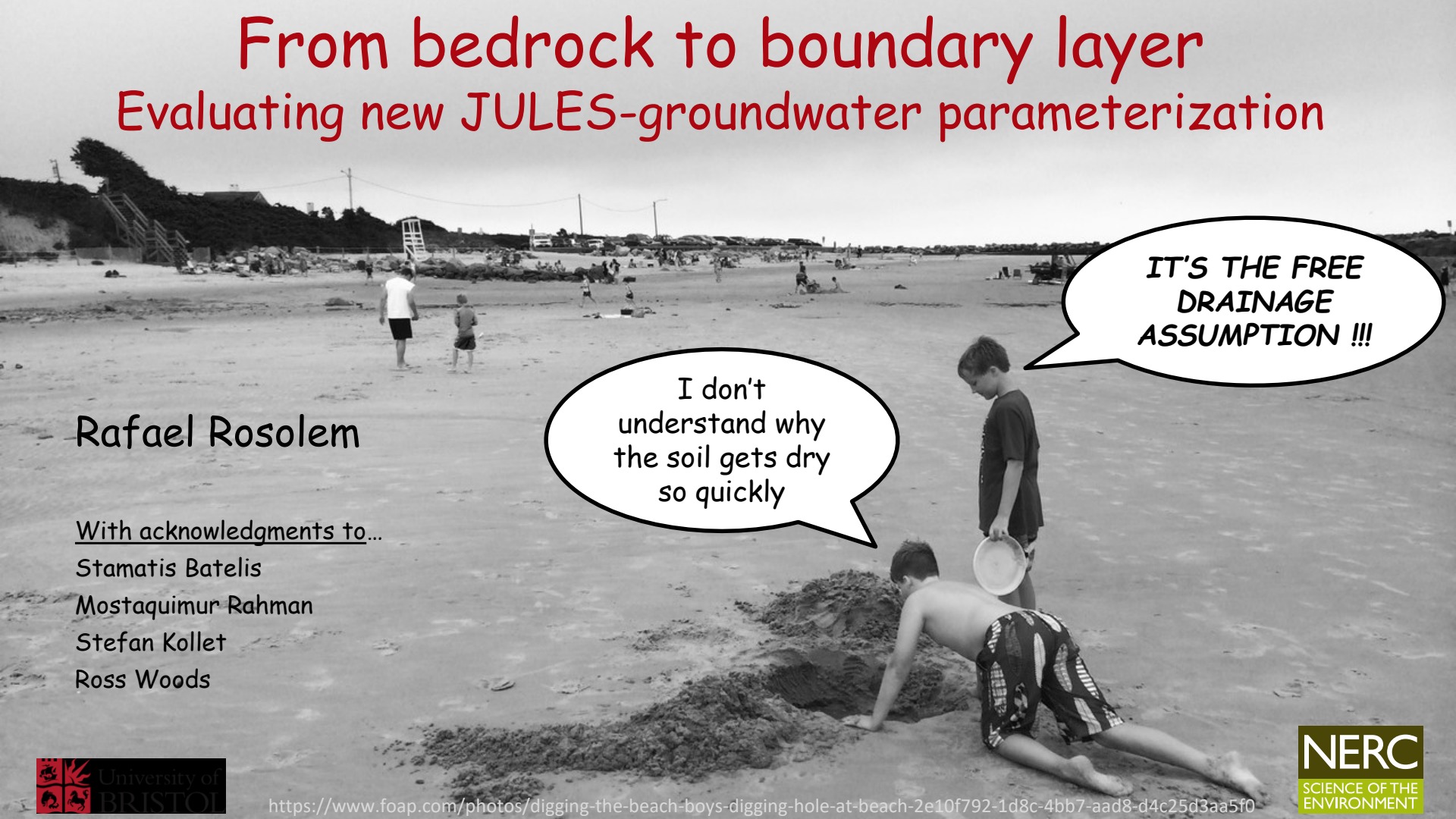
From bedrock to boundary layer

Evaluating new JULES-groundwater parameterization



Rafael Rosolem

With acknowledgments to…
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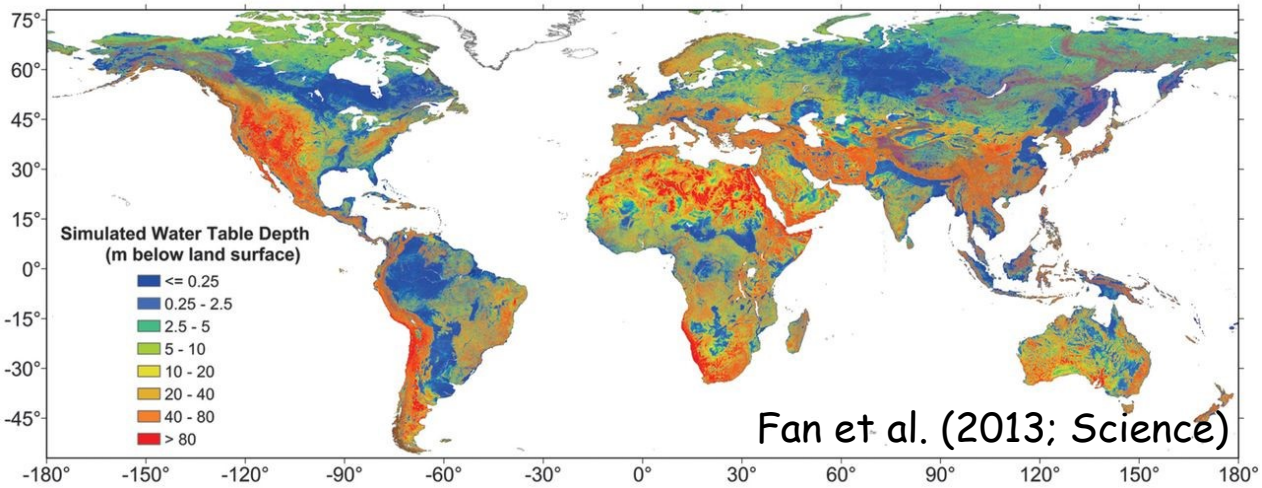
Mostaquimur Rahman
Stefan Kollet
Ross Woods

