Developing user-friendly tools to explore future changes in dissolved organic matter in upland drinking water sources

Don Monteith &
Heidrun Feuchtmayr

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Project Team

Heidrun Feuchtmayr, Amy Pickard, Amy Pickard, Jenny Williamson, Ellie Mackay, Justyna Olszewska, Chris Evans
(Centre for Ecology & Hydrology)

Fraser Leith, Zoe Frogbrook, Nic Booker, Graeme Moore, Jon Moses, Gillian Stewart, Stewart Sutherland
(Scottish Water)

Advisory Group

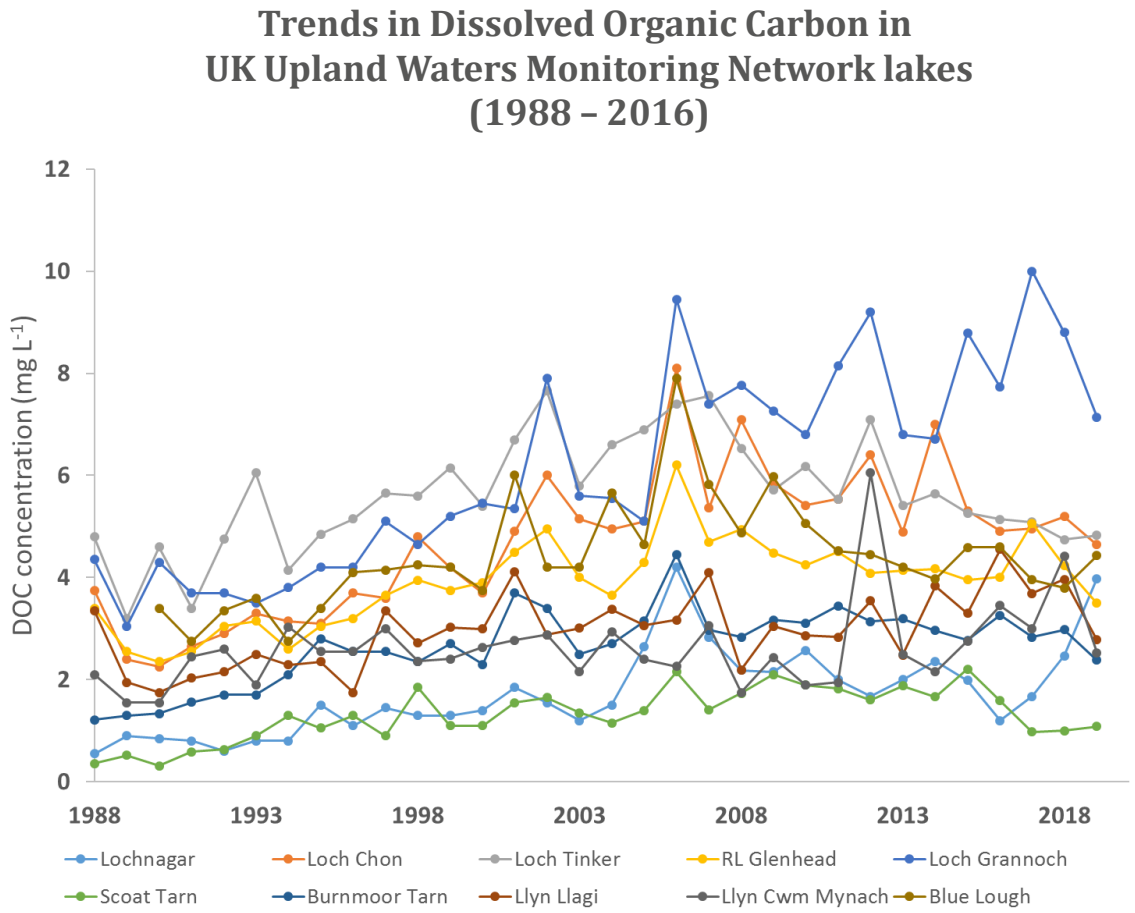
Susan Waldron[1], Pippa Chapman[2], Tara Froggatt/Sophie Straiton[3], Clare Bullen[4], Trudy Higgins/Lorraine Gaston[5]

[1]University of Glasgow, [2]University of Leeds, [3]Welsh Water, [4]United Utilities & [5]Irish Water

Special thanks to local Scottish Water staff

The water industry problem

- Soils of upland drinking water catchments in the UK often contain high amounts of organic matter
- A significant proportion of this ends up in streams and lakes in the form of Dissolved Organic Matter (DOM)
- These catchments have experienced increases in DOM in recent decades
- The Water Industry must minimise DOM levels to avoid:
  - Taste and odour problems
  - Fouling of plant
  - Disinfection Byproduct (DBP) formation
- Significant cost implications for:
  - Coagulant use
  - Sludge removal
  - Energy consumption
  - New infrastructure



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The FREEDOM project

Forecasting **R**isks to upland water treatment assets from the **E**nvironmental **E**xacerbation of **D**issolved **O**rganic **M**atter levels

- **Funded under NERC Environmental Risks to Infrastructure Innovation Programme (ERIIP) – with co-funding from Scottish Water**
- **Initial challenges issued by Scottish Water:**
  - "to gain a better understanding of drivers of change in the quantity and quality of DOM in raw water reaching treatment plant"
  - "to develop capability to predict DOM changes in light of future environmental change"
- **Major project aim:**
  - To develop a visualisation tool to inform the water industry of likely future DOM trajectories for its source waters

Operational definitions

- **Dissolved Organic Matter (DOM):**

All organic matter in water passing through a fine filter (e.g. 0.45 µm)

