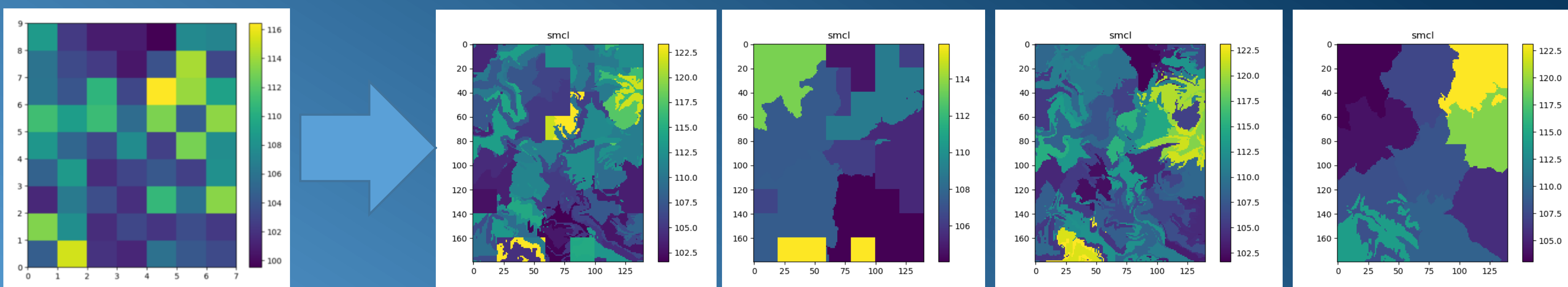
Clustering approaches for JULES

Elizabeth Cooper, Rich Ellis, Eleanor Blyth, Simon Dadson UKCEH



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Usually we run JULES on a gridded system.
Each grid cell has

- a column of soil with derived soil physics parameters (and e.g. Carbon content…..)
- a/several land cover type(s) (PFTs)
- met drivers (usually up or downscaled from a modelled product)
- no communication between neighbouring cells

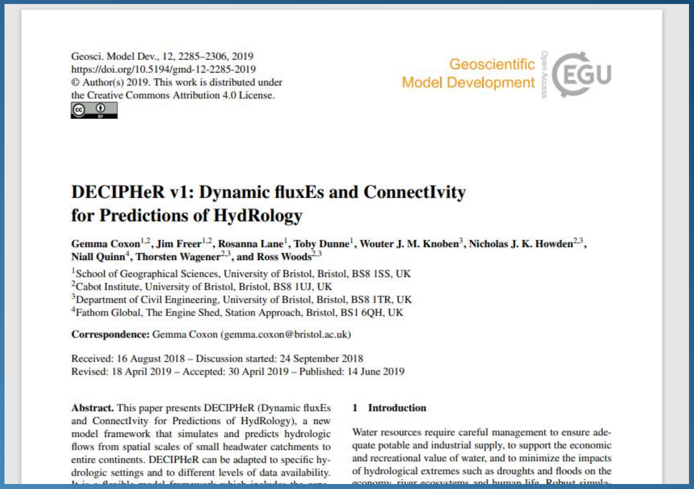
We can then route our surface and subsurface flows to give streamflows (usually no further interaction with the land)

HRU or hillslope approach is different because

We cluster 'SIMILAR' grid cells together

These clusters may then exchange water between them (communication)

Some existing clustering approaches:


Geosci. Model Dev., 12, 2285–2306, 2019
https://doi.org/10.5194/gmd-12-2285-2019
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Geoscientific Model Development

DECIPHeR v1: Dynamic fluxEs and ConnectIvity for Predictions of HydRology

Gemma Coxon[1,2], Jim Freer[1,2], Rosanna Lane[1], Toby Dunne[1], Wouter J. M. Knoben[3], Nicholas J. K. Howden[2,3], Niall Quinn[4], Thorsten Wagener[2,3], and Ross Woods[2,3]

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[2]Cabot Institute, University of Bristol, Bristol, BS8 1UJ, UK
[3]Department of Civil Engineering, University of Bristol, Bristol, BS8 1TR, UK
[4]Fathom Global, The Engine Shed, Station Approach, Bristol, BS1 6QH, UK

Correspondence: Gemma Coxon (gemma.coxon@bristol.ac.uk)

Received: 16 August 2018 – Discussion started: 24 September 2018
Revised: 18 April 2019 – Accepted: 30 April 2019 – Published: 14 June 2019

Abstract. This paper presents DECIPHeR (Dynamic fluxEs and ConnectIvity for Predictions of HydRology), a new model framework that simulates and predicts hydrologic flows from spatial scales of small headwater catchments to entire continents. DECIPHeR can be adapted to specific hydrologic settings and to different levels of data availability.

