Hydro-JULES : A groundwater model of the UK?

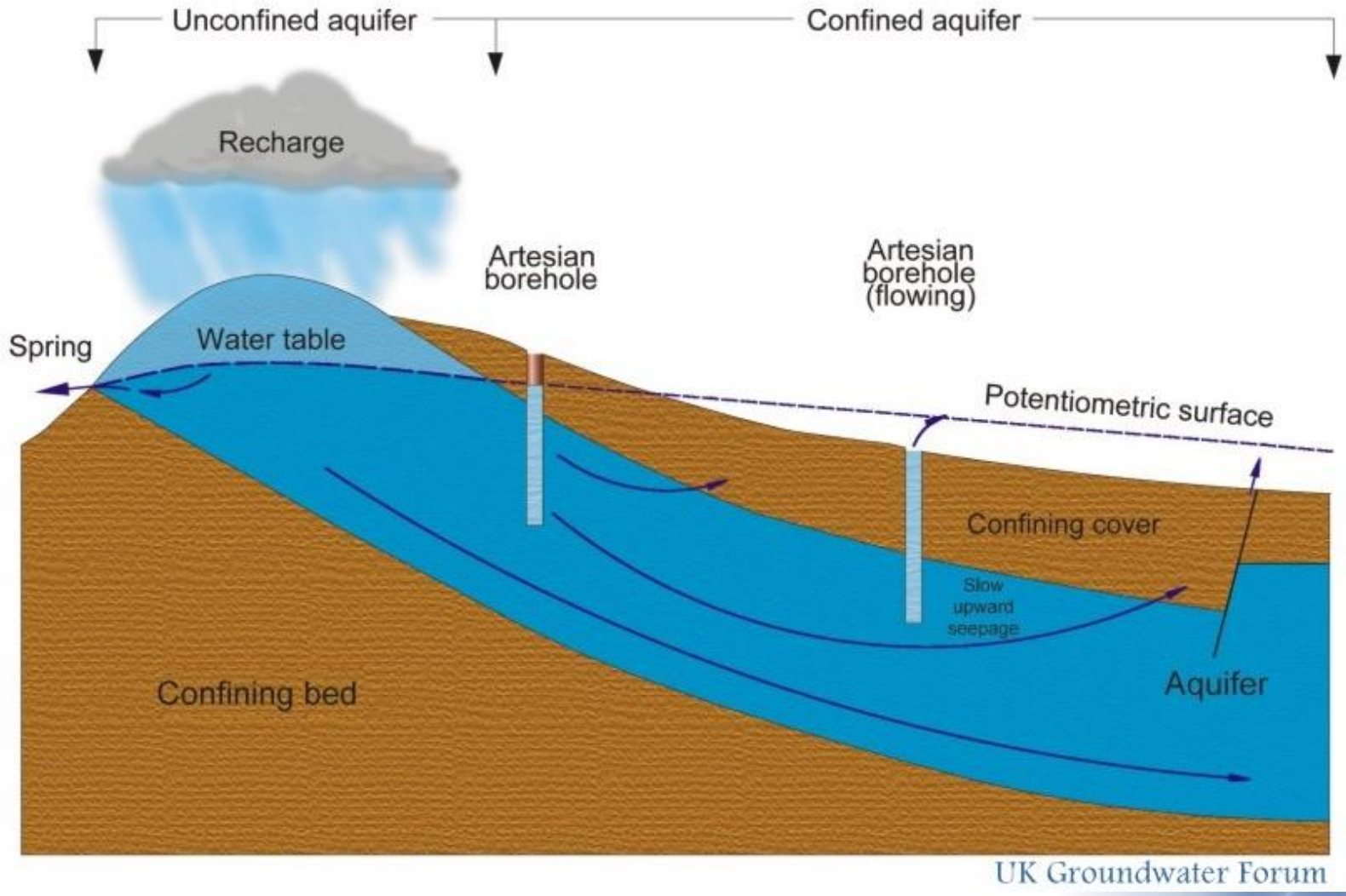
10th September 2018

Andrew Hughes (and others)