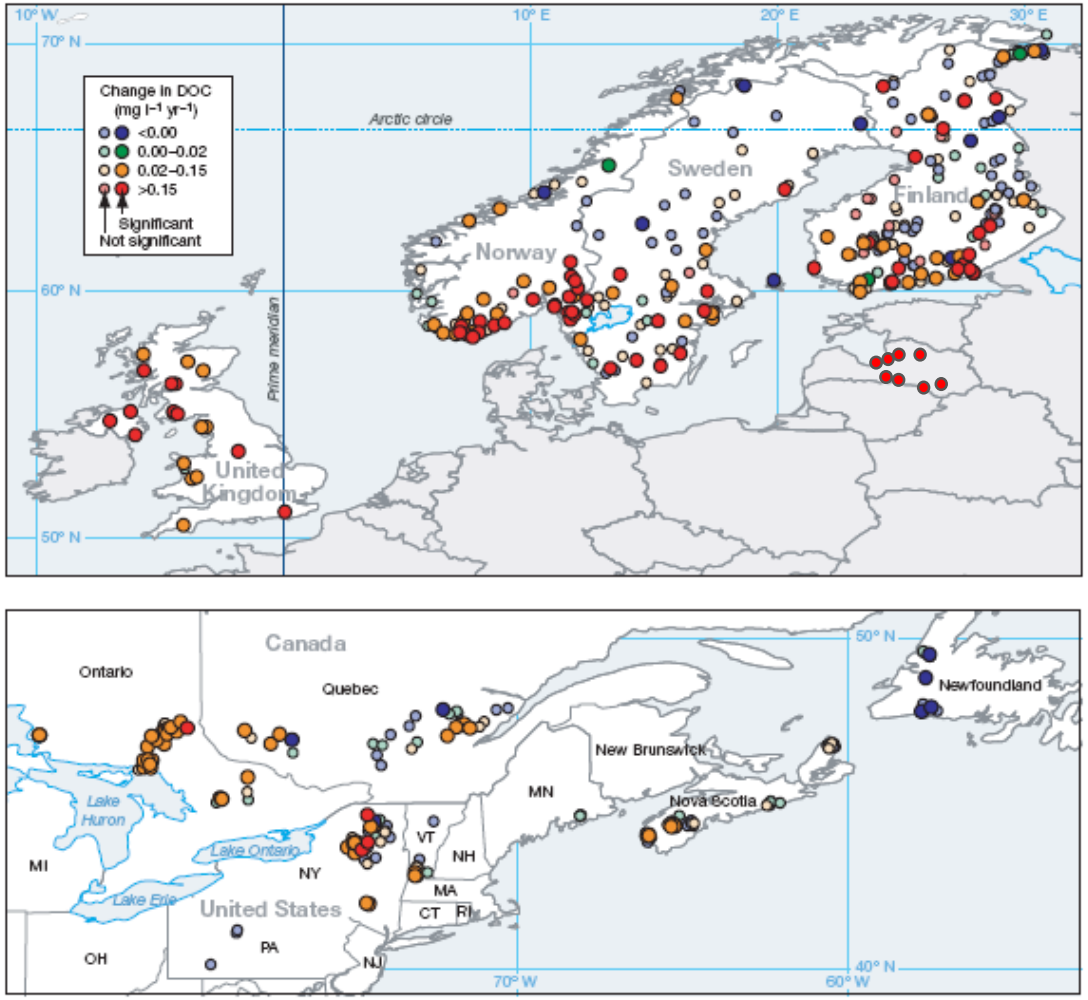
- **Dissolved Organic Carbon (DOC)**

The carbon contained within DOM

- **Total Organic Carbon (TOC)**

All organic carbon in unfiltered water

Rising DOC concentrations in remote surface waters (1990 – 2004)



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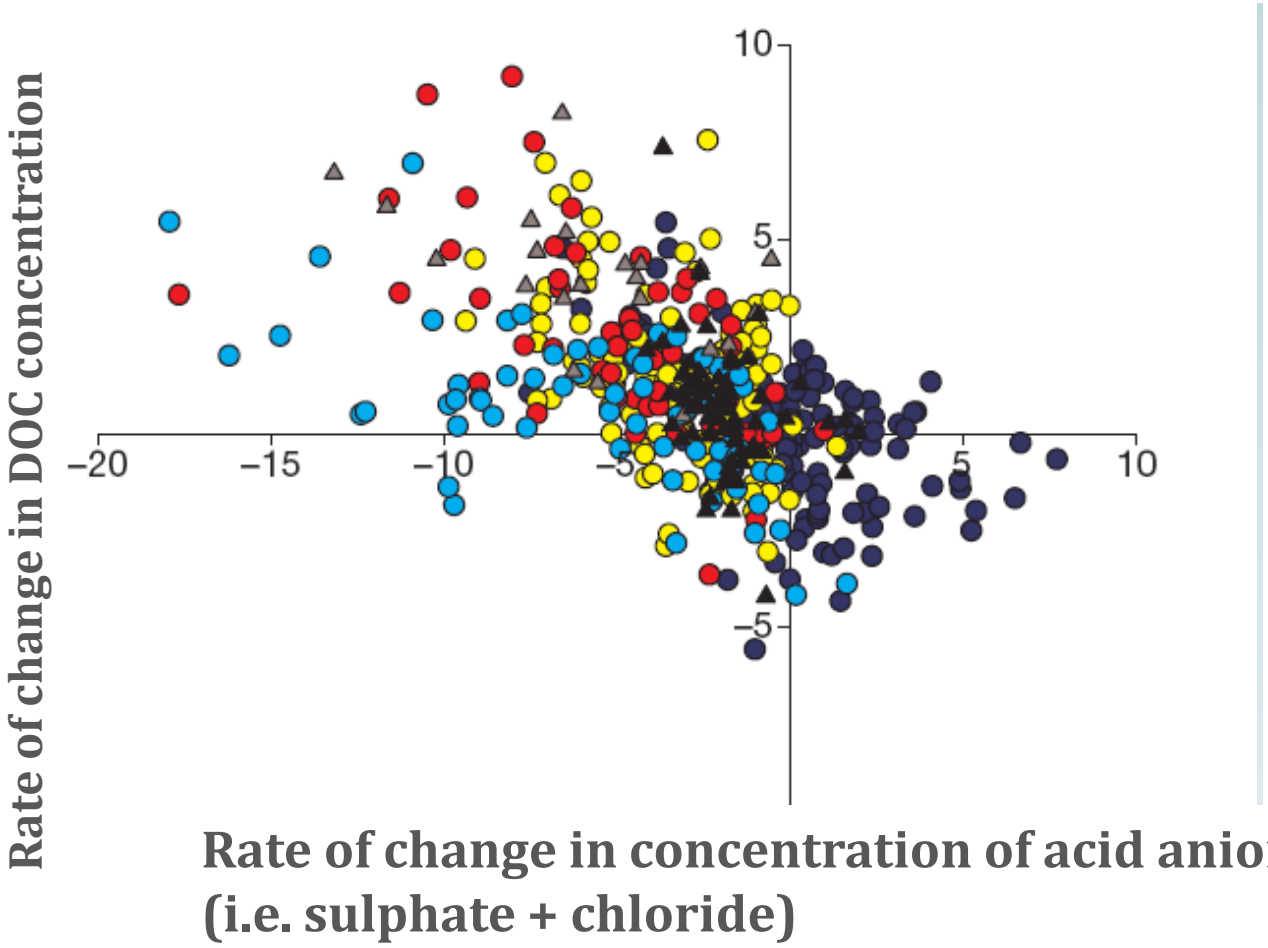
Monteith et al., 2007. Nature

DOC increasing in proportion to reduction in acid pollutants

DOC change versus acid anion change: 522 sites



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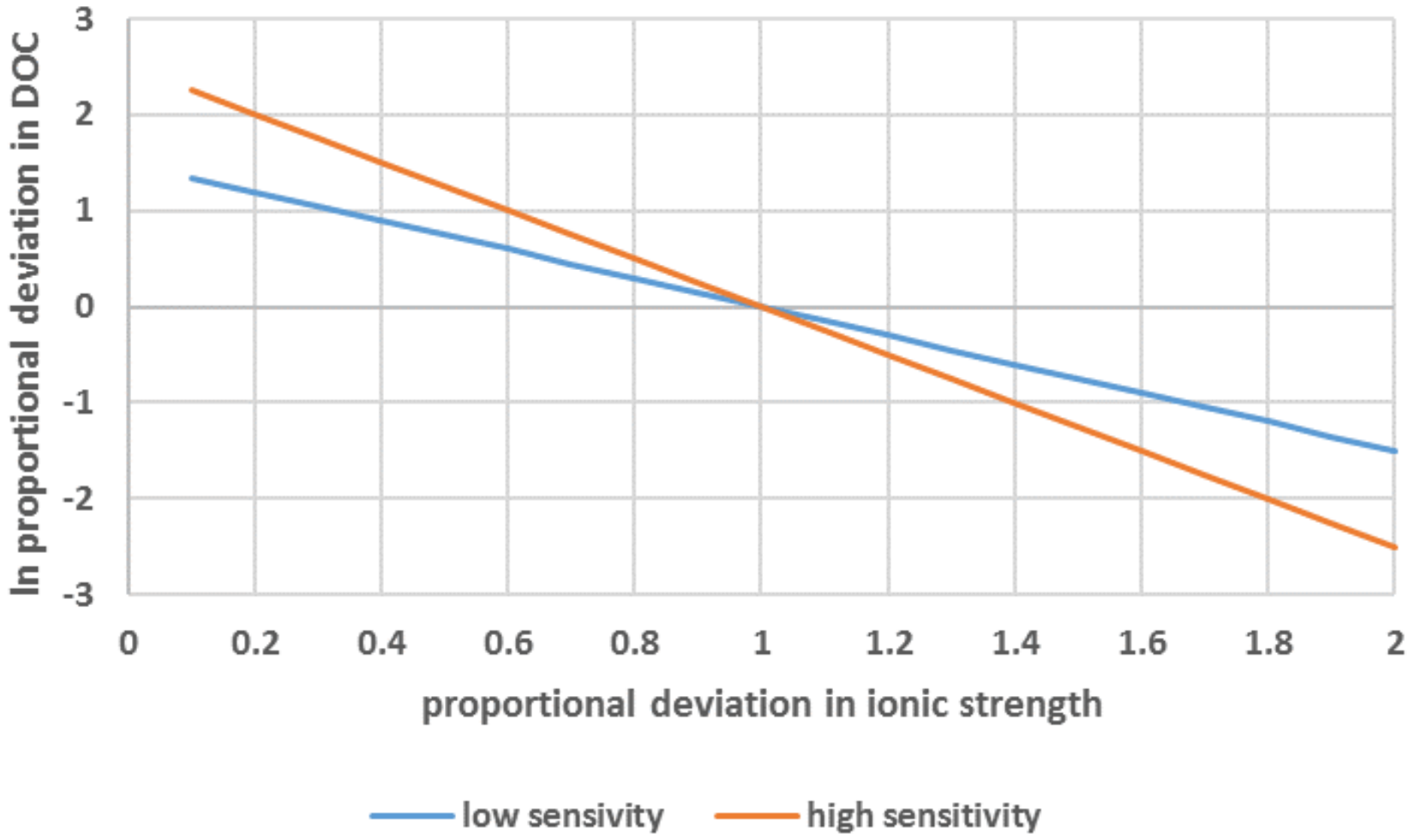
Monteith et al., 2007. Nature