1 Introduction

Water resources require careful management to ensure adequate potable and industrial supply, to support the economic and recreational value of water, and to minimize the impacts of hydrological extremes such as droughts and floods on the


AGU100 ADVANCING EARTH AND SPACE SCIENCE

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2019MS001833

Representing Intrahillslope Lateral Subsurface Flow in the Community Land Model

Sean C. Swenson[1], Martyn Clark[2], Ying Fan[3], David M. Lawrence[1], and Justin Perket[4]

HYDROLOGICAL PROCESSES
Hydrol. Process. 30, 3543–3559 (2016)
Published online 19 August 2016 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/hyp.10891

HydroBlocks: a field-scale resolving land surface model for application over continental extents

Nathaniel W. Chaney, Peter Metcalfe[2] and Eric F. Wood[1]

Geosci. Model Dev., 14, 6813–6832, 2021
https://doi.org/10.5194/gmd-14-6813-2021
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Geoscientific Model Development

HydroBlocks v0.2: enabling a field-scale two-way coupling between the land surface and river networks in Earth system models

Nathaniel W. Chaney[1], Laura Torres-Rojas[1], Noemi Vergopolan[2], and Colby K. Fisher[3]

[1]Department of Civil and Environmental Engineering, Duke University, Durham, NC, USA
[2]Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ, USA
[3]Princeton Climate Analytics, Princeton University, Princeton, NJ, USA

Correspondence: Nathaniel W. Chaney (nathaniel.chaney@duke.edu)

Received: 27 August 2020 – Discussion started: 28 October 2020
Revised: 14 September 2021 – Accepted: 23 September 2021 – Published: 9 November 2021

All of these involve hydrology (as well as land)

Here we take the HYDROBLOCKS approach but apply only to the LAND parts of JULES

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Land response units (LRUs) in JULES/hydroJULES

Digital terrain

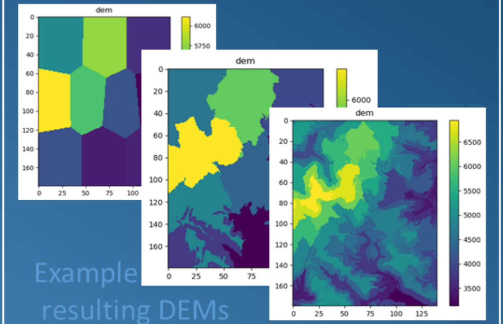
Land cover

Meteorology

Soil properties

Topmodel pars

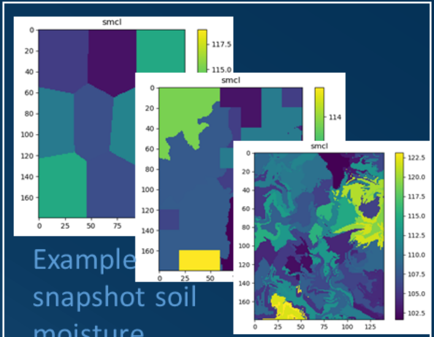
HYDROBLOCKS
Partition domain into N HRUs with chosen clustering covariates



Example resulting DEMs

JULES runs for N columns

HYDROBLOCKS
Map back into physical space



Example snapshot soil moisture

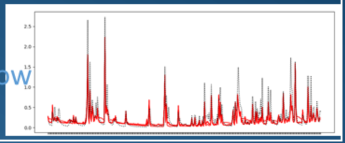
Soil moisture

Runoffs

Flow dirs

Flow acc

UNIFHY streamflows



Example streamflow w/obs

IHDTM 50m resolution

CHESS 1km resolution

OUTPUTS 50m resolution

For basis of clustering code see: https://github.com/chaneyn/HydroBlocks
For unifhy see: https://github.com/unifhy-org

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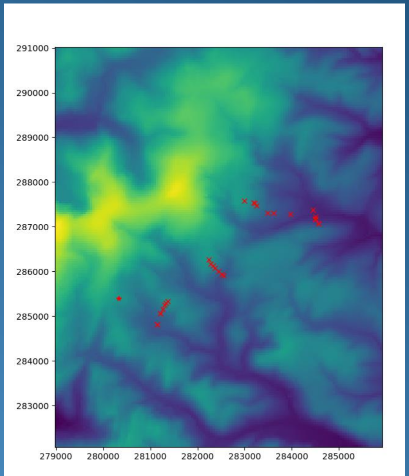
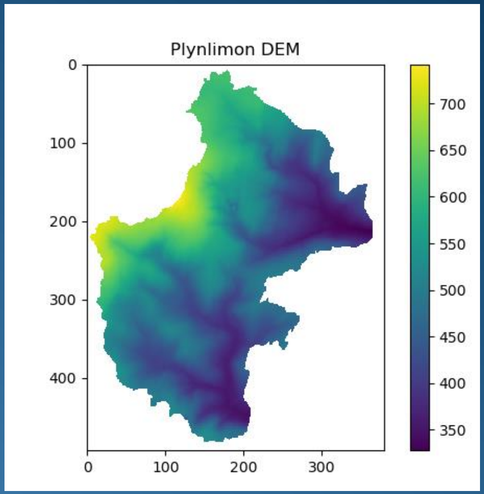
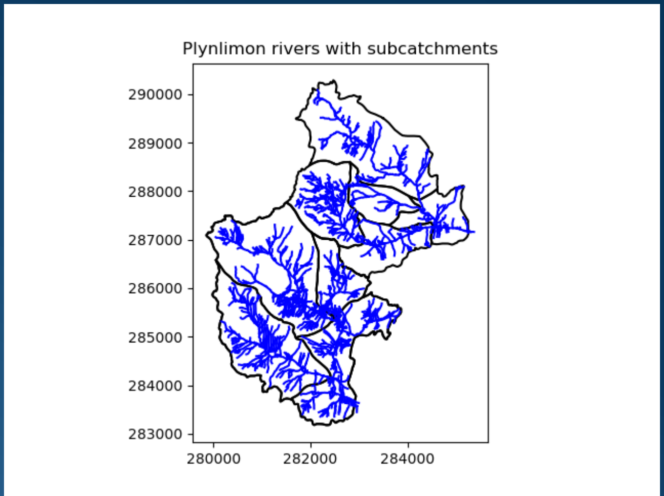
Initial POC: Plynlimon, Wales







