Advances in drought monitoring and early warning in the UK

Jamie Hannaford

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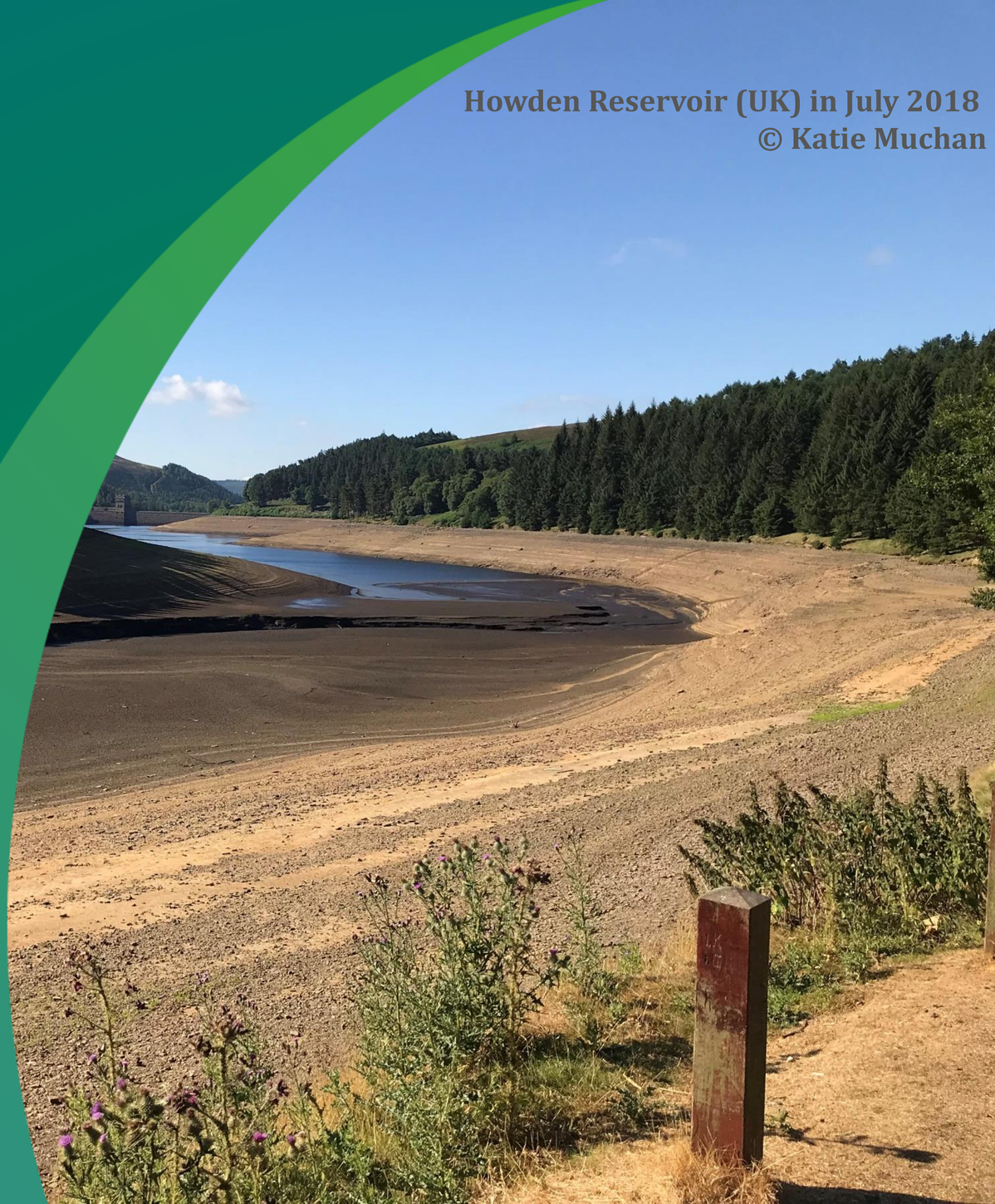
With thanks to many UKCEH Colleagues

UK Centre for Ecology & Hydrology

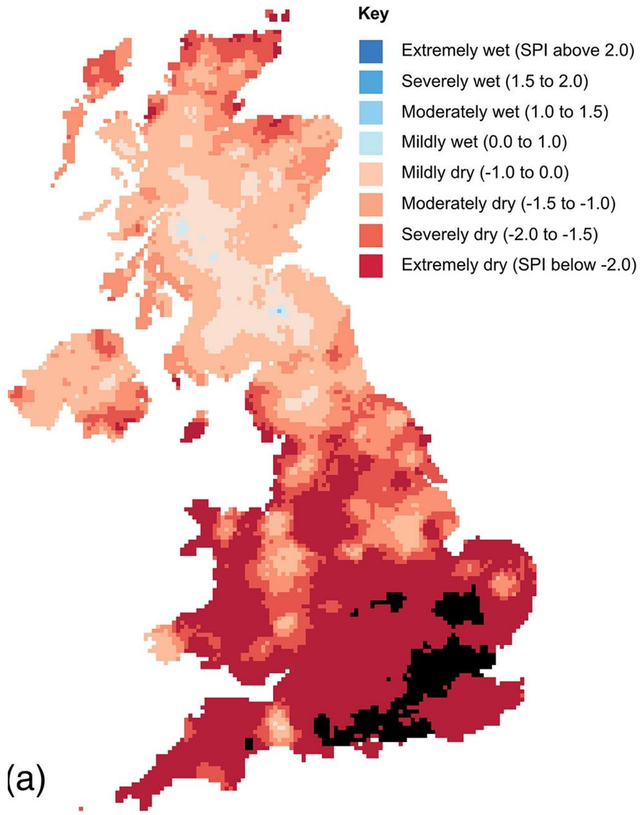
ICARUS



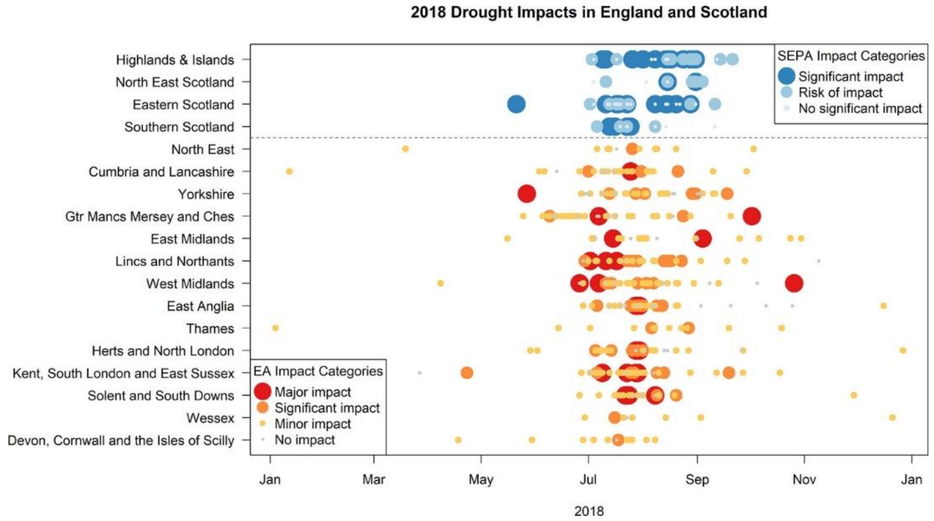
Howden Reservoir (UK) in July 2018
© Katie Muchan

Yes , we do have droughts in the UK!