relationship between ionic strength and DOC in UK upland waters



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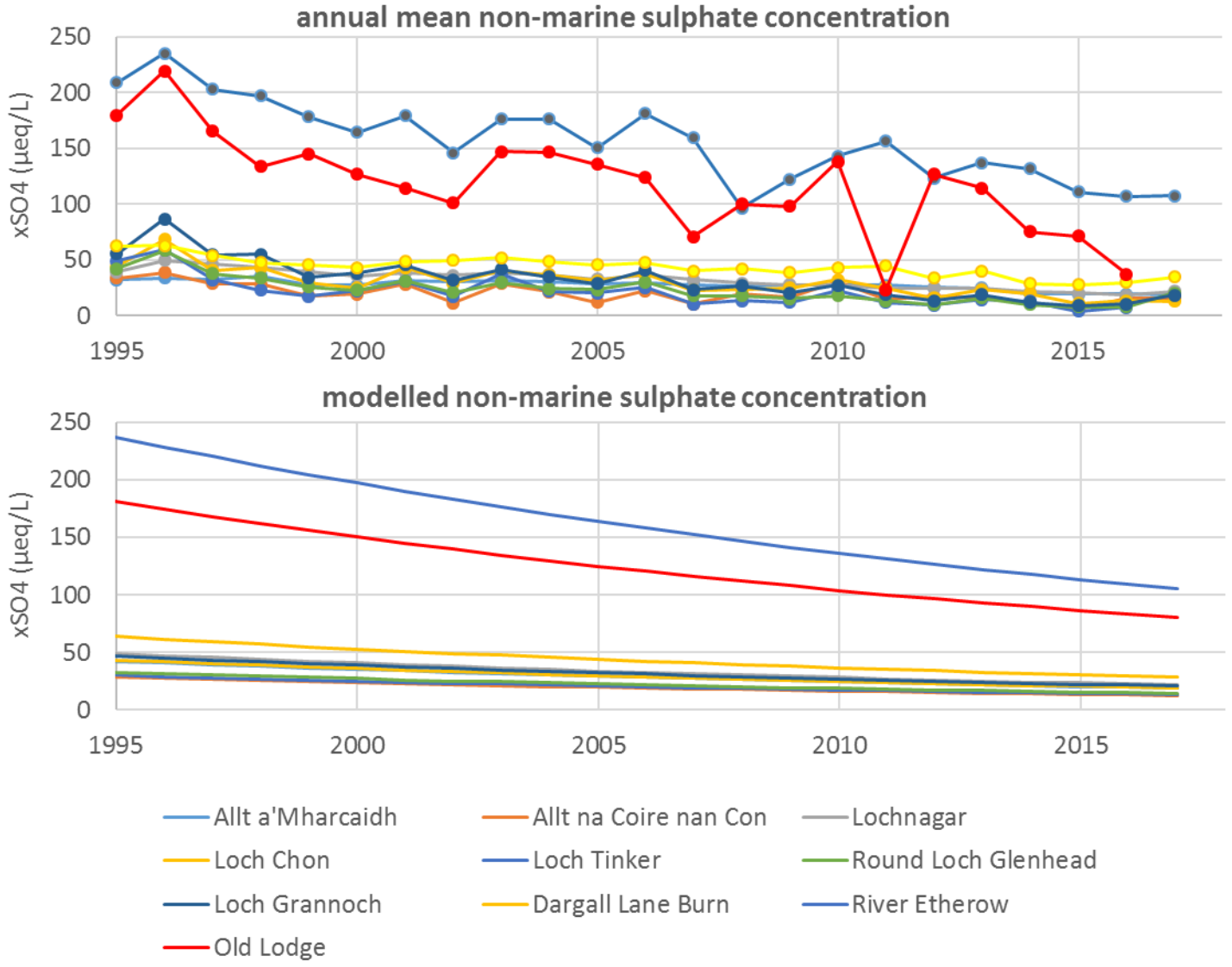
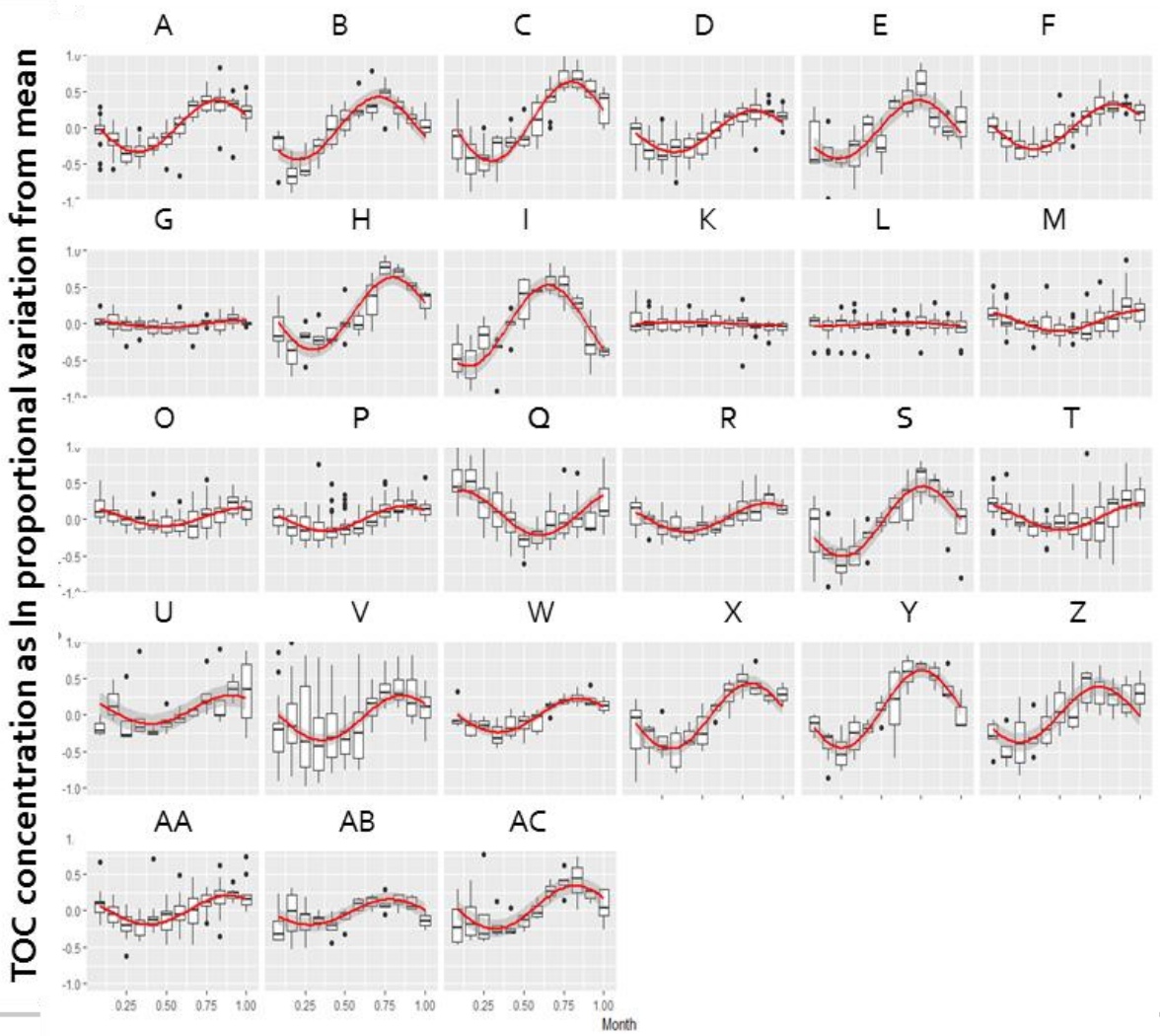
Rate of long term rate of change in non-marine sulphate can be predicted from current concentration