50m resolution, total area = (140*180*50m*50m) = 63km^2

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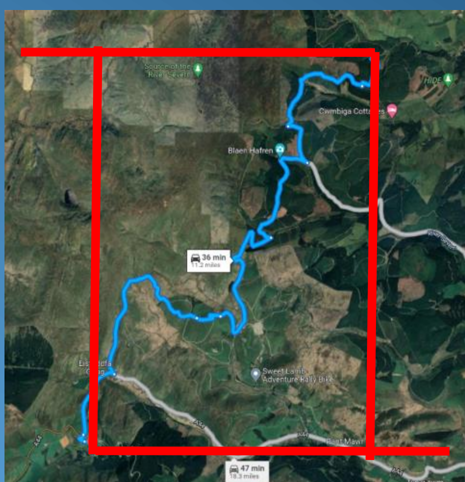
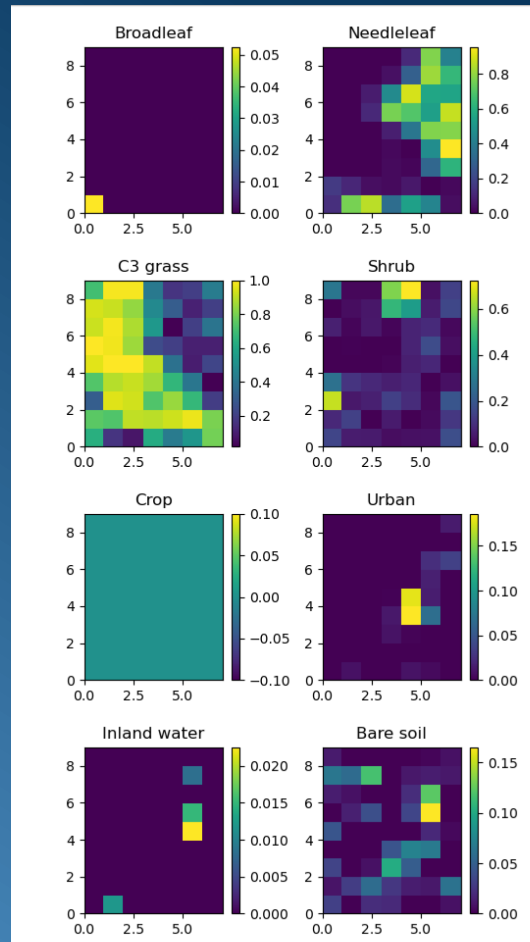
Land cover

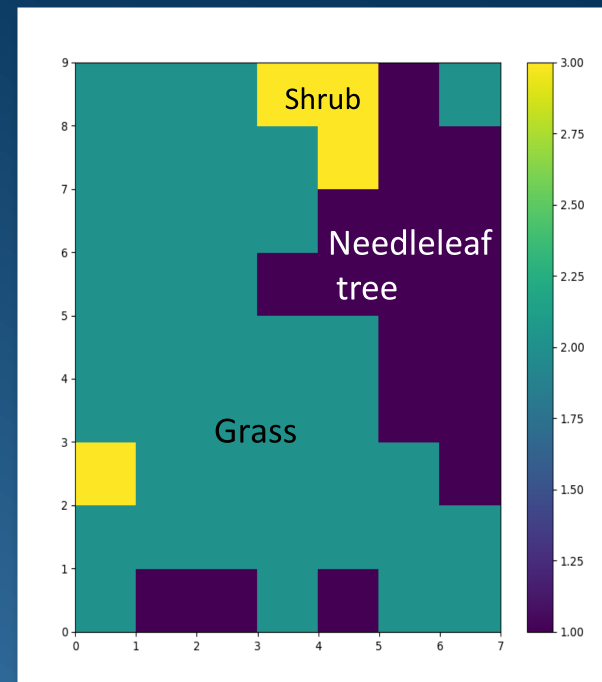
NB soil ancils all the same!



Credit: Google maps



JULES CHESS fractions



Dominant land type for use in clustering

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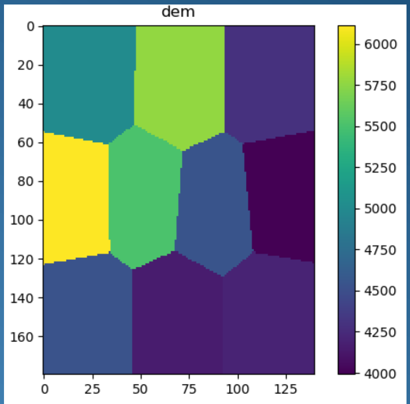
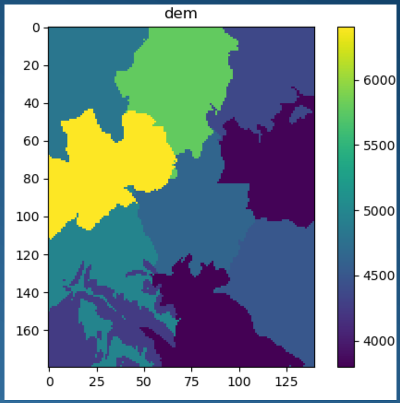
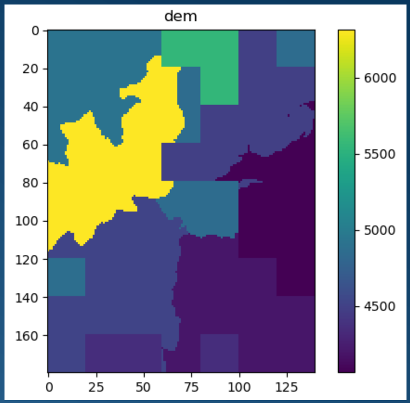
Some clustering results: DEM