University of BRISTOL

https://www.foap.com/photos/digging-the-beach-boys-digging-hole-at-beach-2e10f792-1d8c-4bb7-aad8-d4c25d3aa5f0

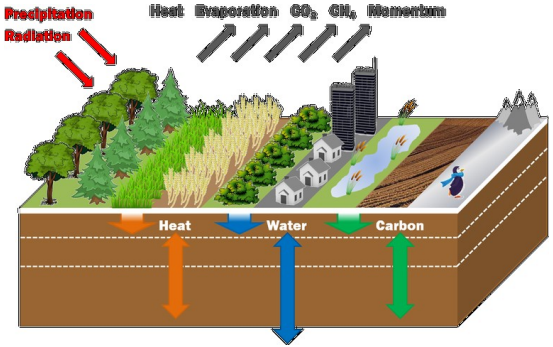
NERC SCIENCE OF THE ENVIRONMENT

Shallow groundwater influences 22-32% of land area but has limited representation in Earth System Models

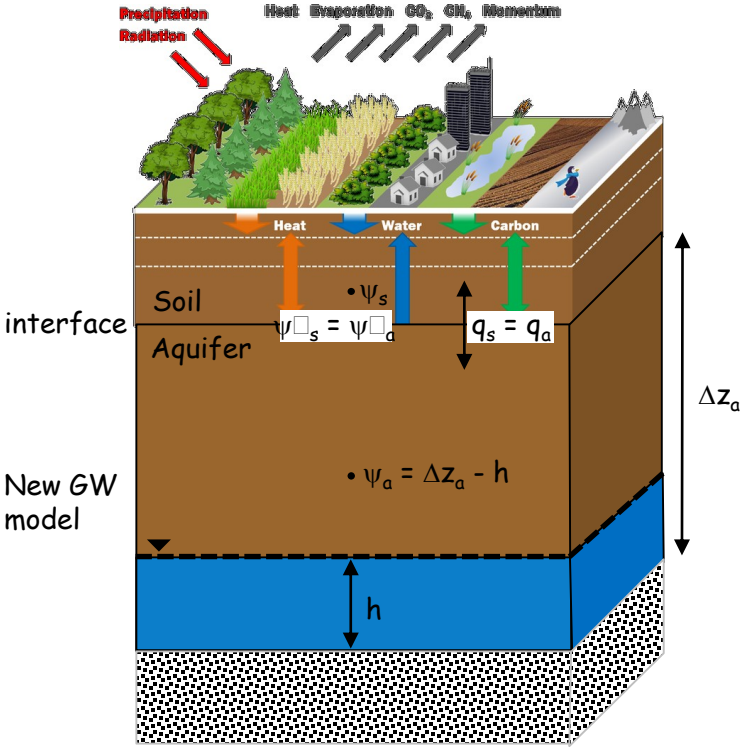


How to represent global high-resolution groundwater dynamics accurately/efficiently to better understand processes and controls?

New Groundwater Flow Boundary (GFB) condition replaces the default Free Drainage (FD) assumption



Free Drainage (i.e., gravity flow)



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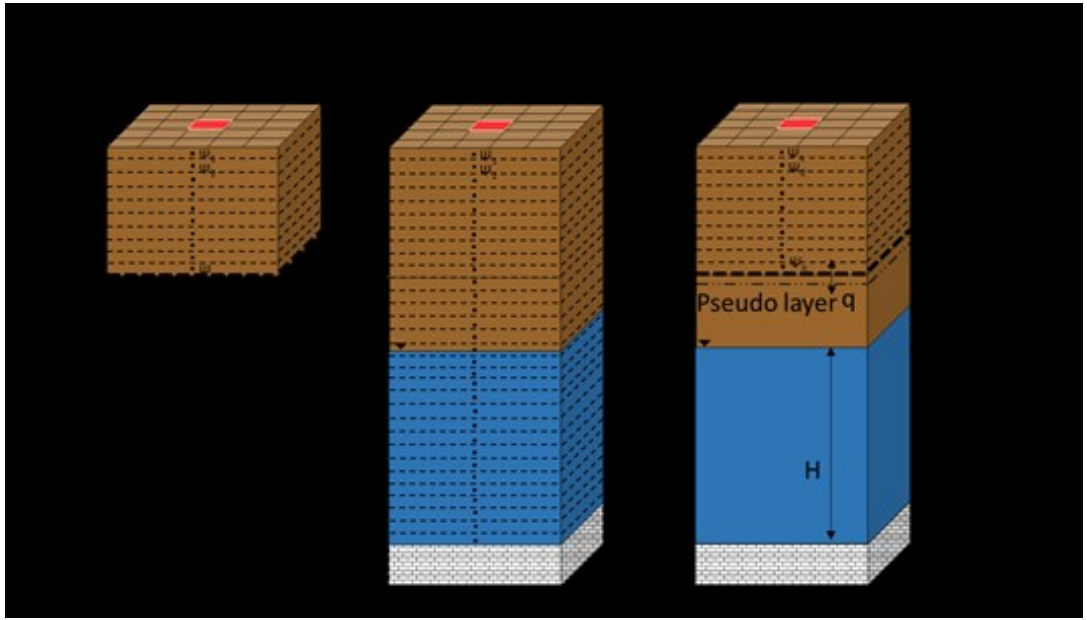
Towards a computationally efficient free-surface groundwater flow boundary condition for large-scale hydrological modelling

