The eFLaG Projections: future river flow and groundwater for the UK

Nationally consistent projections to enhance drought resilience

Jamie Hannaford

Hydrological Status & Outlooks Group (Wallingford)

With thanks to the eFLaG team

Met Office

UK CLIMATE RESILIENCE PROGRAMME

UK Centre for Ecology & Hydrology

BGS British Geological Survey

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Thanks to the eFLaG Team!

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Jon McKay
(BGS lead, GW modelling)

Matt Ascott
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Chris Jackson
(Stakeholder engagement)

Majdi Mansour
(ZOODRM)

Chris Counsell
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(WR modelling. engagement)

Gemma Nash
(Portal)

Adam Griffin
(Spatial statistics)

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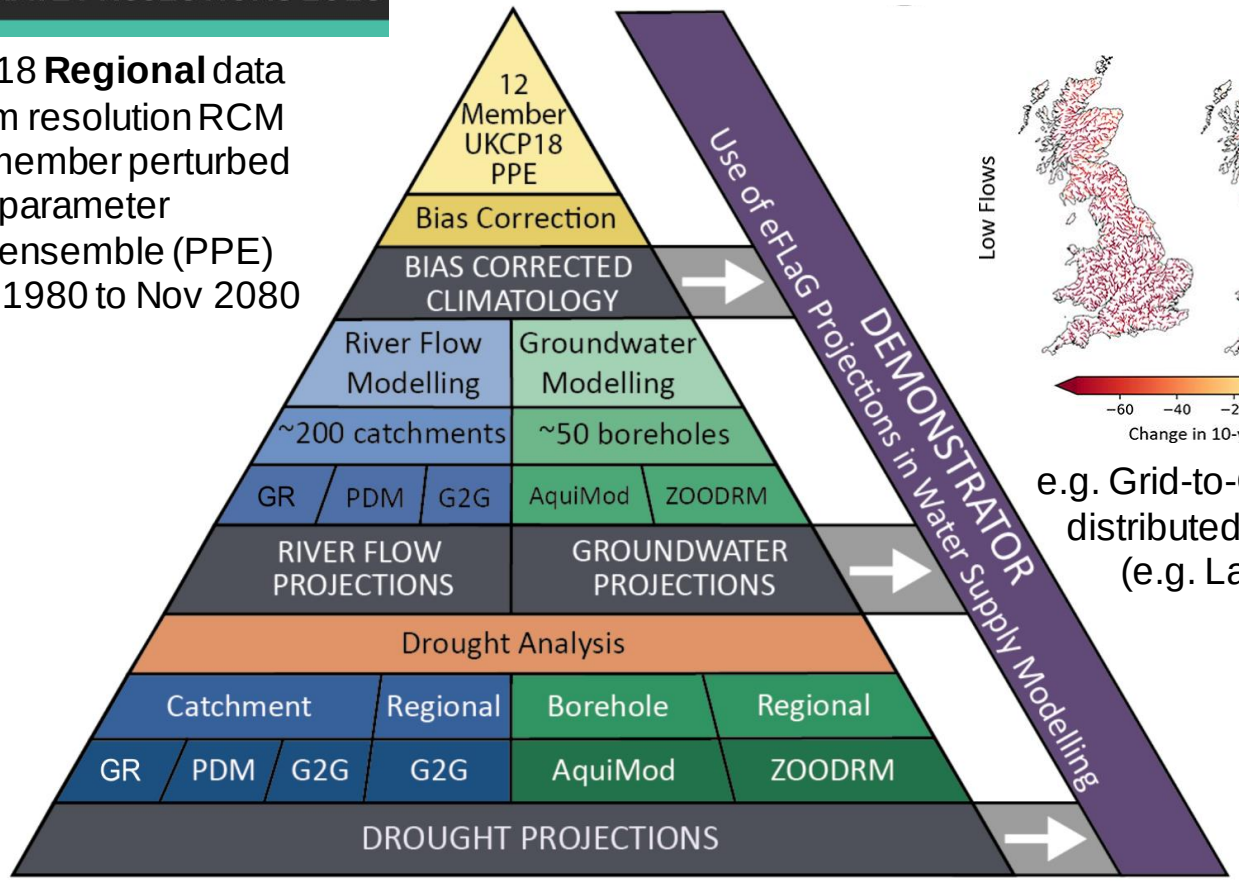
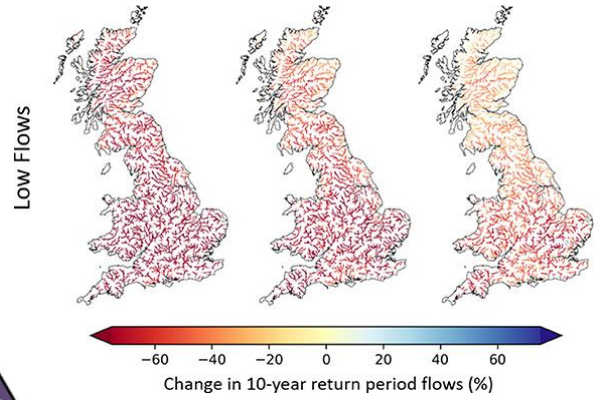
Howden Reservoir – around 15% capacity, August 2022.
Richard Severn, Environment Agency

What is the eFLaG dataset?

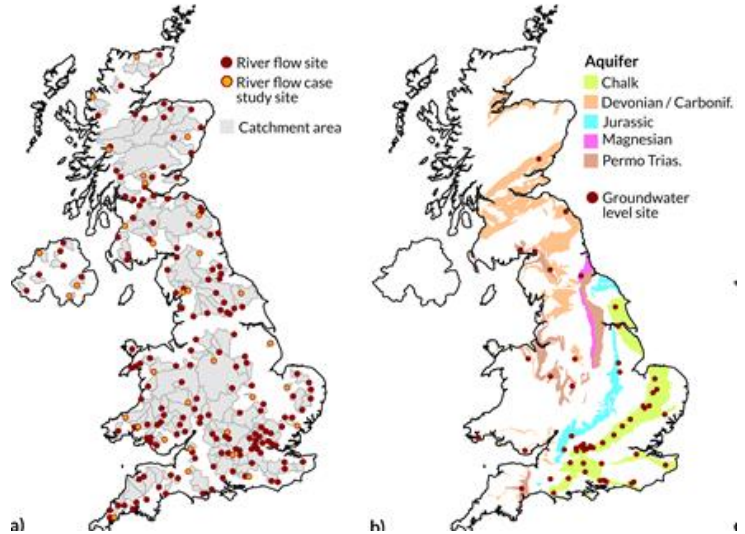
UK CLIMATE PROJECTIONS 2018

UKCP18 **Regional** data
12km resolution RCM
12-member perturbed parameter ensemble (PPE)
Dec 1980 to Nov 2080





e.g. Grid-to-Grid: a national-scale distributed hydrological model (e.g. Lane & Kay 2021)



Maps of the 200 eFLaG Catchments and 54 Boreholes


eFLaG: enhanced future FLows and Groundwater. A national dataset of hydrological projections based on UKCP18