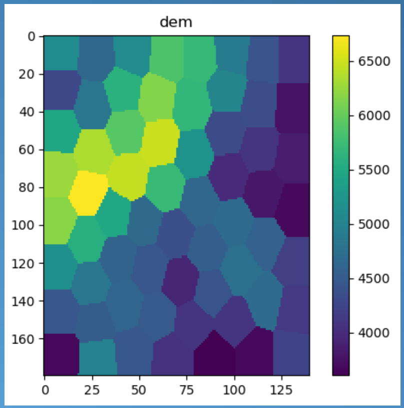
Lat and lon

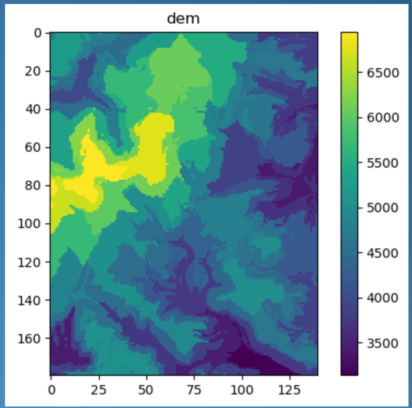


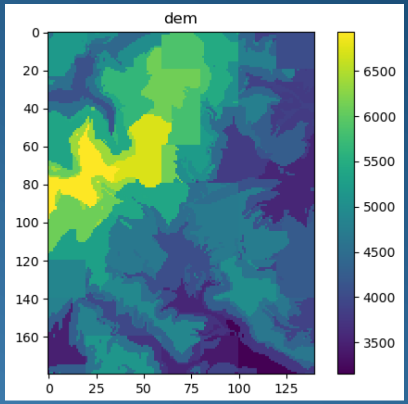
+ elevation and slope

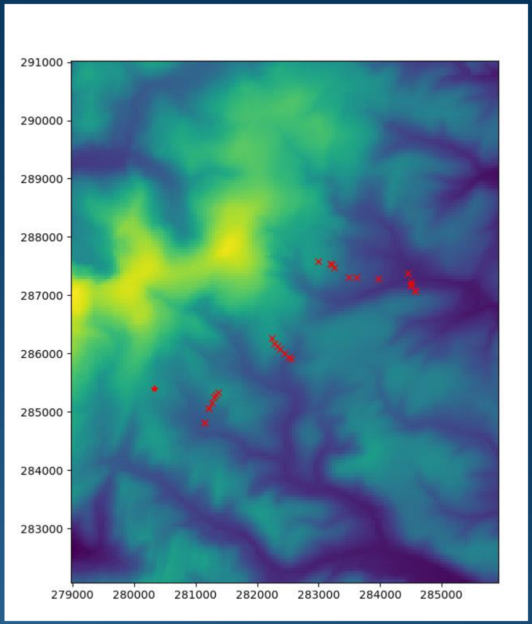


+ land cover









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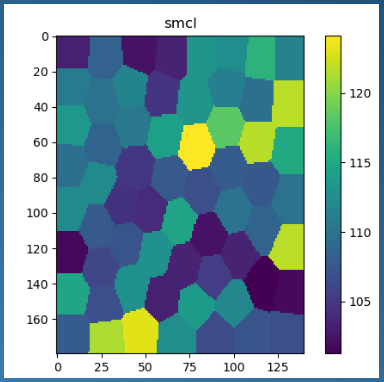
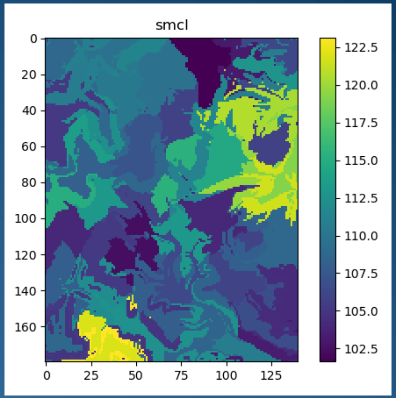
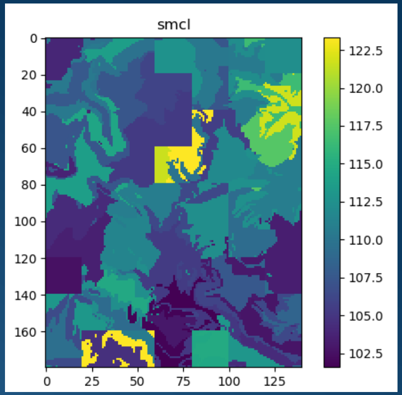
Some output results: snapshot soil moisture



