Groundwater flow in the JULES LSM – an update

9th September 2020

Collins S, Scheidegger J, Martinez de la Torres A and Hughes A

Hydro-JULES

UK Centre for Ecology & Hydrology

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NATURAL ENVIRONMENT RESEARCH COUNCIL

An equation: 2D unconfined groundwater

$$K\frac{\delta}{\delta x}\left(h\frac{\delta h}{\delta x}\right)+K\frac{\delta}{\delta y}\left(h\frac{\delta h}{\delta y}\right)=S_y\frac{\delta h}{\delta t}$$

Challenges:

K – Hydraulic conductivity (L/T)
S_y – Specific yield (-)
q – Boundary flux (L/T)

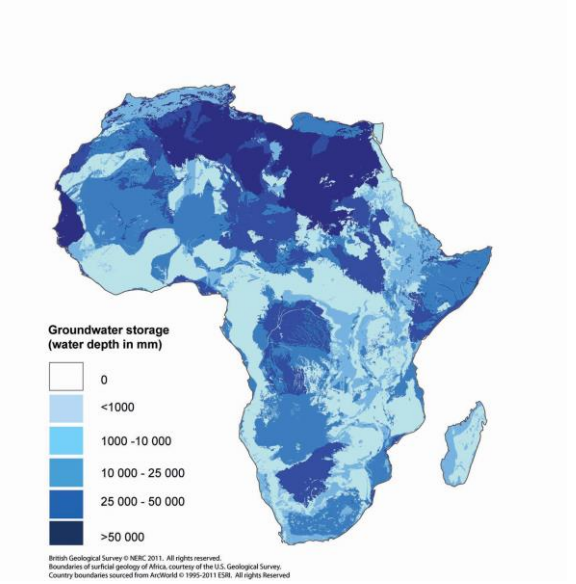
Global groundwater modelling − challenges

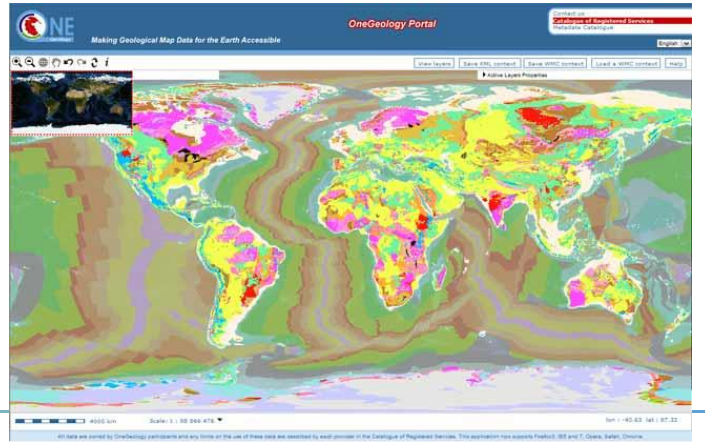
Compared to Land Surface and Climate models: physics of groundwater flow is a (mostly) lot simpler, but…

…Challenges do exist:

Complexity, lack of data and resulting uncertainty

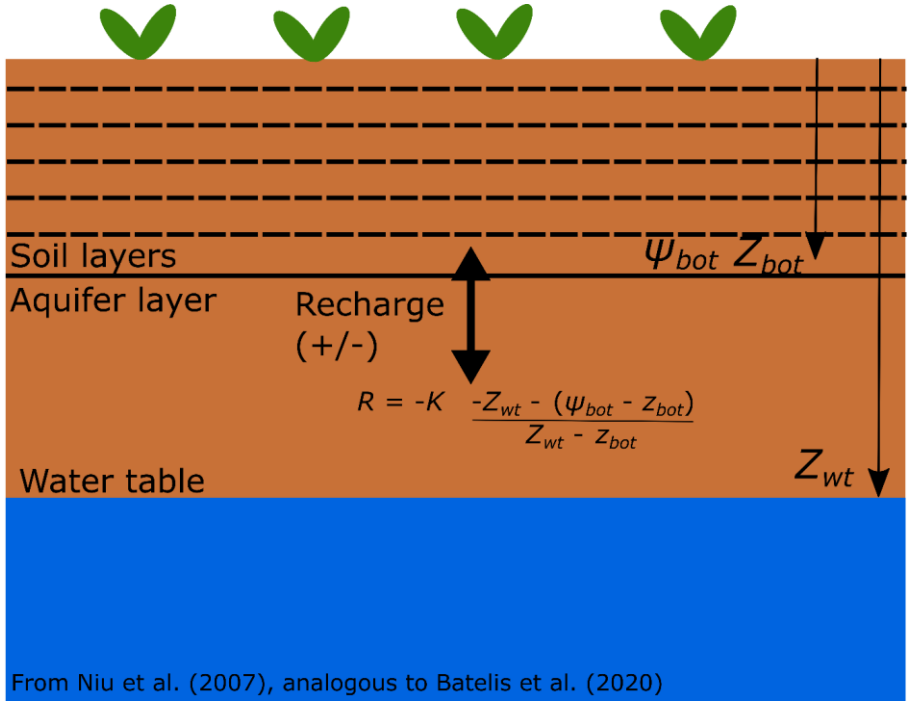
- Complexity: 3D nature of the sub-surface - aquifers are not laterally connected necessarily
- Data availability: low density of boreholes, particularly globally
- Uncertainty wrt parametrisation: driven by lack of confidence in geological structure and rock mass properties



