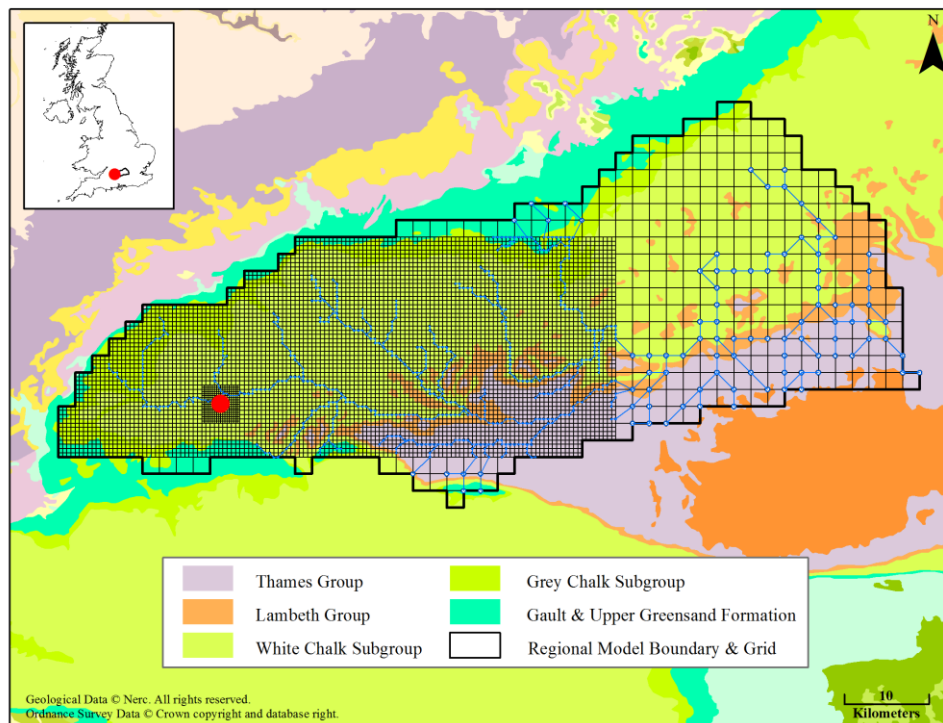


OpenMI: Linking SPIDERR Flow Model with ZOOMQ3D

- OpenMI standard for linking models
- Data exchange maintains consistency between two models
- Quick and easy to link several borehole models
- Make use of existing regional models

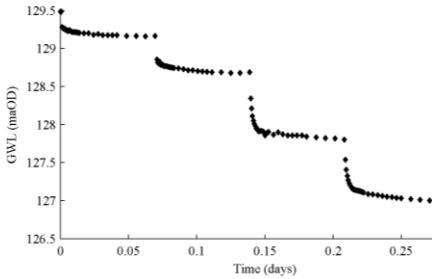
Model Application

1. Calibration of SPIDERR using pumping test data
2. Coupling of SPIDERR with ZOOMQ3D regional model
3. Historic simulation and comparison with operational data
4. Abstraction scenarios to inform sustainable yield assessment

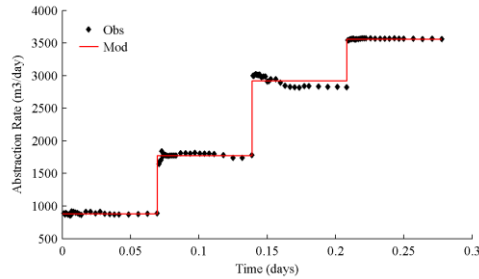


Model Application

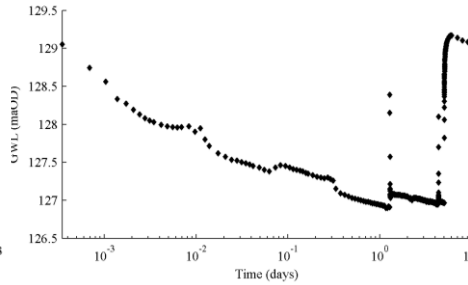
1. Calibration of SPIDERR using pumping test data