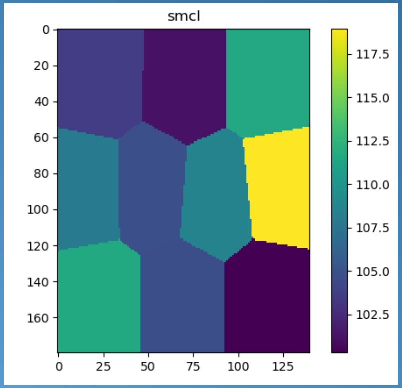


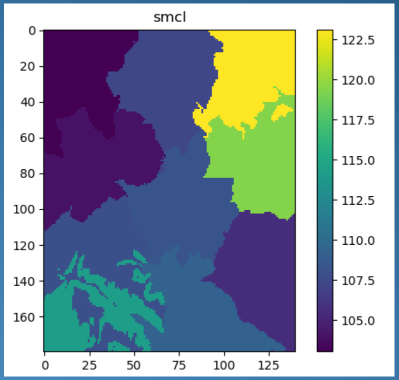


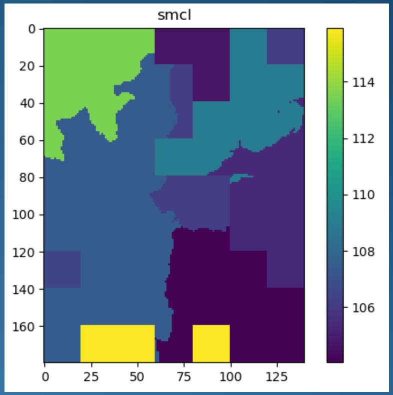
Lat and lon

+ elevation and slope

+ land cover







Increasing complexity, but now we have no ‘truth’

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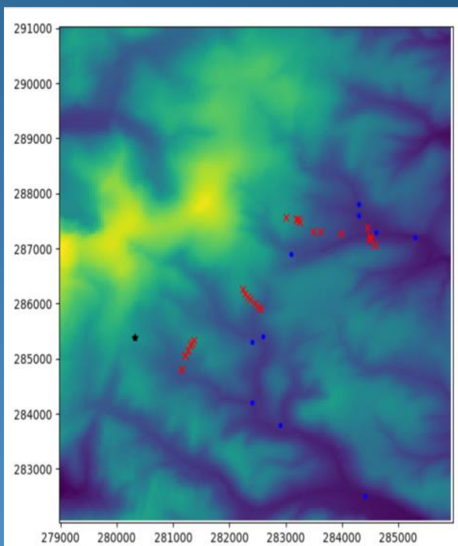
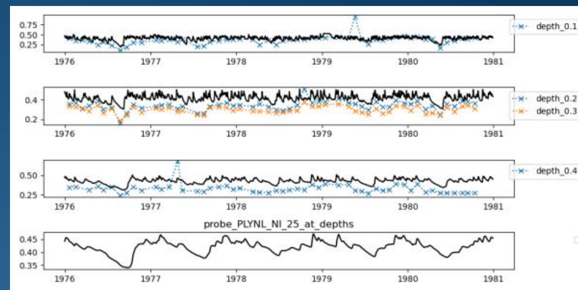
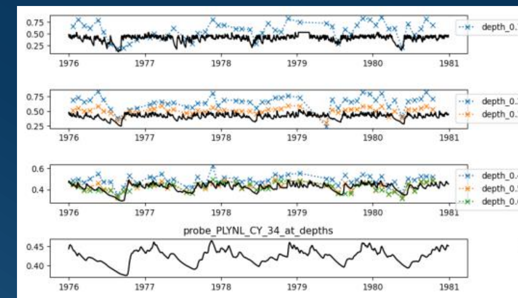
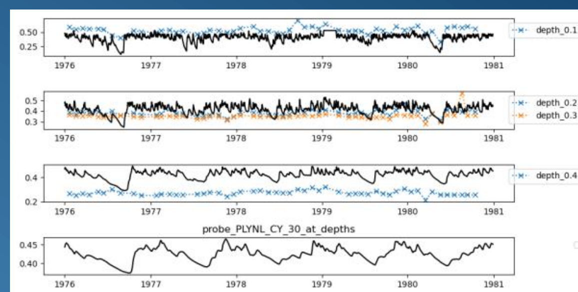
Some output results: soil moisture









Mix of results!
Remember: point probes are not representative of LRU average (or km grid cell!)

(Bell, V.A.; Davies, H.N.; Fry, M.; Zhang, T.; Murphy, H.; Hitt, O.; Hewitt, E.J.; Chapman, R.; Black, K.B. (2022). Collated neutron probe measurements and derived soil moisture data, UK, 1966-2013. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/450bb14b-c711-47af-8792-f9bd88482cd4)

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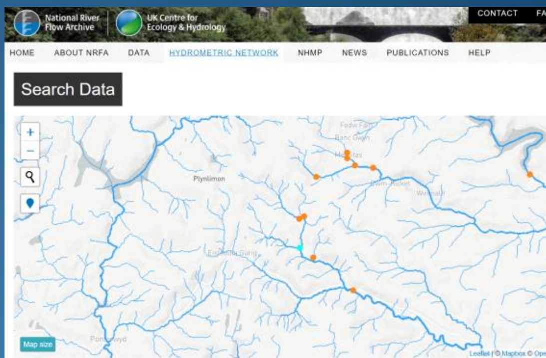
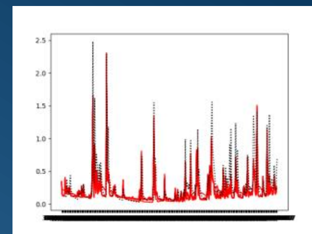
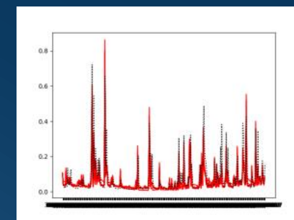
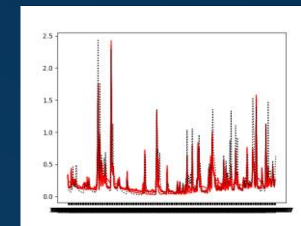
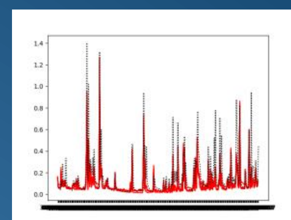
Some output results: river flow