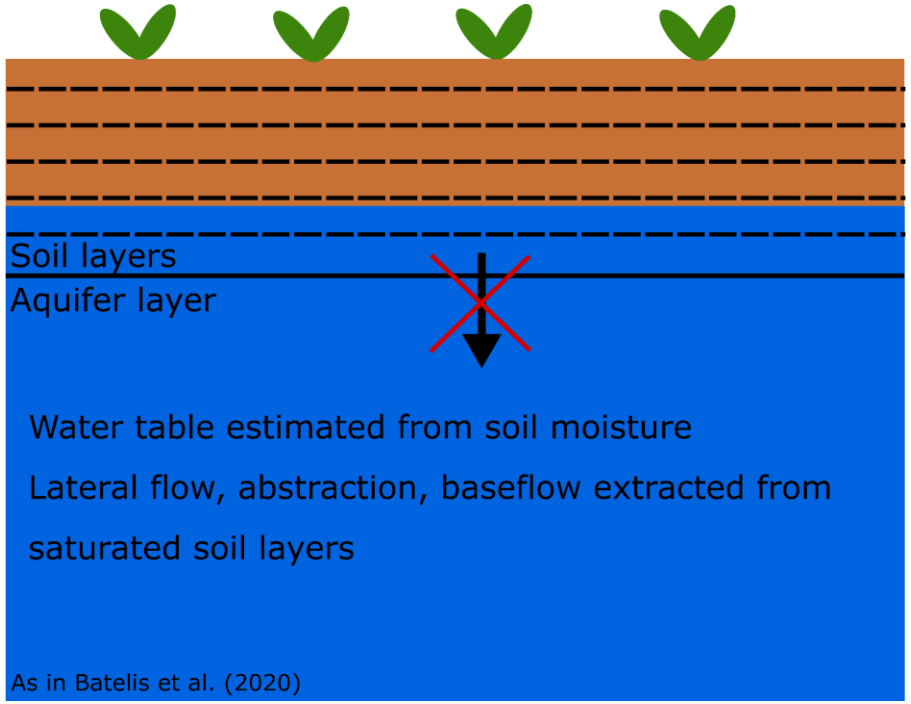


JULES-DGW – saturated–unsaturated zone coupling

Water table below soil layers



Water table within soil layers



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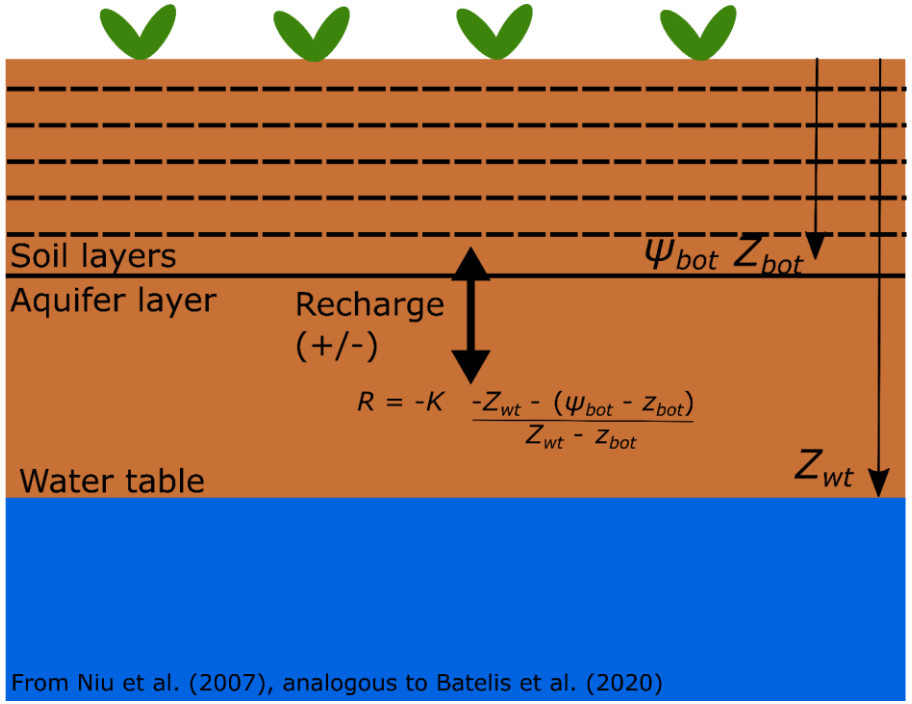
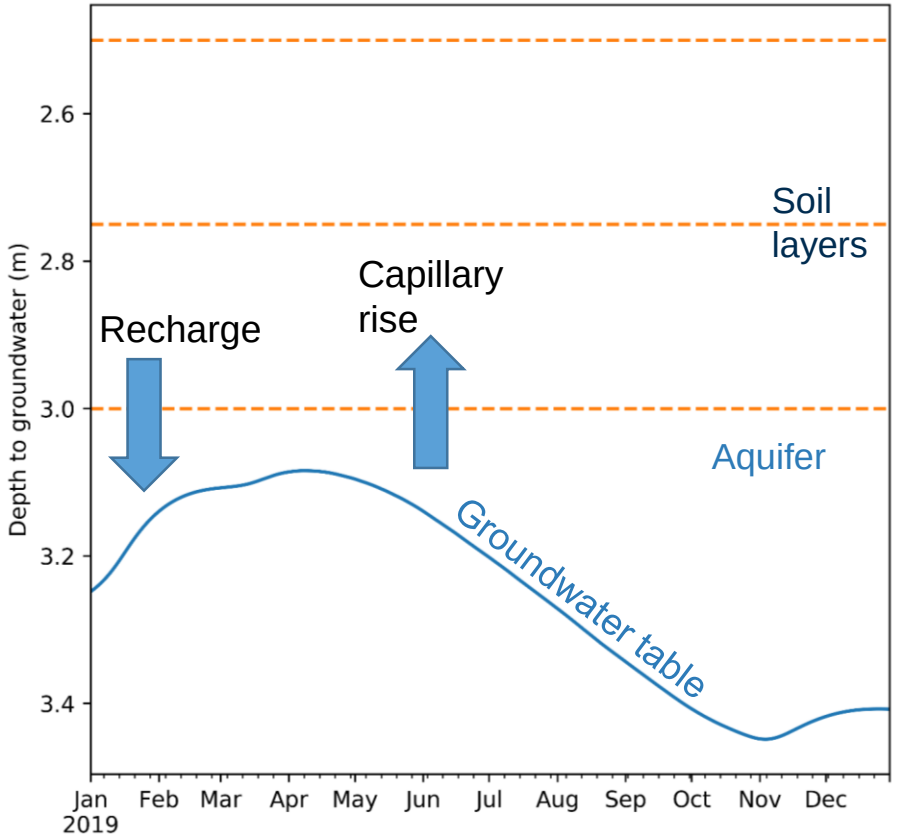
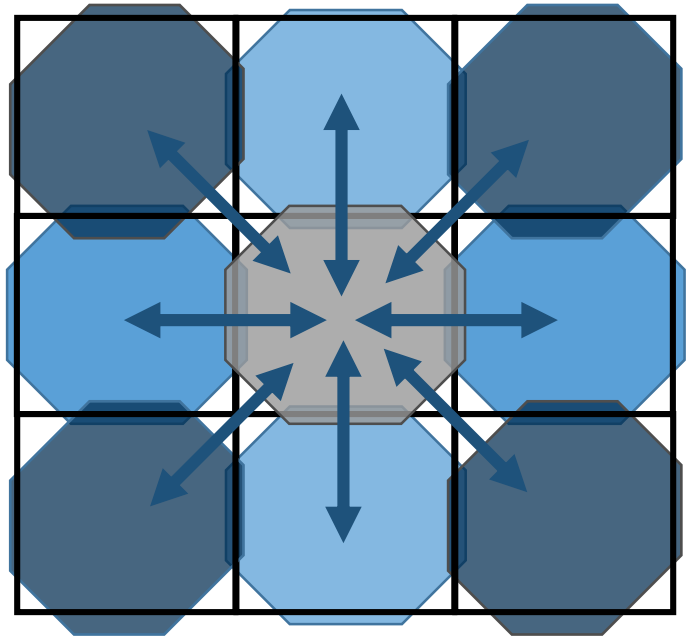