The 2018 – 2019 drought



Record-breaking June 2018 aridity



Drought impacts captured by regulators in England and Scotland in 2018

Howden Reservoir (UK) in July 2018 © Katie Muchan

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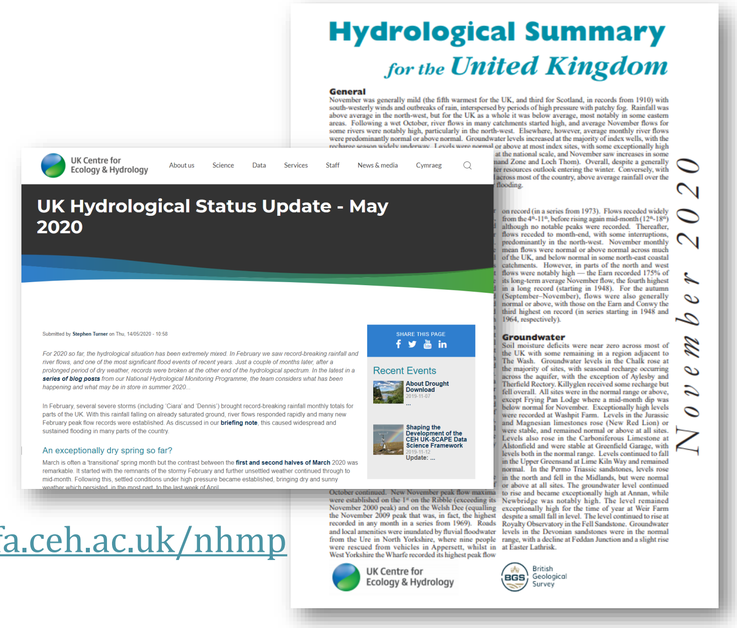
Steve Turner et al. 2021. *Weather*

Monitoring and early warning (MEW) 1980s - present

National Hydrological Monitoring Programme

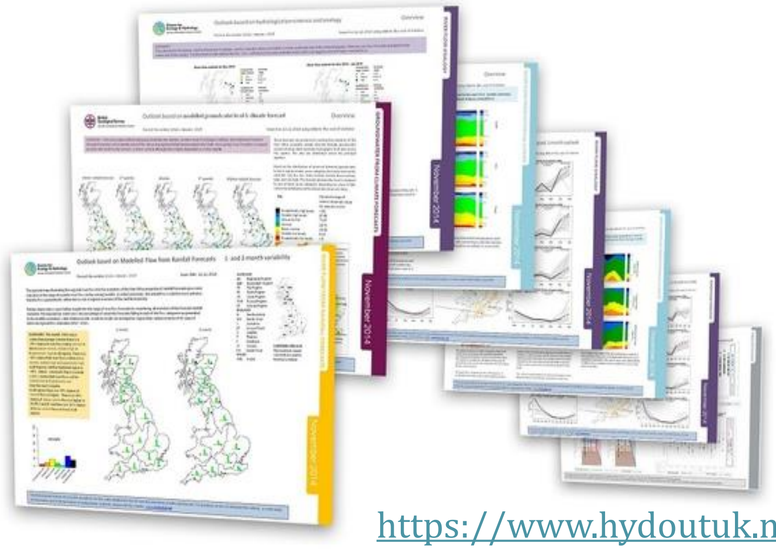


https://nrfa.ceh.ac.uk/nhmp

‘Where are we now’?

Monthly status updates, briefing reports (since 1988)

UK Hydrological Outlook



https://www.hydoutuk.net/

‘Where are we heading?’

Monthly Outlooks for the next 1 – 3months (since 2013)

UK Centre for Ecology & Hydrology

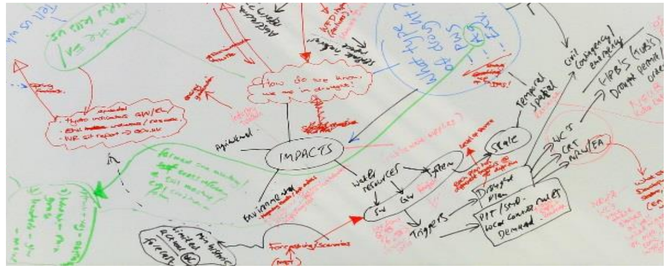
UK-SCAPE
UK Status, Change and Projections of the Environment

Prudhomme et al. 2017. *Hyd. Sci. J.*

New approaches to MEW: engaging decision-makers

Workshops in 2015-2016

→ Delegates from government, environmental regulators, public water suppliers, farmers, power generation & public health



Different sectoral needs (e.g. timescales)
but some similarities
(e.g. historical benchmarks)

Translation of national scale tools to local-scale impacts & decision making needed

Types of drought e.g. meteorological, agricultural, hydrological….
'whisky', 'salmon', 'navigational'?

Importance & diversity of **impacts** but not systematically collected

Consistent messaging helps with drought management & communication

Hannaford et al. 2018. Weather Climate and Society.
https://doi.org/10.1175/WCAS-D-18-0042.1

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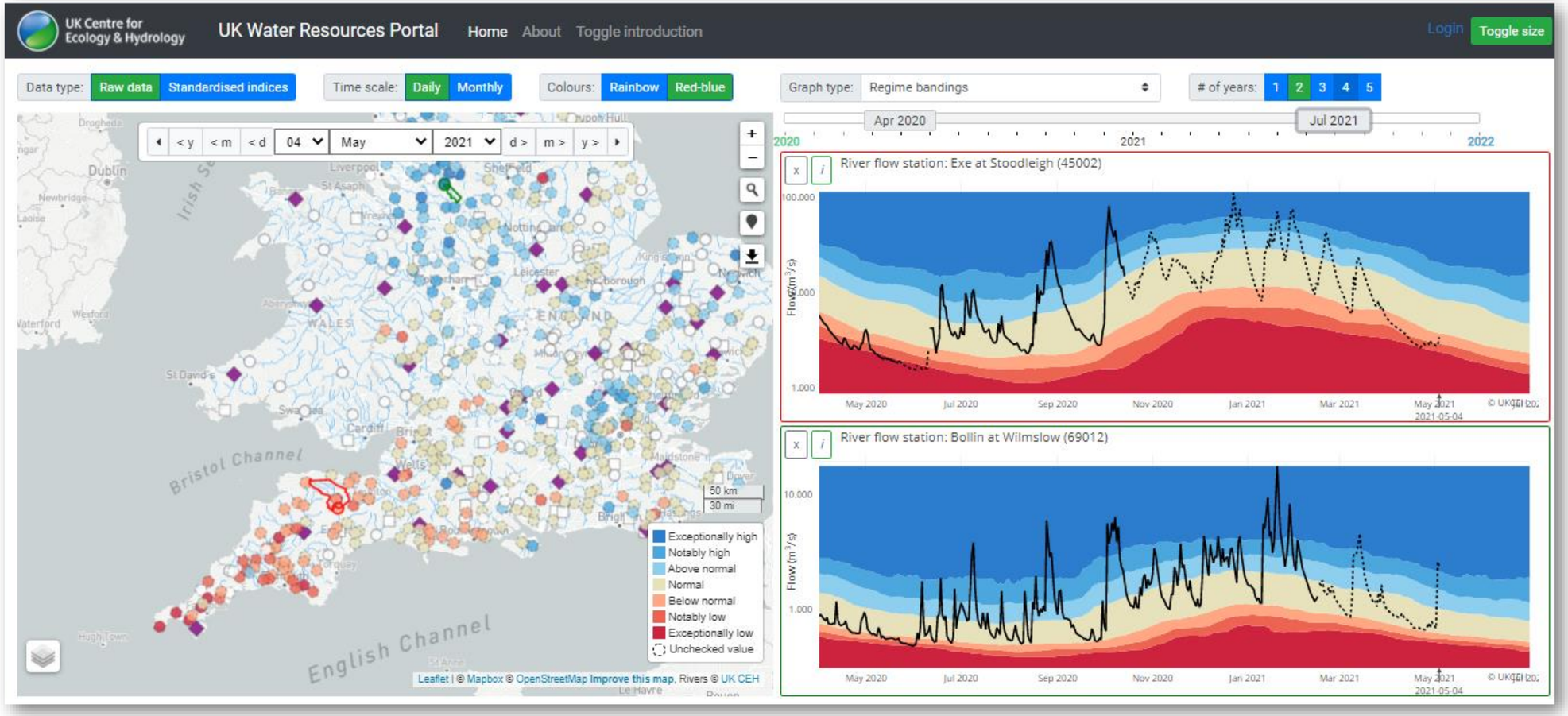
Historic Droughts

IMPETUS
IMPROVING PREDICTIONS OF UK DROUGHT

driver

Interactive, real-time status monitoring



- Daily **real-time** river flows (>900 sites)
- **Real-time** COSMOS-UK soil moisture (50 sites)
- Groundwater (>50 boreholes)
- Rainfall (900 catchments and 1km^2 grid across UK)

Matt Fry, Gemma Nash
Paper by Lucy Barker in review in *Frontiers* Special Issue

https://eip.ceh.ac.uk/hydrology/water-resources/

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UK-SCAPE
UK Status, Change and Projections of the Environment