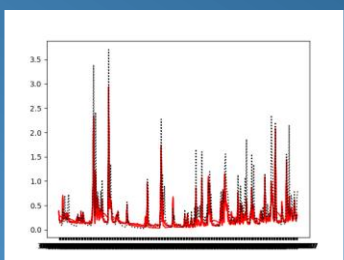


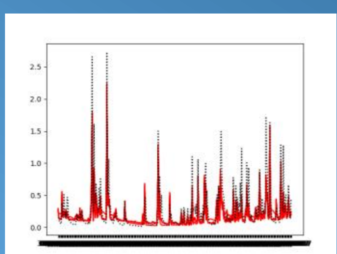




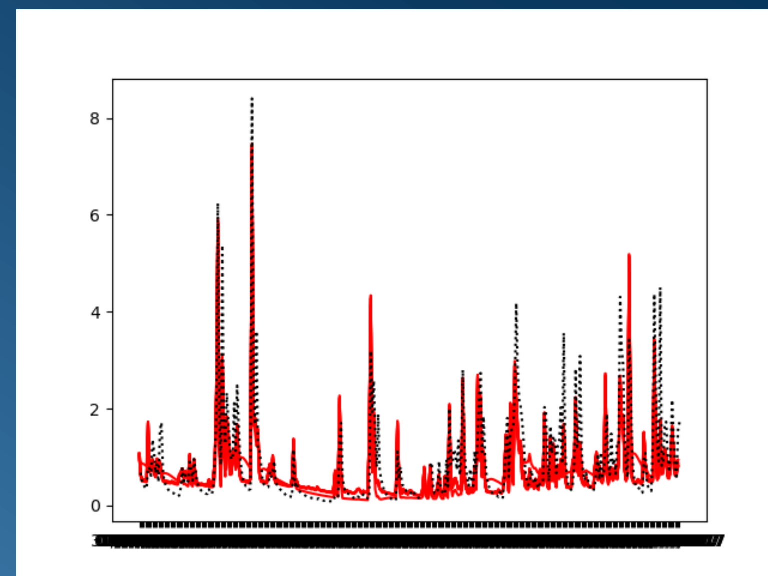








Hydrographs (daily m3/m3) for 2017 show NRFA obs in balck and model output in red. **Hardly any difference for 10 or 63 LRU** configurations



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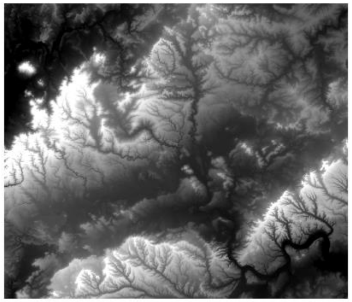
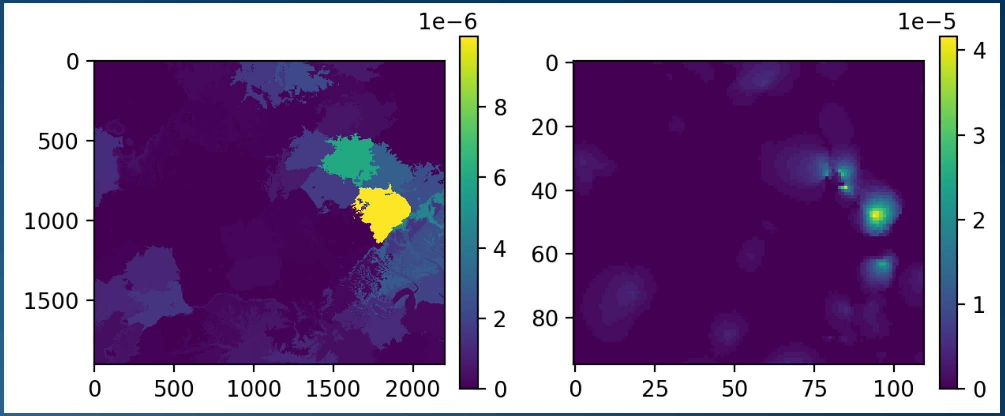
Next stop: the Thames! (to Reading)

