Groundwater flow modelling at the British mainland scale

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Hydro-JULES

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
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National groundwater flow modelling: Questions

- How can an integrated approach improve the simulation of major flooding events such as the 2013/4 floods?

- How can a holistic approach be undertaken to assess water resources under drought conditions?

- National state of groundwater at regional scale

If water table is connected to land surface:
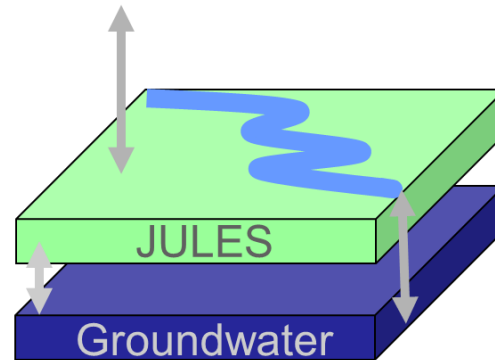
If water table is disconnected from land surface:
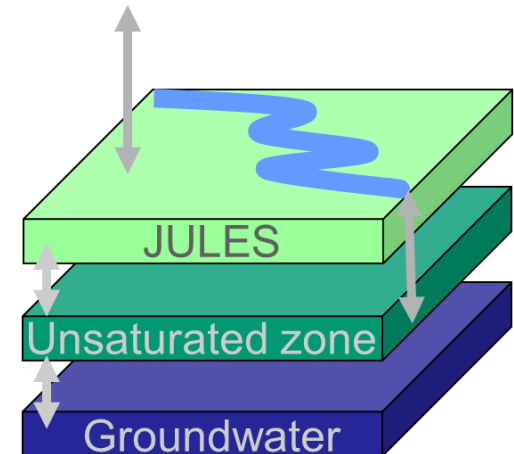
Talk overview

- ## Testing of the model at the British mainland scale

  - Model set-up

  - Initial results

  - Problems

- ## Refining of the national scale model at a local scale

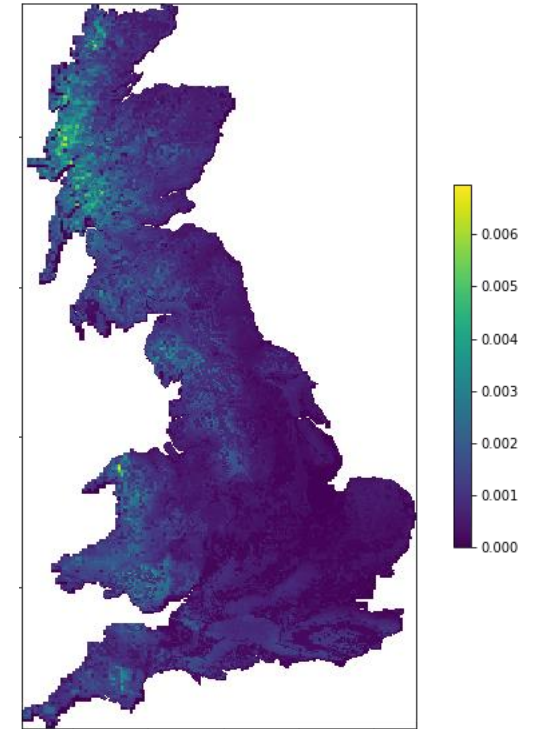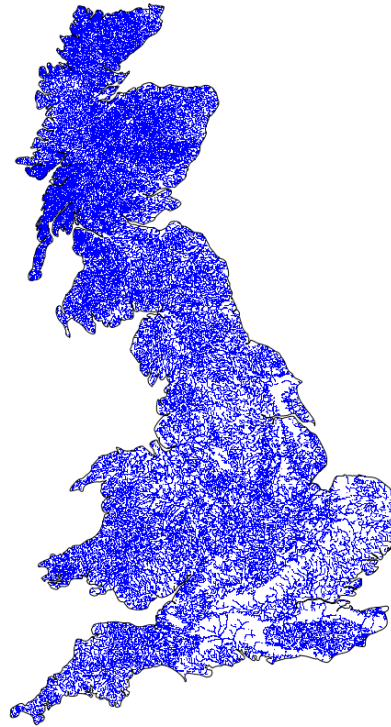- ## Next steps

Testing of MODFLOW 6 for BM mainland: Model boundaries
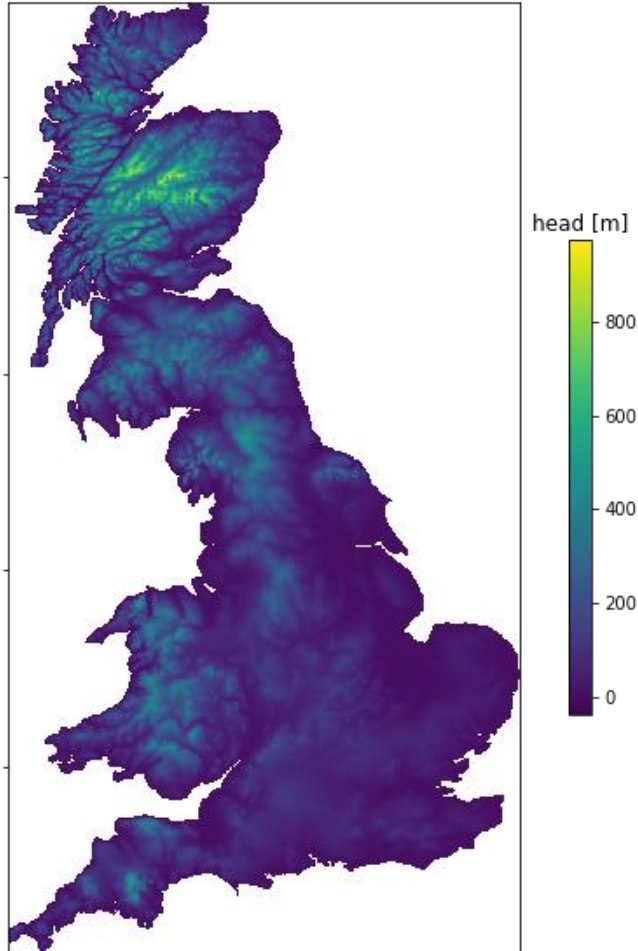
coast   lakes   rivers   Recharge