M. Rahman[a,*], R. Rosolem[a,b], S.J. Kollet[c,d], T. Wagener[a,b]

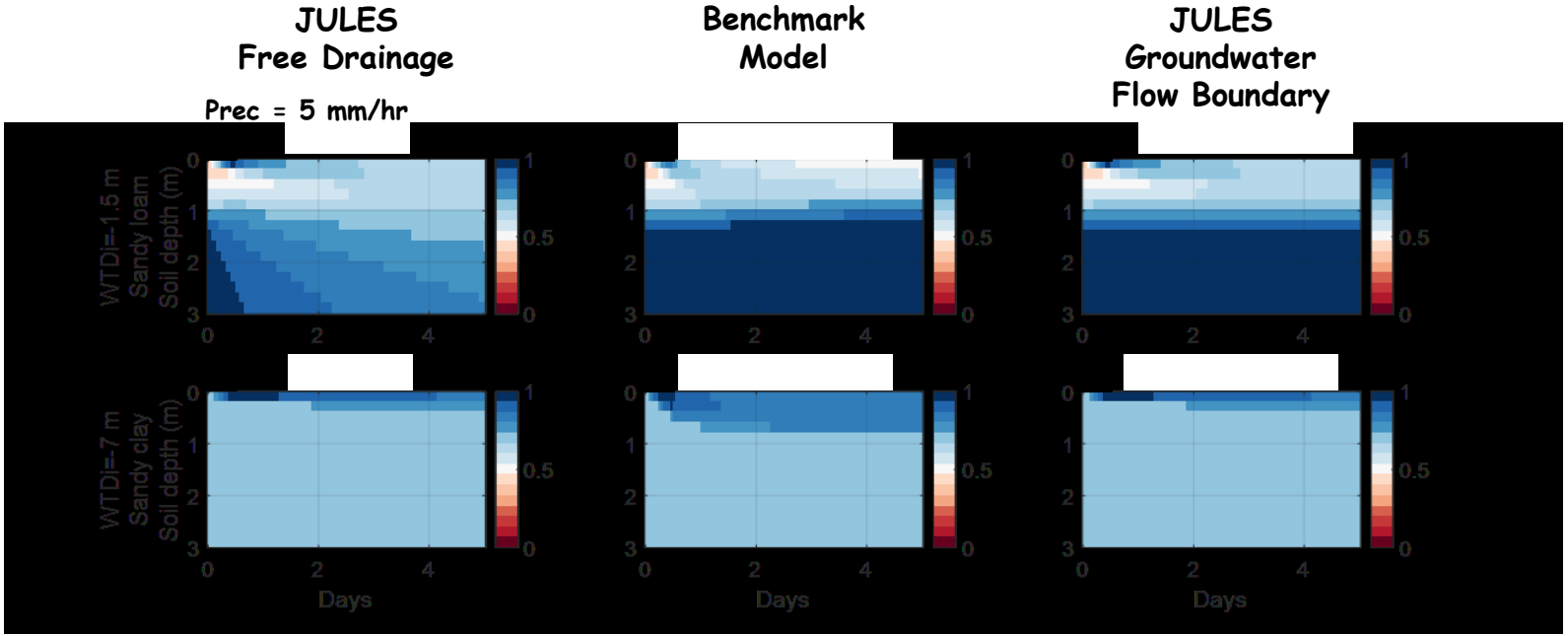
https://doi.org/10.1016/j.advwatres.2018.11.015

Simulating potential groundwater recharge

Synthetic column experiment focuses on infiltration in JULES, and compares against Benchmark Model



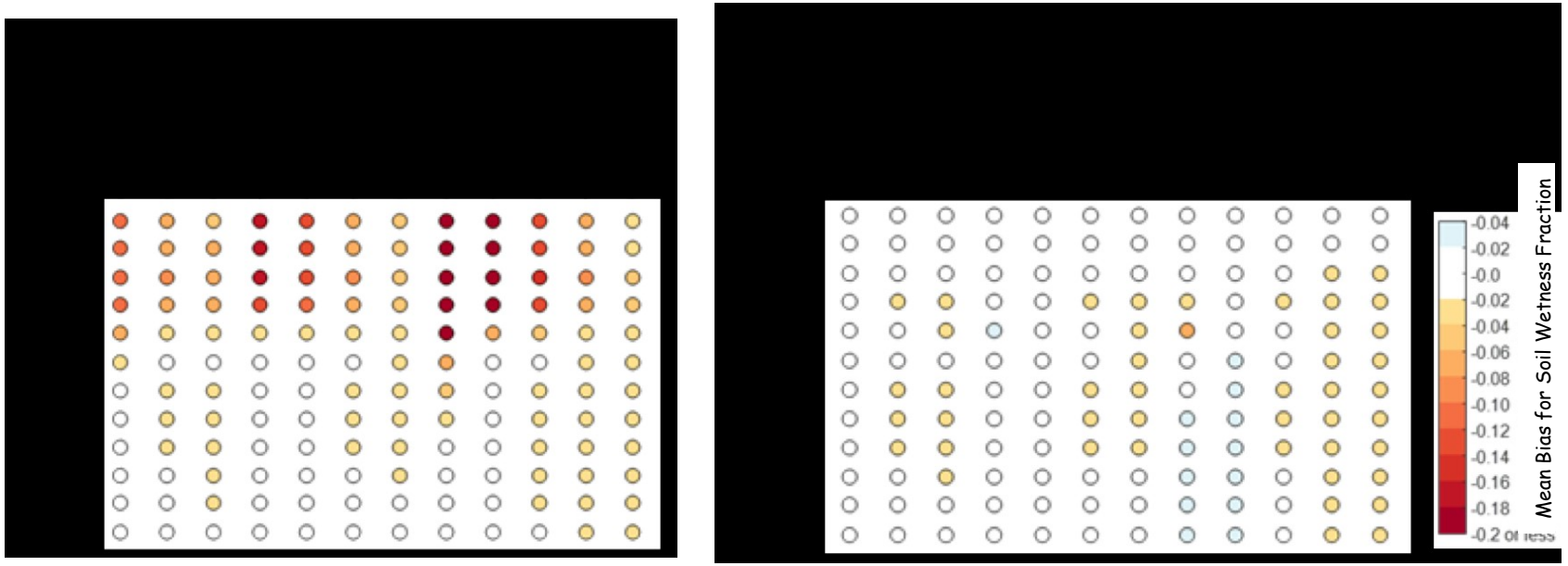
Adding our new model improves JULES representation of soil wetness fraction in certain cases