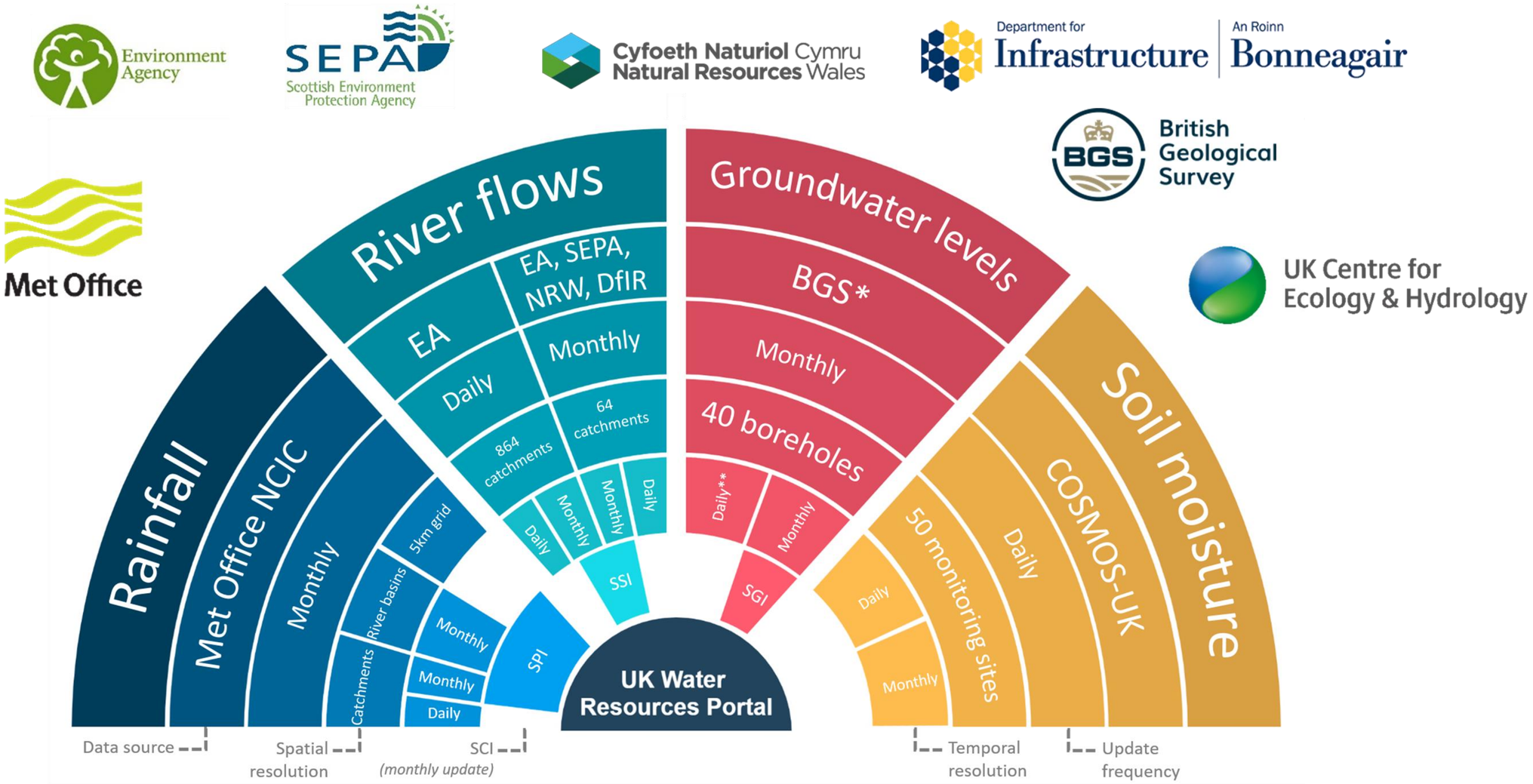
Design input from:

Environment Agency

South West Water

About Drought
Maximising the impact of UK research on drought & water scarcity

What's on the Portal?



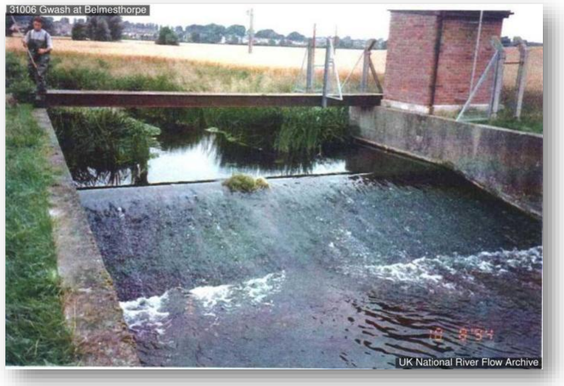
- **Rainfall: from 1891**
- **River flows & groundwater: from 1960s/1970s (some longer)**
- **COSMOS-UK: from 2013+**

UK Centre for Ecology & Hydrology

Lucy Barker et al. in press. *Frontiers in Environmental Science*

Innovations in *real-time* data feeding the portal

National River Flow Archive



https://nrfa.ceh.ac.uk/

UK National River Flow Archive

Primary hydrological archive for the UK, >1400 **river flow** gauging stations

Now providing **real-time daily data** via the Environment Agency and SEPA **APIs**

COSMOS-UK

https://cosmos.ceh.ac.uk/

COSMOS-UK

National **soil moisture** observatory of >50 sites

Wide area (12ha), **real-time (15mins)**

Dixon et al. 2013. *Hyd. Sci. J.*
Cooper et al. 2021. *ESSD*

How does it all work?