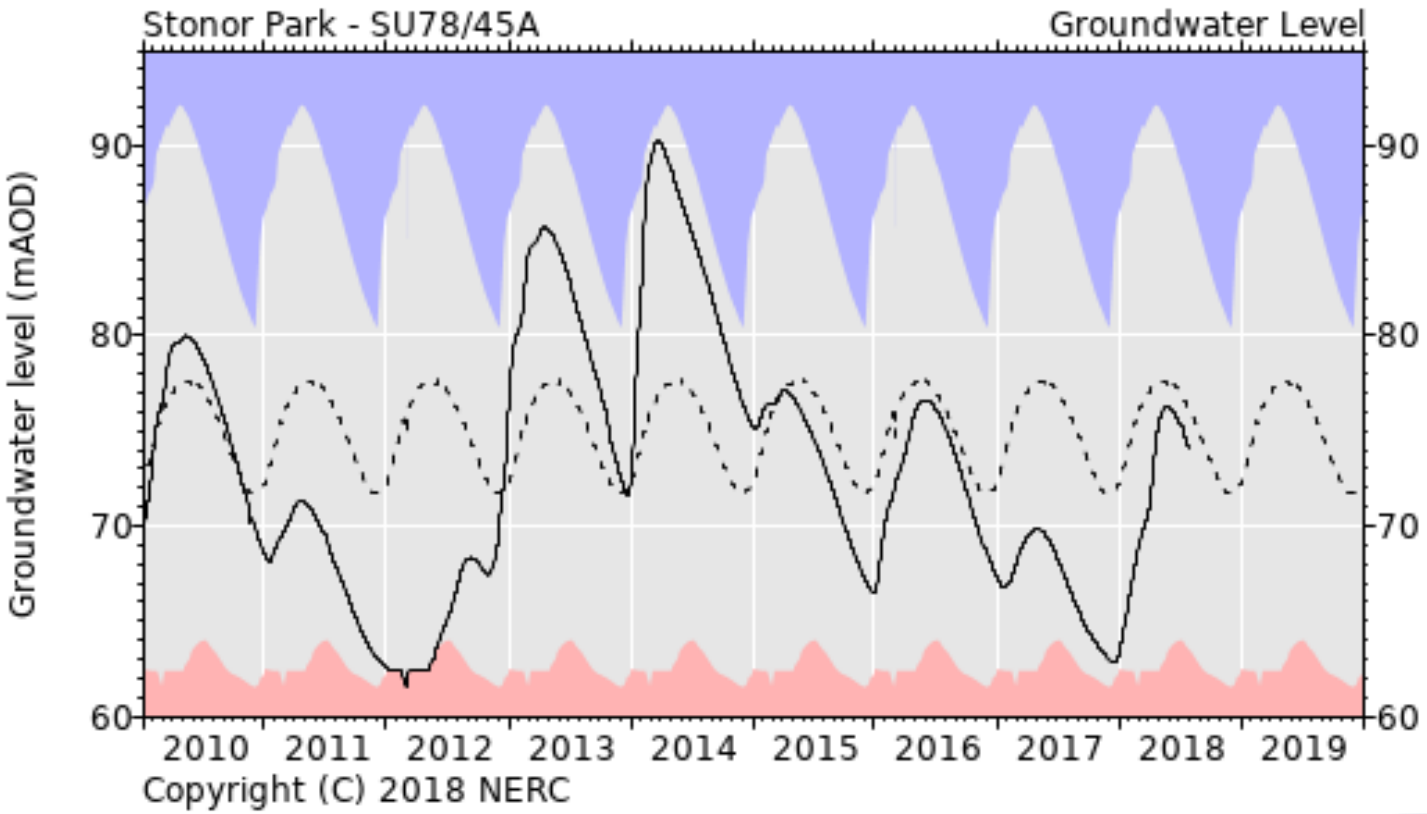
An introduction

- Work for the British Geological Survey in our Keyworth offices
- Based in the Groundwater directorate
- Groundwater modeller who has specialised in producing national scale models as well as exploring integrated modelling