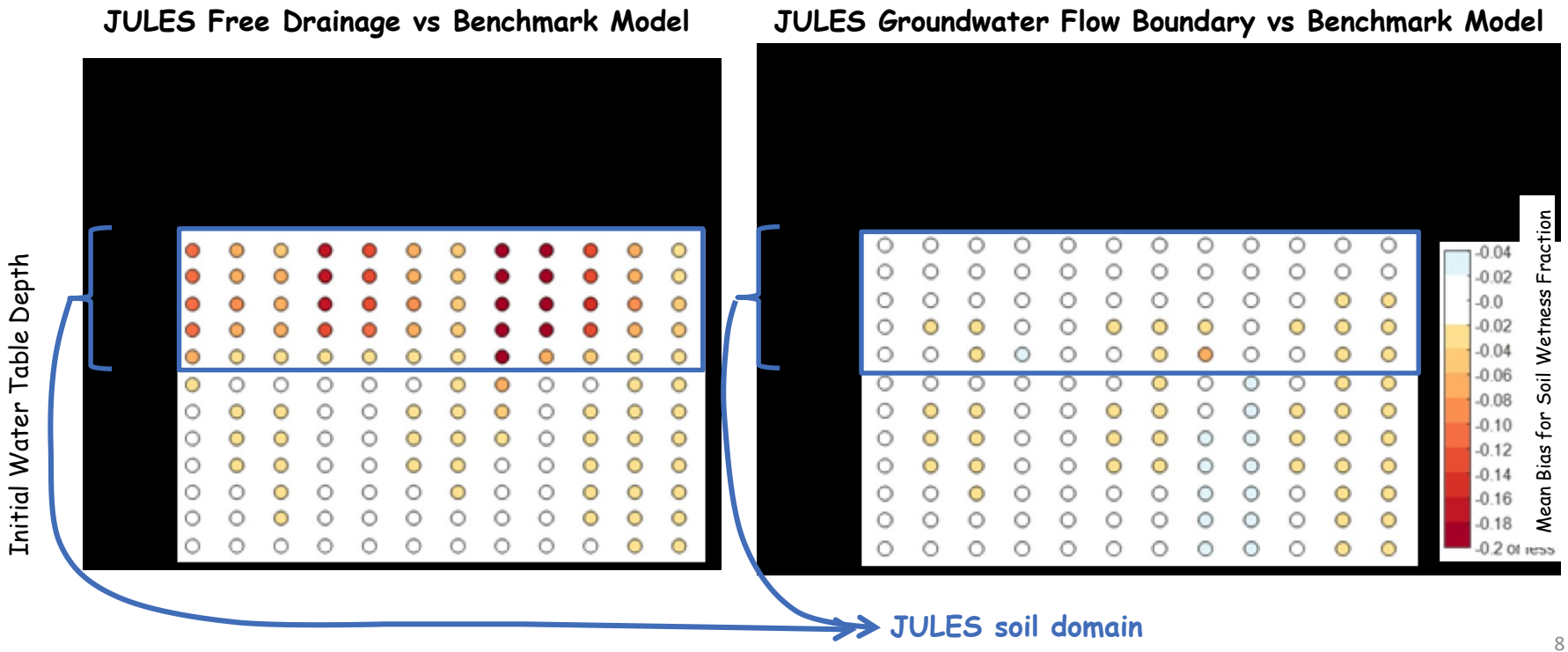
We benchmarked both versions of JULES for a range of soil types and initial water table depths