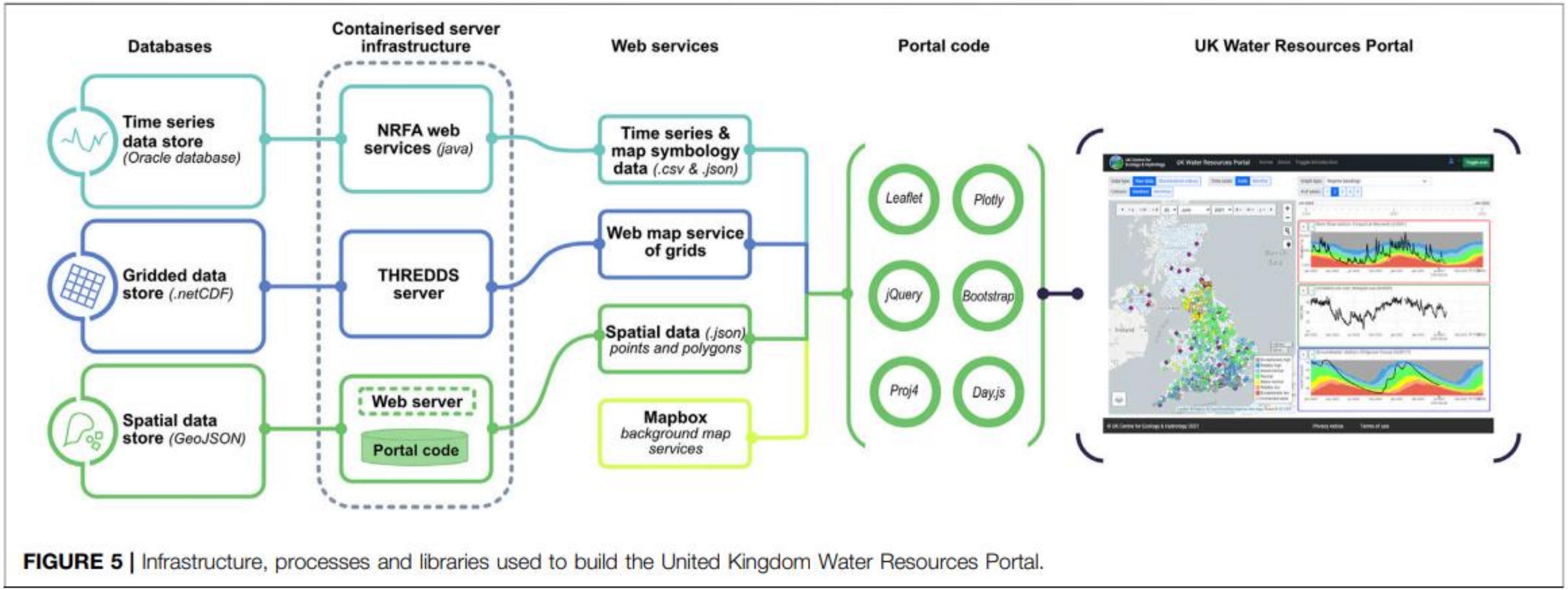
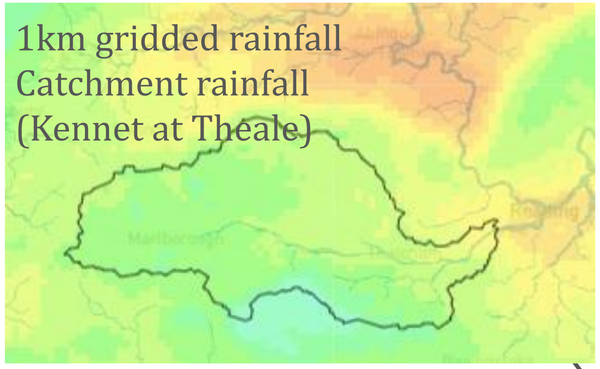
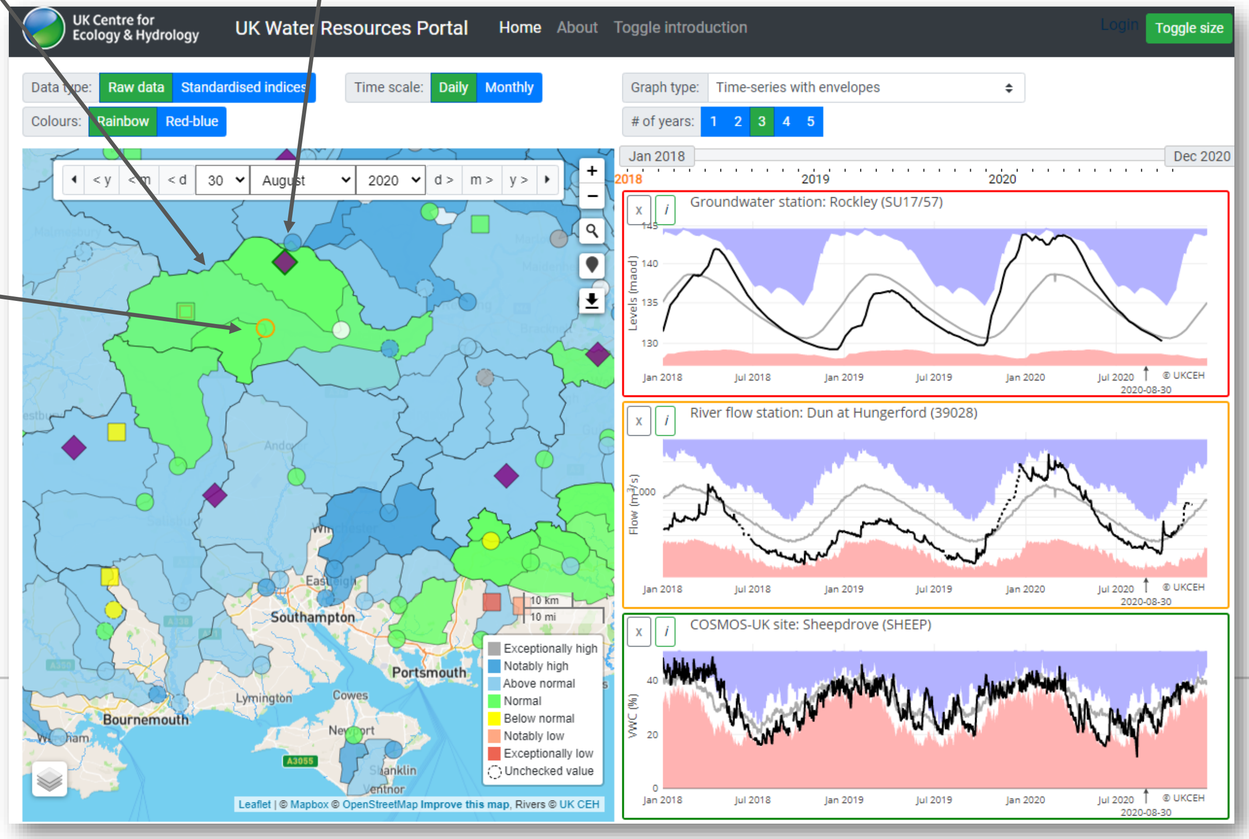


FIGURE 5 | Infrastructure, processes and libraries used to build the United Kingdom Water Resources Portal.

Lucy Barker et al. in press. *Frontiers in Environmental Science*

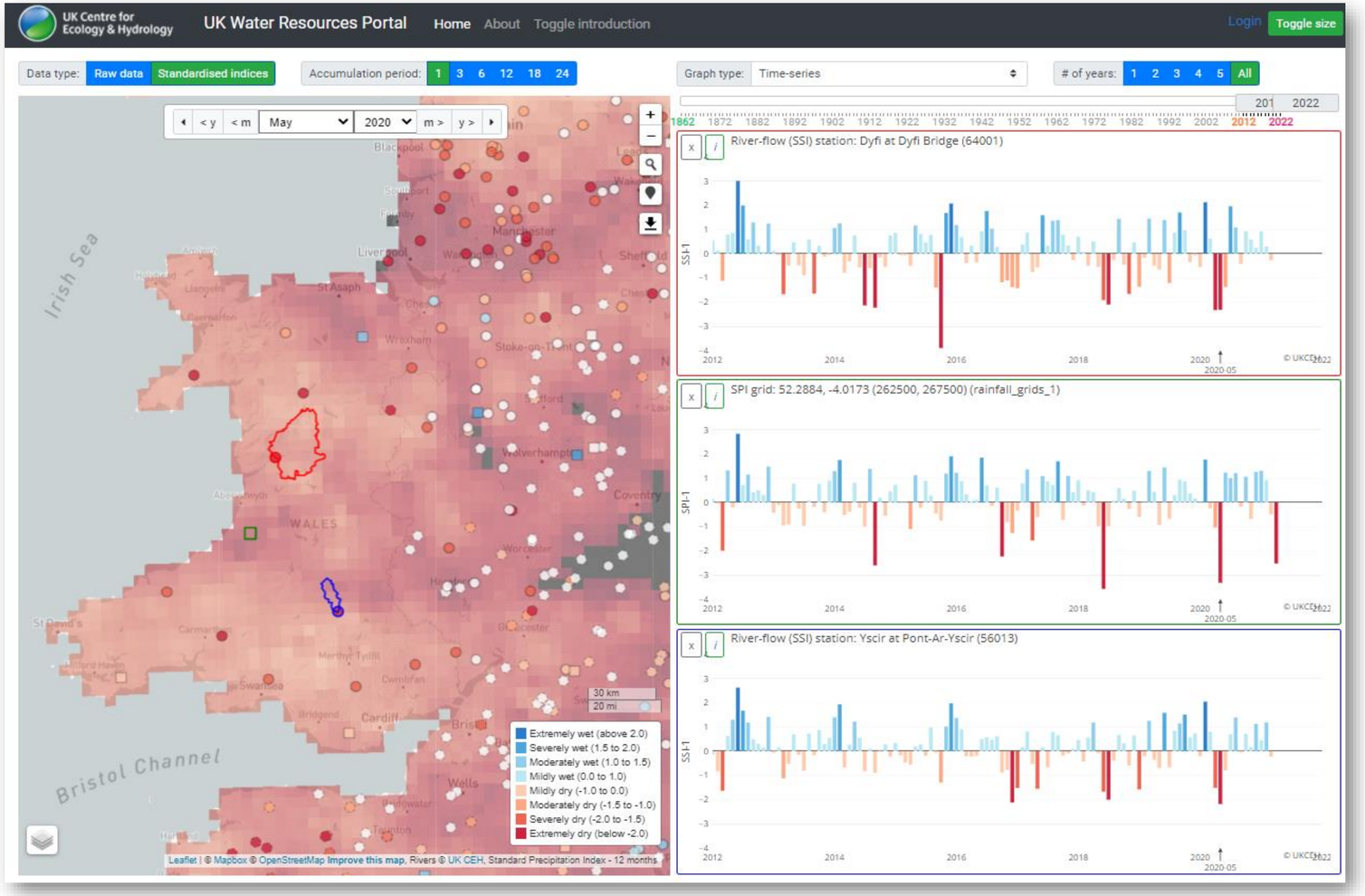
Data integration across the water cycle





Layering catchment rainfall, soil moisture, river flows and groundwater

Interactive, real-time drought status monitoring



"We are actively promoting the use of the Portal via our drought teams and its referenced in our NRW drought plan… as a source for looking (at the) water situation"
Water Resources lead, Natural Resources Wales