Seasonal variation in DOC in upland waters is highly predictable



Sample month

TOC variation in 27 Scottish Water Source Waters

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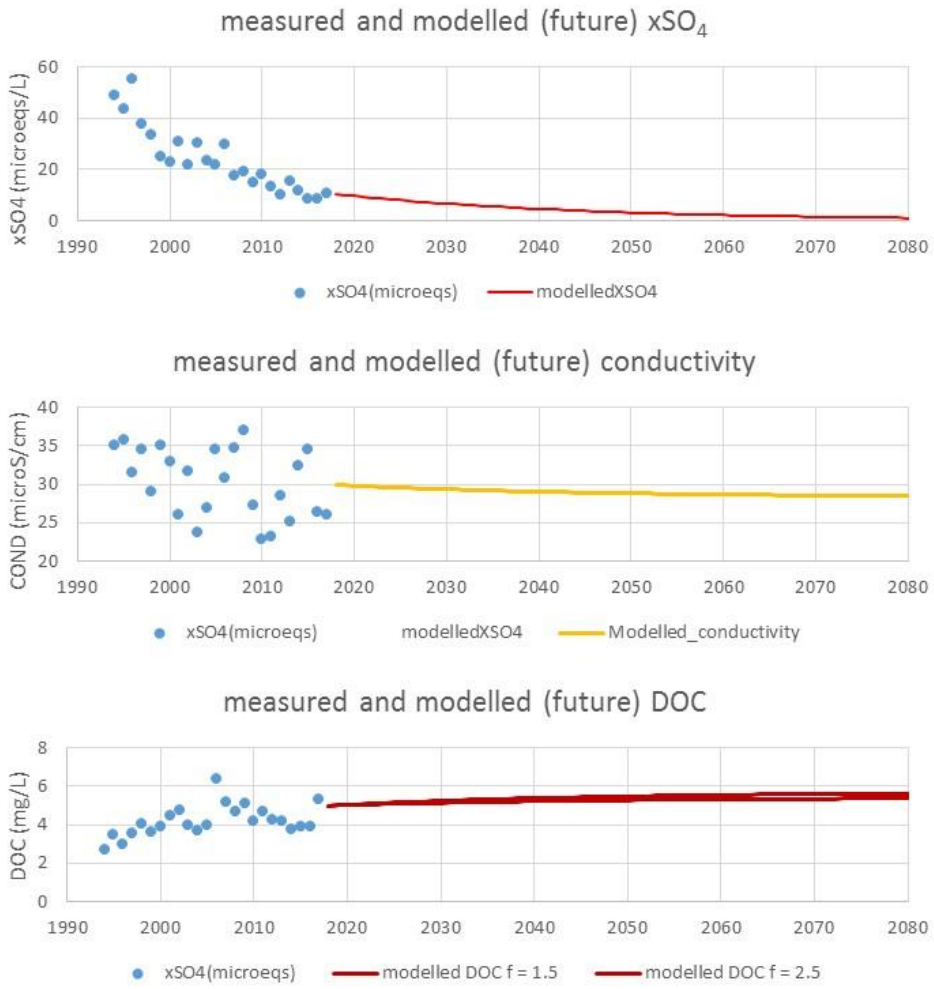
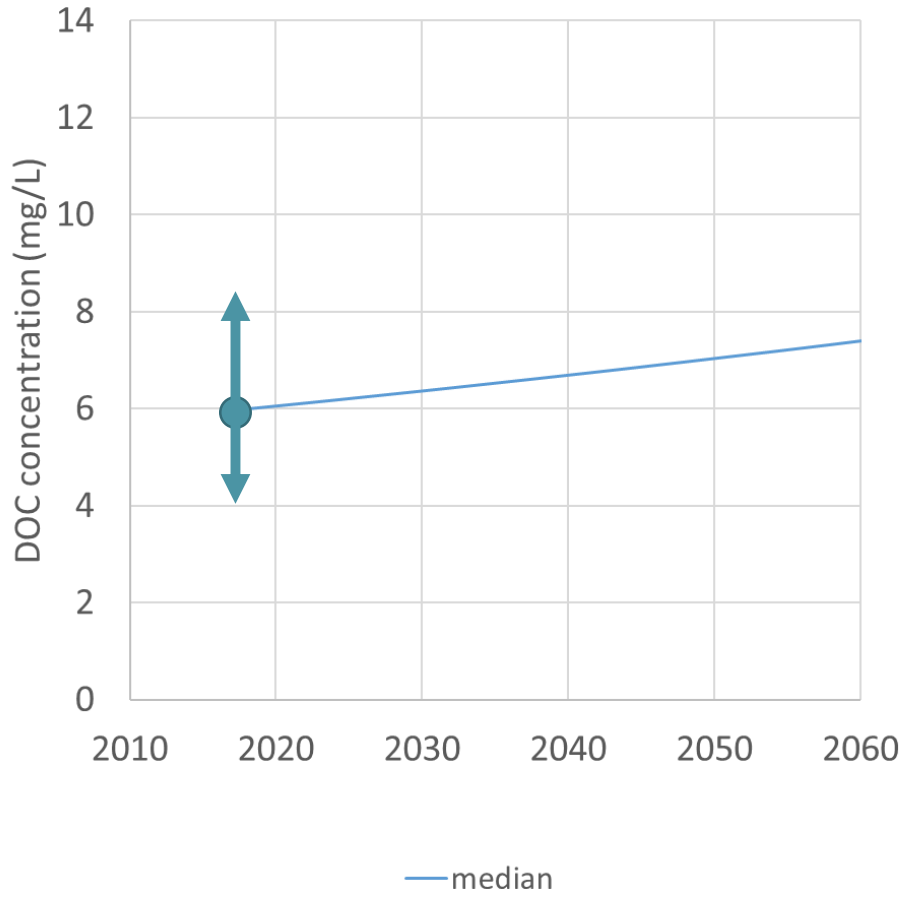
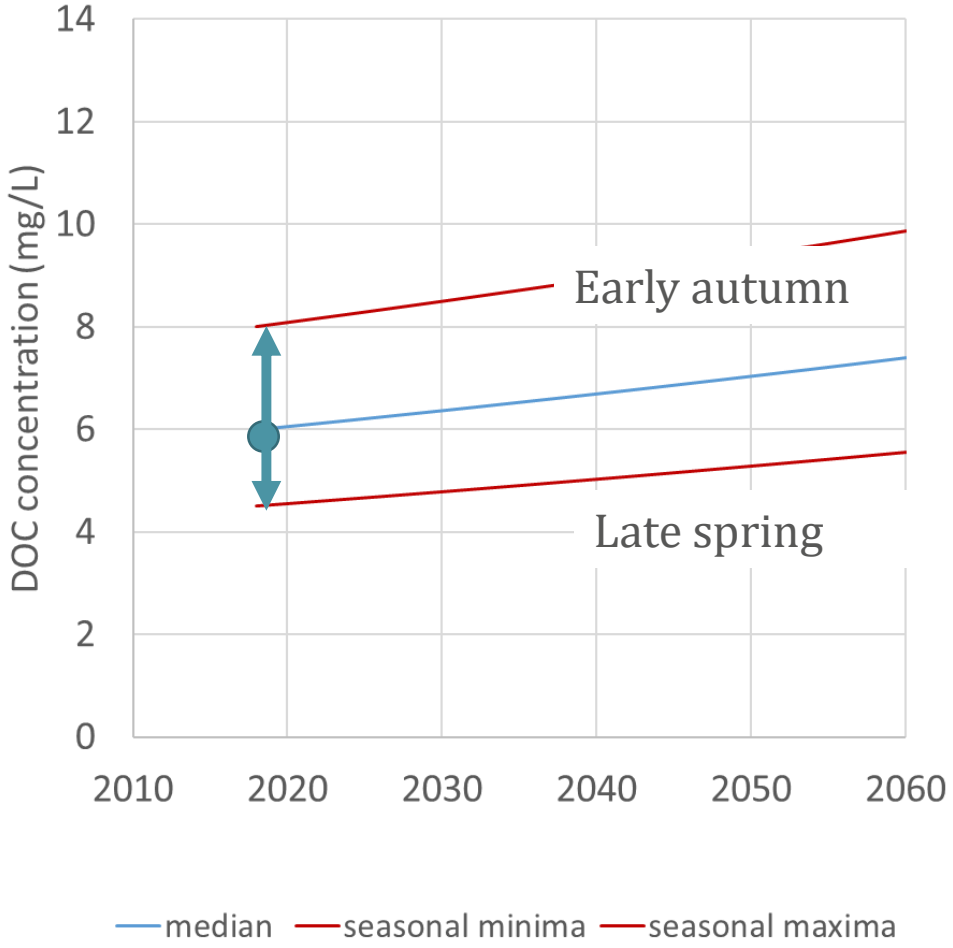
modelled sulphate → modelled conductivity → modelled DOC