JULES-DGW – lateral flow and rivers

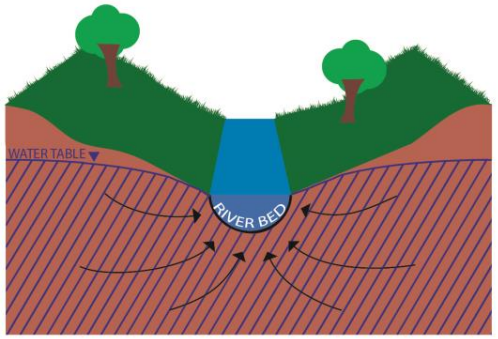
Lateral flow and interaction with rivers is the same as in LeafHydro

Lateral flow between neighbours occurs on a octagonal grid

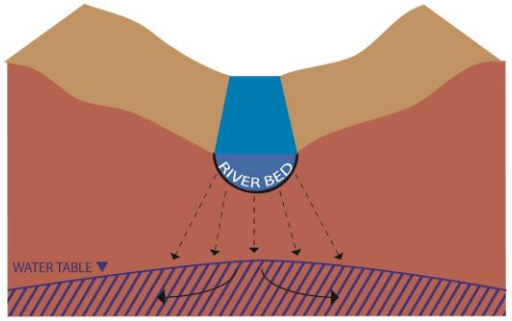


Head-dependent flux to/from rivers (as in Fan et al 2007, Miguez-Macho et al 2007)

Gaining stream



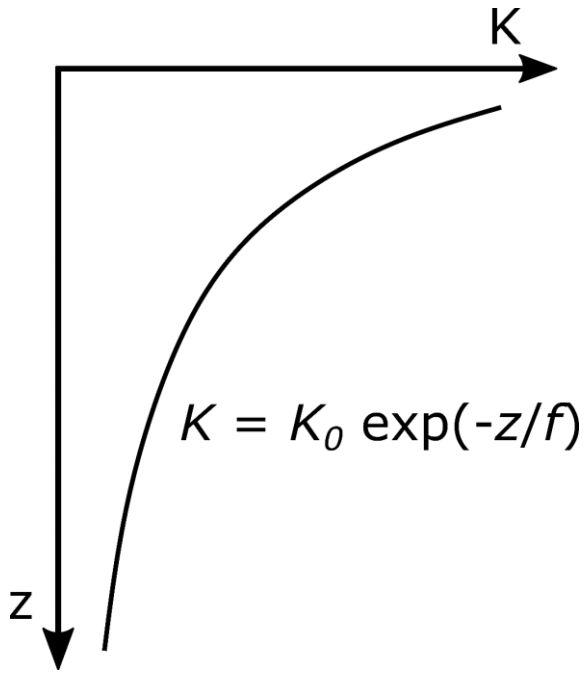
Losing stream



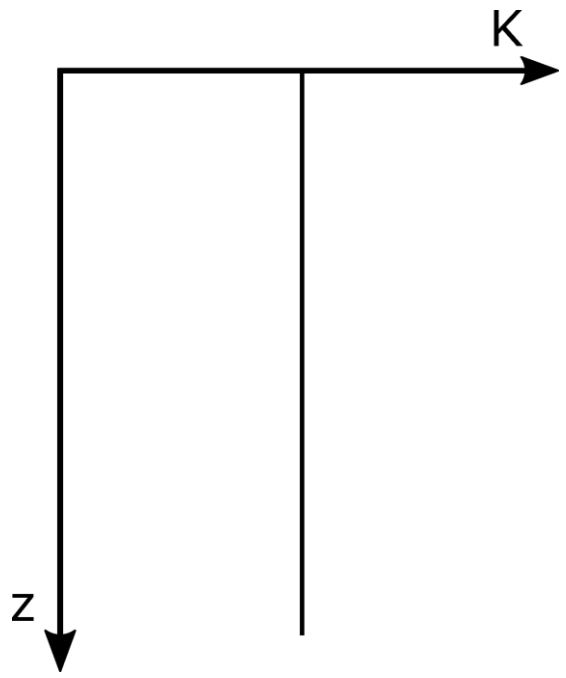
JULES-DGW – hydraulic conductivity

Aquifer hydraulic conductivity can either…

decrease exponentially with depth (as in LeafHydro)