"we use the portal…when water resources are tight. We manage increasing restrictions, and justifying that is backed up by stats from the Portal"
Principal Hydrologist, Canal and Rivers Trust

"I used the Portal during the 2018 drought. It was useful in showing how serious the situation was compared to the past. Data was used alongside other evidence on drought permit applications…."
Senior hydrologist, Yorkshire Water

UK Centre for Ecology & Hydrology

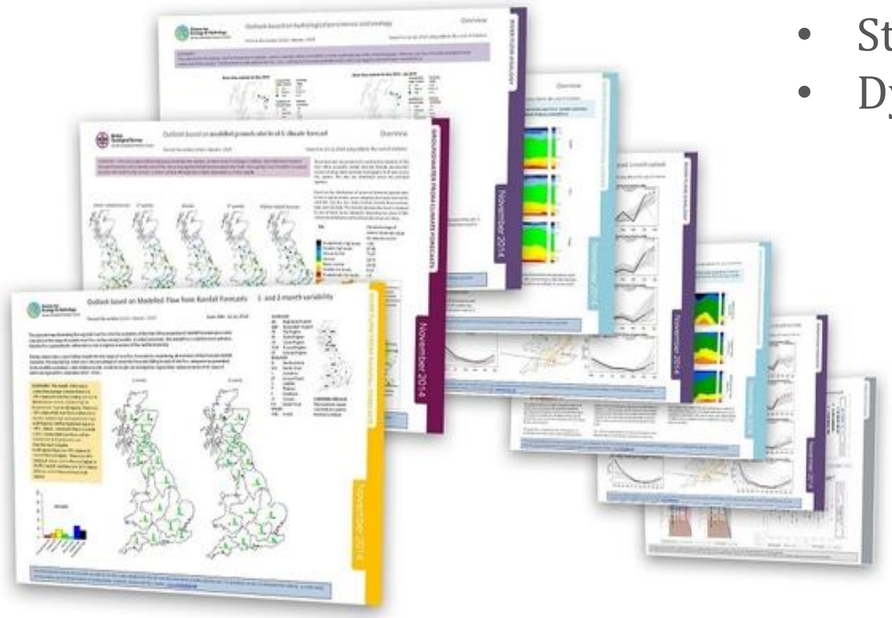
https://eip.ceh.ac.uk/hydrology/water-resources/

About Drought
Maximising the impact of UK research on drought & water scarcity

Forecasting: the Hydrological Outlook UK

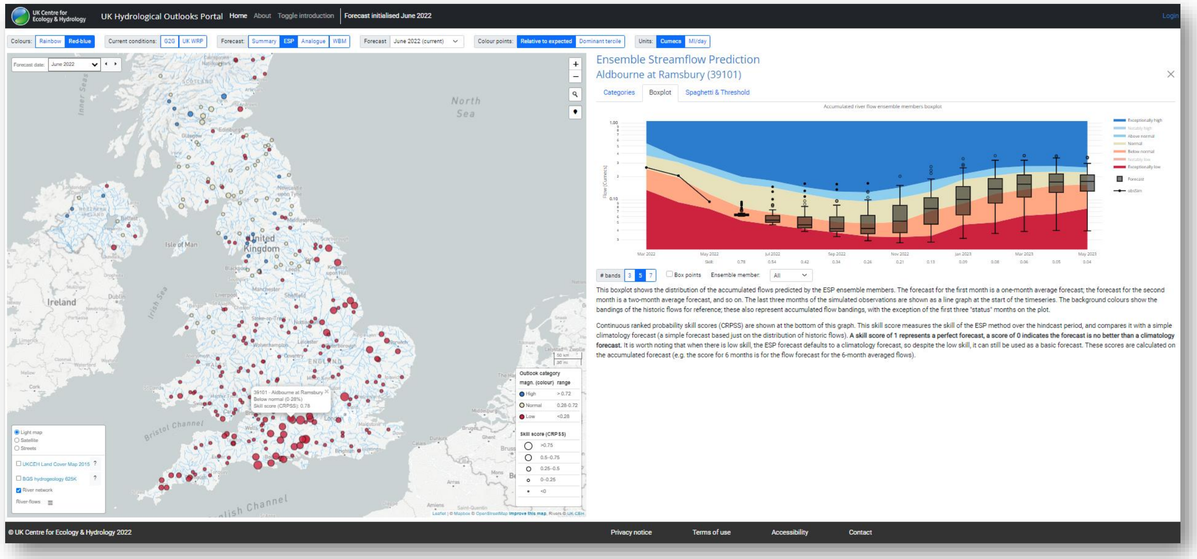
An operational seasonal forecasting service, running since 2013
Flows and Groundwater 1 – 3 months ahead

- Ensemble Streamflow Prediction
- Statistical (Analogue/persistence)
- Dynamical met -> hydro forecasts



https://www.hydoutuk.net/

Monthly reports since 2013



NEW interactive Portal (Apr 2022)
https://eip.ceh.ac.uk/hydrology/outlooks/

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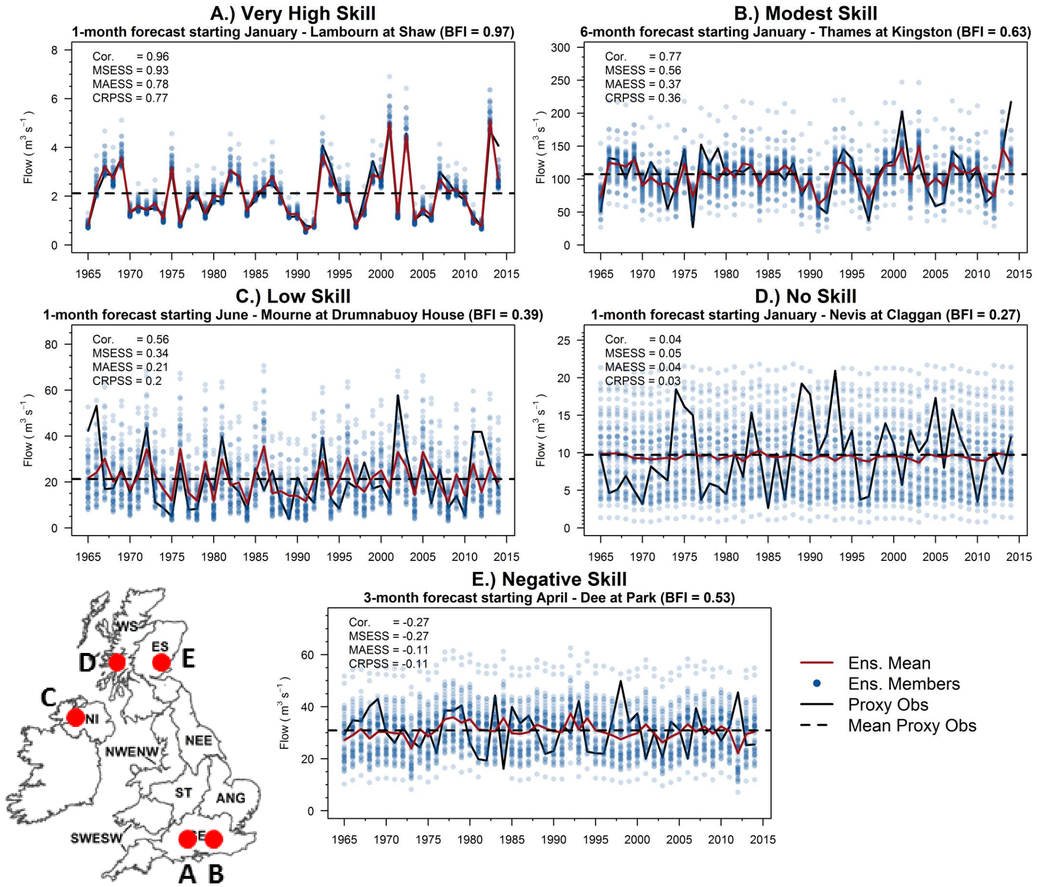
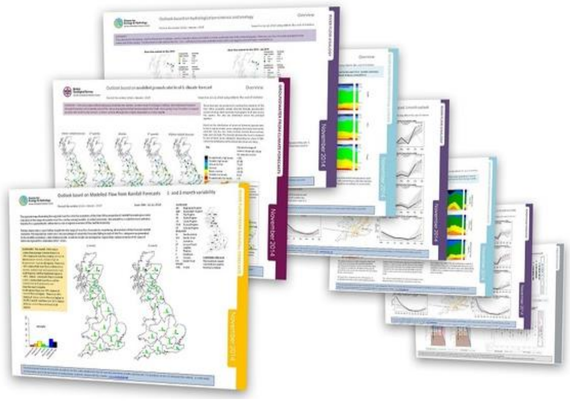
UK Hydrological Outlook