The full story:
Data Paper,

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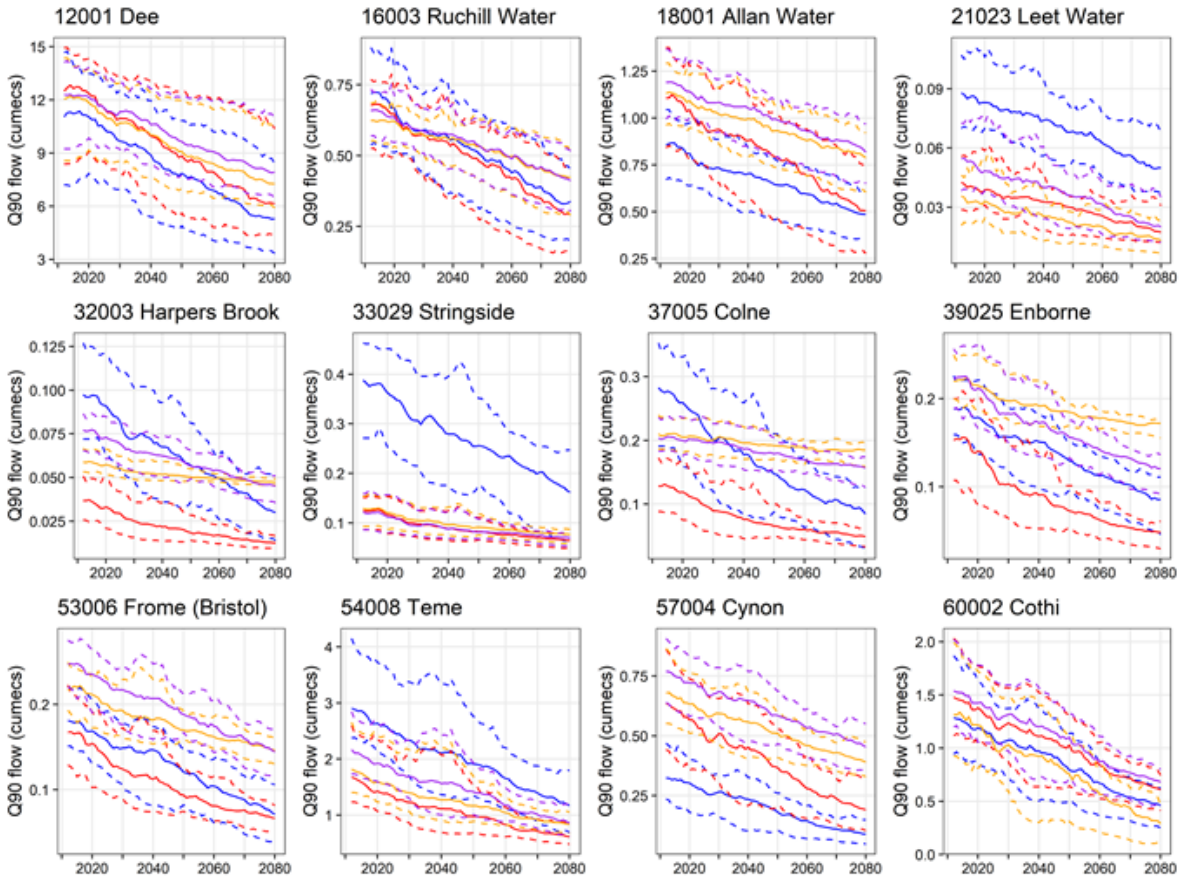
Example results: diminishing future flows

Headline: low flows getting lower, but how low will they go? Uncertainty in magnitude of future changes

Low flows (Q90) in 30 year moving windows, 1980 - 2080



Ensemble projections: Range of 12x RCM ensemble members (climate model uncertainty)

Multi-model: four hydrological models (hydrological model uncertainty)

Transient: look at interannual and interdecadal variability rather than time-slices

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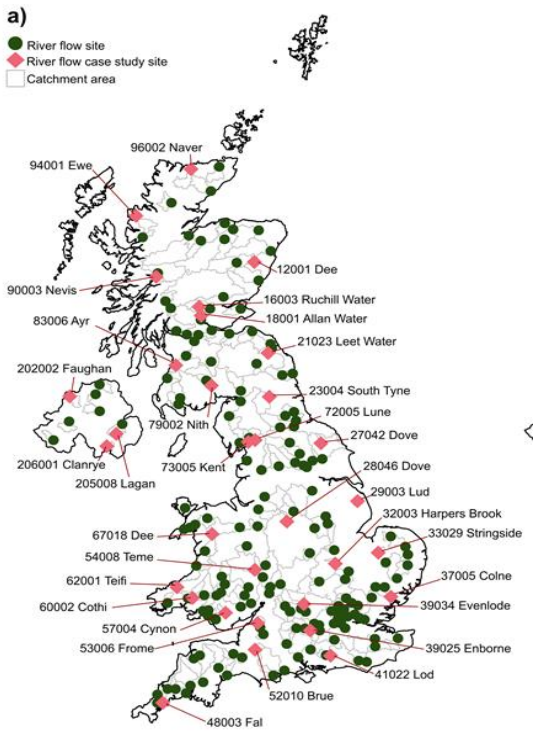
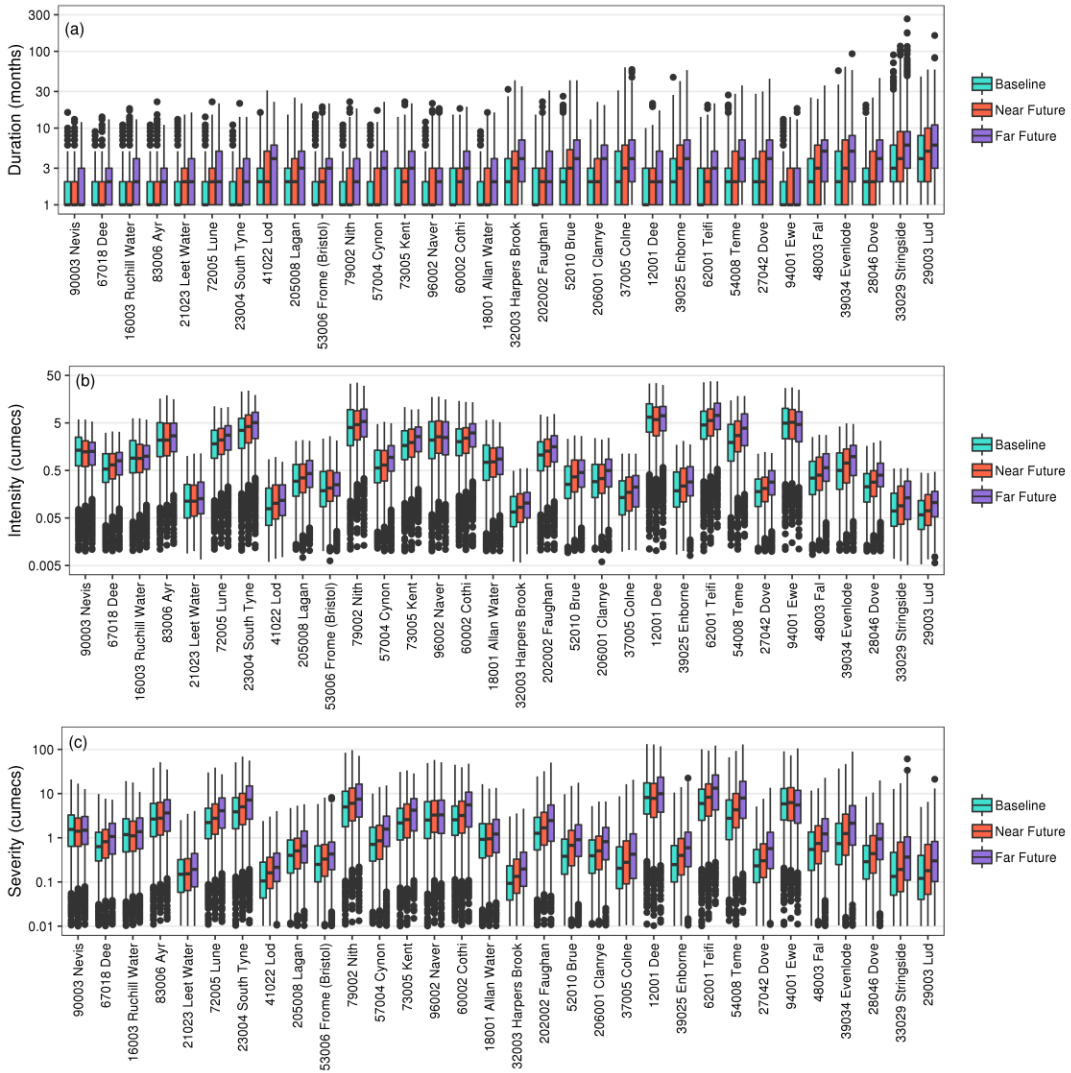
Simon Parry et al. 2023 (HESSD)