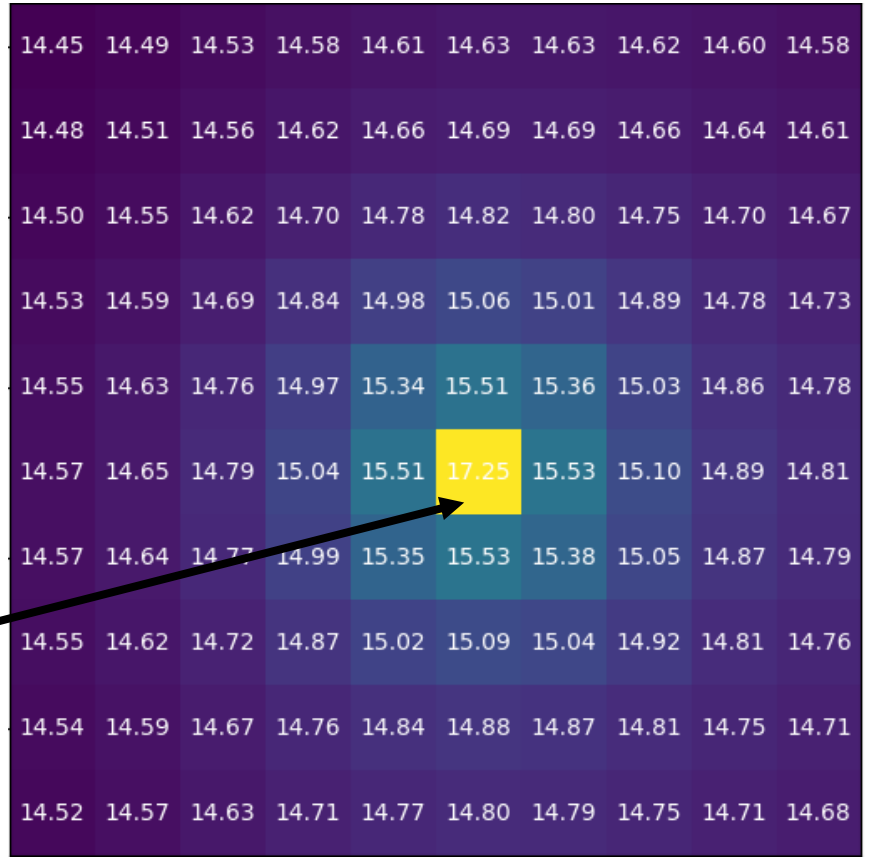
or remain constant with depth (as in most groundwater models)



JULES-DGW – abstraction

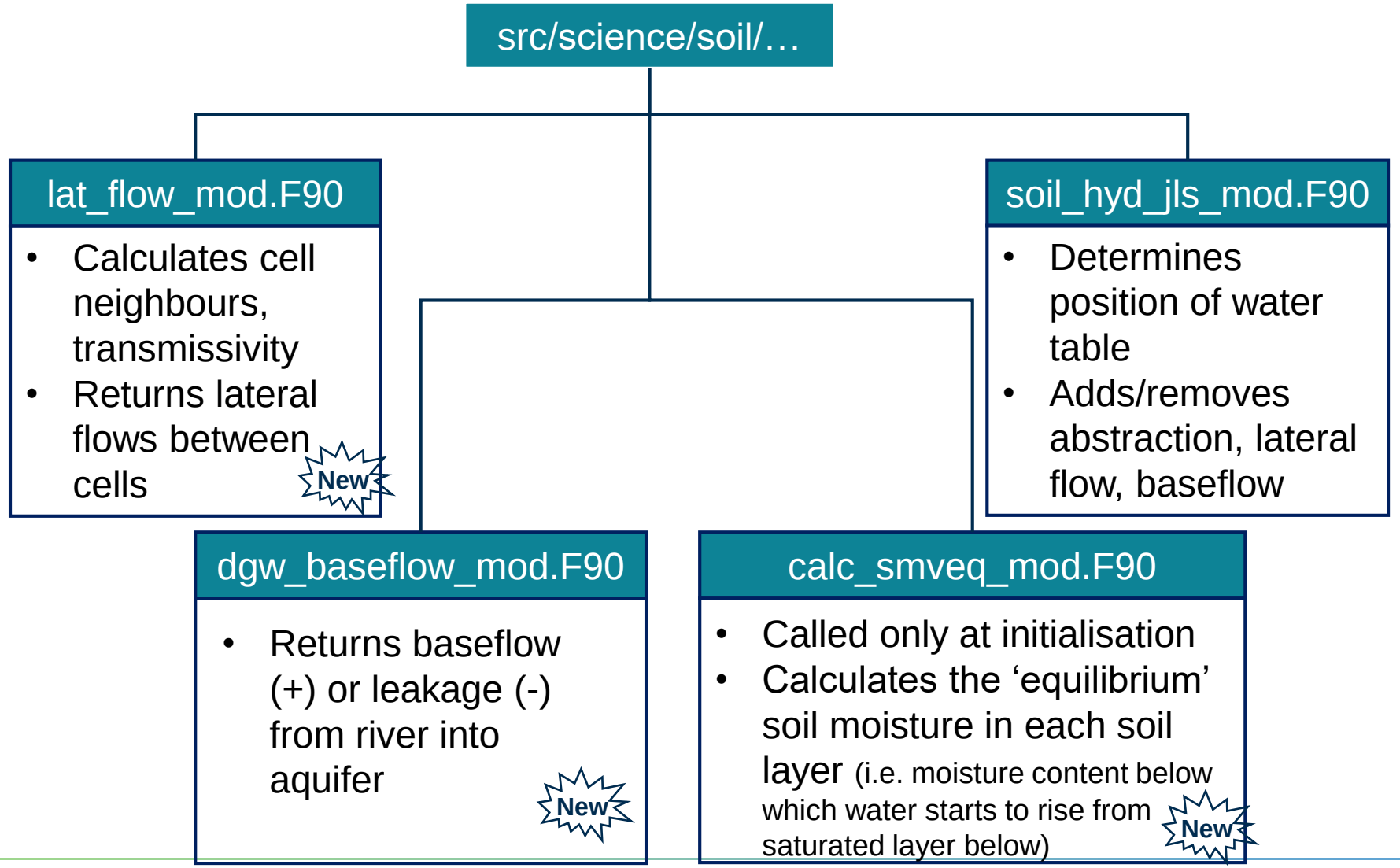
… and abstraction, which was not included in other models, is introduced as prescribed data (i.e. time dependent)