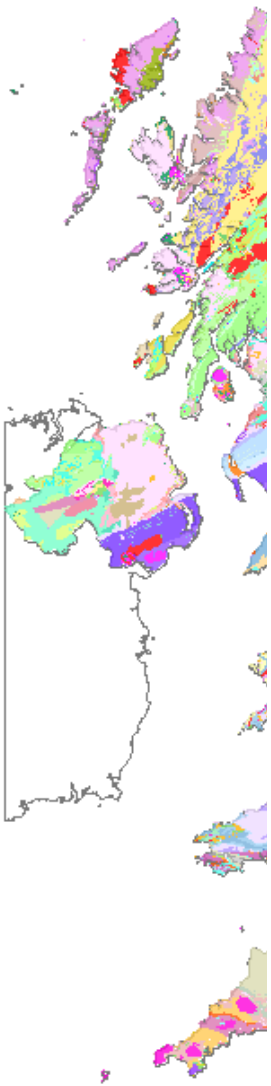
Groundwater in the UK

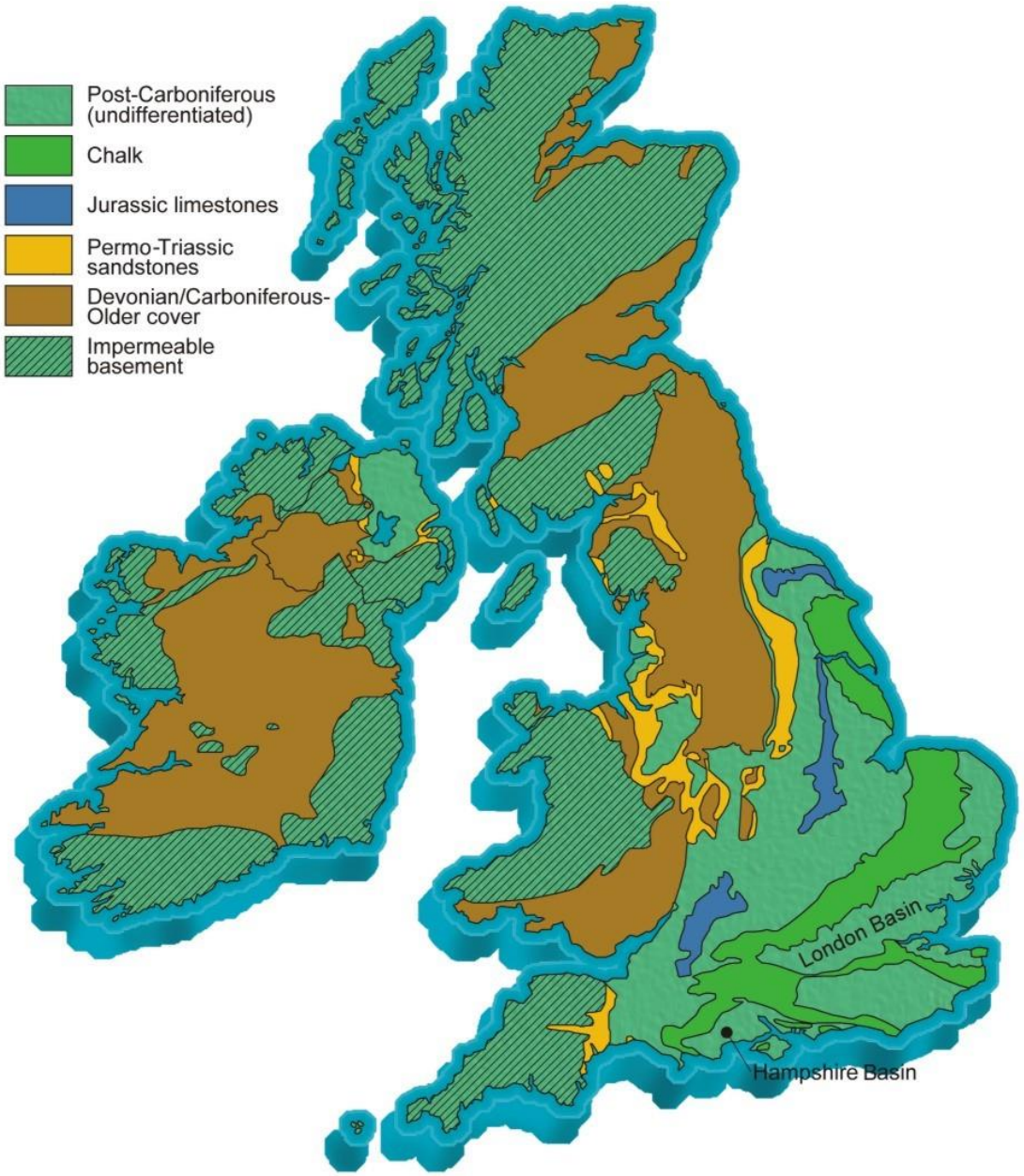


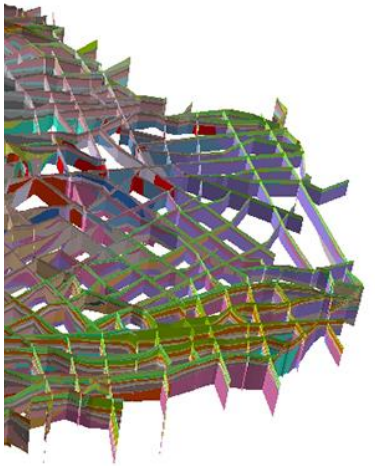
Seasonal variation and its challenges



Hete





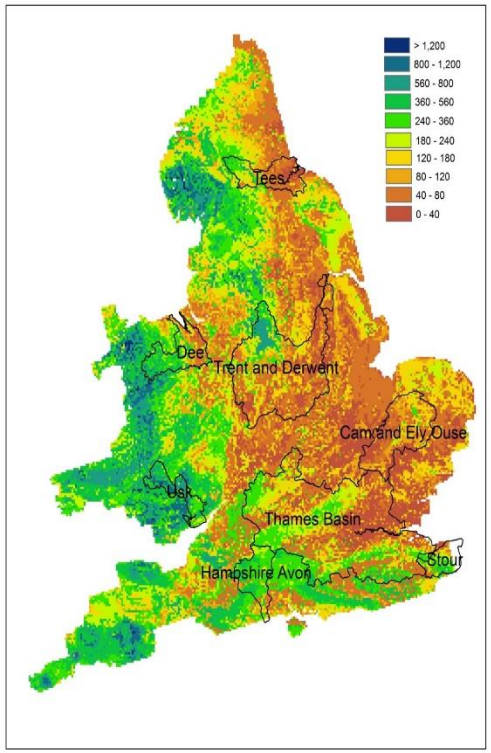


alGeologicalMod

But we have some experience….

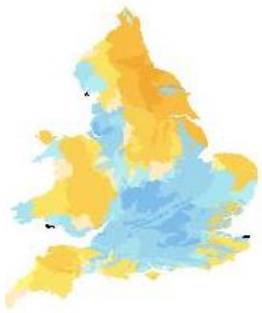
Current climate

Future climate

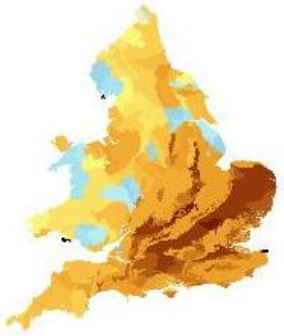


Long term average recharge (mm/a)