Overview of the methods in the Hydrological Outlook:
Prudhomme et al. 2017. *Hyd. Sci. J.*

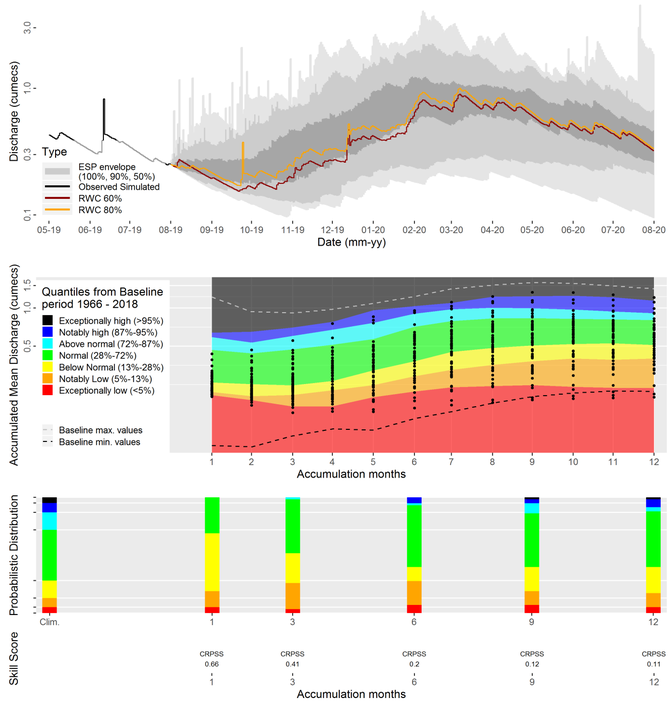
Enhancements in UK seasonal forecasting





UK Hydrological Outlook

12-month ESP forecast from August 2019
Catchment: Pang at Pangbourne (39027)



The Continuous Ranked Probabilistic Skill Score (CRPSS) is one of many scores used by forecasters to assess how skilful (how good) a forecasting system is. It tells us how much better the forecast is at predicting streamflow compared to a benchmark (here: the climatology or long term average). The degree of skill based on CRPSS: very high [0.75, 1]; high [0.5, 0.75); moderate [0.25, 0.5); low (0, 0.25); no skill=0; and negative skill<0 (meaning climatology is a better predictor of what is going to happen than the forecast). To find out how these skill scores were derived, see Harrigan et al. (2018): https://www.hydrol-earth-syst-sci.net/22/2023/2018/hess-22-2023-2018.html

ESP forecasts: variable but useful skill, especially in south-east England

Operationalised in the Hydrological Outlook
Paving the way for making accessible forecasts

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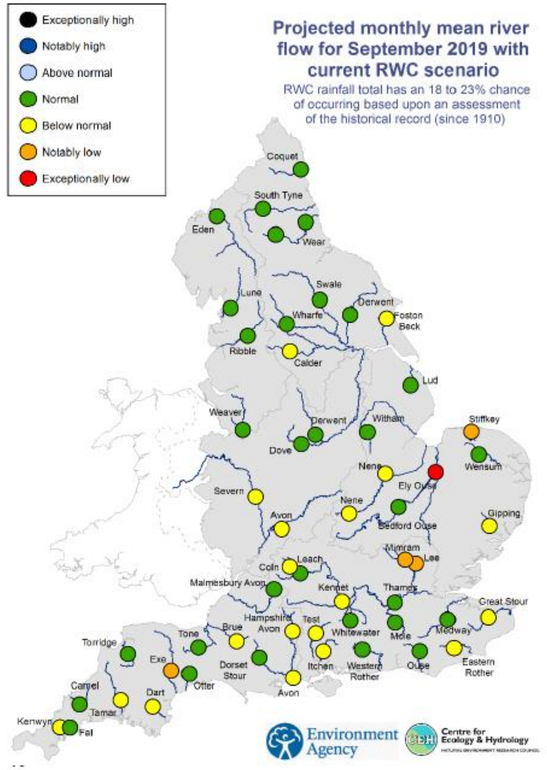
Shaun Harrigan et al. 2017. *HESS*

Engaging users with forecasts

Aim: Work with water managers to demonstrate the benefits of drought forecasts and overcome barriers to uptake

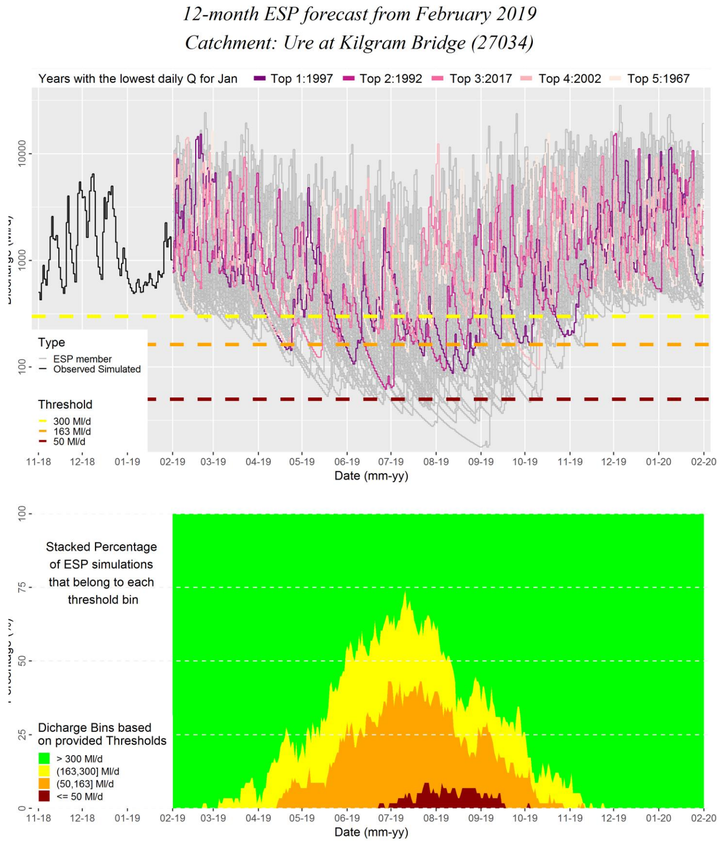
Co-evaluation: How do we co-design and evaluate the forecast reliability, uncertainties, spatial/temporal scales?

Best format to provide our streamflow forecasts?