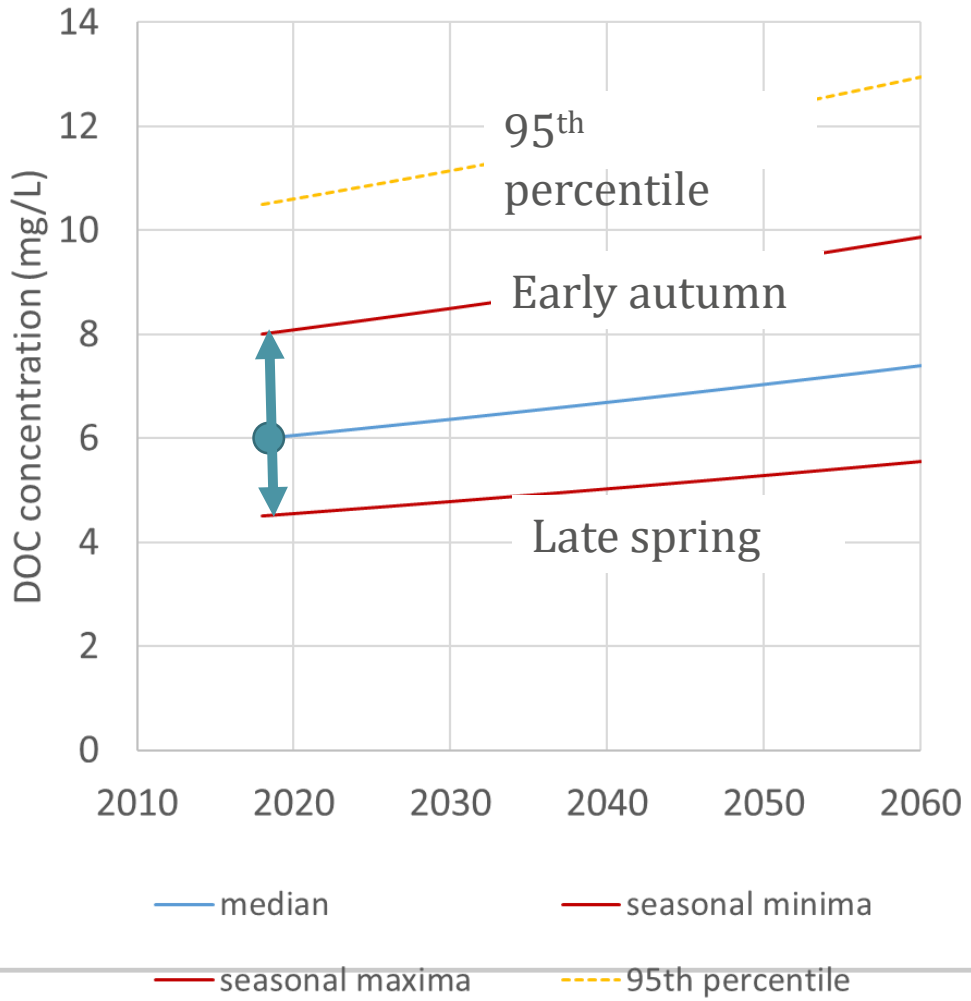
The modelled “moving baseline”



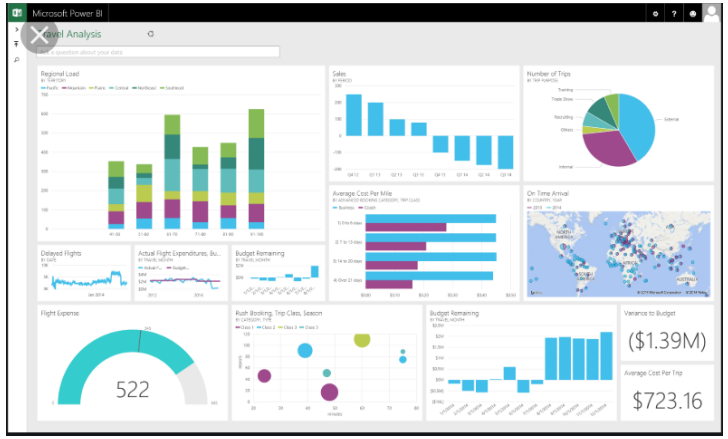
adding a seasonal envelope

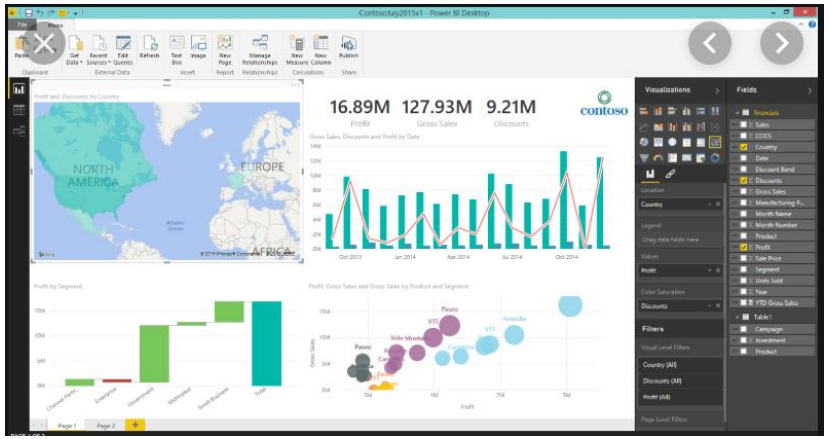


adding episodic extremes



Building the FREEDOM Decision Support Tool (DST): Microsoft Power BI as a data visualisation platform