Mansour et al. 2018

Testing of MODFLOW 6 for BM mainland: Parameterisation

Surface bedrock geology
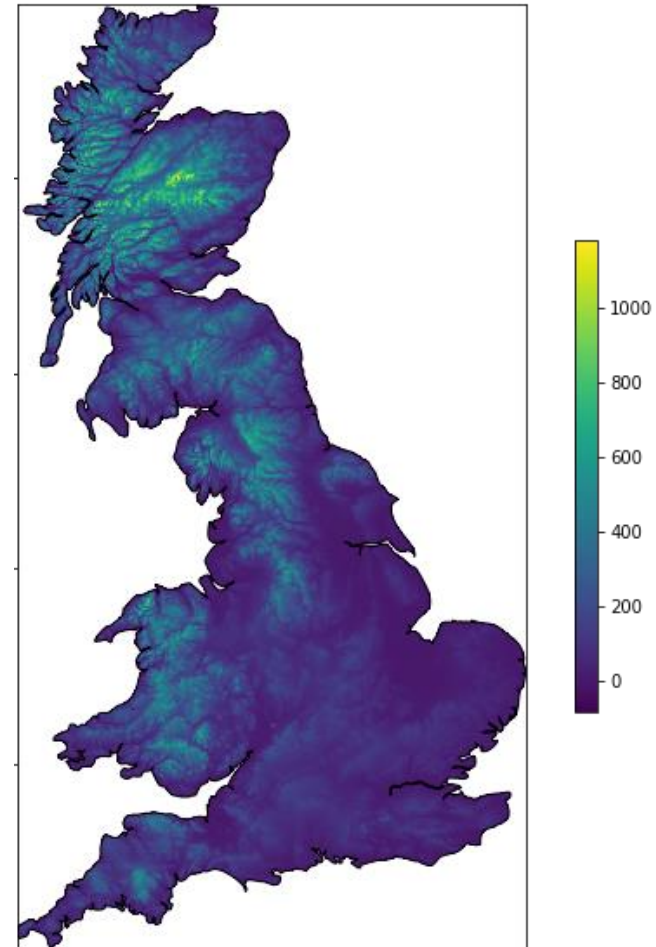
Regional groundwater conceptual models

Ó Dochartaigh,
Farr,
Lewis

Testing of MODFLOW 6 for BM mainland: Initial results

Modelled hydraulic head
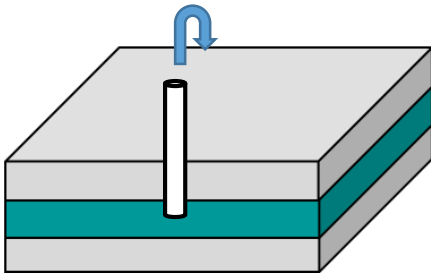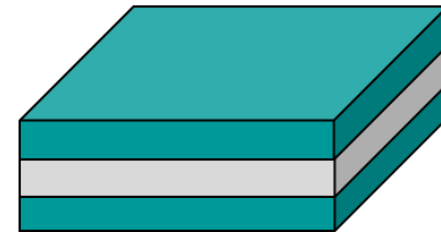
DEM - depth to groundwater product
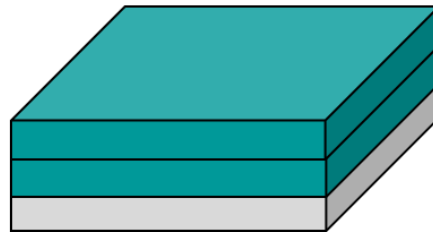
McKenzie (2015)