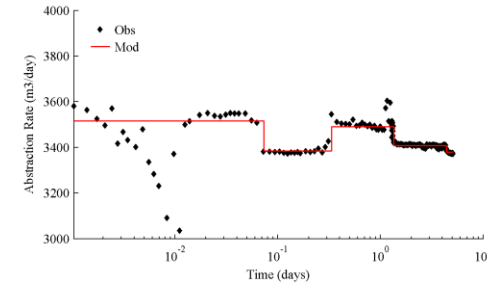
SDT: drawdown



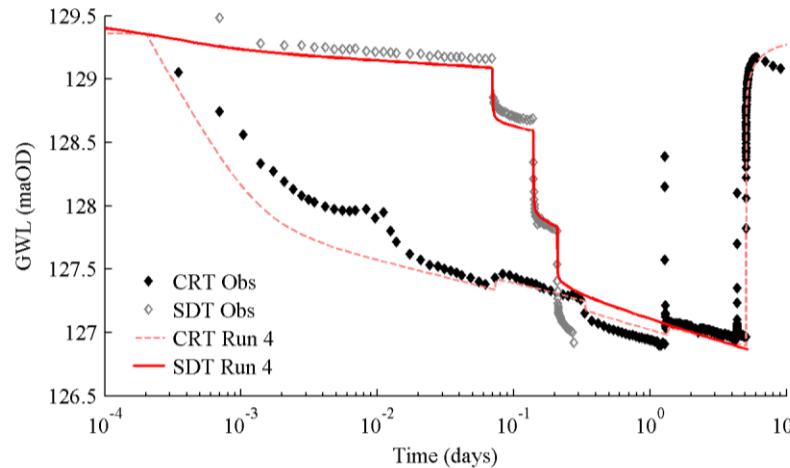
SDT: abstraction rates



CRT: drawdown



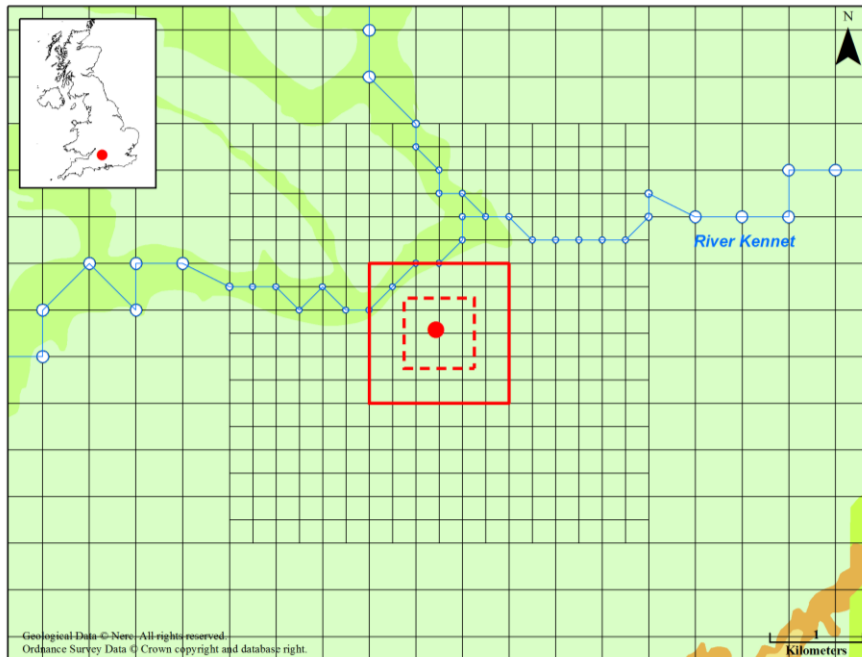
CRT: abstraction rates



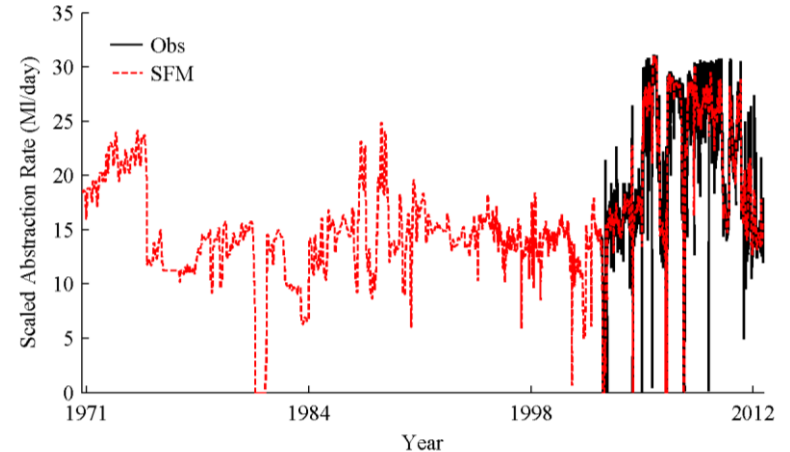
Modelled and observed drawdown for the SDT and CRT