JULES Free Drainage vs Benchmark Model

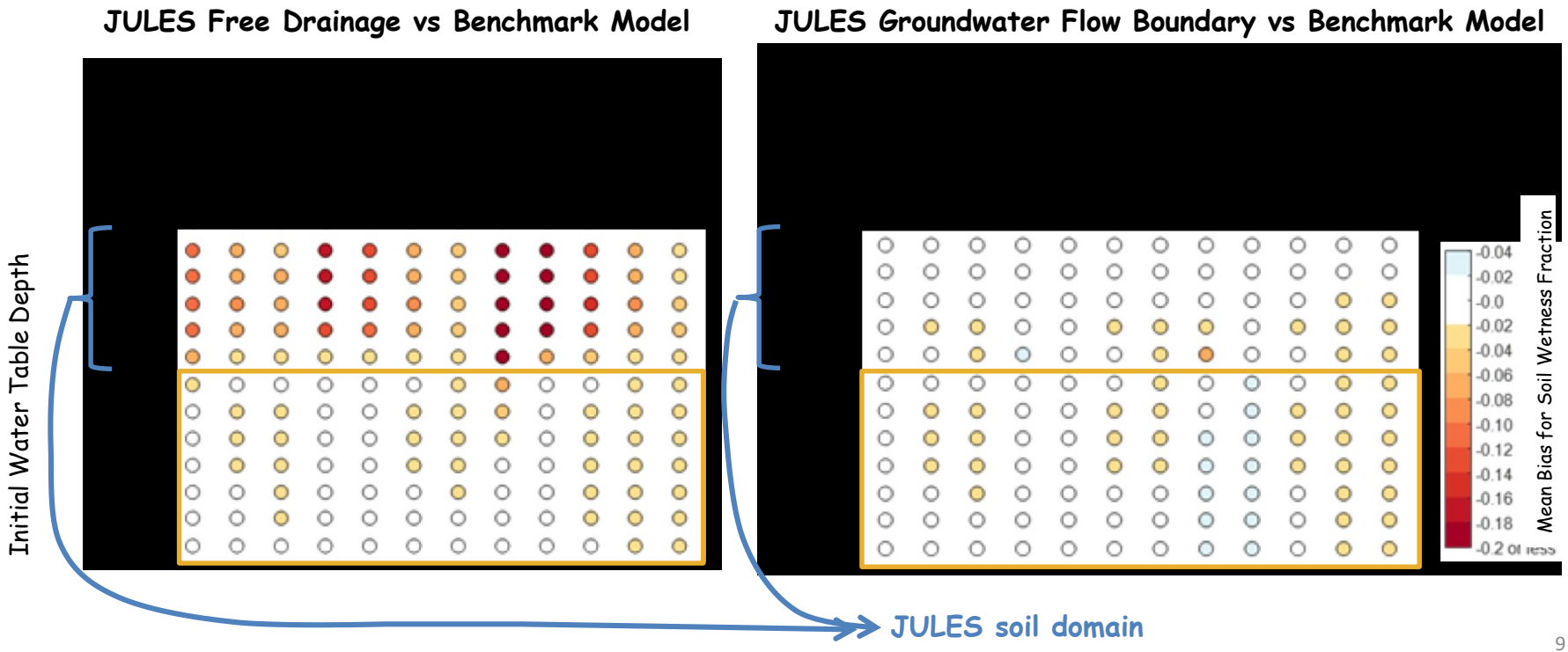
JULES Groundwater Flow Boundary vs Benchmark Model



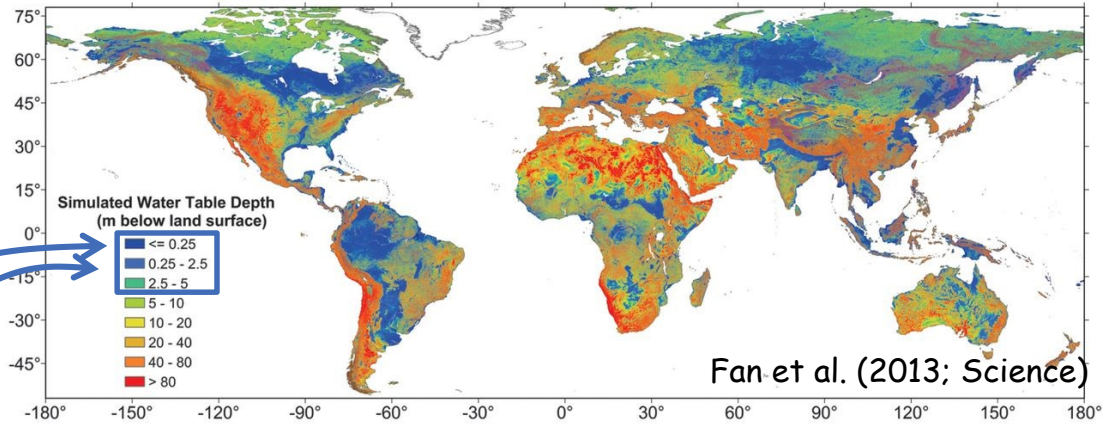
New JULES improves soil moisture dynamics for initial water table depths of less than 3 meters and all soils

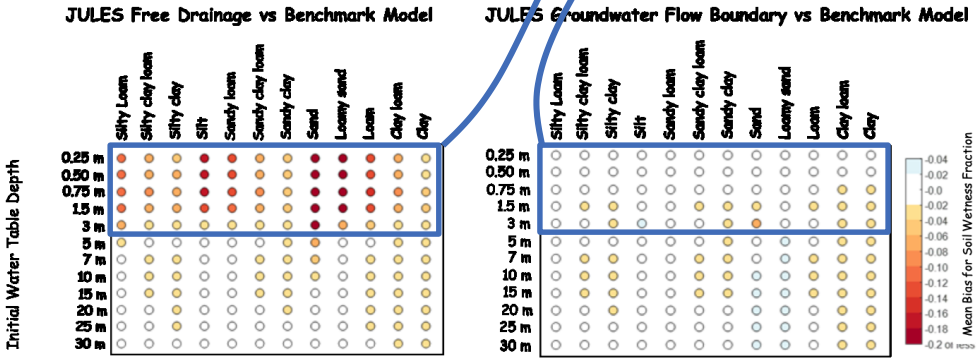


No improvement is observed with our new JULES for initial water depths greater than 5 m and all soils