Testing of MODFLOW 6 for BM mainland: Problems

- Not honouring the 3D geology – Surface geology assumed to be 500 m thick

- Including groundwater abstraction for confined aquifers
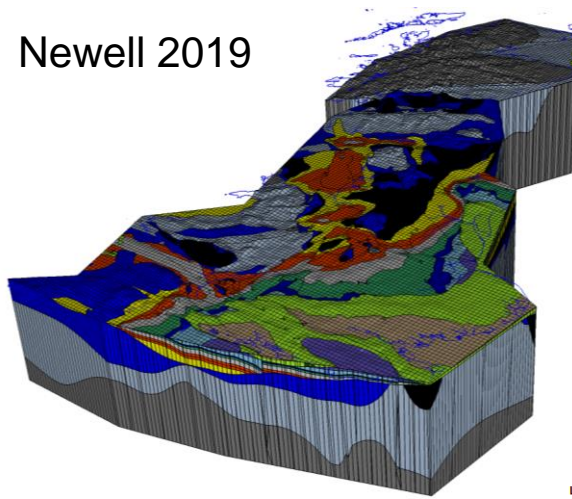
Confined aquifer   Unconfined aquifer 2 aquifer layers separated by
                                            low permeable unit
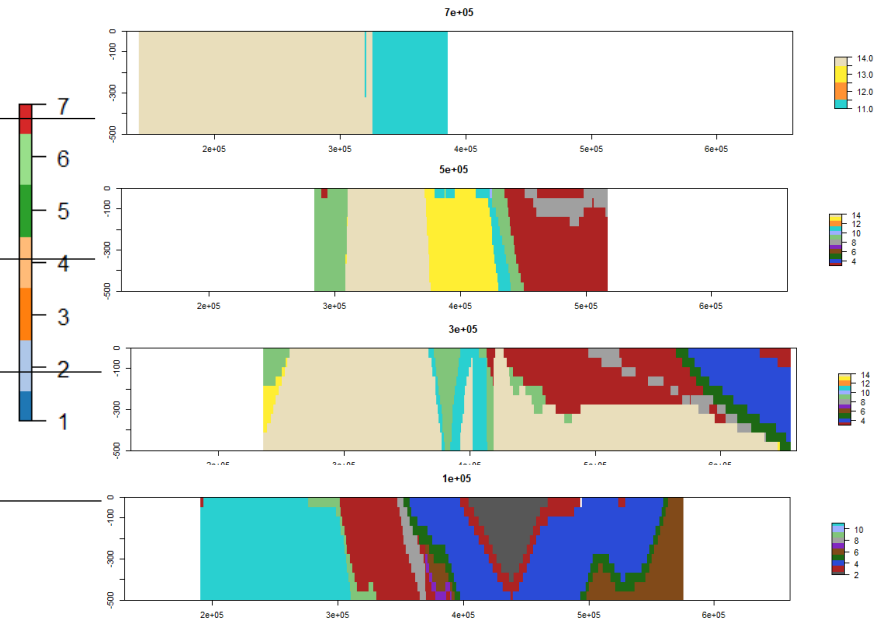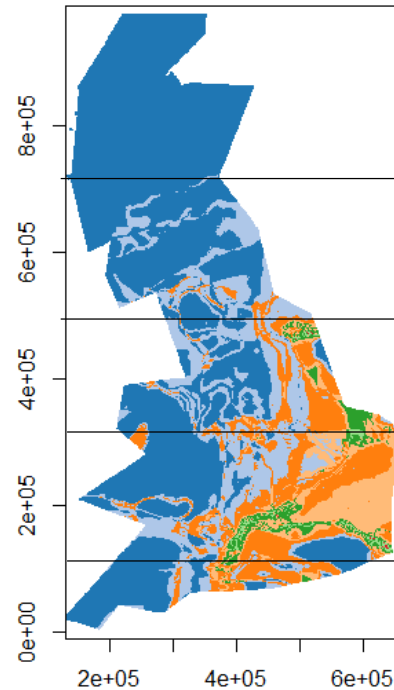
-> Need for better geological representation in the model

Improving the geological representation: 3D framework model

Newell 2019

+1.5 km
to -15 km

Number of
hydrostratigraphic units
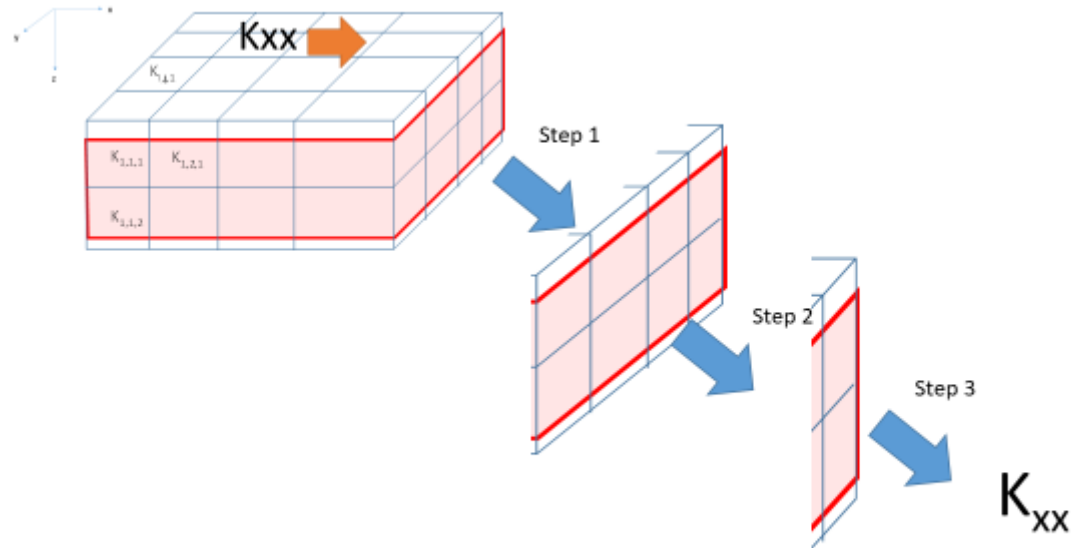at each location