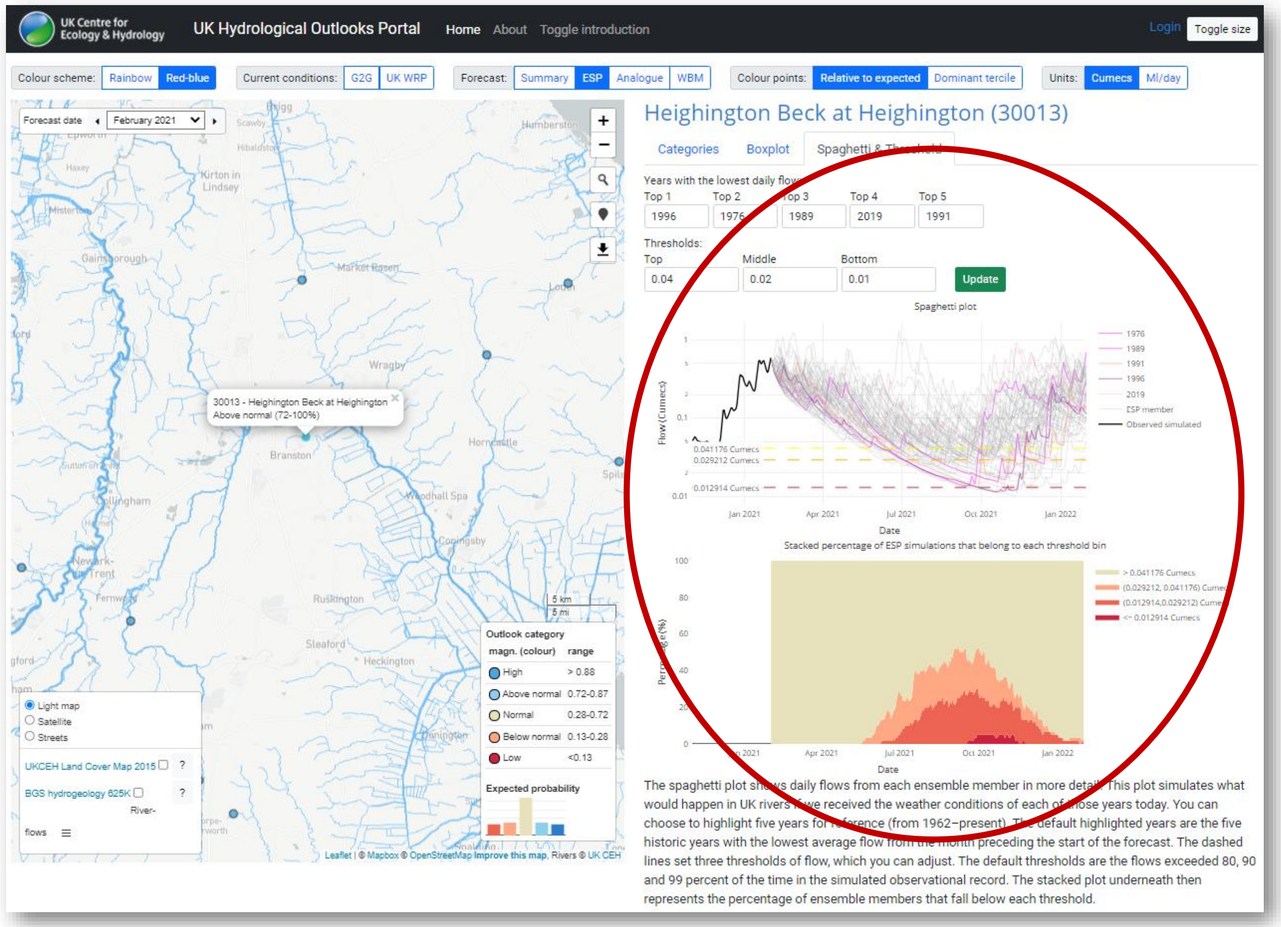
‘Reasonable Worst Case’ scenarios
Provided to EA in the 2018-2019 drought

from use cases to operational systems….



YorkshireWater

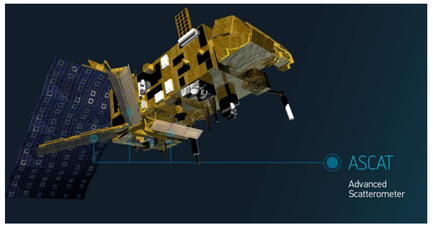
Custom forecasts for 2018-2019 drought
When will we reach restrictions ('Hands-off Flows')?



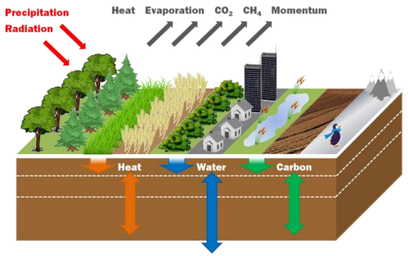
NEW Hydrological Outlooks Portal

Where next? Advances in *spatial* soil moisture

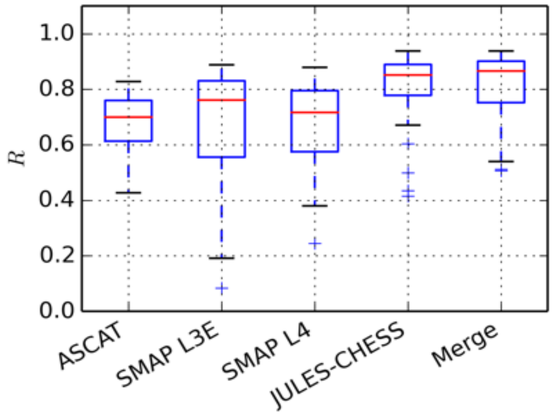
COSMOS-UK



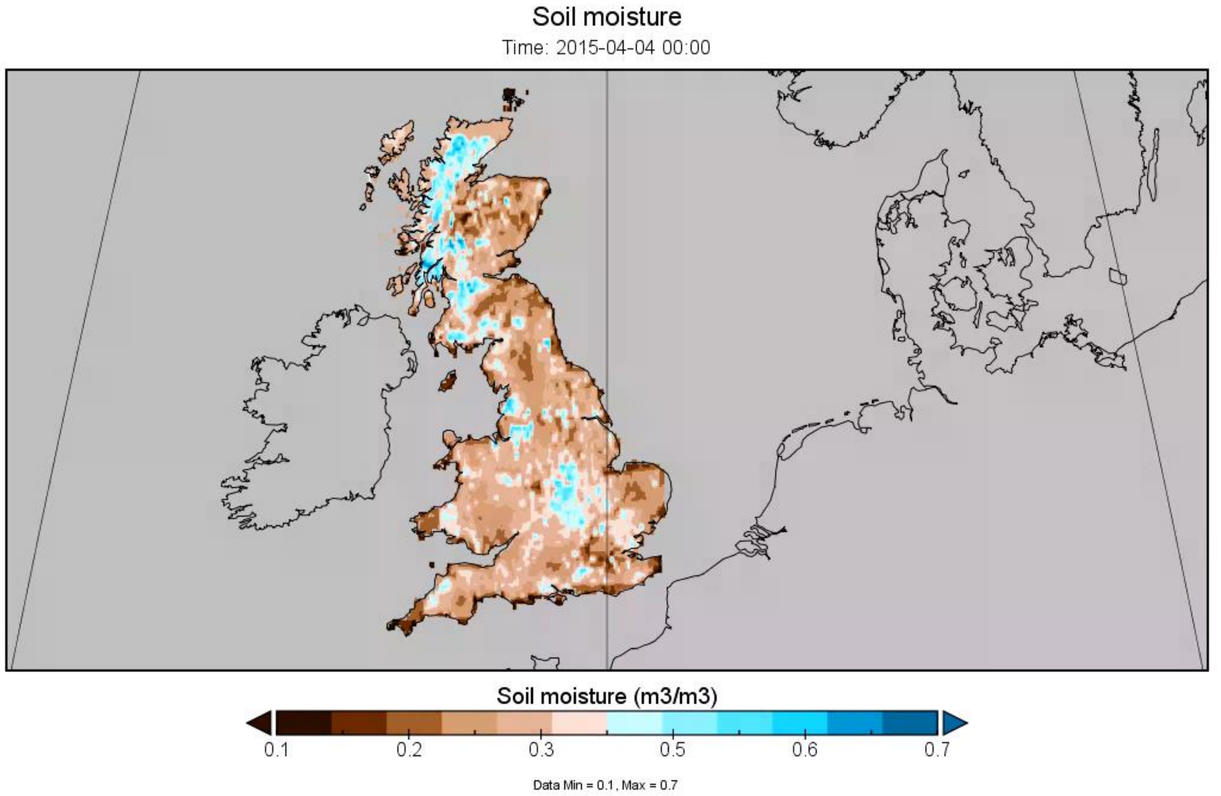
ASCAT Satellite



JULES Land Surface Model



Evaluation of EO, modelled and blended products against COSMOS-UK (Peng et al. 2022)

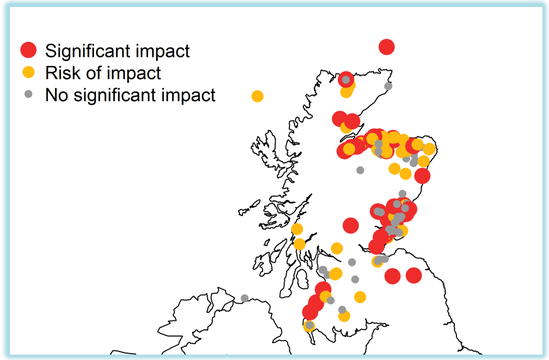


Example of a 1km gridded soil moisture dataset blending Earth Observation & modelling (Tanguy et al. 2022)