Depth to groundwater (m)

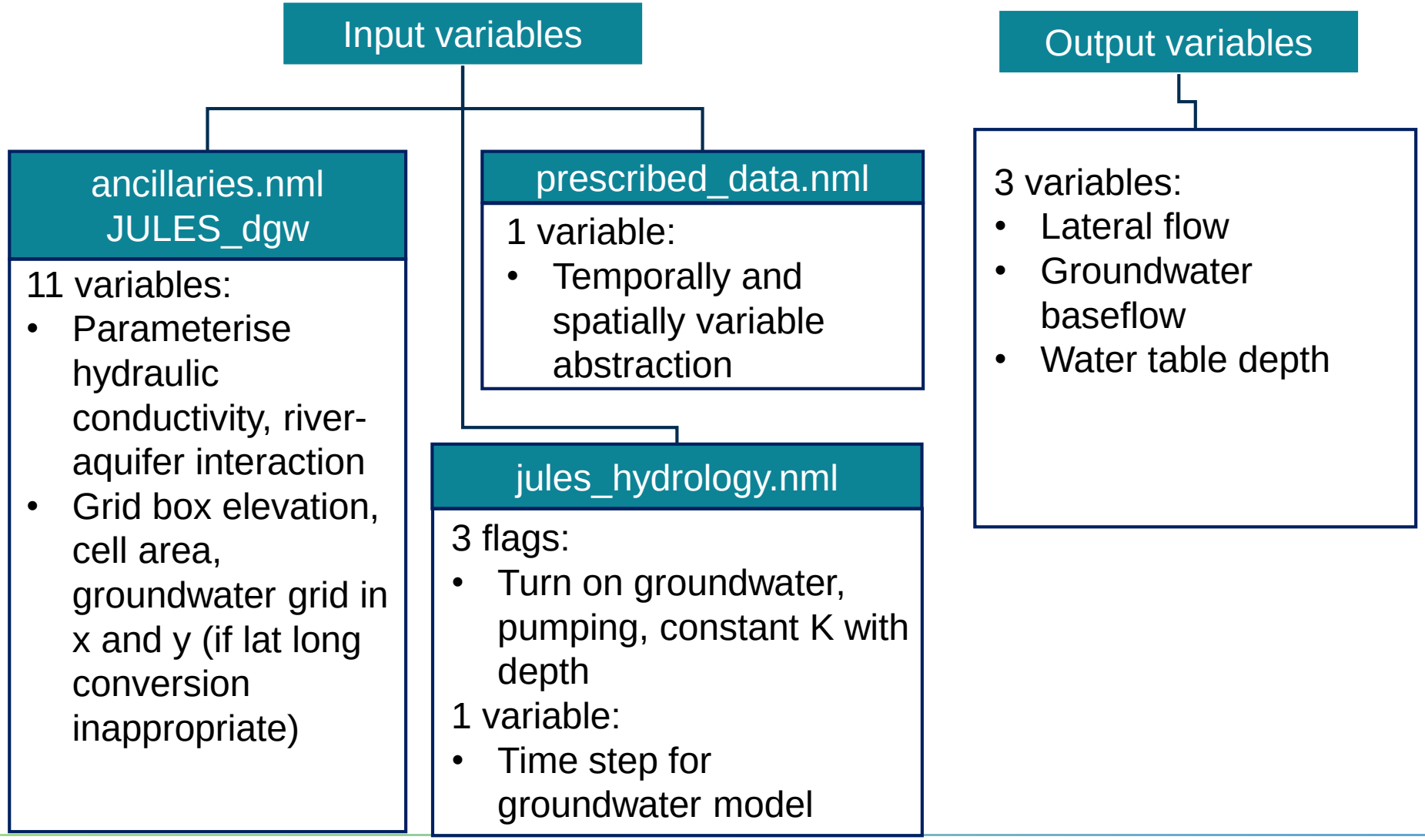


Drawdown from extraction well

Code changes − new (and edited) modules



Code changes – new inputs and outputs



Example 1: Infiltration test

Working with colleagues at University of Bristol. Examples published in Kollet et al (2016), Rahman (2019), Batelis et al (2020)

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Check for updates

RESEARCH ARTICLE

WILEY

Towards the representation of groundwater in the Joint UK Land Environment Simulator