Improving the geological representation: Geological averaging onto the model grid

- Calculate effective hydrogeological properties for each model cell

  - Along the flow direction: harmonic mean – preserves properties with lower values

  - Perpendicular to the flow direction: arithmetic mean – preserves properties with higher values

Improving the geological representation: Test 3D geology on a small area
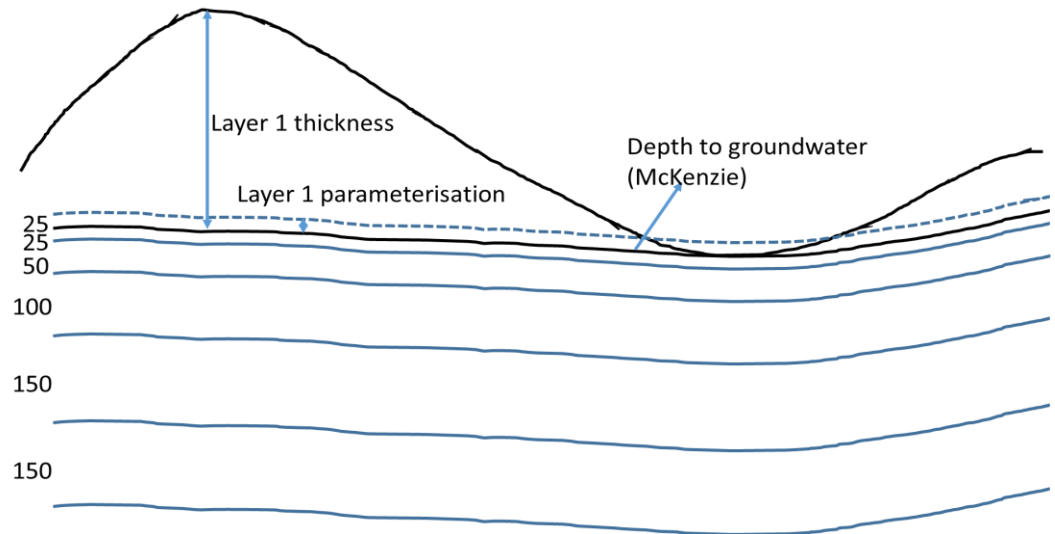
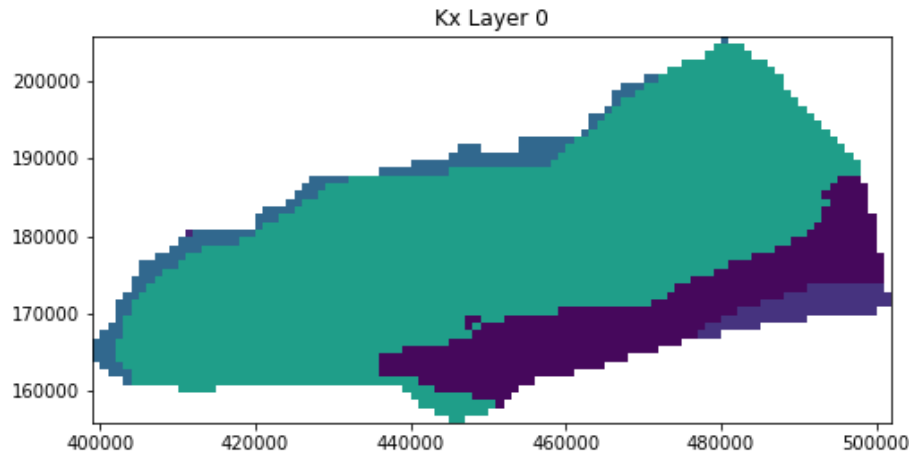Marlborough and Berkshire Downs, South-west Chilterns
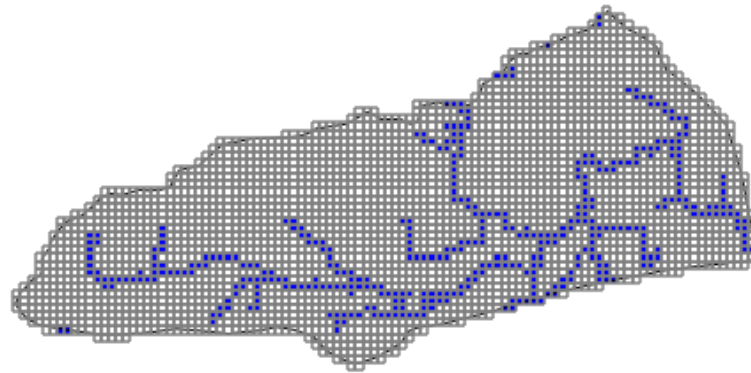
Set-up otherwise unchanged from UK mainland model:
- grid (1 km)
- rivers
- recharge

- 1 Layer using the surface geology
- 1 Layer using geological averaging
- 6 Layers: more refined near the surface