Example results: increasing river flow drought severity





Baseline, 1989-2018
Near Future, 2020-2049
Far Future, 2050-2079

Boxplots containing:

- **Durations**
- **Severity**
- **Intensity** for all droughts

(threshold method, Q70) extracted from all 12 RCM ensembles and 4x models

Headline: droughts generally projected to be more prolonged and more severe

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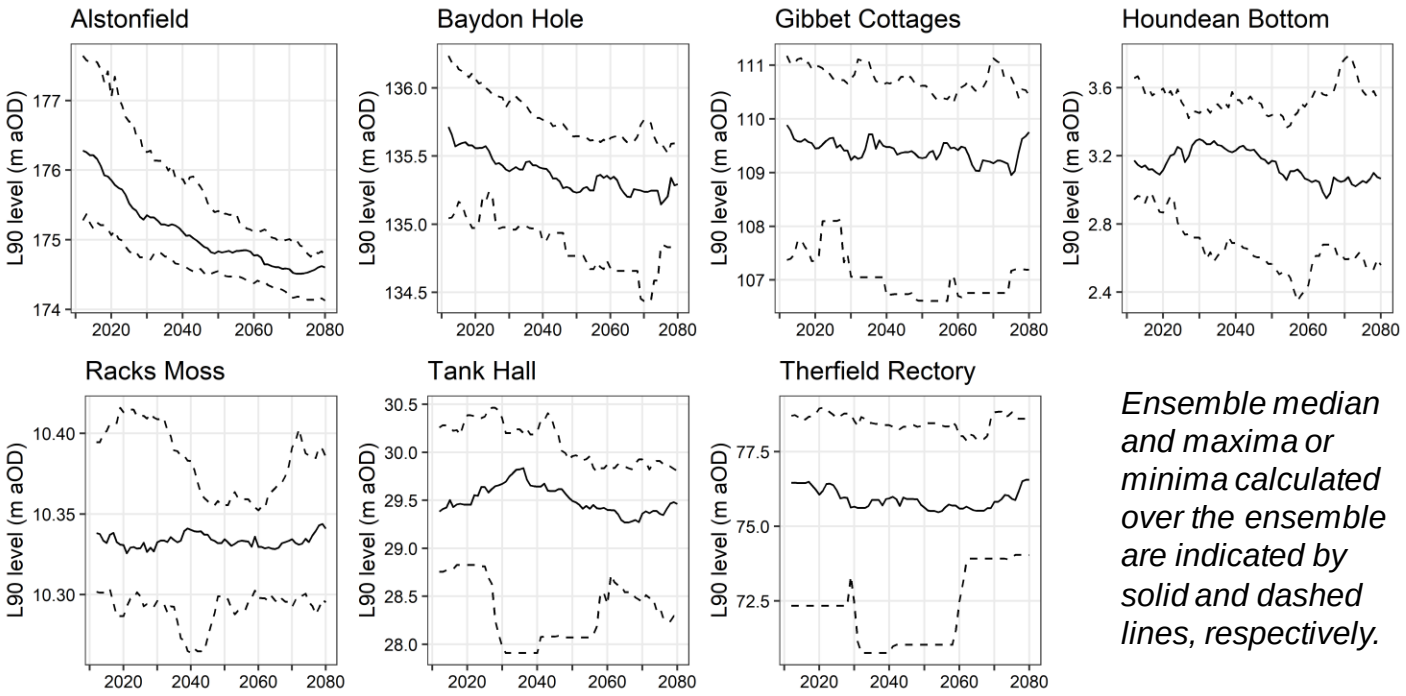
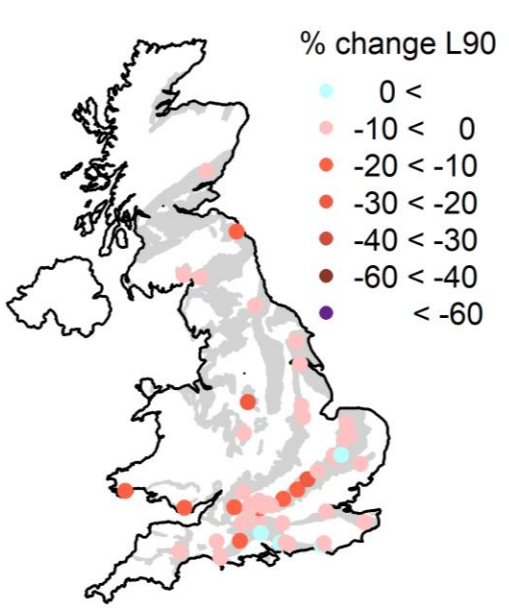
Parry et al. 2023 (HESSD)

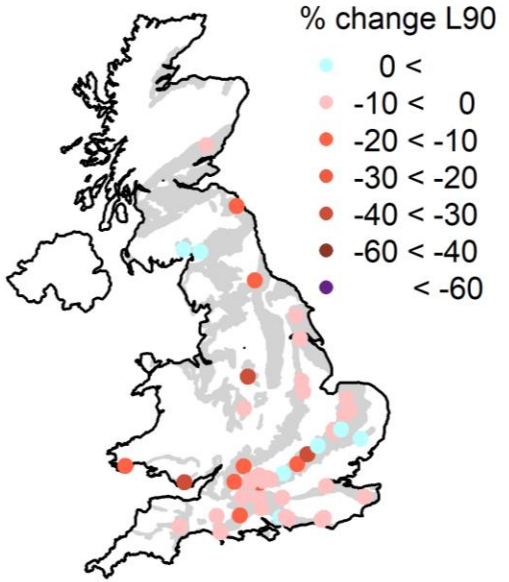
Results: divergent flow and groundwater

Low levels (L90) in 30 year moving windows, 1980 - 2080



Ensemble median and maxima or minima calculated over the ensemble are indicated by solid and dashed lines, respectively.