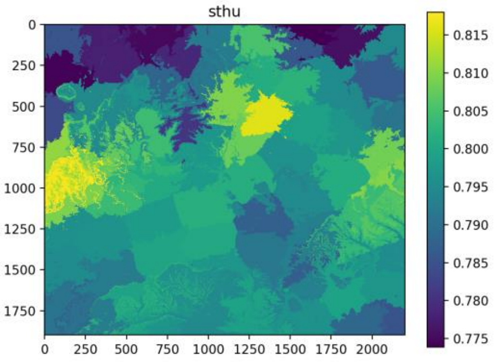
Plynlimon 63km^2

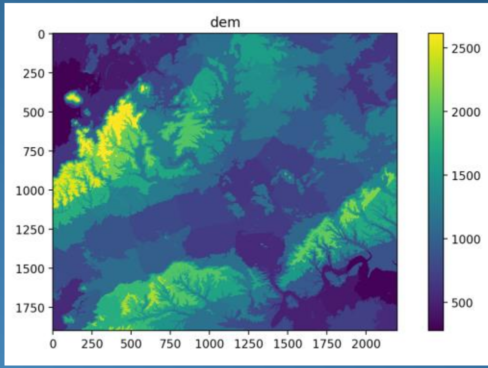
Thames to Reading 10,450km^2

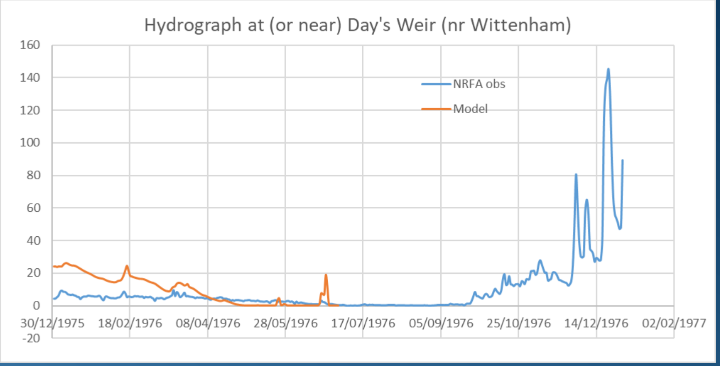


Precip









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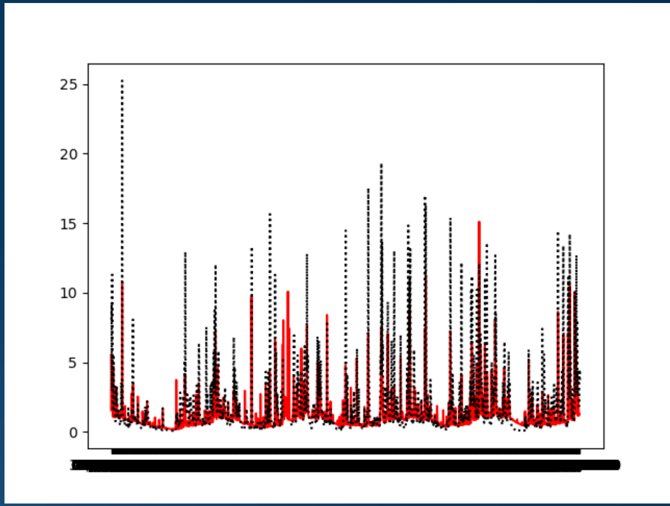
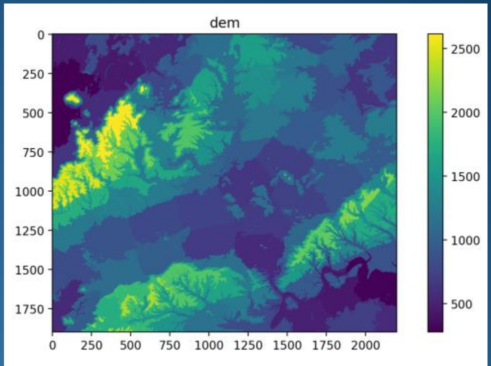
Conclusions and future

- Plynlimon river results promising – indicate 10 HRUs can be as good as 63 grid cells(?)
- Streamflow VERY sensitive to river routing resolution
- Thames results likely to be more interesting – larger, more heterogenous etc
- Hope to answer:
  - Is this a useful approach in JULES?
  - WHICH characteristics are most important for LRUs?