Layer 1 thickness

Depth to groundwater (McKenzie)
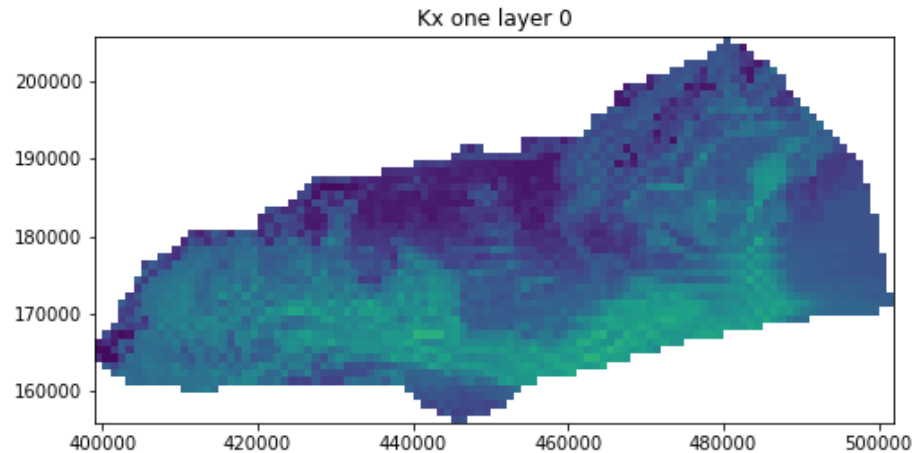
Layer 1 parameterisation

25
25
50
100
150
150

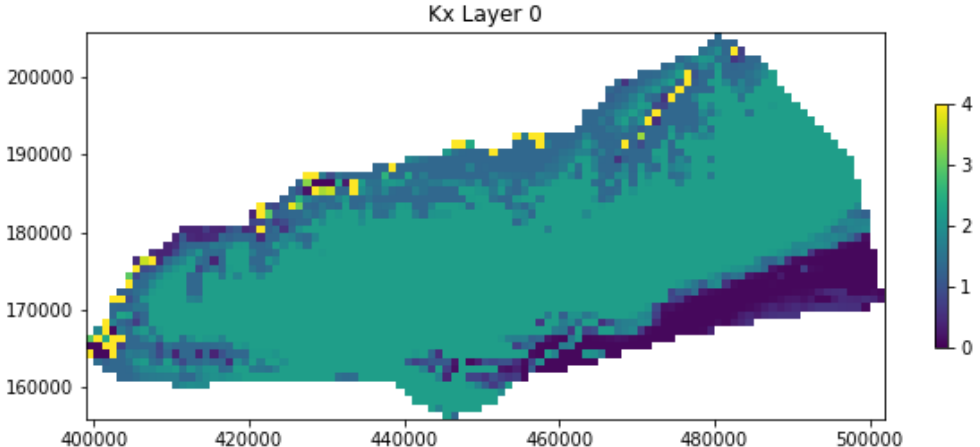# Improving the geological representation: Hydraulic conductivity 1 Layer model
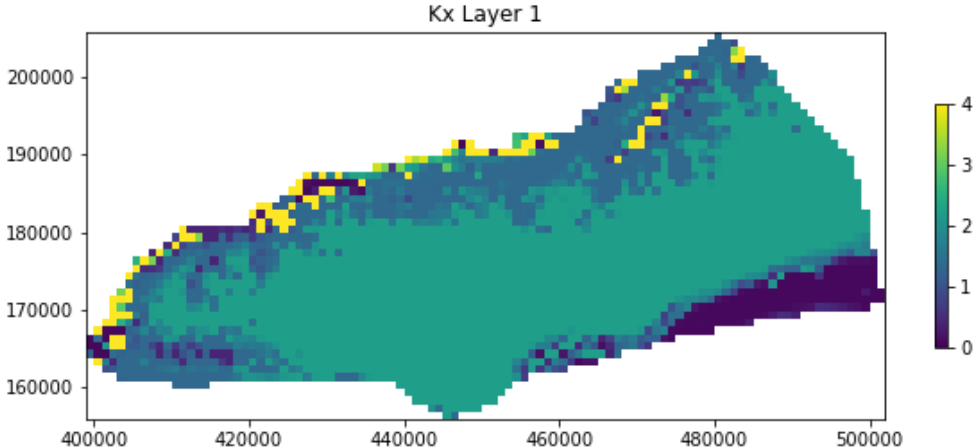