Headline: 'it's complicated' for groundwater, droughts/low levels not universally becoming more severe

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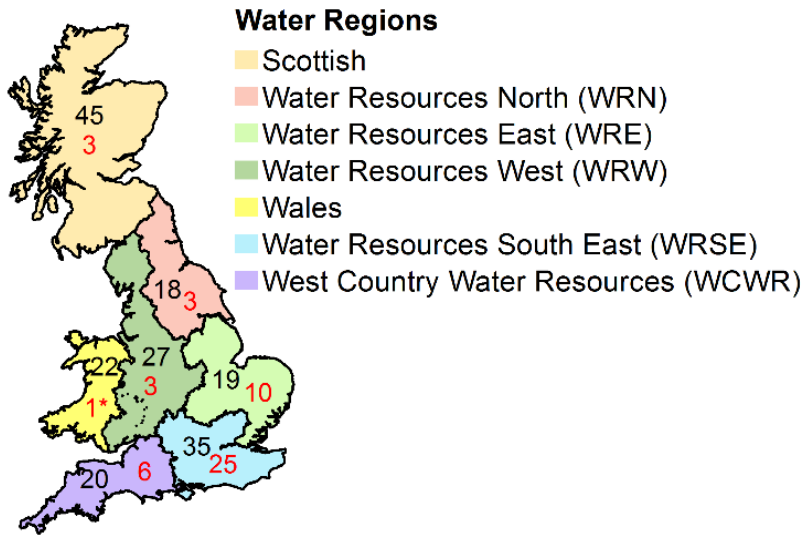
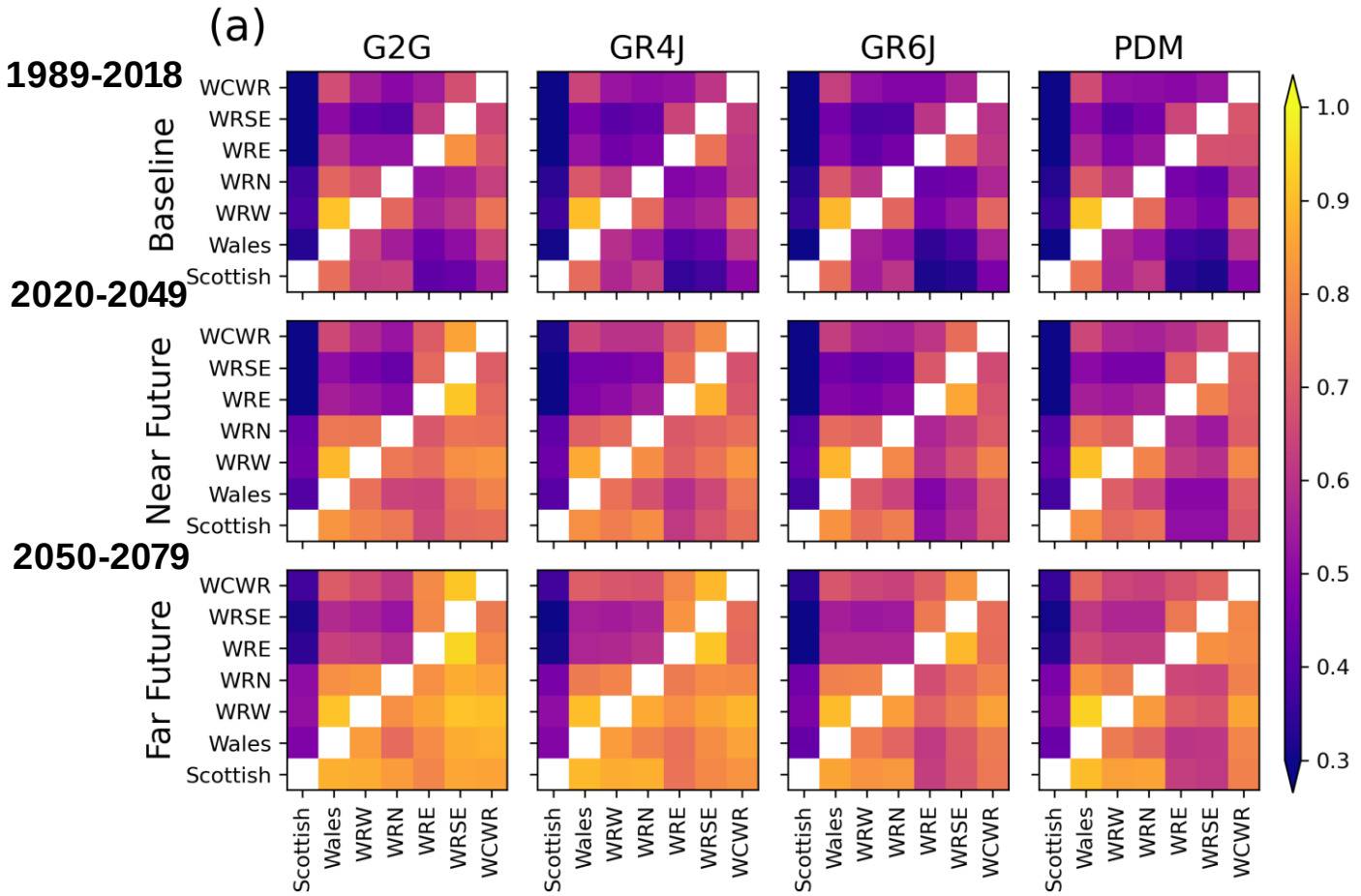
Parry et al. In prep (HESS)

Example results: increasing spatial coherence of drought



Headline: significant increase in spatial coherence that could have major impacts on planned water transfers



Matrices showing conditional probability of pair of regions being in drought simultaneously

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Maliko Tanguy et al. submitted (ERL)

Water Industry Demonstrators

Four contrasting case studies

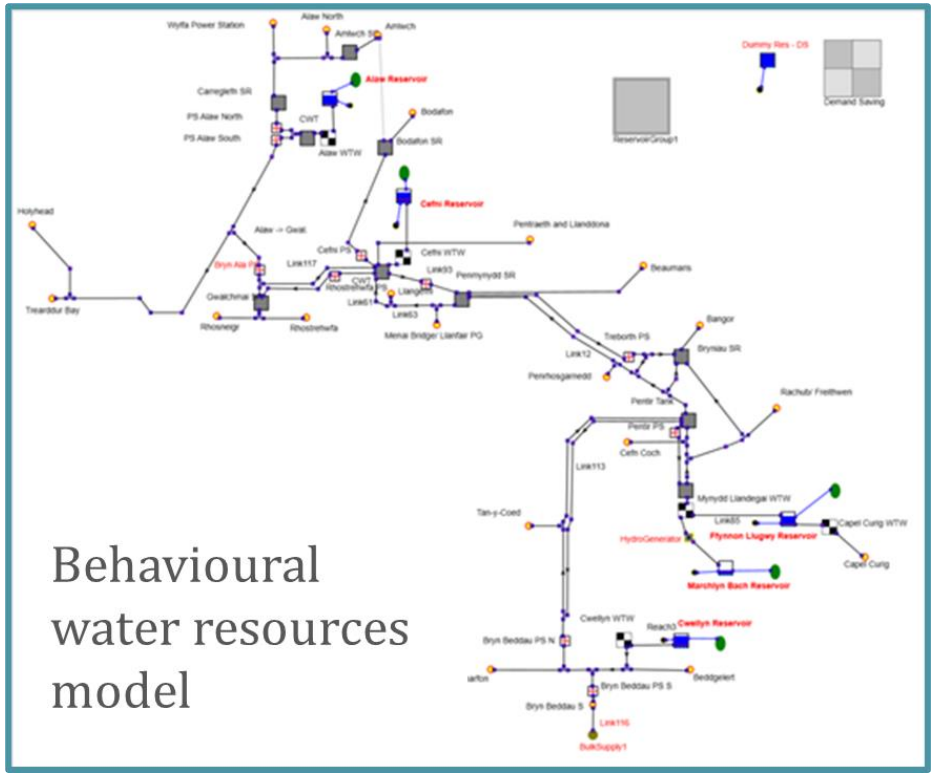
- Dŵr Cymru Welsh Water (DCWW)
- Thames Water
- Affinity Water
- Scottish Water

Demo use of FLaG datasets

Run through common industry supply system models (e.g. Aquator / pyWR)

How do eFLaG projections compare to current approaches (e.g. Change Factors)

More info: webinars here.