Model Application

2. Coupling of SPIDERR with ZOOMQ3D regional model



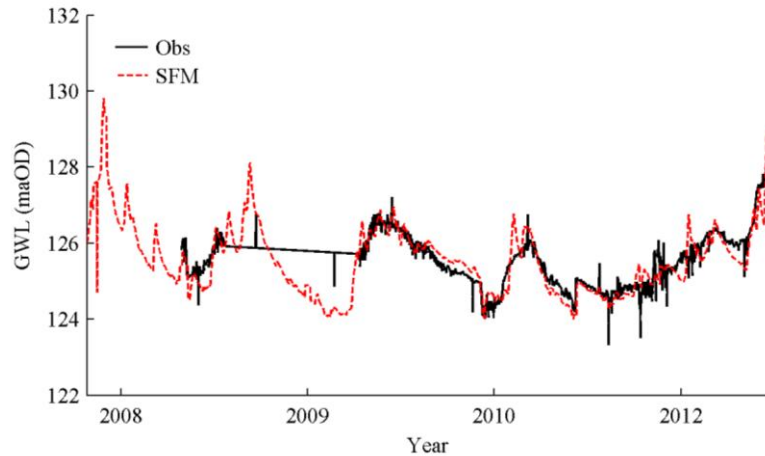
- ABH Location
- - - SPIDERR: radial extent
- SPIDERR: Cartesian extent



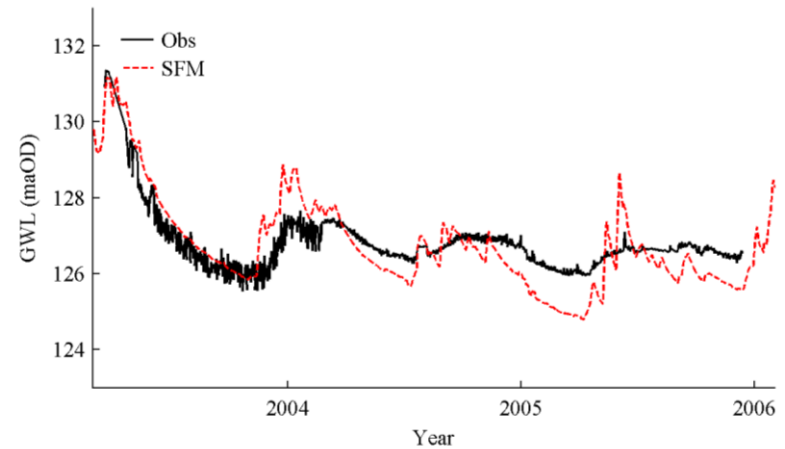
Observed (daily) and modelled (weekly) abstraction rates with reconstruction back to 1971

Model Application

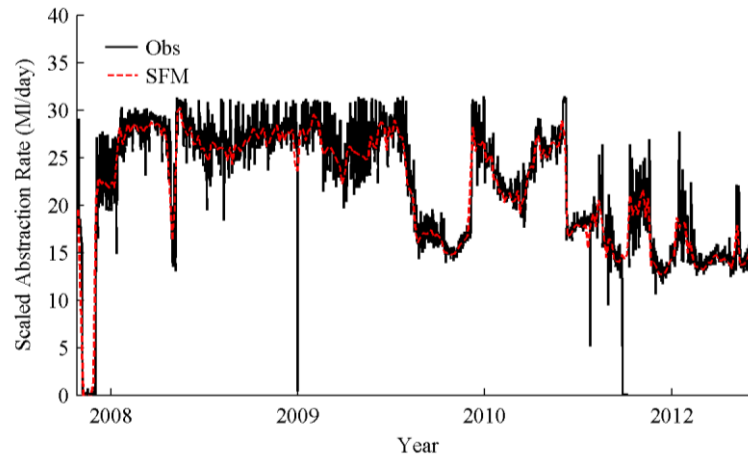
3. Historic simulation and comparison with operational data



Modelled and observed operational GWLs (ABH)