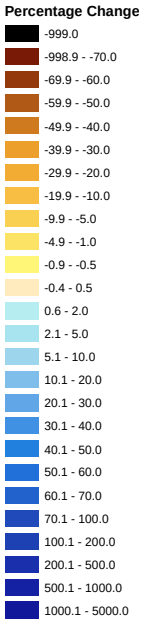
nora.nerc.ac.uk/id/eprint/519402/

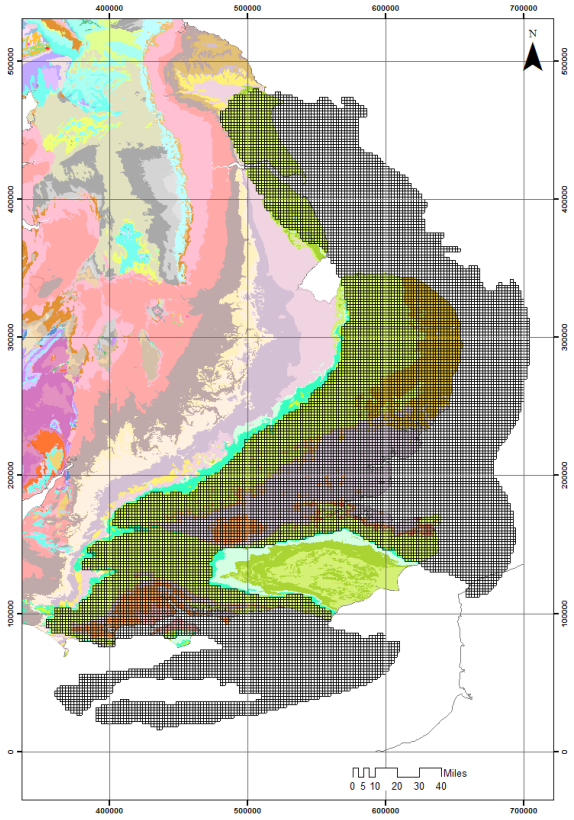


2050s median March



2050s median October

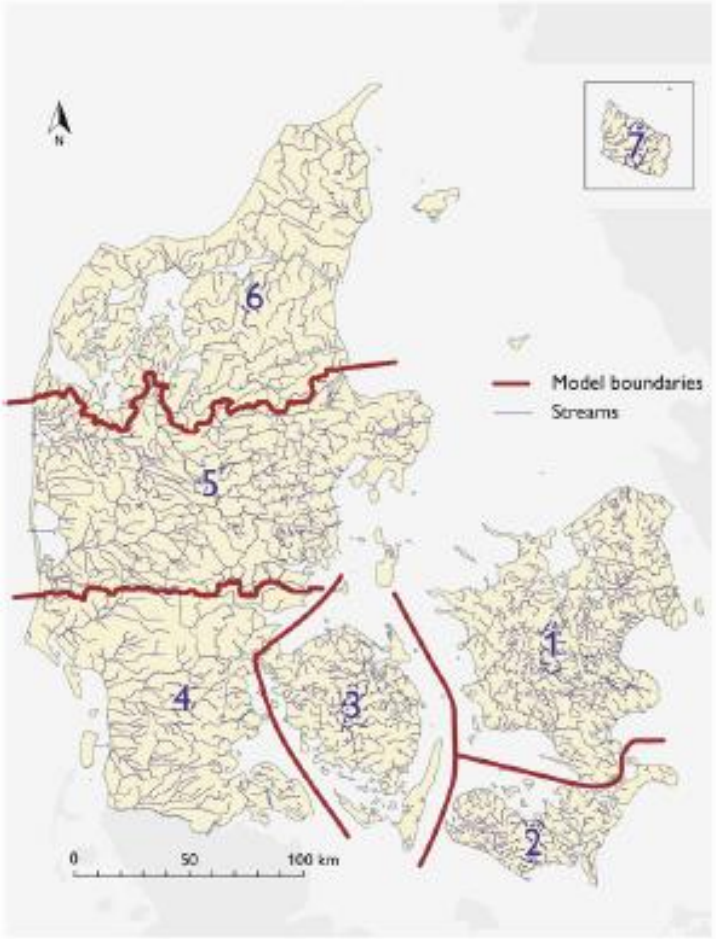




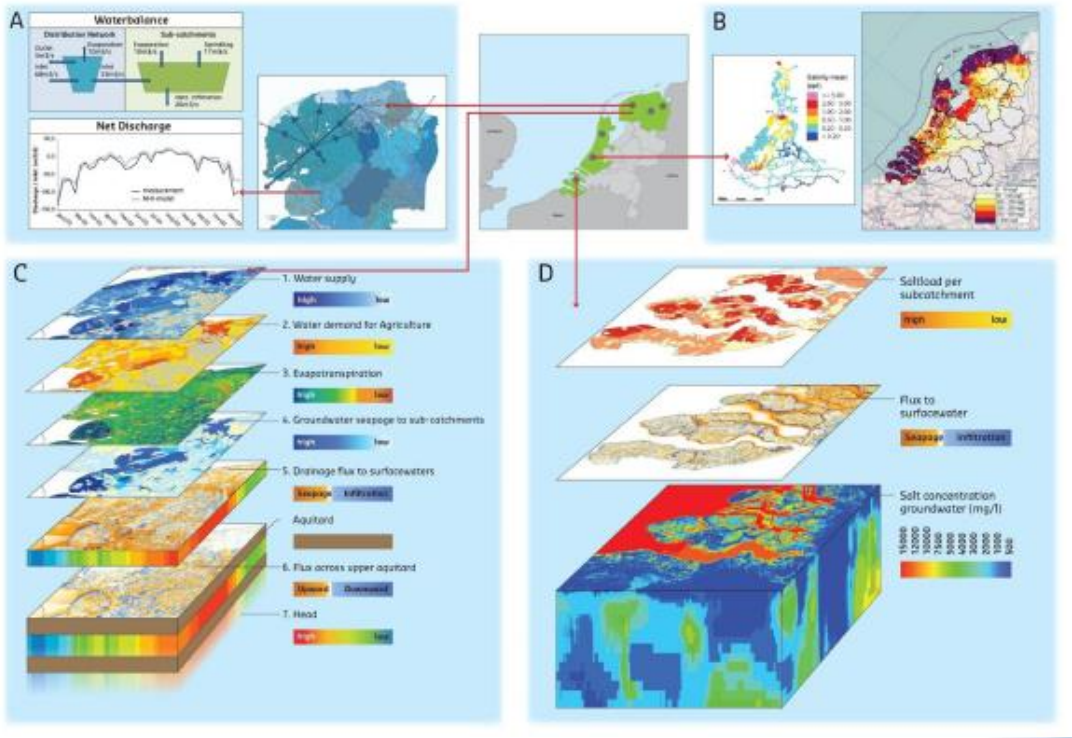
11 RCMs – Future Flow and Groundwater Level (FFGWL) datasets