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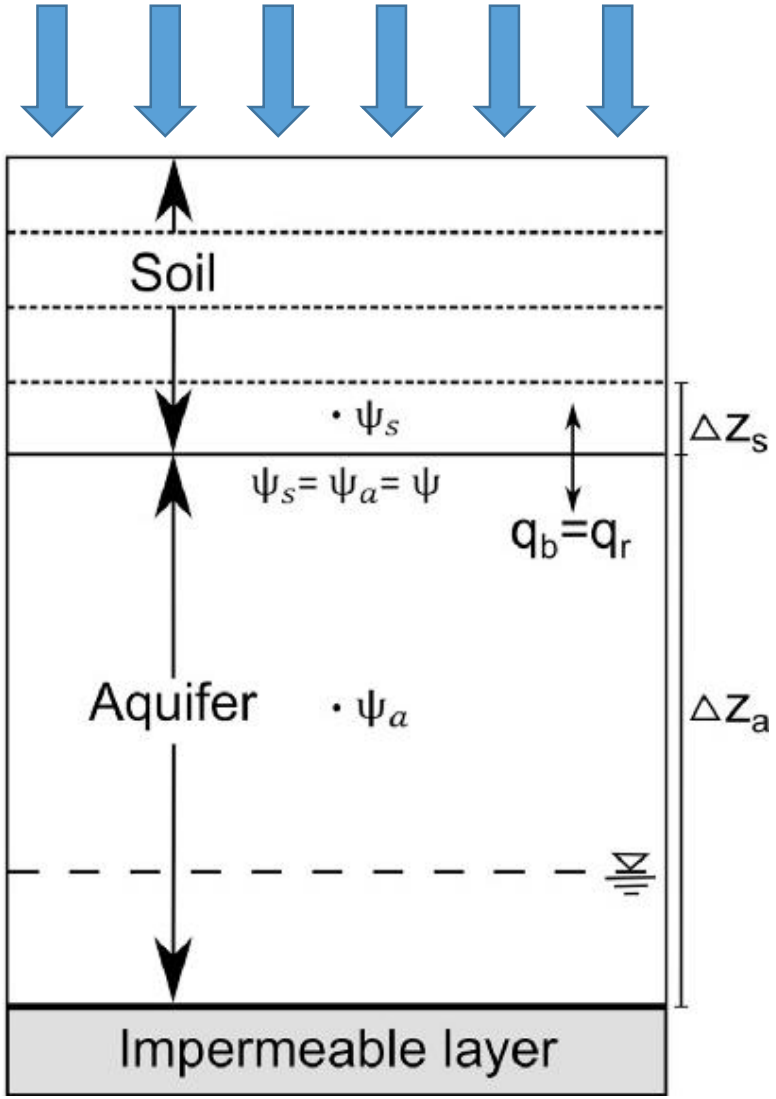
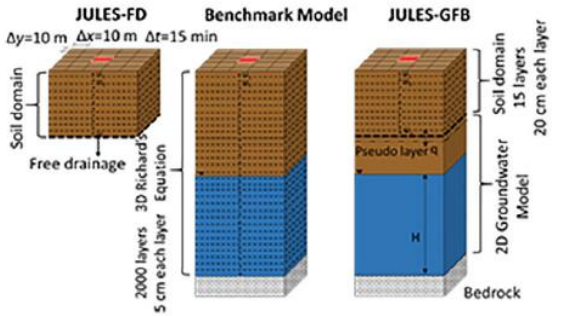
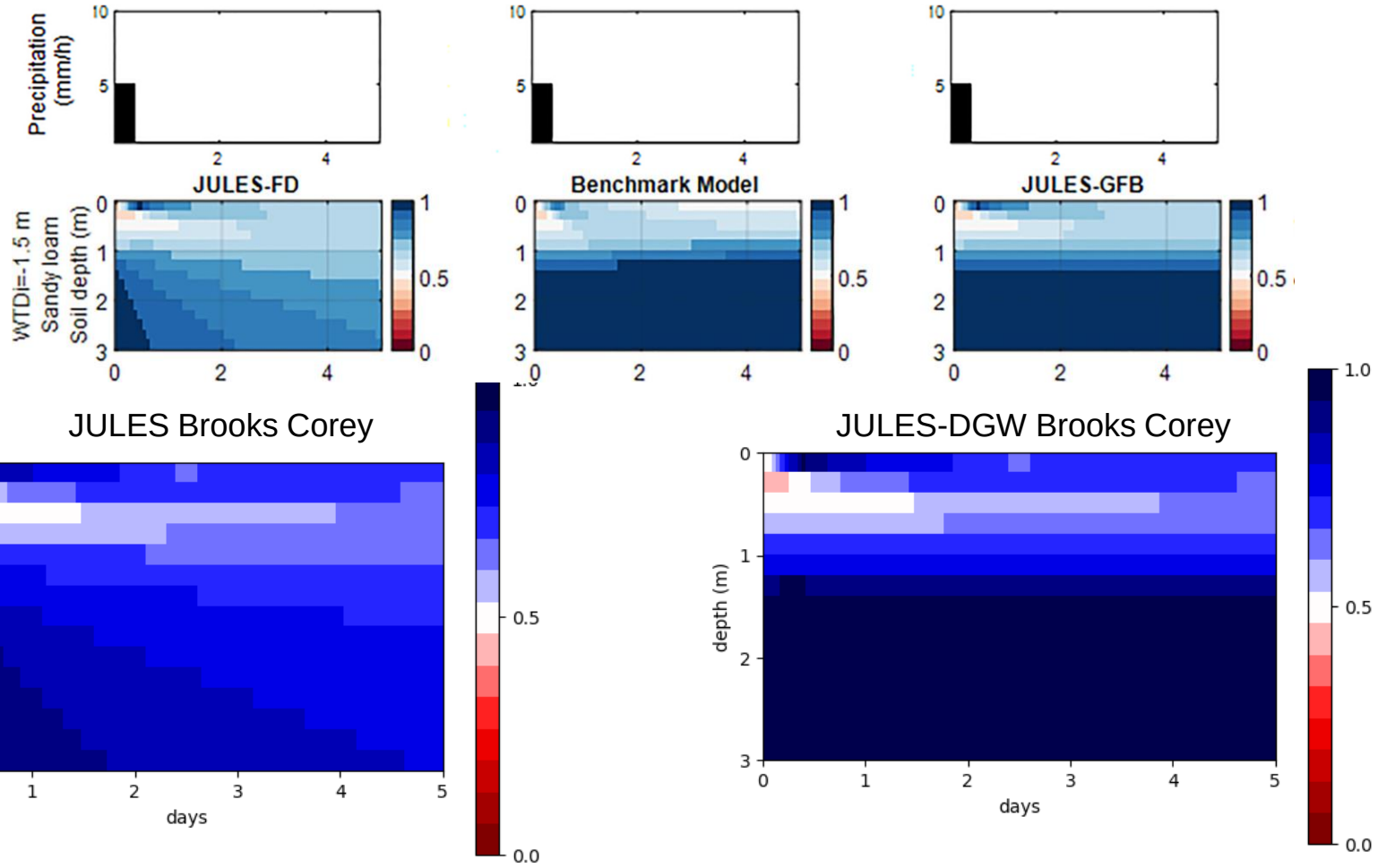