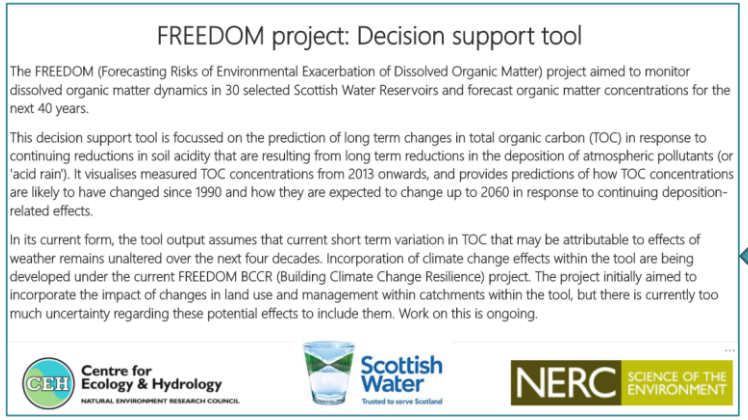
- Business analytics service
- Provides interactive visualisation
- Can visualise underlying computer coded graphs (R)
- Requested as platform by Scottish Water– fits with existing systems
- Has not reached its full potential yet

Underpinned by R programming language

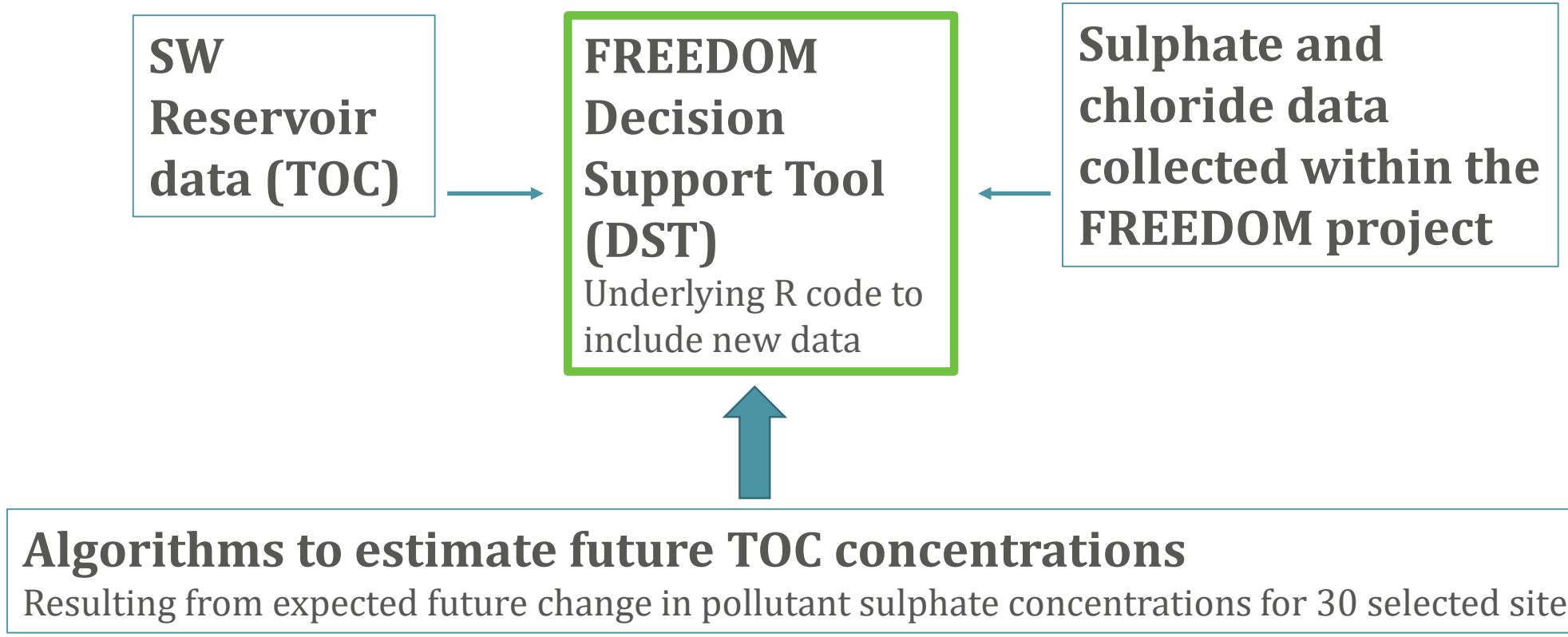
```
#################################################################
#######################  FREEDOM R script   #####################
####for analysis of TOC data, baseline modelling predictions and ####
########generating tables for Decision Support tool ###############
#################################################################
```

+

New data
(TOC, chloride, sulphate)



FREEDOM Decision Support Tool (DST)



FREEDOM DST: regional view

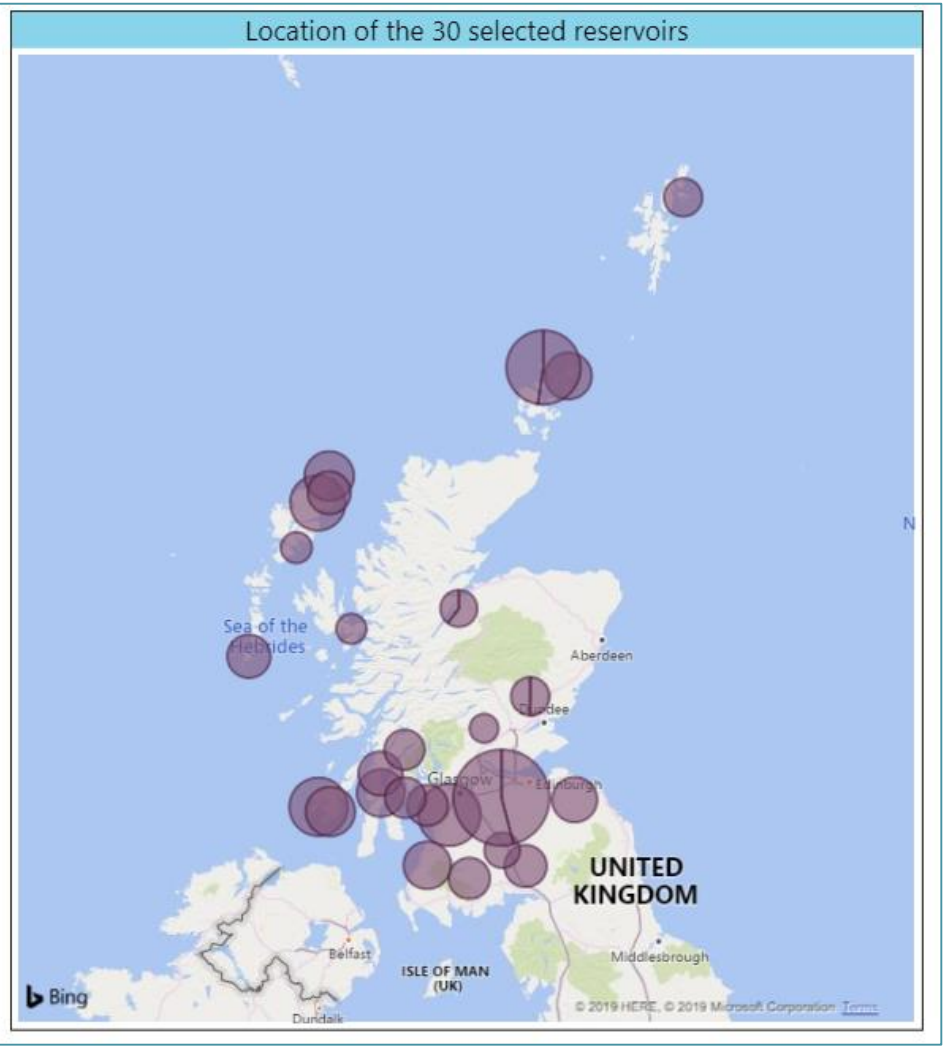
...