Surface hydraulic conductivity

Effective hydraulic conductivity

Improving the geological representation: Hydraulic conductivity 6 Layer model

Kx Layer 0

Improving the geological representation: Hydraulic conductivity 6 Layer model
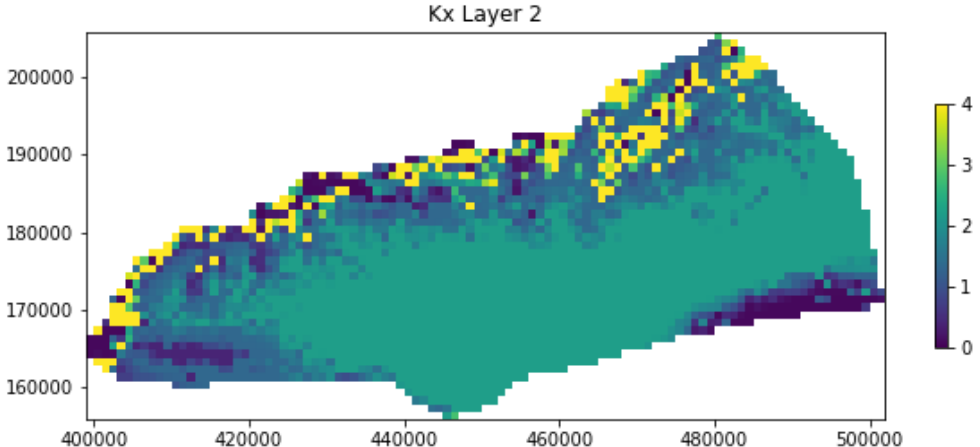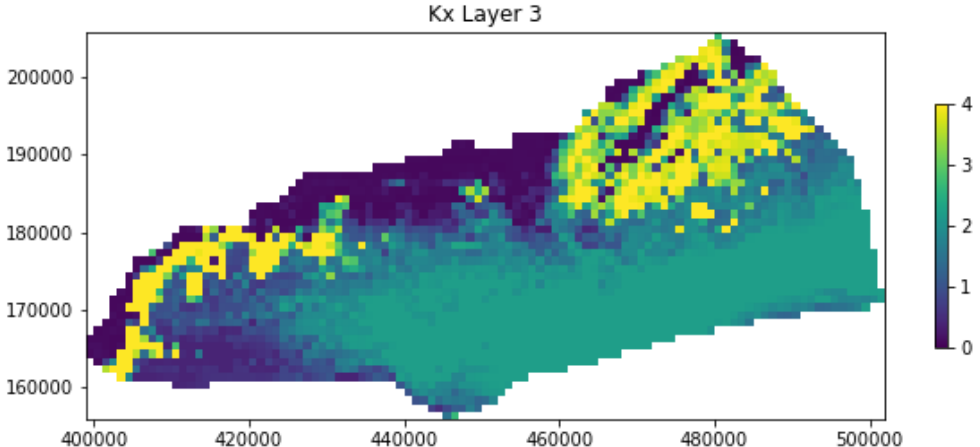

Kx Layer 1

Improving the geological representation: Hydraulic conductivity 6 Layer model

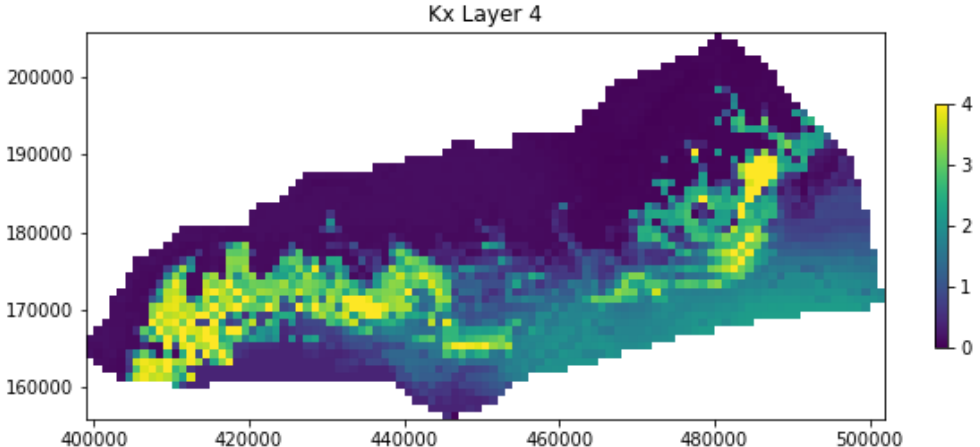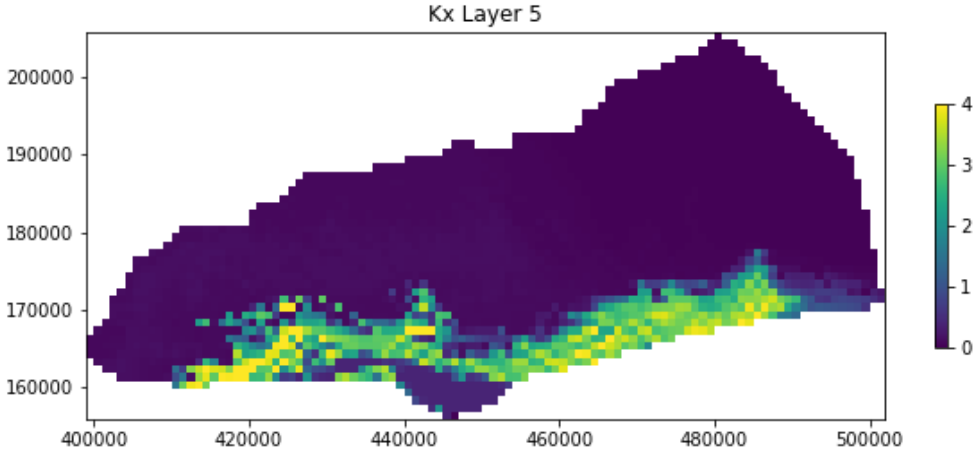# Improving the geological representation: Hydraulic conductivity 6 Layer model