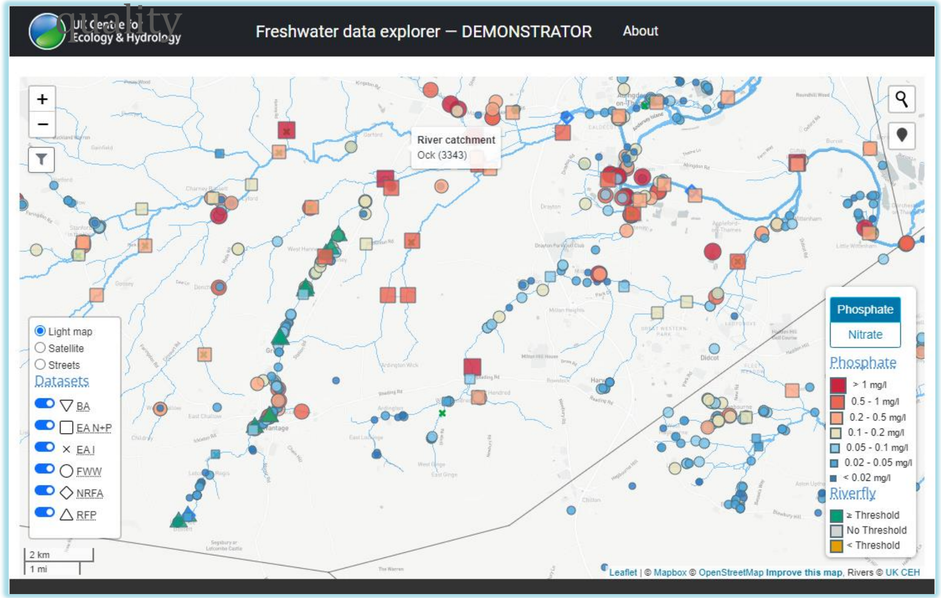
Where next? From indicators to impacts

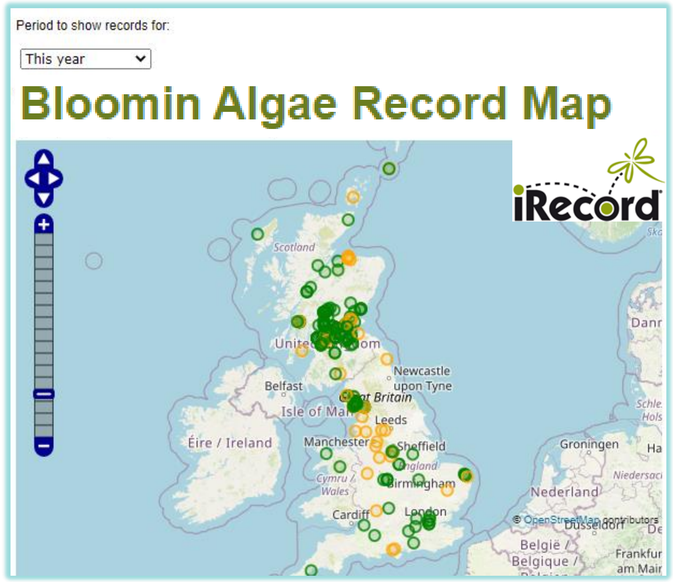
Integrating or linking to impact information for specific sectors: e.g. incident data from regulators, water quality information, reservoir stocks, citizen science tools like Bloomin' Algae, CrowdWater…

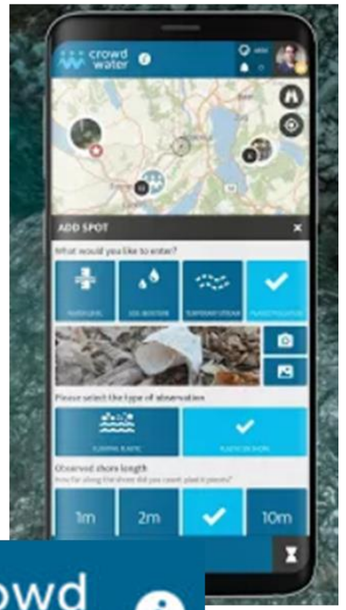
SEPA (Scotland) 2018 drought incidents



Freshwater data explorer – EA (England) and citizen science data for invertebrates and water quality







crowd water

Thank you for listening!

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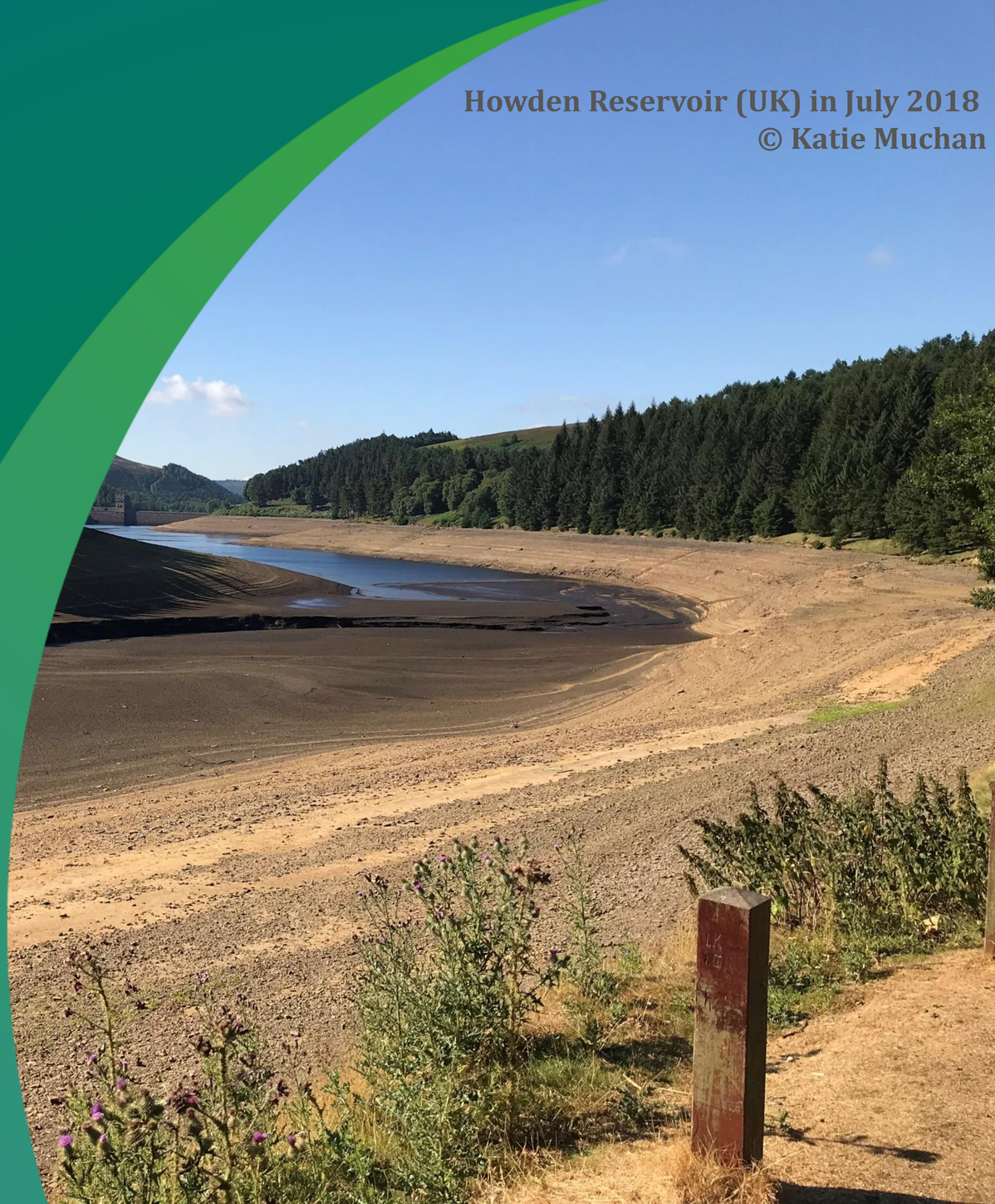

Howden Reservoir (UK) in July 2018
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