http://nora.nerc.ac.uk/id/eprint/507537/

…as do others



dk.vandmodel.dk/in-english/

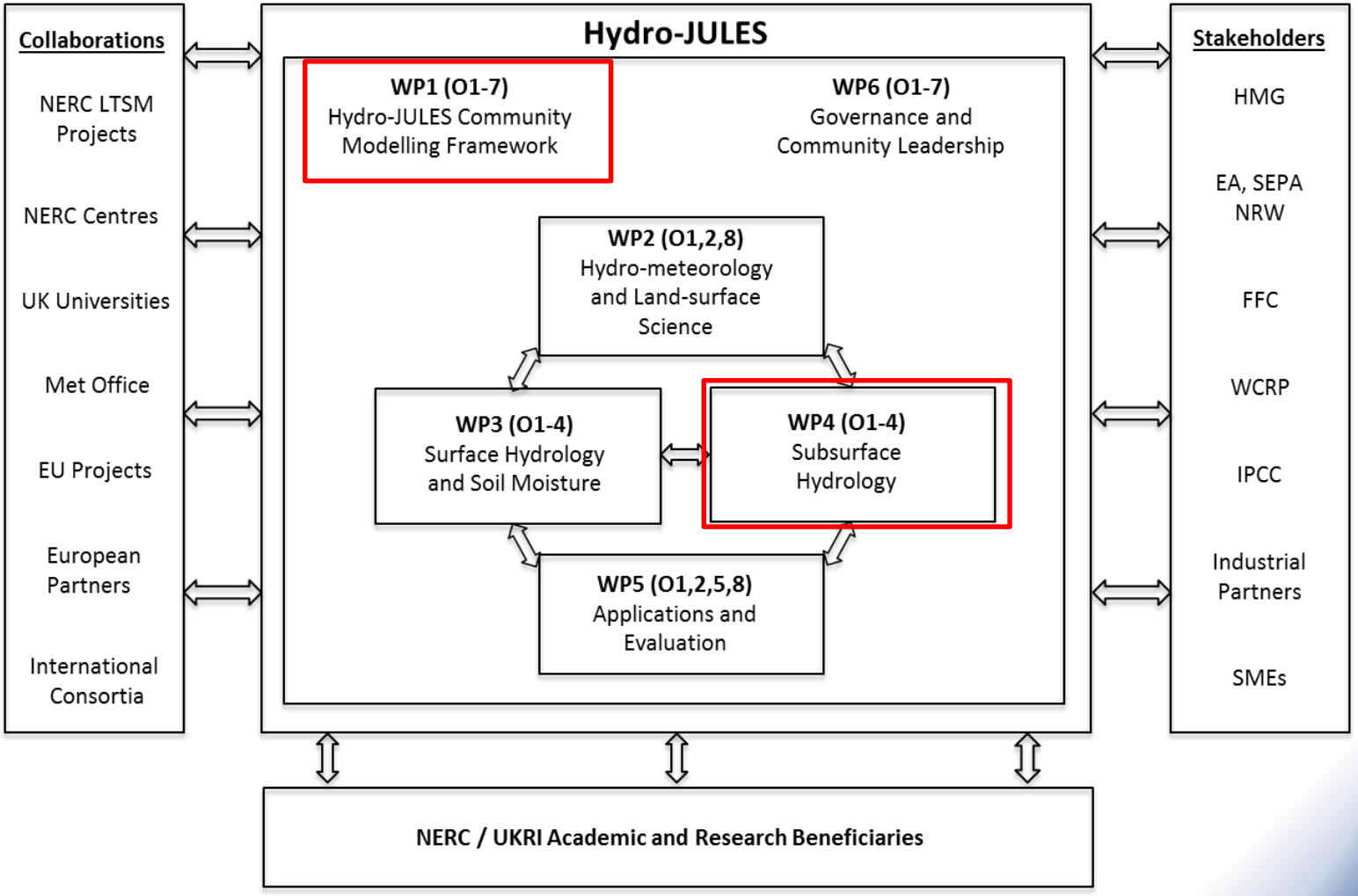


https://www.sciencedirect.com/science/article/pii/S1364815214001406

Challenges (and questions)

- How and where might drought affect groundwater supply in the UK?
- How can the large-scale use of groundwater for irrigation affect local climate?
- How and where does groundwater contribute to flooding?
- How does conceptualisation of groundwater flow affect hydrological understanding at a global scale?
- How could the interaction of the atmosphere with the land surface under future climate change affect recharge?
- How can heat be represented in groundwater and what benefits does it bring?