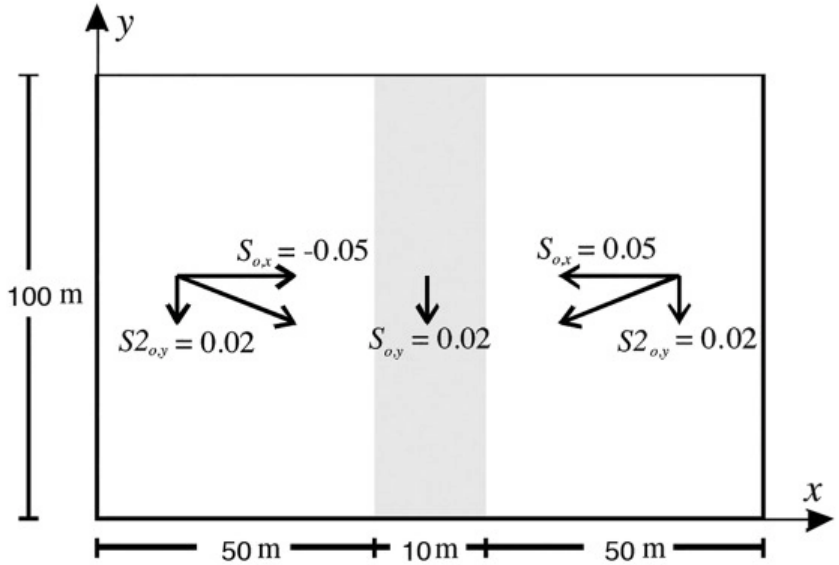
Infiltration test – sandy loam soil moisture profiles (fractional saturation)

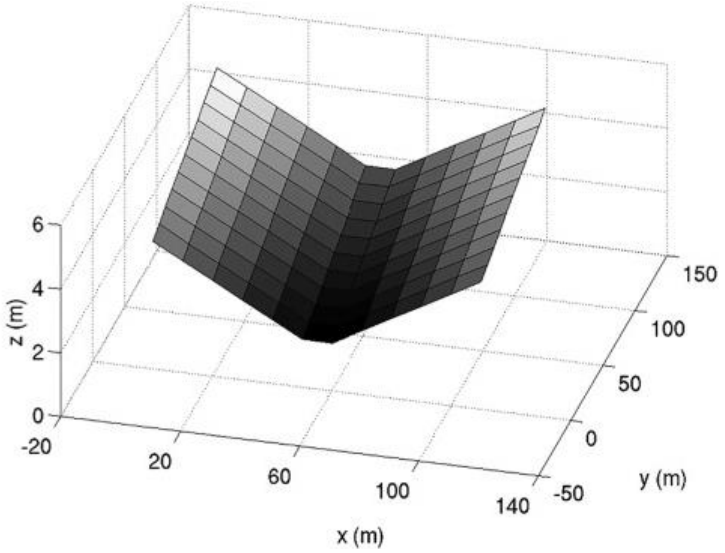


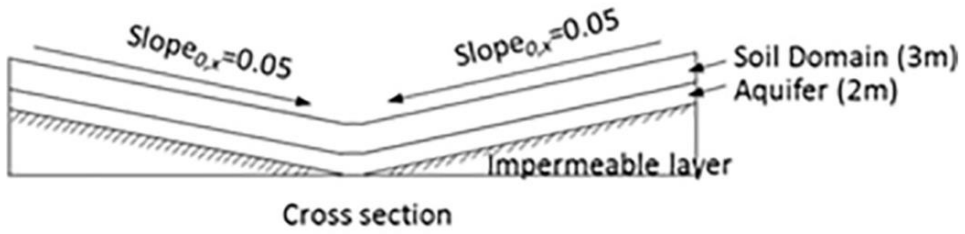


Example 2: V-shaped valley test

Working with colleagues at University of Bristol. Examples published in Kollet et al (2016), Rahman (2019), Batelis et al (2020)