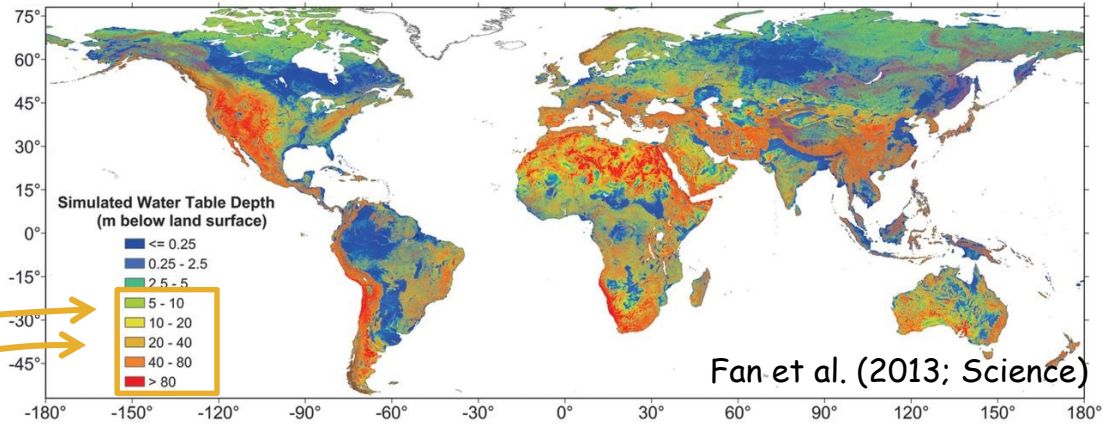


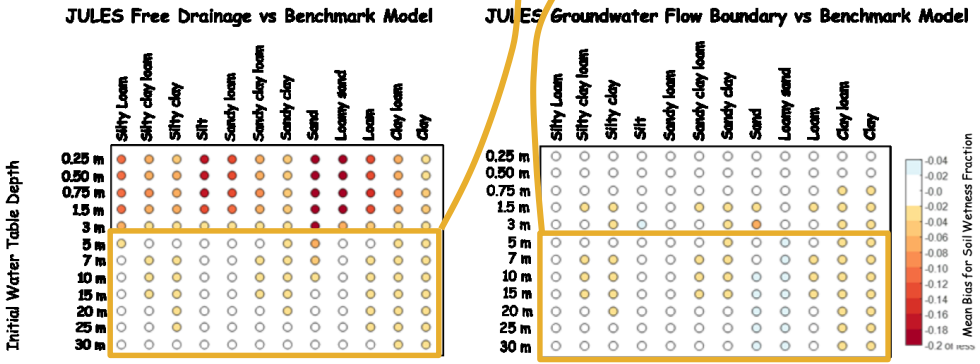
Shallow groundwater influences 22-32% of land!
Ignoring regional differences in meteorological forcing…





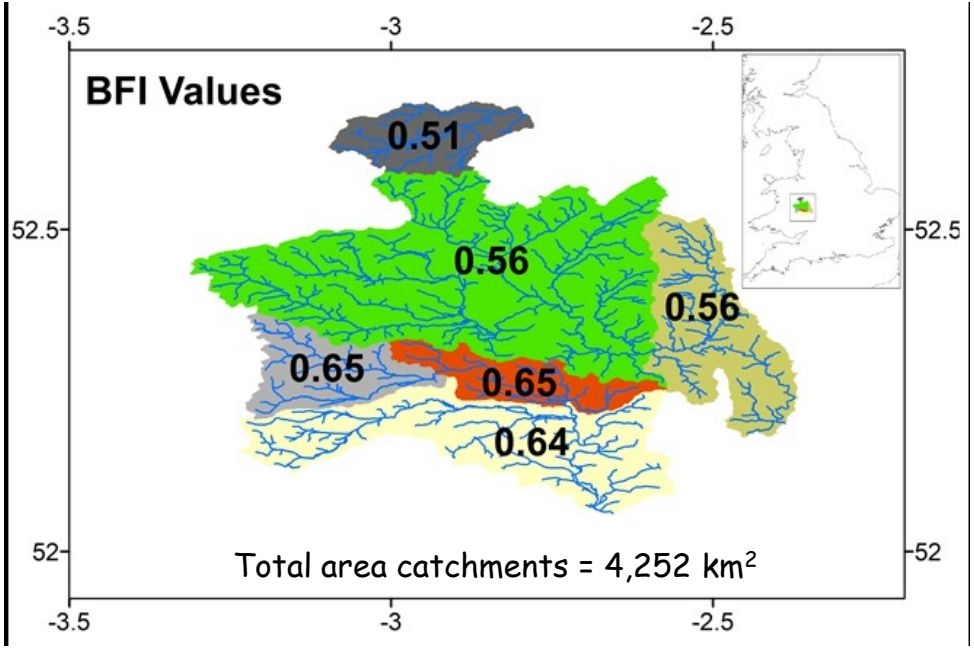
For deep groundwater, added complexity in JULES may not be justified in terms of shallow soil water dynamics

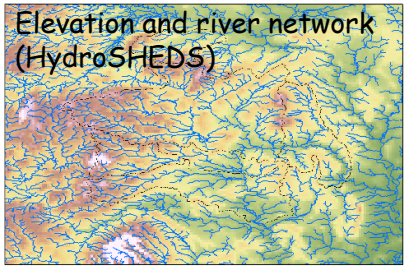


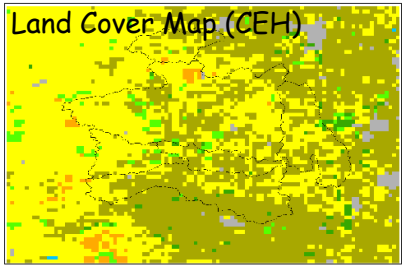


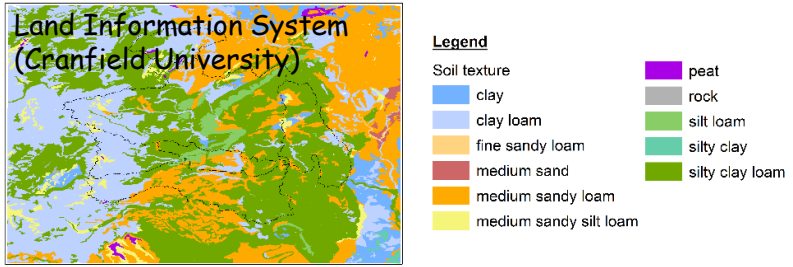
Regional analysis of soil moisture patterns

Regional domain is characterized by groundwater-dominated catchments with Base Flow Indices > 0.50