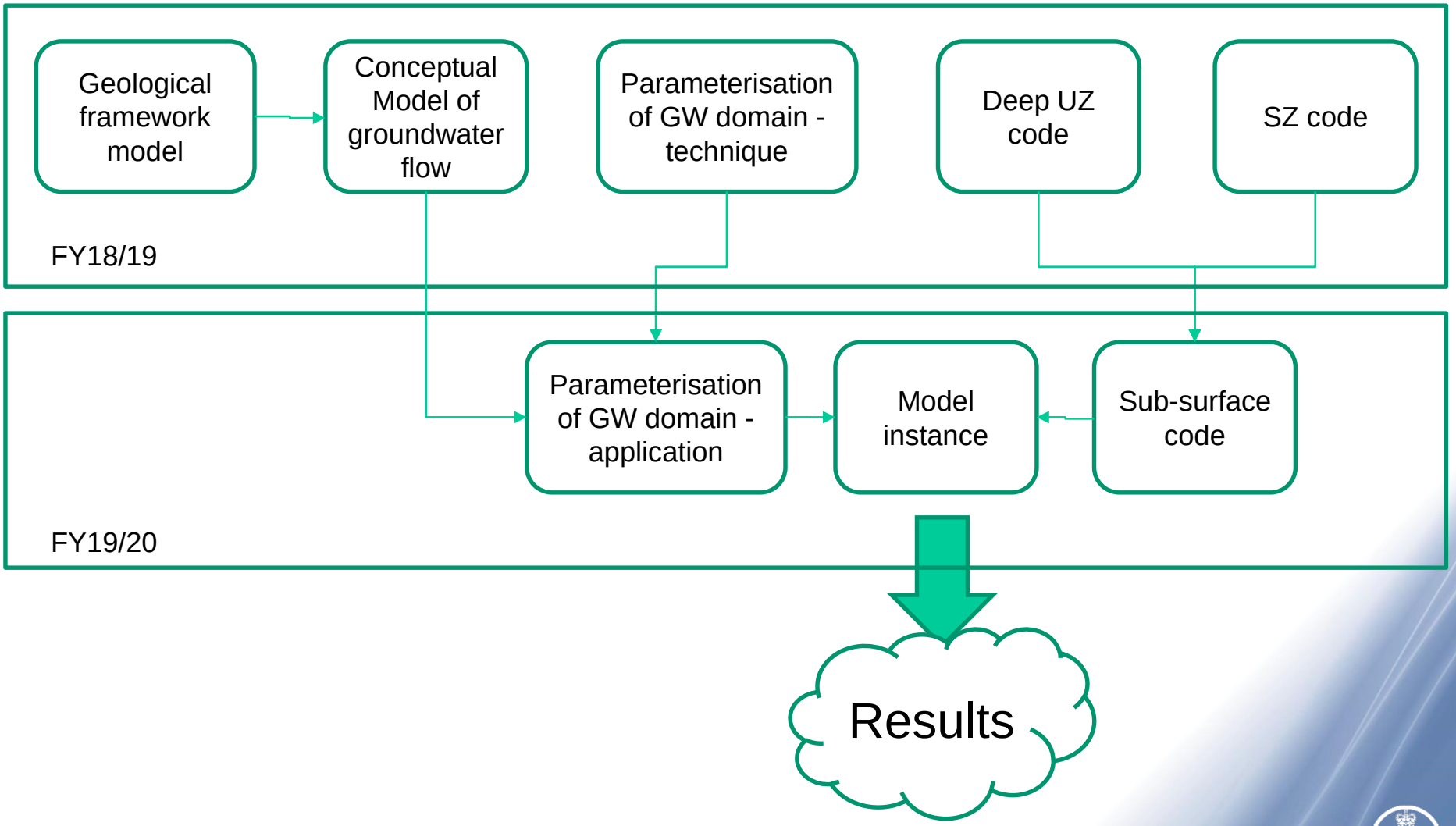
Where we fit into Hydro-JULES



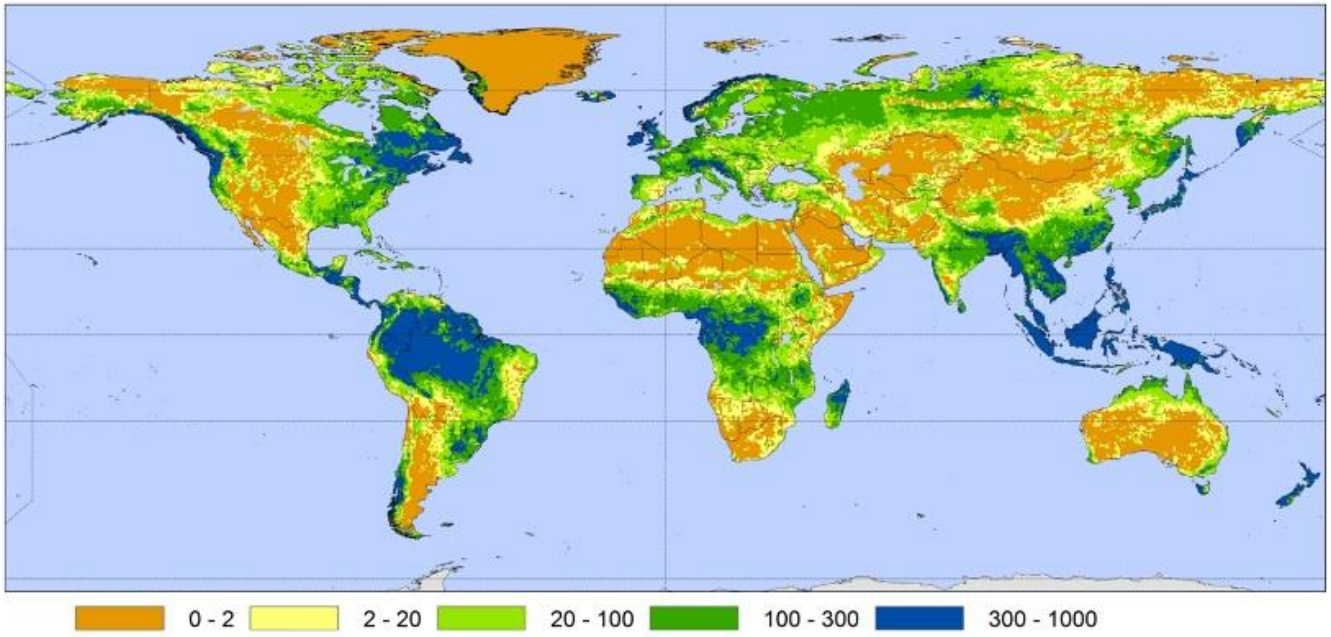
Longer-term plan

Task		Year 1				Year 2				Year 3				Year 4				Year 5			
No.	Description	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	National-scale (British mainland) (Task 4.1)																				
N1	Geological model for British Mainland	P	P	P	P																
N2	Flow conceptualisation - unsaturated zone (UZ)	P	P	P	P	P	P														
N3	Flow conceptualisation - saturated zone (SZ)	P	P	P	P	P	P														
N4	Code production - UZ flow			P	P	P	P	P	P												
N5	Code production - SZ flow			P	P	P	P	P	P												
N6	Model instance - trial at catchment-scale			P	P	P	P														
N7	Model instance - application at national-scale (British Mainland)						P	P	P	F	F										
N8	Heat conceptualisation - national scale											P	P	P	P	P	P				
N9	Nitrate conceptualisation - national scale											P	P	P	P	P	P				
N10	Code production - heat													P	P	P	P	P	P		
N11	Code production - nitrates													P	P	P	P	P	P		
N12	Model instance - heat at national scale															P	P	P	P	P	P
N13	Model instance - nitrates at national scale															P	P	P	P	P	P
	Global-scale (Task 4.2)																				
G1	Scoping modelling approach based on current work	P	P	P	P																