Kx Layer 3

Improving the geological representation: Hydraulic conductivity 6 Layer model
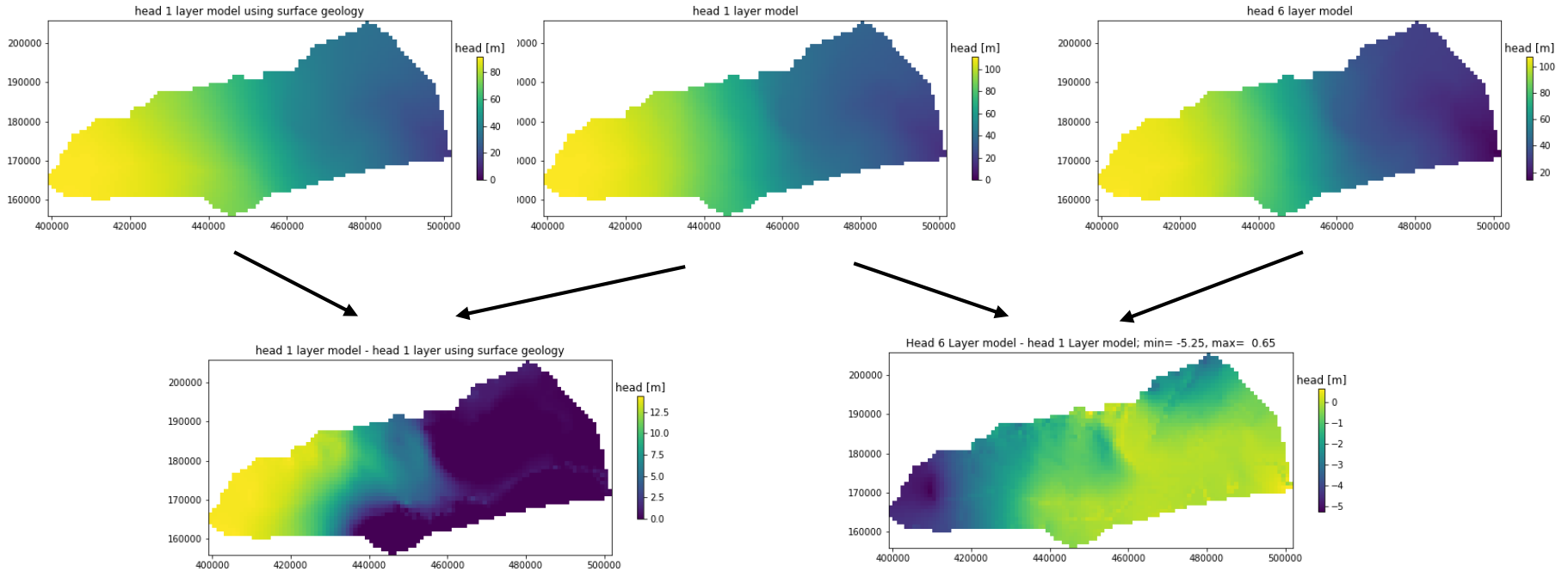

Kx Layer 4

Improving the geological representation: Hydraulic conductivity 6 Layer model

Effect of geological averaging on steady state hydraulic head

Surface properties
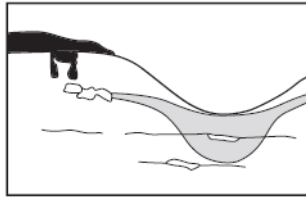
Equivalent hydrogeological properties

- Large difference of using properties at surface and equivalent hydrogeological properties
- Smaller difference if one layer or several layers using equivalent hydrogeological properties are used
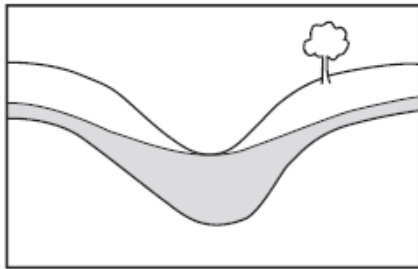- Including abstraction will likely change this