This map shows the location of the 30 selected reservoirs. The sites were selected by various criteria:

- Loch/reservoir sources only
- WTWs with less than three water source sample points
- Sites with good availability of TOC data
- Sites where additional data on organic matter quality is available
- Good geographical spread
- Data checked by Asset Capability and Sustainable Land Management teams.

The size of the circle represents the concentration of TOC measured in the Source Water (except for Daer Reservoir where raw water measurements were used).

Move the mouse over the circles for information on average (mean) TOC and reservoir names.



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FREEDOM DST: site summaries

Total organic carbon concentrations of the 30 selected reservoirs from 2013

Please select one site for graphs to work

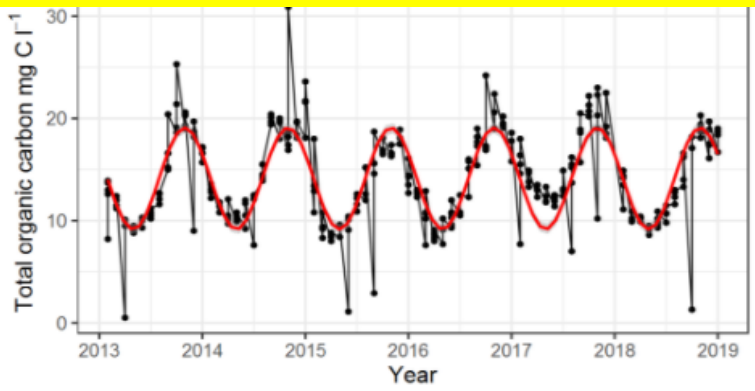
Site	TOC Average	TOC Max
Source Water A	14.8	30.9
Source Water B		
Source Water C		
Source Water D		
Source Water E		
Source Water F		
Source Water G		
Source Water H		
Source Water I		
Source Water J		
Source Water K		
Source Water L		
Source Water M		
Source Water N		

Please select year(s)

2013 2018

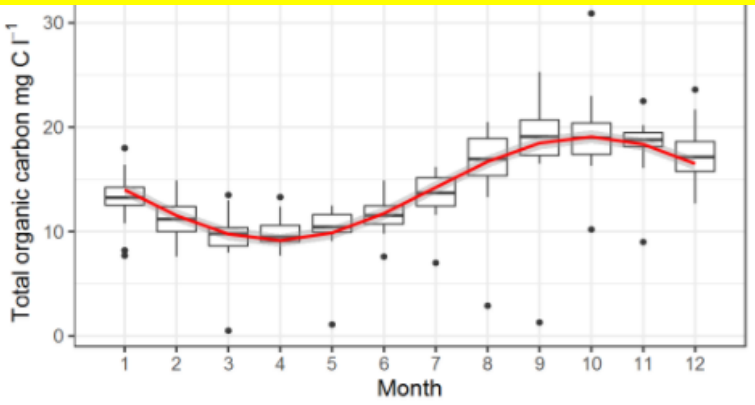
TOC over time with sinusoidal curve fitting

Source Water A



Monthly averaged TOC with sinusoidal curve fitting

Source Water A



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FREEDOM DST: site summaries

Total organic carbon concentrations of the 30 selected reservoirs from 2013

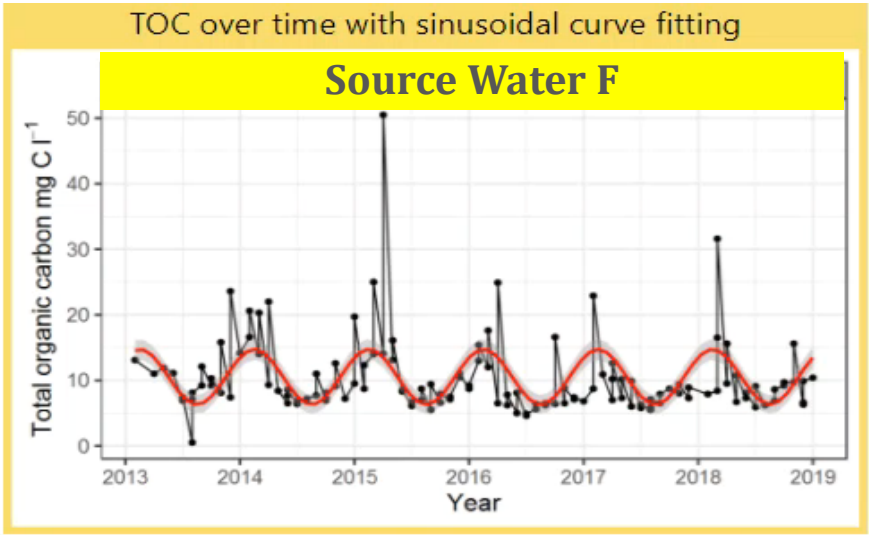
Please select one site for graphs to work

Site	TOC Average	TOC Max
Source Water A		
Source Water B		
Source Water C		
Source Water D		
Source Water E		
Source Water F	10.0	50.2
Source Water G		
Source Water H		
Source Water I		
Source Water J		
Source Water K		
Source Water L		
Source Water M		
Source Water N		

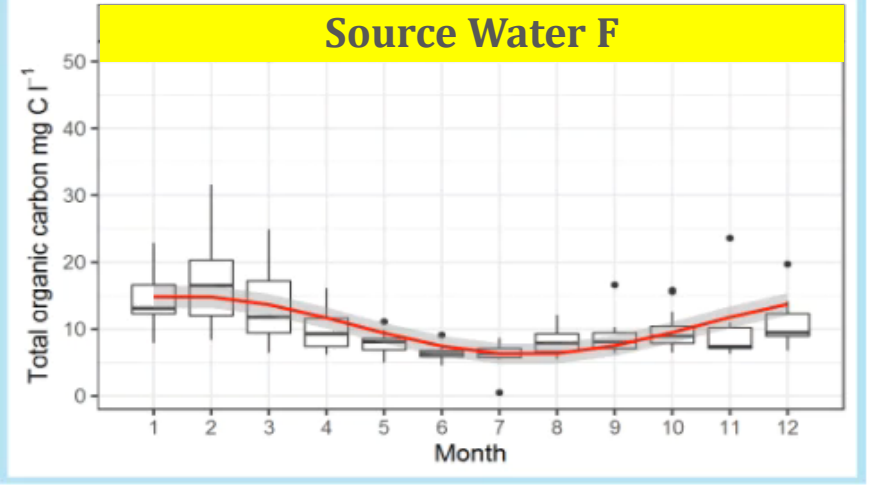
Please select year(s)