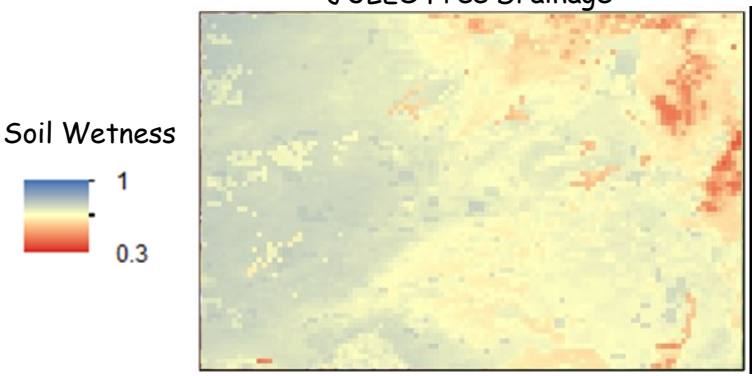




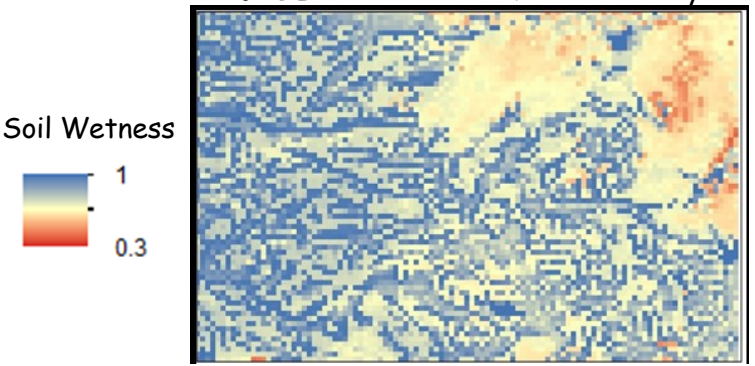


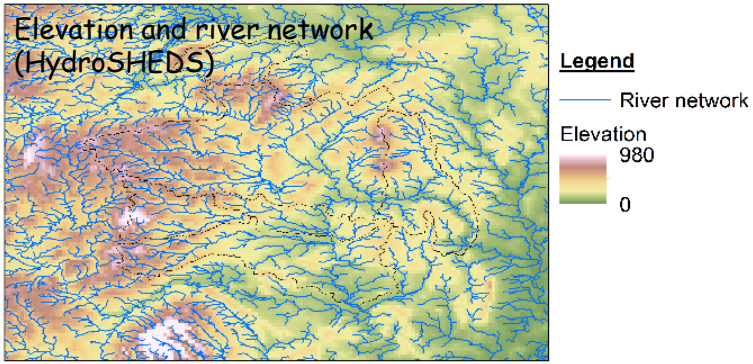
Soil moisture from JULES-groundwater shows spatial patterns consistent with the river network

JULES Free Drainage



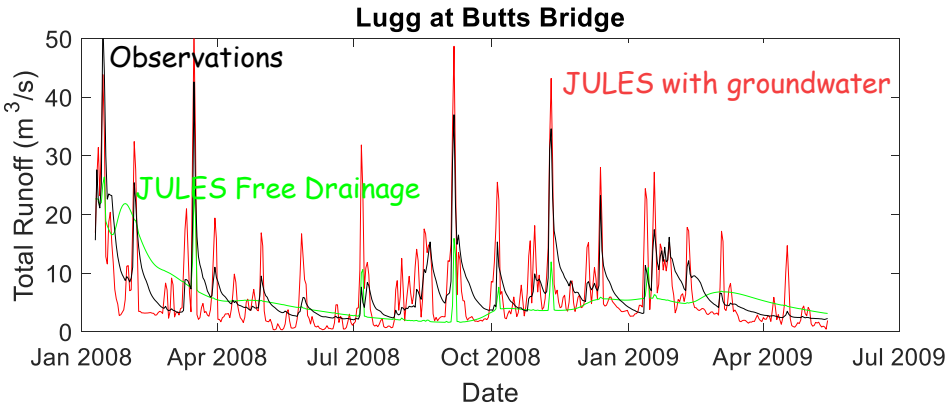
JULES Groundwater Flow Boundary





Regional analysis of river flow at individual catchment

Initial results suggest good performance of our JULES groundwater when simulating river flow