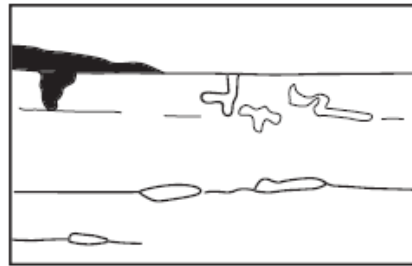# Next steps: Update parameterisation of the Chalk
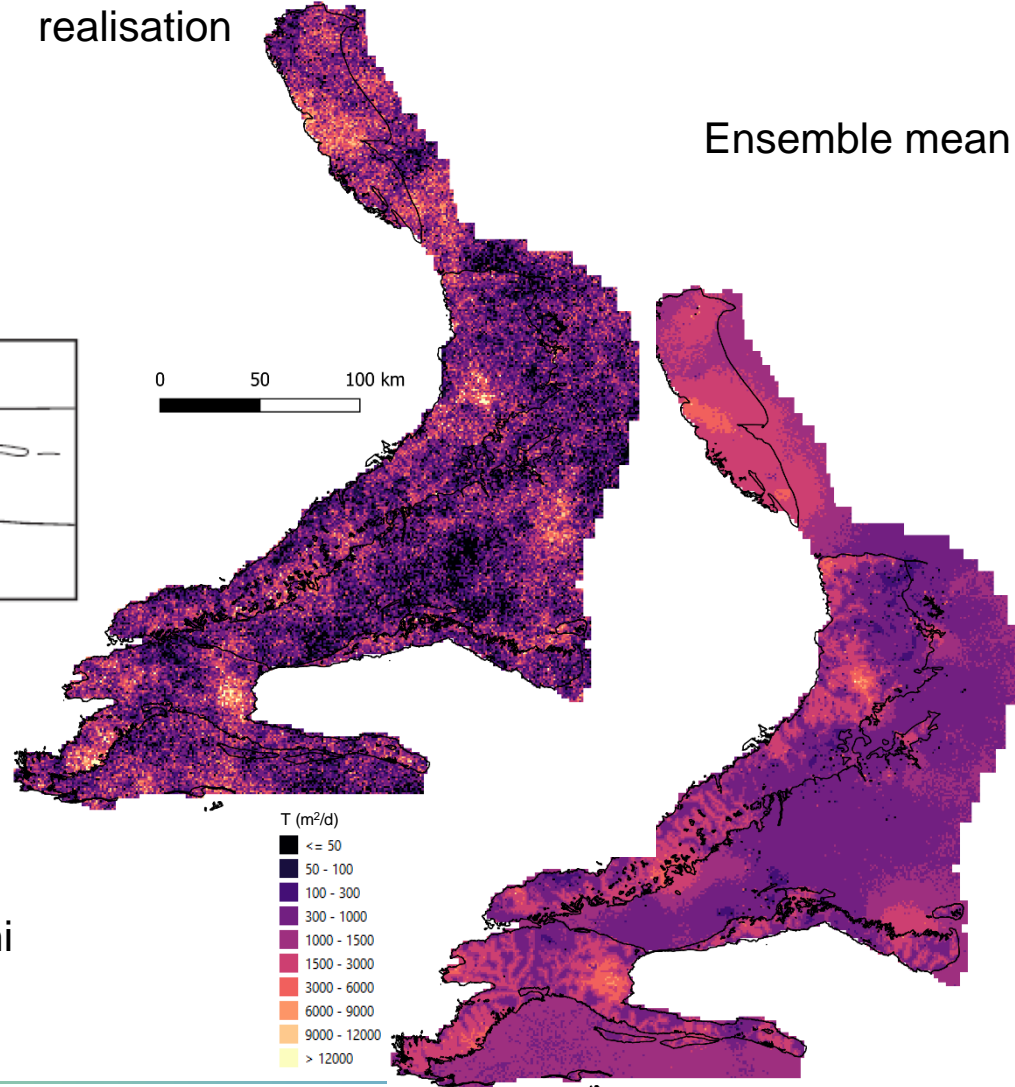
Allen et (1997)

Single realisation

Ensemble mean

Marco Bianchi

T (m²/d)
- <= 50
- 50 - 100
- 100 - 300
- 300 - 1000
- 1000 - 1500
- 1500 - 3000
- 3000 - 6000
- 6000 - 9000
- 9000 - 12000
- > 12000
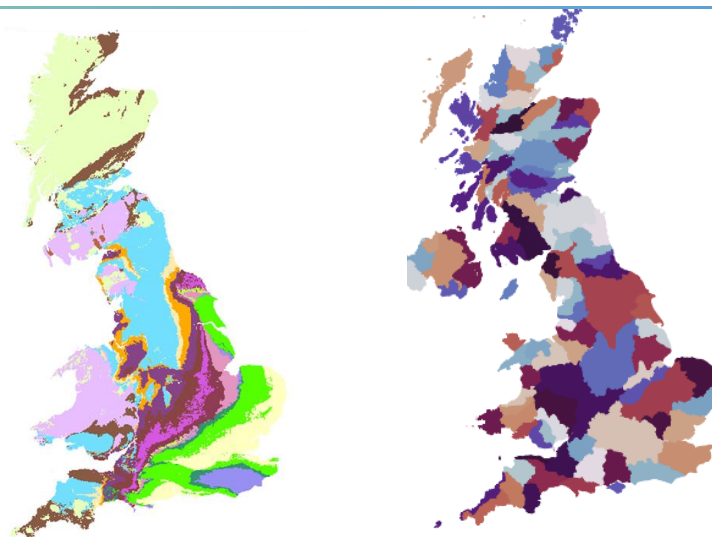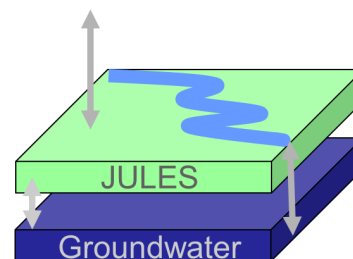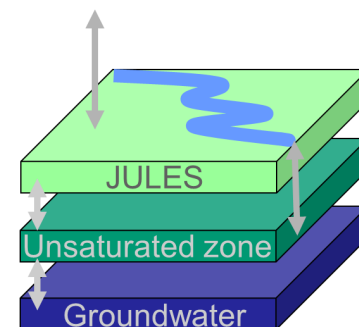
Next steps

- **Model calibration**

  - Observed groundwater heads

  - Compare the simulated and observed heads and river flows for different river catchments and geological units

  - Seasonality and extremes

- **Integration into the Hydro-Jules framework**

  - MODFLOW 6 integration into the Hydro-JULES modelling framework

  - British Mainland model will be an example for an integrated model

  - Integrated groundwater – surface water assessment for flooding and drought

If water table is connected to land surface:

JULES

Groundwater

If water table is disconnected from land surface:

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Unsaturated zone

Groundwater

Questions?