G2	Geological model development			P	P	P	P	P	P	P	P										
G3	Data gathering / assimilation	P	P	P	P	P	P	P	P												
G4	Conceptual model of groundwater flow at global scale					P	P	P	P	P	P	P									
G5	Code for global application		P	P	P	P	P	P	P	P	P	P	P								
G6	Model instance - test for Africa			P	P	P	P	P	P												
G7	Model instance - global									P	P	P	P	P	P	P	P	P	P	P	P
	Other																				
O1	Dissemination	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
O2	Interaction with other WPs	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
O3	Project management	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

British mainland (WP4.1)



Global groundwater modelling



PCR-GLOBWB : mean annual groundwater recharge (mm/a)

www.globalhydrology.nl/models/pcr-globwb-2-0/

LEAFHYDRO (CEH)

The LEAFHYDRO dynamic groundwater scheme was first presented in *Fan et al.* (2007) and *Miguez-Macho et al.* (2007).

Initial condition EWTD calculated at high-res the long-term balance between vertical recharge (P-E-Qr) estimation and the topographically driven lateral flow (Fan et al., 2007, 2013)

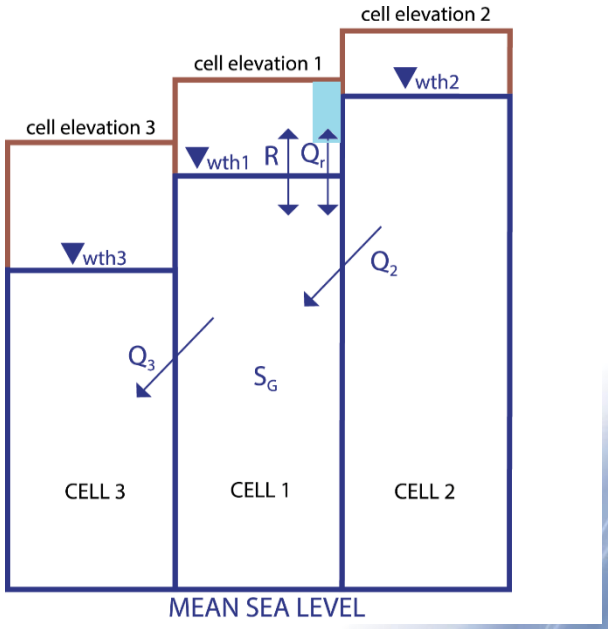
Dynamical behaviour of the groundwater reservoir and its interactions with the land-atmosphere system:

$$\frac{\mathrm{d}S_G}{\mathrm{d}t} = \Delta x \Delta y R + \sum_{n=1}^{8} Q_n - Q_r$$