Hydrographs for 1976 – 1980 (inc)
Black NRFA obs, red JULES_10LRU



Thames dem 100LRU

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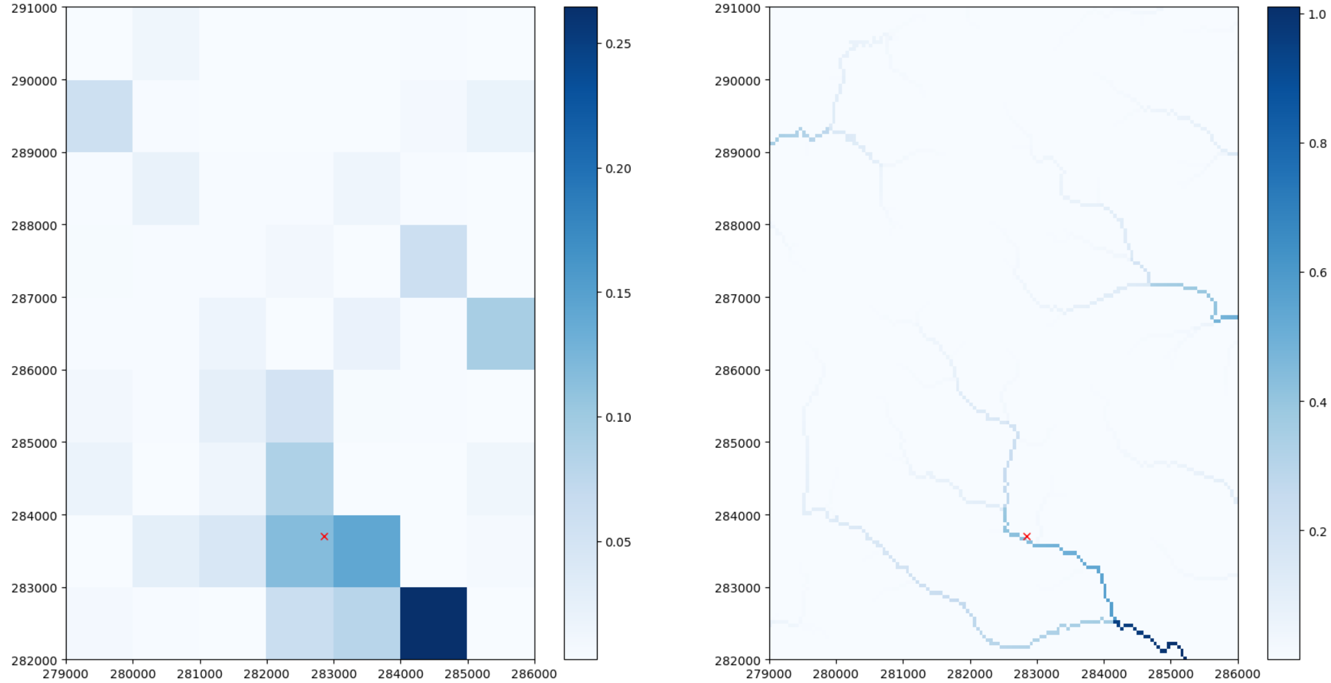
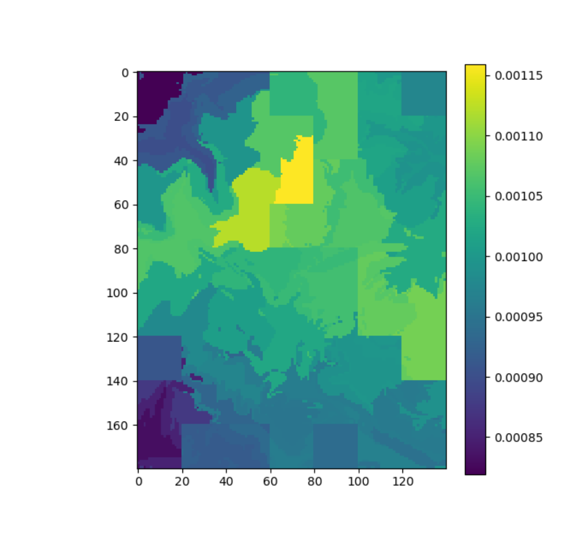
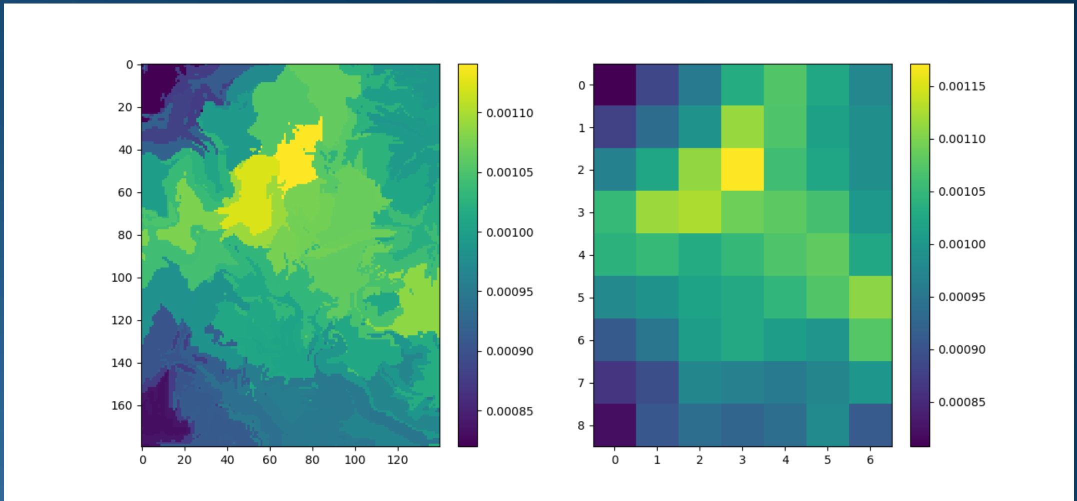
Comparison with JULES GRIDDED



… is a bit tricky……

Some clustering results: snapshot precip

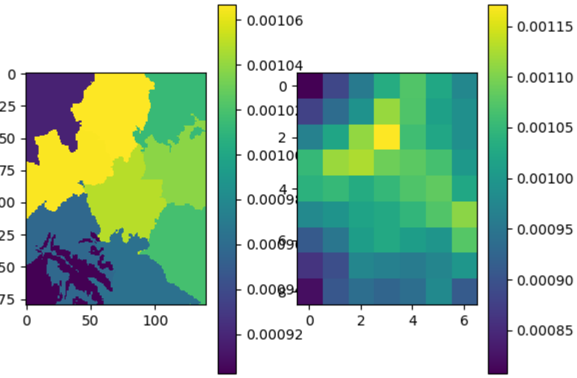




BUT WHAT about the precip for 10HRUs?

smcl (layer **2** day 75) for 10 hrus ll, llds, llsd+lc covariates

llds



lldslc