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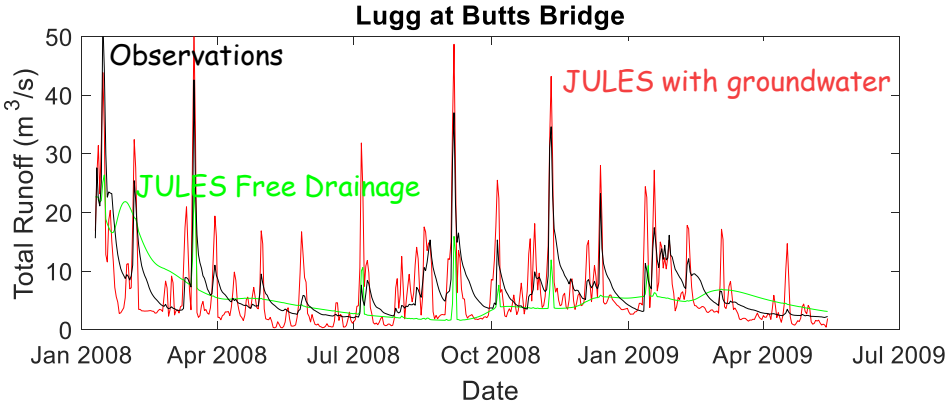
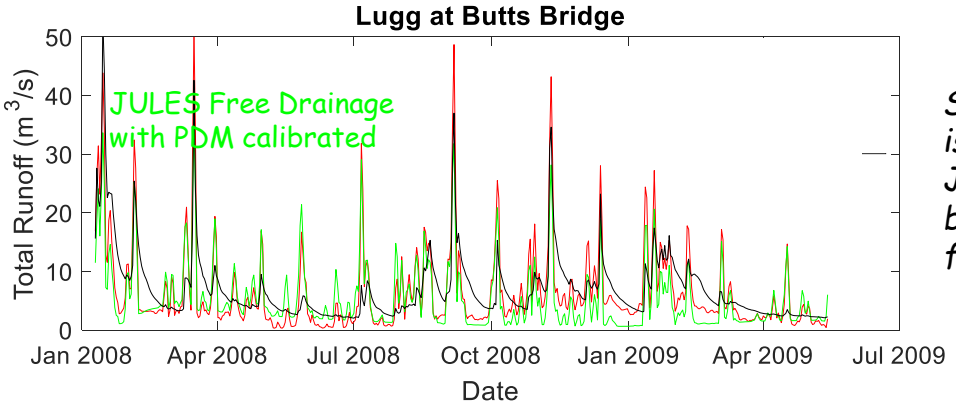
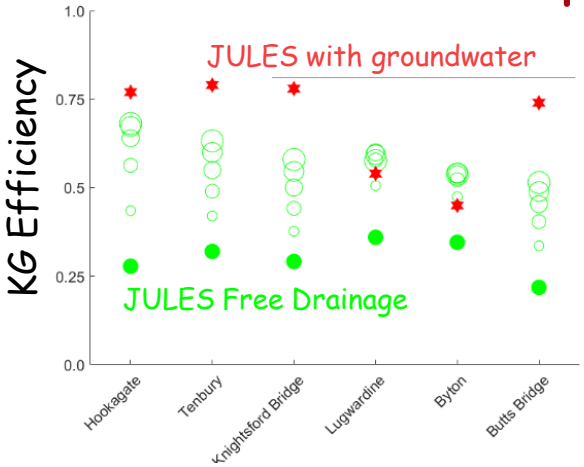




Similar performance is achieved with JULES Free Drainage but relies heavily on further calibration!

Overall, JULES with groundwater performs better even when JULES-PDM parameters are calibrated

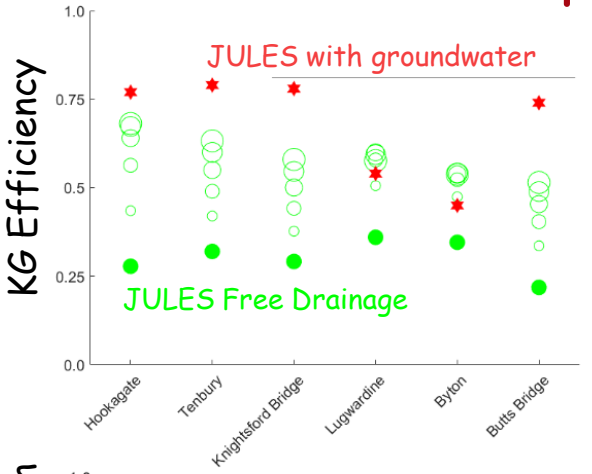


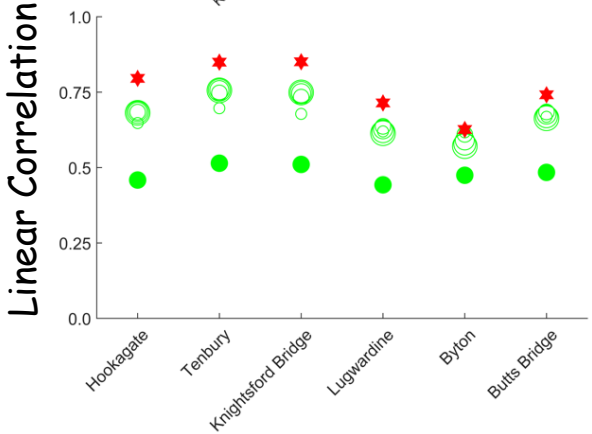
Without PDM

with PDM (varying 'b' parameter)

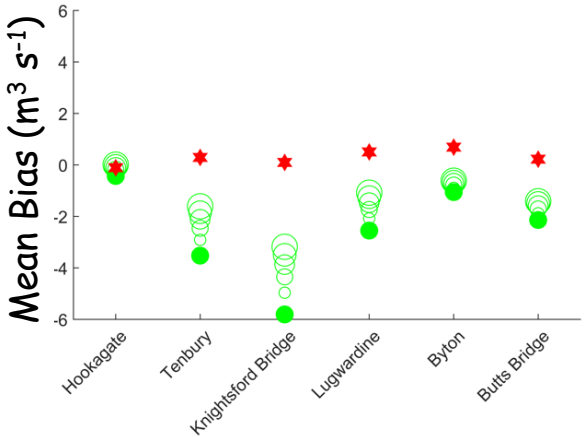
Model performance metrics against daily streamflow data from National River Flow Archive for 2008-2012 period

Overall, JULES with groundwater performs better even when JULES-PDM parameters are calibrated





Model performance metrics against daily streamflow data from National River Flow Archive for 2008-2012 period



Summary

1. Our results suggest benefits in explicitly representing soil-aquifer interactions in JULES especially for shallow water table conditions

2. The added complexity of groundwater parameterization in JULES may not be fully justified (from a traditional land surface modeling aspect) for relatively deep water table

3. When tested over a region in the UK characterized by groundwater-dominated catchments, our new model suggests good performance in reproducing observed river flow while maintaining some degree of realism in reproducing spatial patterns of soil moisture within the domain

Acknowledgements: NERC AMUSED and BEMUSED projects; and EPSRC WISE CDT