Scottish Water
Always serving Scotland
Dŵr Cymru
Welsh Water
Thames Water
AffinityWater

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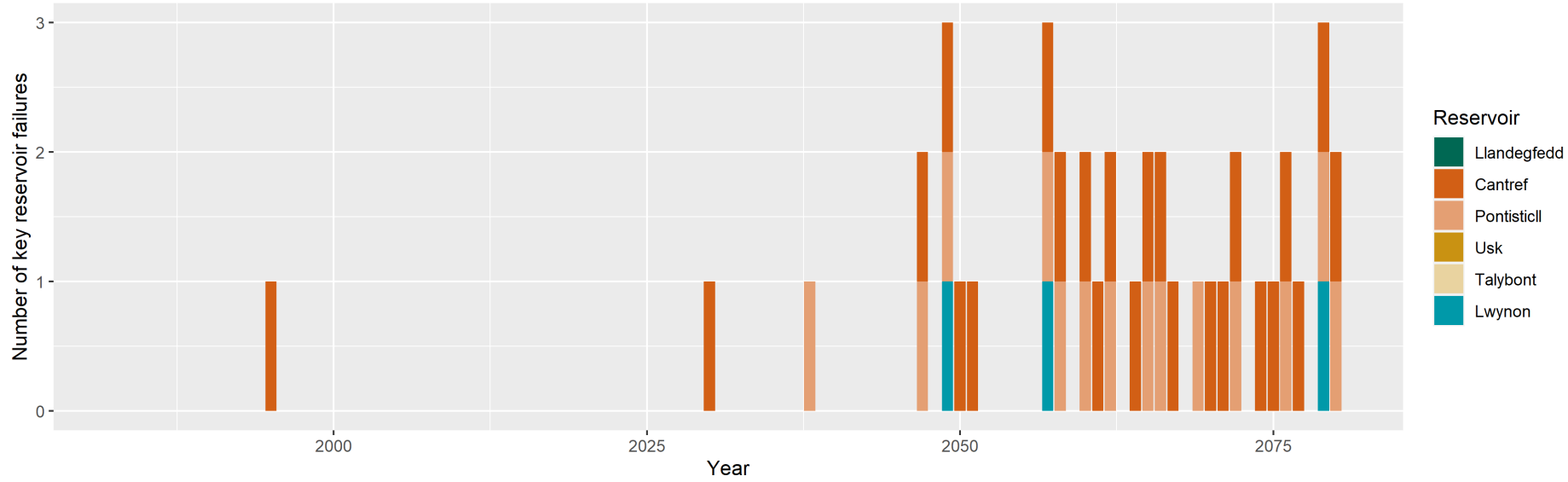
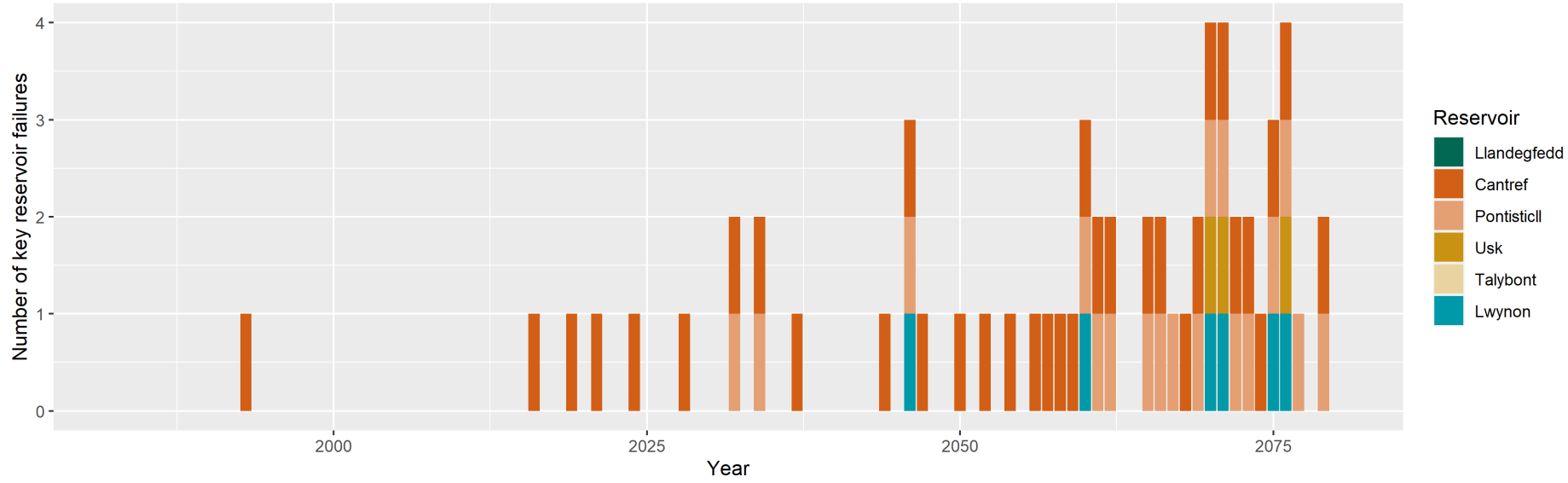
Example Demonstrator Outcomes: DCWW