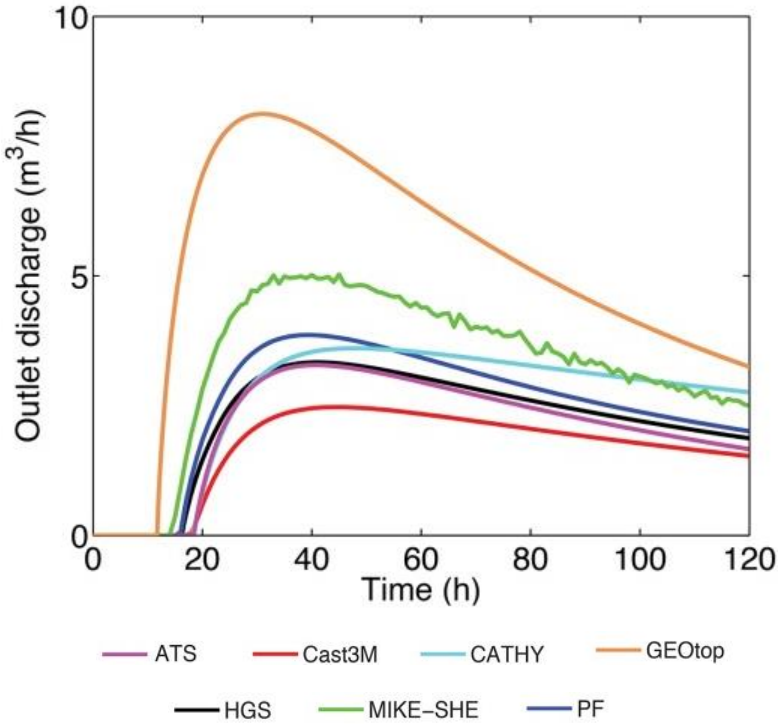




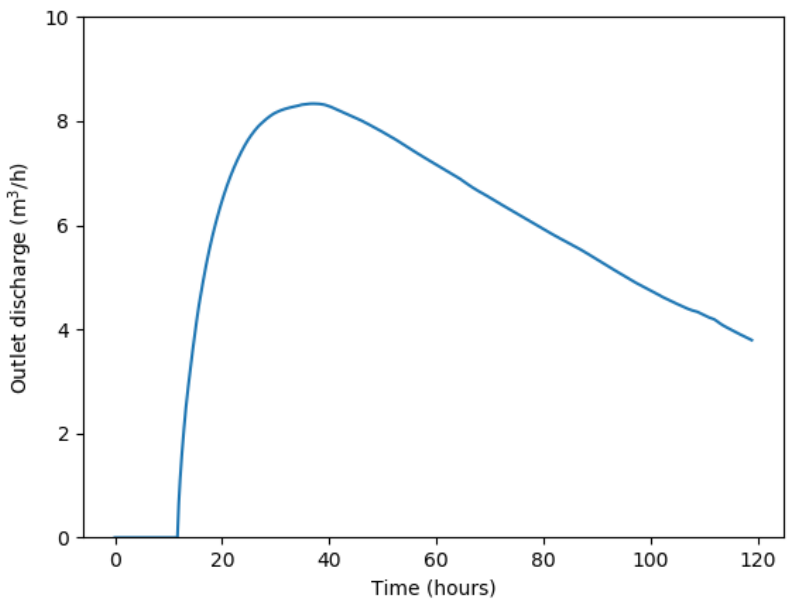
V-shaped valley test: sandy soil outlet discharge

(Benchmarks all use van Genuchten, JULES-DGW Brooks Corey)

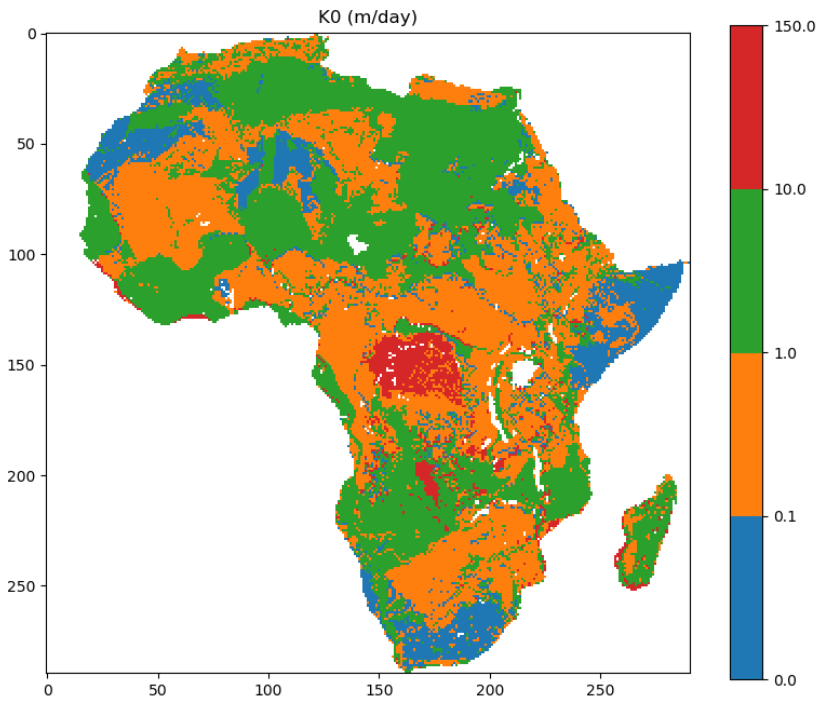
Benchmark models



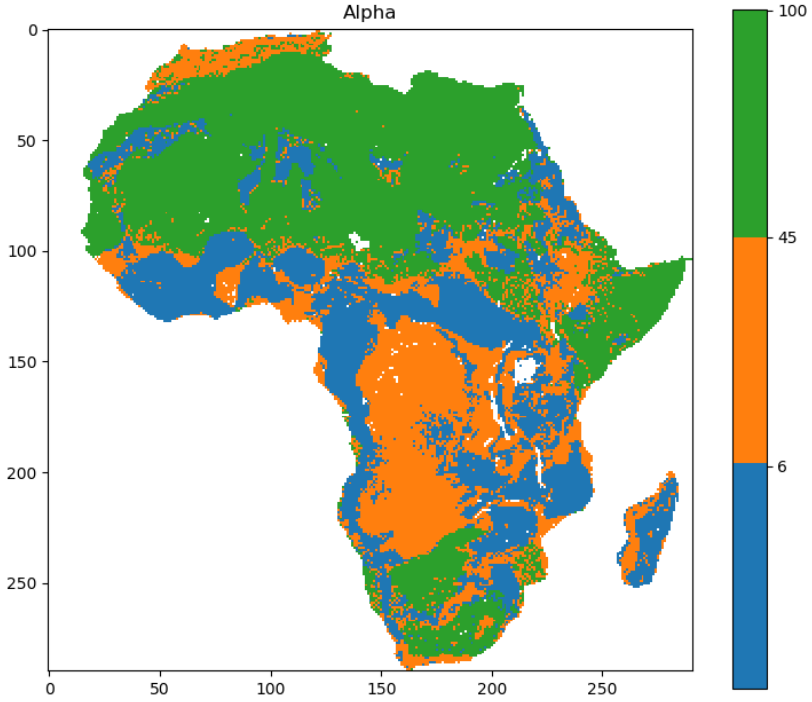
JULES-DGW



Finish validation and combine code with data….



Ksl to back-calculate the anisotropy ratio



e-folding depth

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