2013 2018

TOC over time with sinusoidal curve fitting



Monthly averaged TOC with sinusoidal curve fitting



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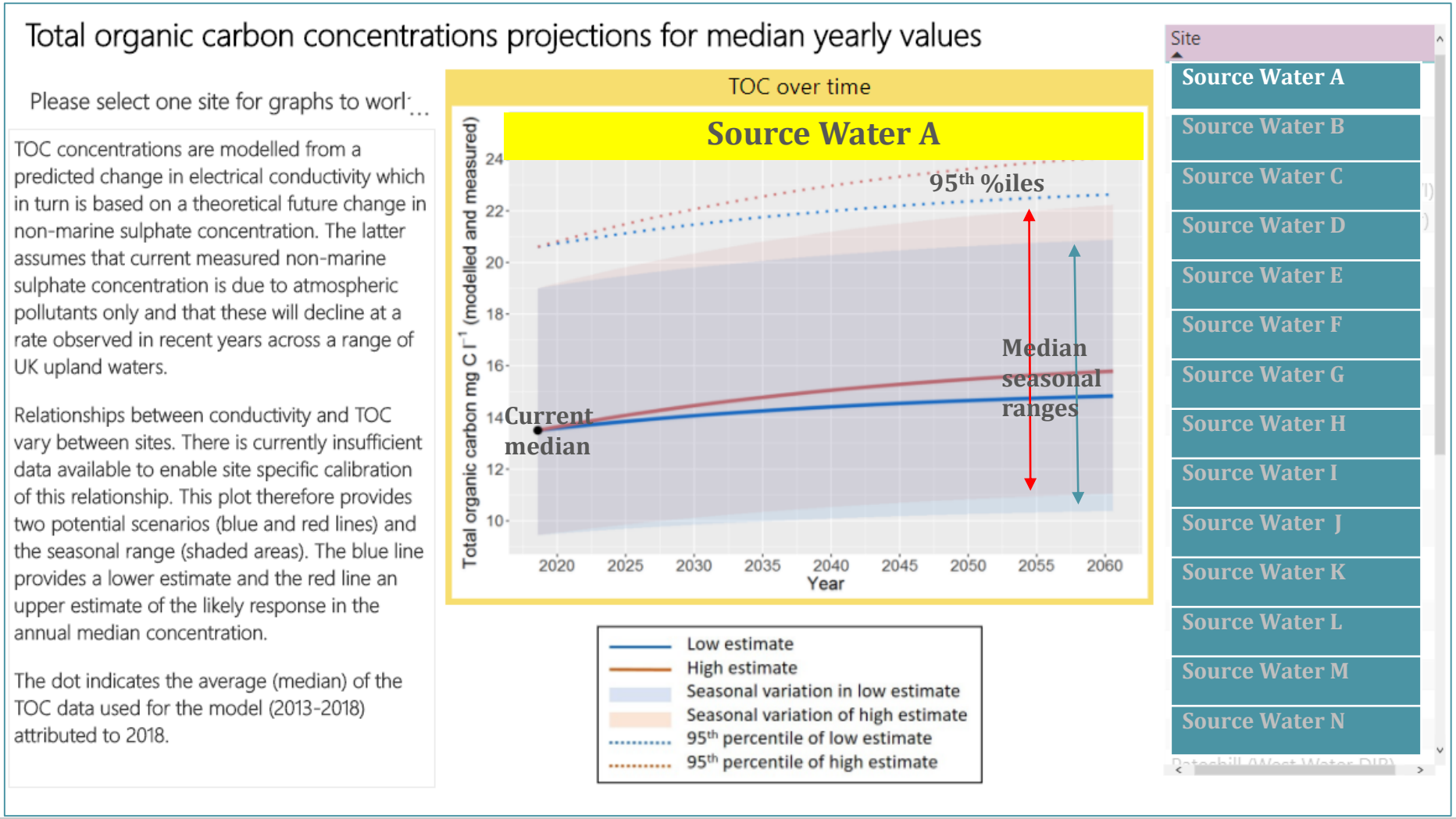
FREEDOM DST: Future DOM projections



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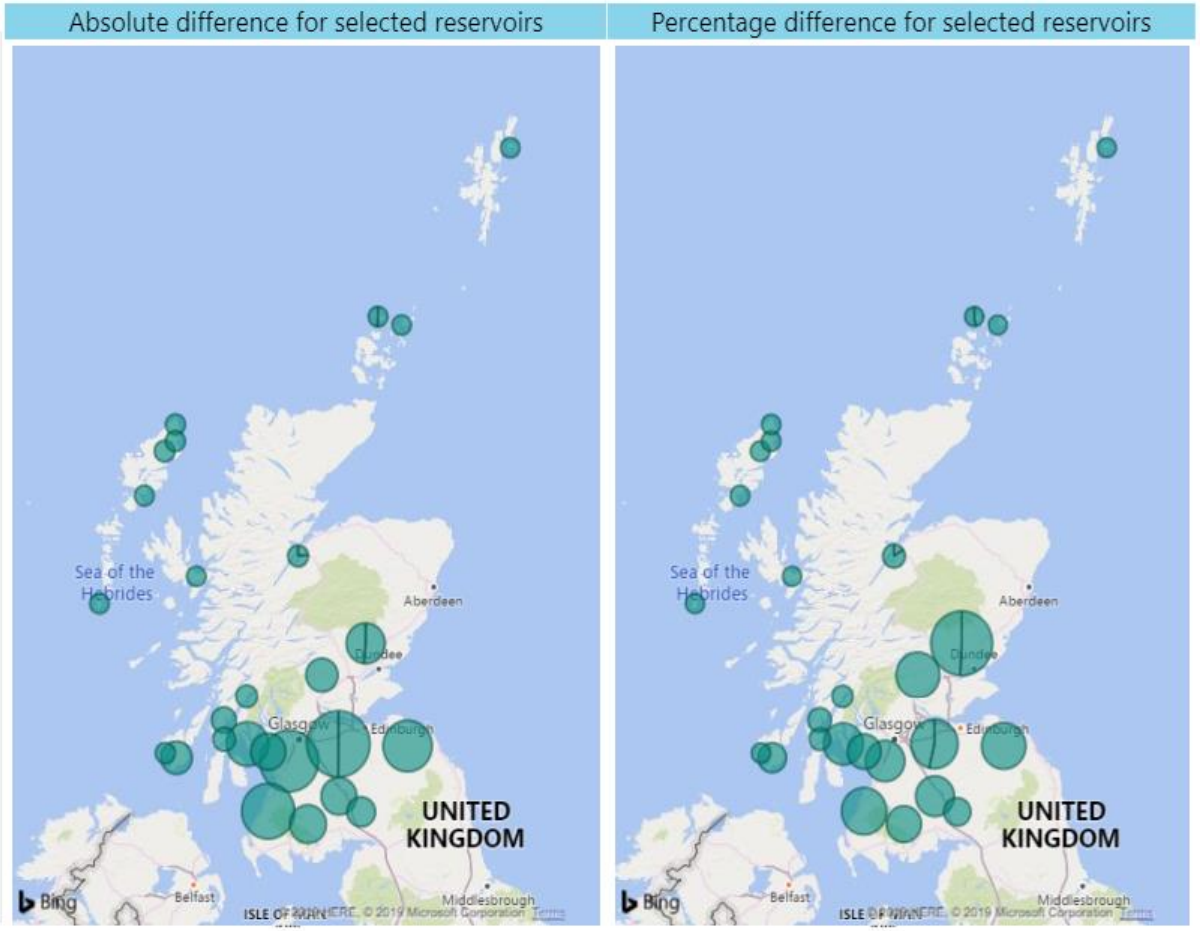
FREEDOM DST: Regional comparisons of projected TOC change

Spatial variation in projected change in annual median TOC

These maps provide an estimate of change in modelled TOC from 2018 to 2060 in terms of both absolute (mg Carbon /L) change (left) and percentage change in TOC relative to 2018 (right), in response to the anticipated future change in non-marine sulphate concentration.

The estimated change is derived from the average of the low and high estimates presented in the 'Projections of baseline over time' page.

Move the mouse over the circles for information on absolute and percentage change in TOC and reservoir names.



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summary

As part of the FREEDOM project, we set out to develop a tool to project future DOM in raw waters reaching a range of Scottish Water plant.

Focus has been on:

- developing capability to project a “moving baseline” for DOC (response to reduction in acid deposition) for a range of sites for which some historical data are available
- The FREEDOM tool takes the form of a computer-based graphical interface driven by computer code that draws from an updatable central database
- Provides a foundation for a more widely applicable tool. Considerable potential for further development of the tool to address other stressors, e.g. climate change, and application to other regions

FORECASTING RISKS OF ENVIRONMENTAL EXACERBATION OF DISSOLVED ORGANIC MATTER – BUILDING CLIMATE CHANGE RESILIENCE (FREEDOM-BCCR)

Don Monteith (UKCEH) and Fraser Leith (Scottish Water)

4th November 2020

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https://www.ukclimateresilience.org/news-events/1955/