RCM 11



RCM 13



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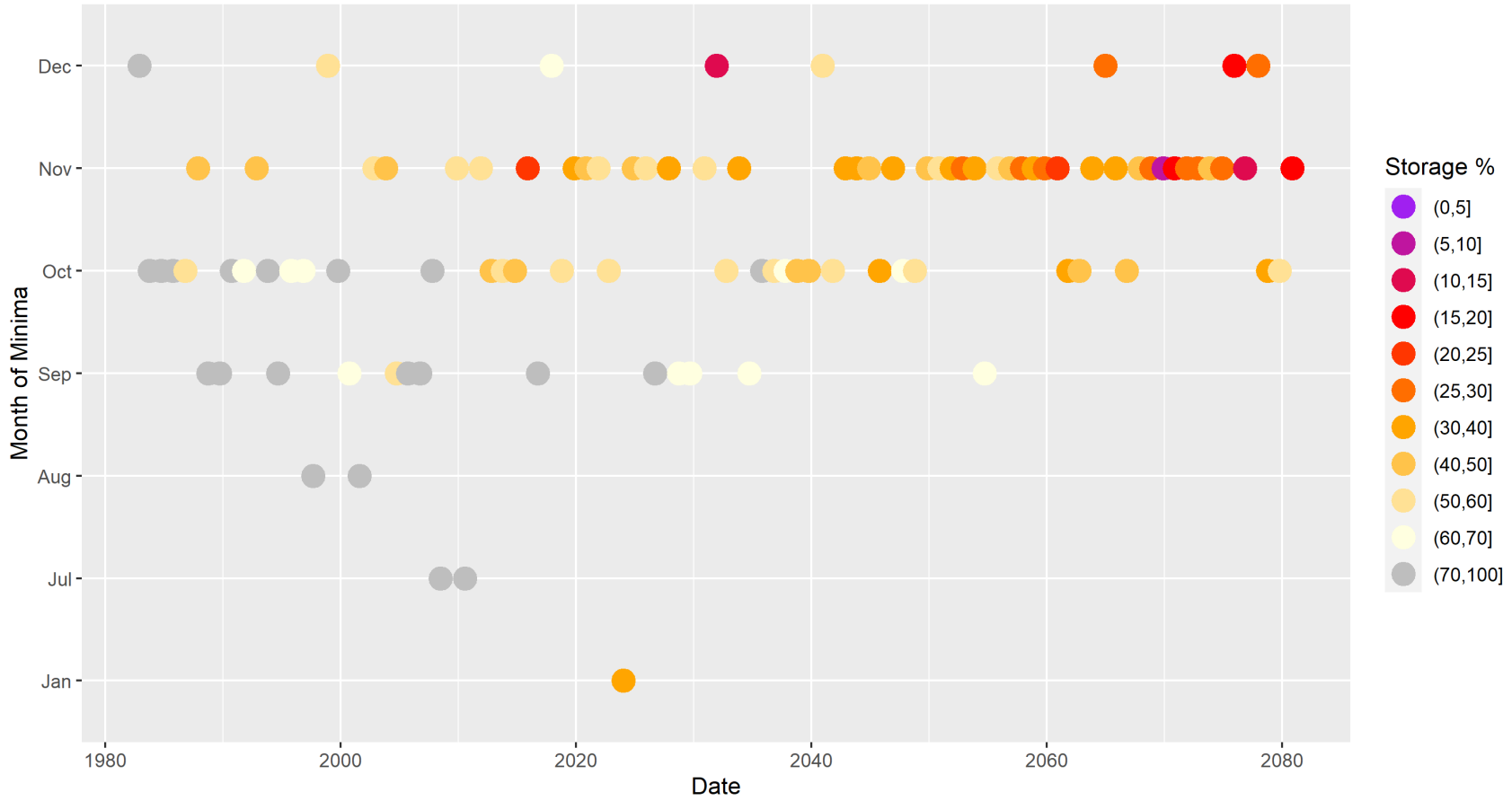
Example Demonstrator Outcomes (DCWW)



Usk reservoir drawdown at constant demand (RCM13)

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Across the demonstrators

London

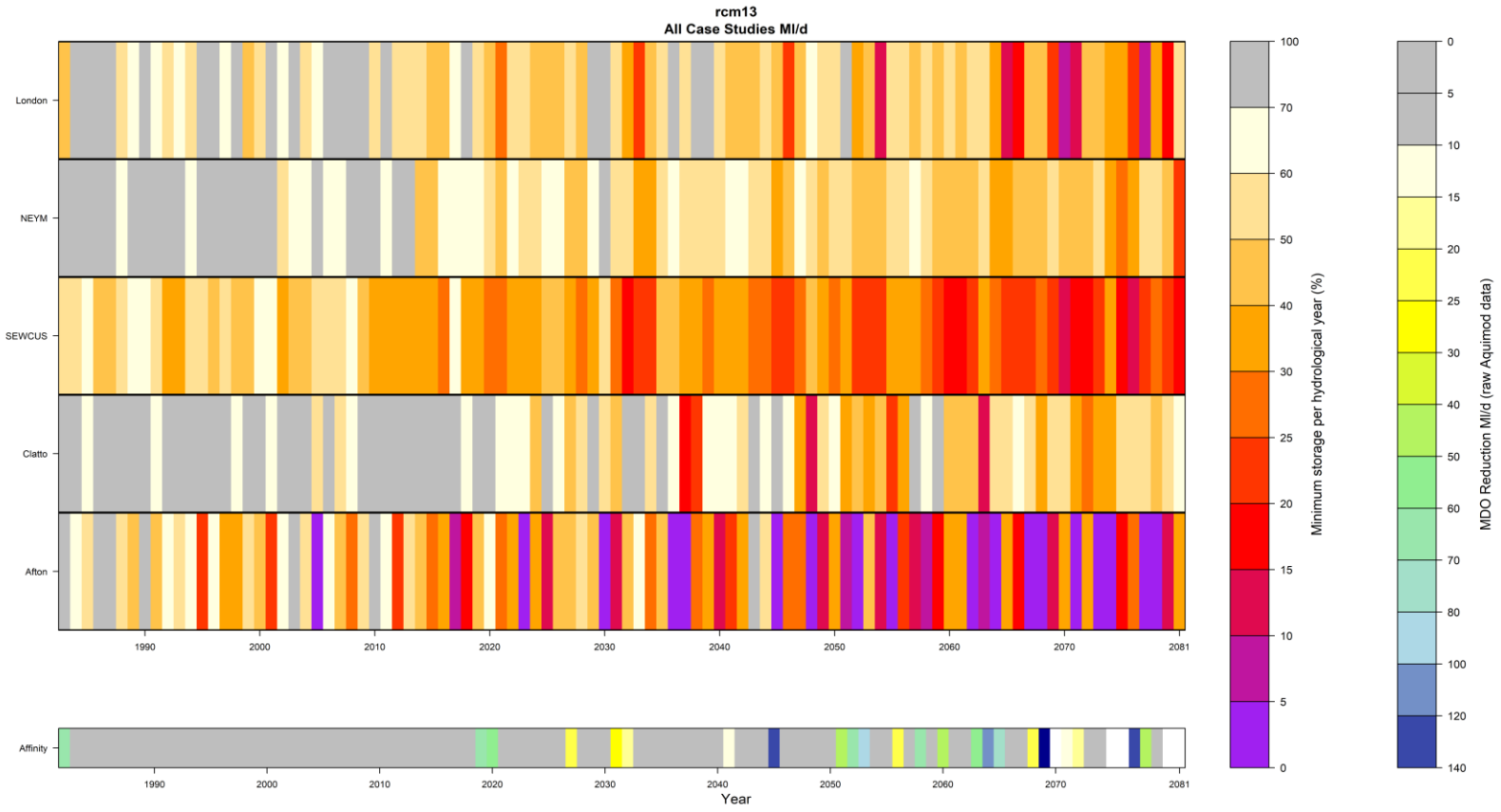
NEYM (N Wales)

SEWCUS (SE Wales)

Clatto (Dundee)

Afton (Ayrshire)

Affinity (SE England)



Headline: multi-model, spatially coherent, transient projections like eFLaG could add significant value to water resources planning

What else could eFLaG be used for?