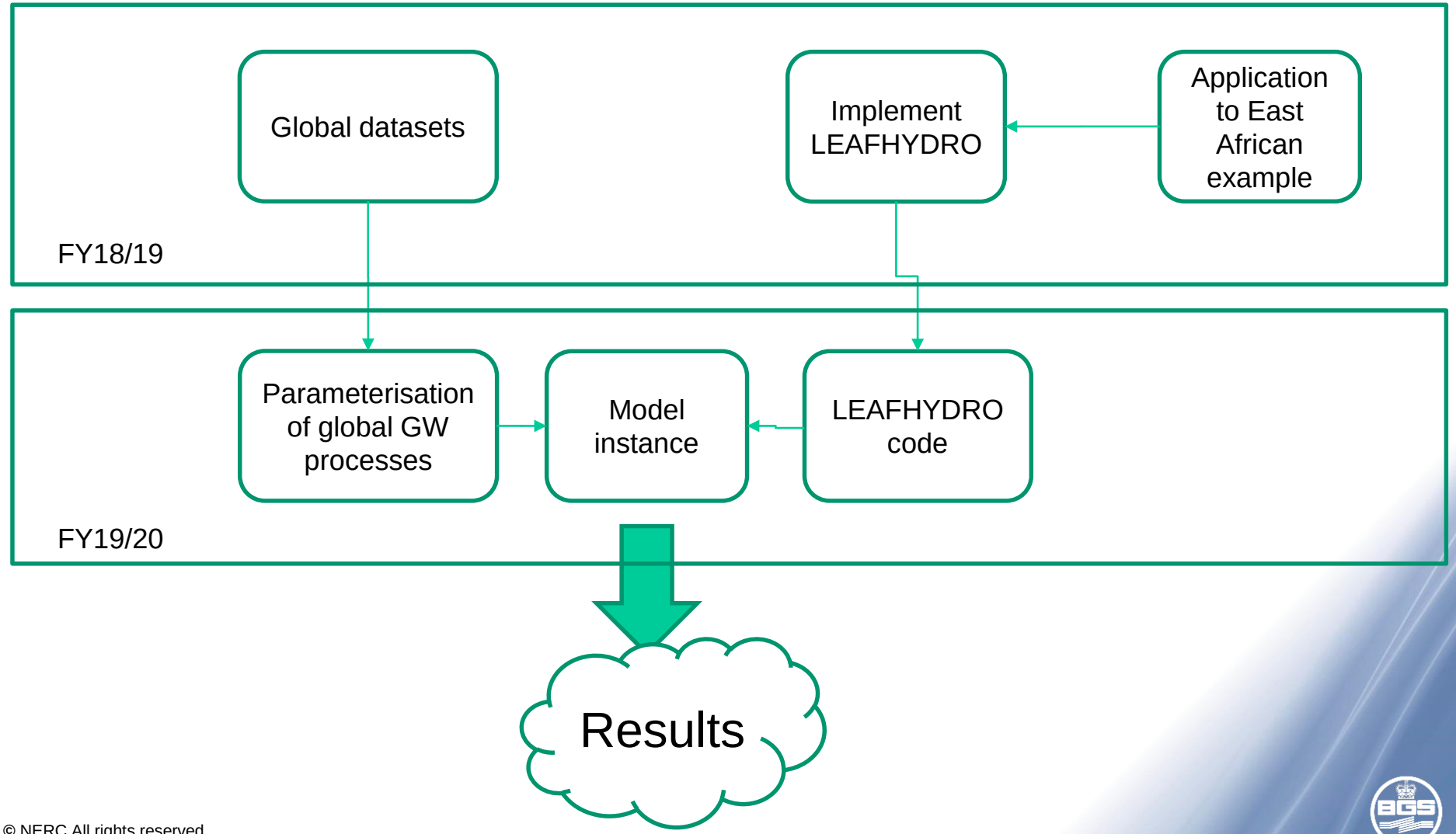
- **Groundwater recharge**: Water flux between the groundwater reservoir and the soil. Depending on the soil wetness and the atmosphere demands, the recharge can be downwards, causing the water table to rise, or upwards, causing the water table to deepen.

- **Lateral groundwater flow**: Water flux to or from neighbour cells within the saturated groundwater reservoir. This flux is governed by topography and the water table head elevation in the cells.

- **Groundwater-river flow**: It can occur as groundwater discharge (subsurface runoff) into the streams when the water table head is above the river bed, maintaining the streams baseflow, or as river infiltration to the groundwater reservoir when the water table head is below the river bed.



Global (WP4.2)



Final thoughts

- Described the planned 5 year programme to build a groundwater model for the British mainland and add groundwater into global LSM
- It is ambitious
- But…
  - It builds on existing BGS and CEH work
  - and would welcome stakeholder input

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