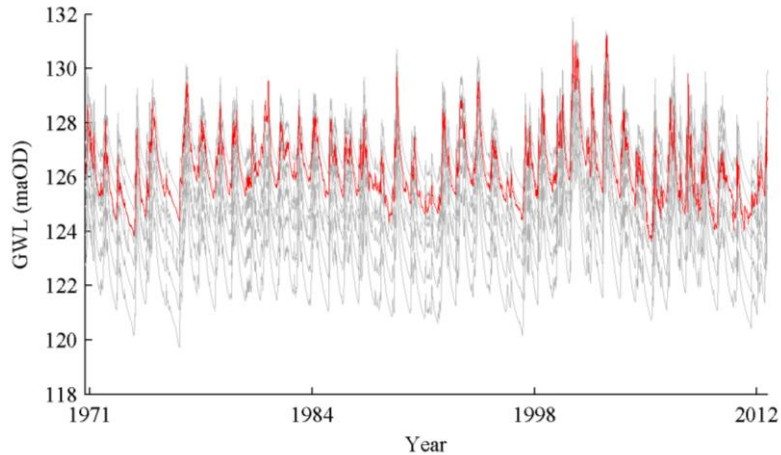
Modelled and observed GWLs (OBH)



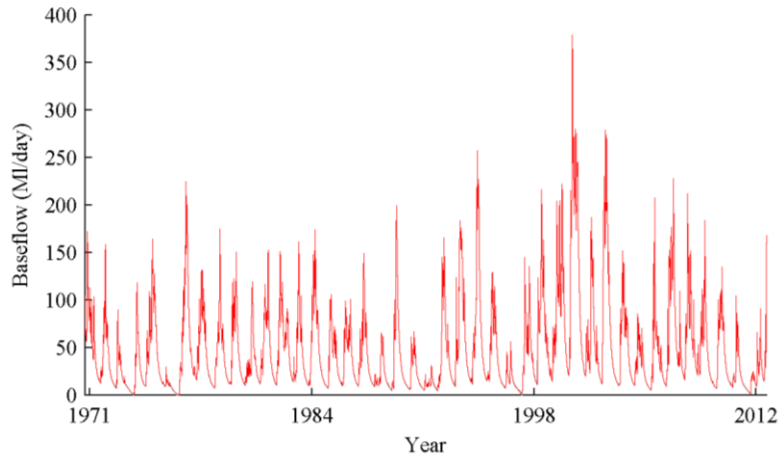
Observed (daily) and modelled (weekly) operational abstraction rates

Model Application

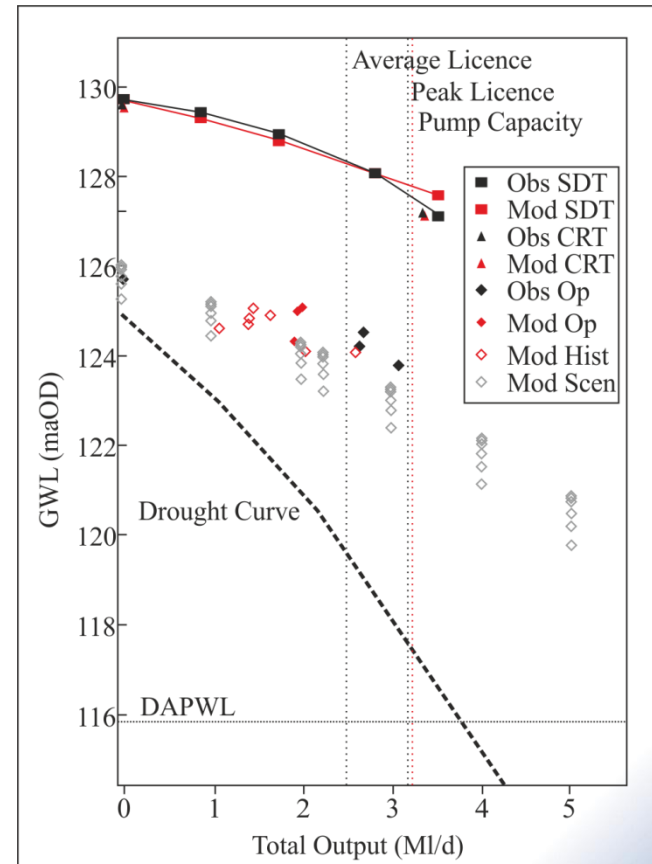
4. Abstraction scenarios to inform sustainable yield assessment



Modelled operational GWLs (ABH) under abstraction scenarios



Modelled baseflow under abstraction scenarios



Conclusions

- **Multi-scale methodology provides useful tool for assessing the sustainable yield of supply boreholes during drought**
- **Suggests whether further work would be useful to determine whether larger yield could be sustained OR if deployable output should be reduced**
- **Coupling allows impacts on neighbouring abstractions/rivers to be assessed**
- **Development to allow two radial models to be simulated in a single Cartesian grid**
- **Tool for assessing climate change impacts**