Earth Syst. Sci. Data, 5, 101–107, 2013
www.earth-syst-sci-data.net/5/101/2013/
doi:10.5194/essd-5-101-2013

Open Access Earth System Science Data

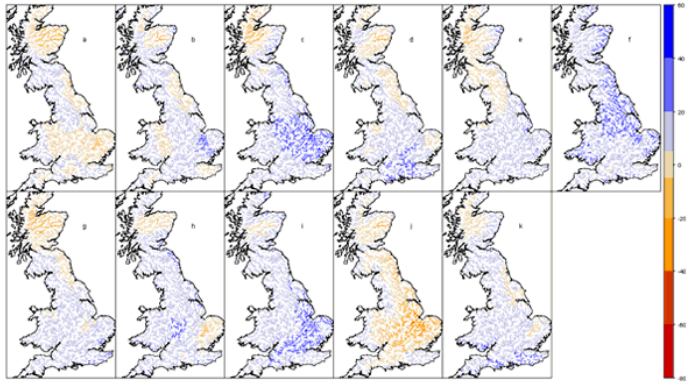
Future Flows Hydrology: an ensemble of daily river flow and monthly groundwater levels for use for climate change impact assessment across Great Britain

C. Prudhomme[1], T. Haxton[2], S. Crooks[1], C. Jackson[3], A. Barkwith[3], J. Williamson[1,*], J. Kelvin[2], J. Mackay[3], L. Wang[3], A. Young[2], and G. Watts[4]

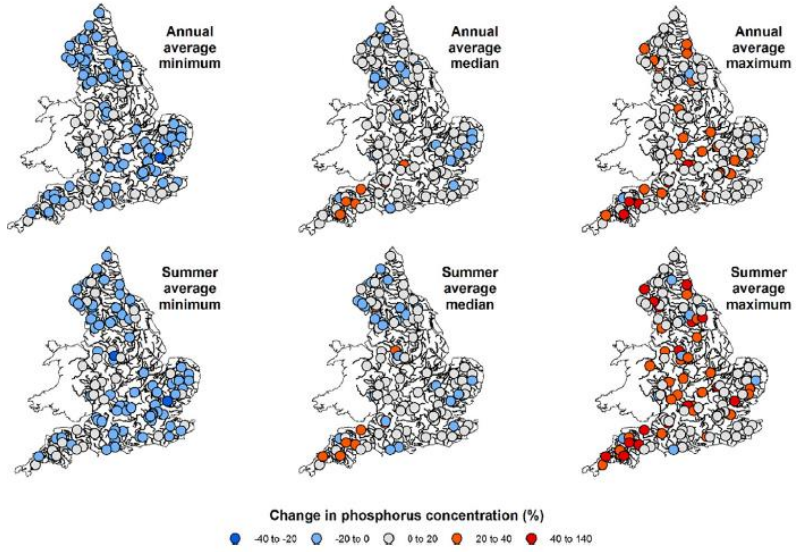
[1]Centre for Ecology and Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OXON, OX10 8BB, UK
[2]Wallingford HydroSolutions, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OXON, OX10 8BB, UK
[3]British Geological Survey, Environmental Science Centre, Keyworth, Nottingham, NG12 5GG, UK
[4]Environment Agency for England and Wales, Horizon House, Deanery Road, Bristol, BS1 5AH, UK
*now at: Dwr Cymru, Welsh Water, Caernarfon, UK

Correspondence to: C. Prudhomme (chrp@ceh.ac.uk)

Received: 26 November 2012 – Published in Earth Syst. Sci. Data Discuss.: 4 December 2012
Revised: 8 February 2013 – Accepted: 12 February 2013 – Published: 13 March 2013



The predecessor to eFLaG: Future Flows (2013)



Used for water quality…. (e.g. future phosphorous; Charlton et al. 2018)

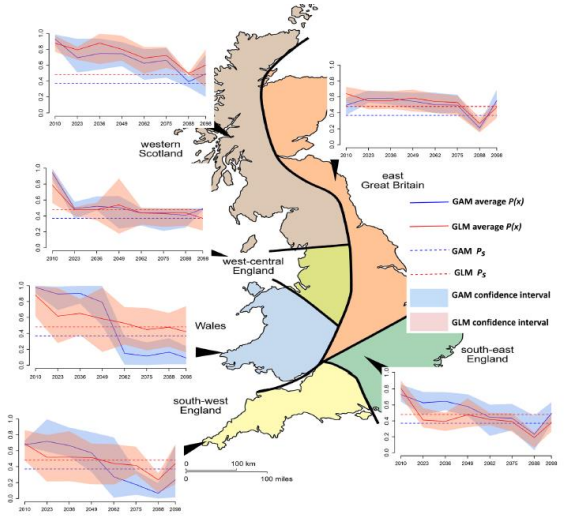


Fig. 2. GAM (blue line) and GLM (red line) predicted trends in the regionalized average $P(x)$ of Dipper (y axes), between a baseline period through seven future periods (x axes), with shaded regions illustrating the range between 5th and 95th percentiles as an indication of the uncertainty in climate predictions across the 11 plausible scenarios. Dashed lines represent P_s for both the GAM and GLM models, whereby values above and below the lines represent a likelihood of occurrence and absence, respectively.

…to hydroecology. (e.g. future bird distributions; Royan et al. 2015)

<u>Final Thoughts:</u> potential for other applications. Please let us know if you see a use for eFLaG

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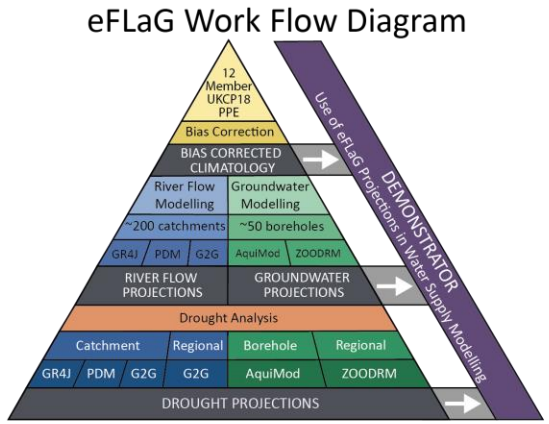
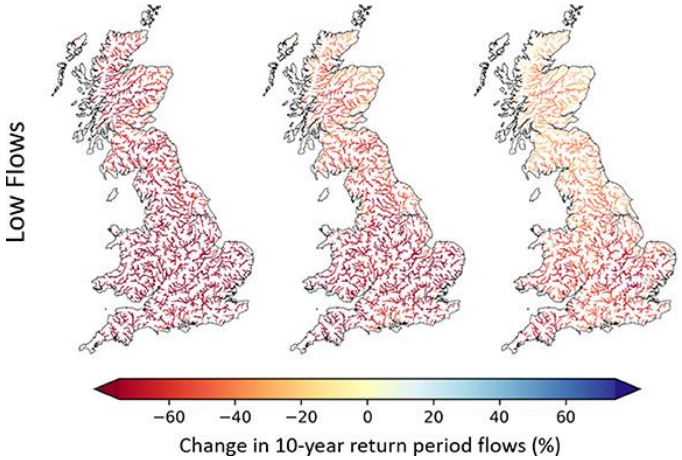
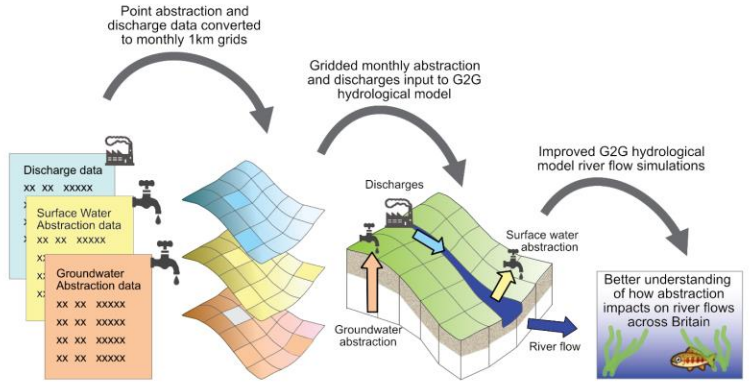
A follow-up: adding the human dimension (CS-N0W)



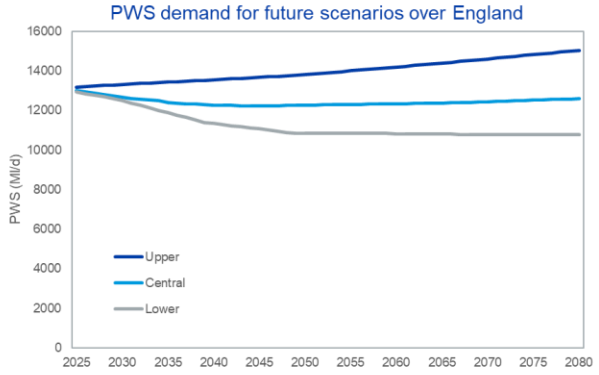
- Building on the latest UKCP18 climate and river flow projections (eFLaG)…



…including 1km gridded *naturalized* model flows (Grid2Grid) projections to 2080….



- Building on MaRIUS layer of Artificial Influences (abstractions and discharges)…(Rameshwaran et al. 2021)

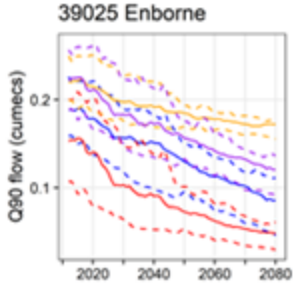


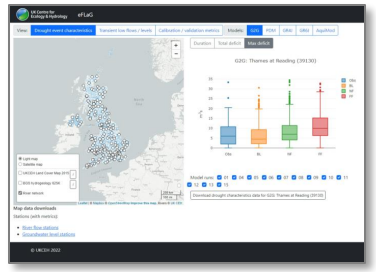
…perturbed by new scenarios of future water demand (Baron et al. 2022)…

New projections of future water availability *(naturalised and influenced)* at 1km resolution

Analyse projections to quantify future changes (e.g. drought, low flows)

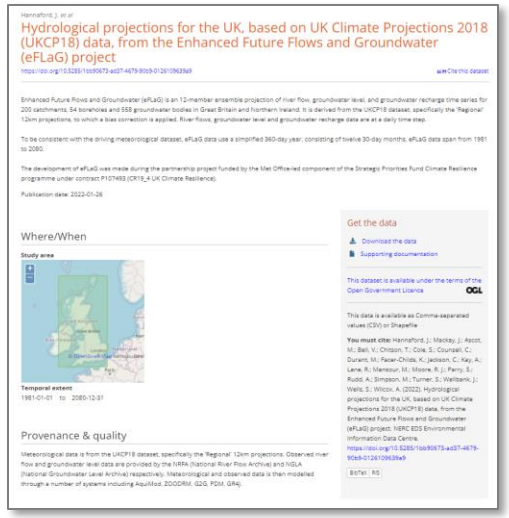
Tools for data access and visualisation



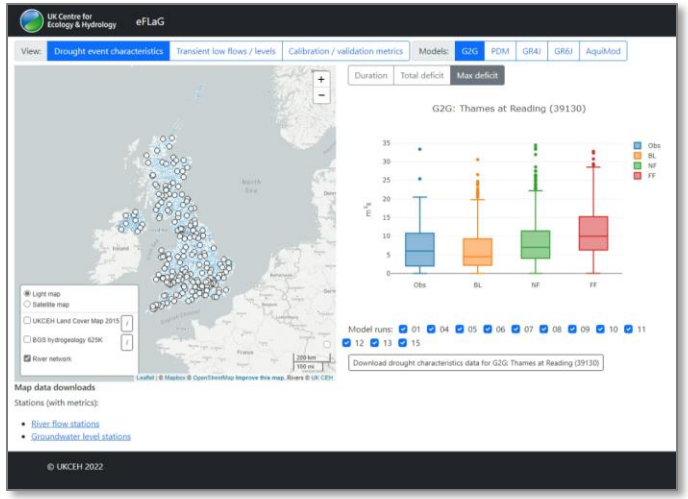


More information…

[Data Paper,](#) Earth Systems Science Data



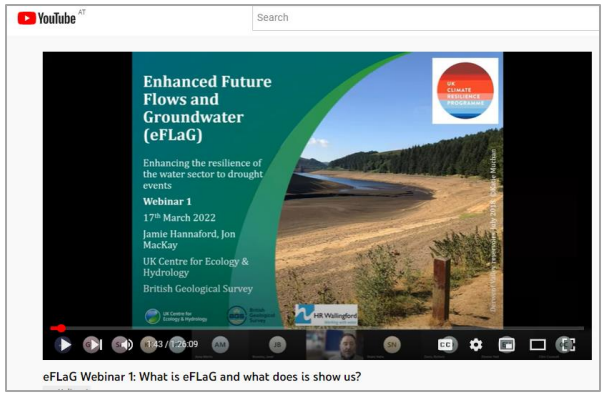
[DOI Dataset](#) outputs with Environmental Informatics Data Centre (EIDC)



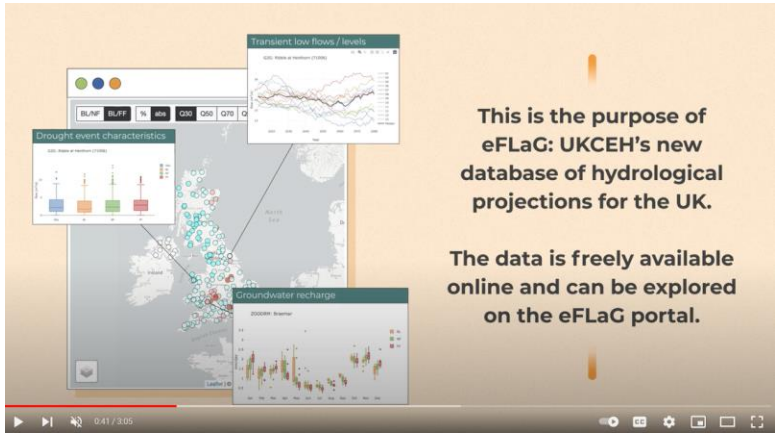
eFLaG interactive Web [Portal](#)

Papers on drought analyses:

Parry et al. submitted(HESS)
Tanguy et al. submitted (ERL)



Webinars on [YouTube](#)



Data Stories on [YouTube](#)

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Thank you

jaha@ceh.ac.uk

This study was funded by the Met Office-led component of the Strategic Priorities Fund Climate Resilience programme (https://www.ukclimateresilience.org) under contract P107493 (CR19_4 UK Climate Resilience).

Summary on key benefits of eFLaG:

- Accessible (DOI dataset, Portal)
- Transient
- Spatially coherent
- Nationally consistent
- Ensemble based (climate model uncertainty)
- Multimodel (hydrology model uncertainty)

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Ladybower reservoir
Sat 12th November 2022
40% full