TWENTY65

Theme 5:
Adapting to Changing Catchments

Future Treatability and Quality of Drinking Water

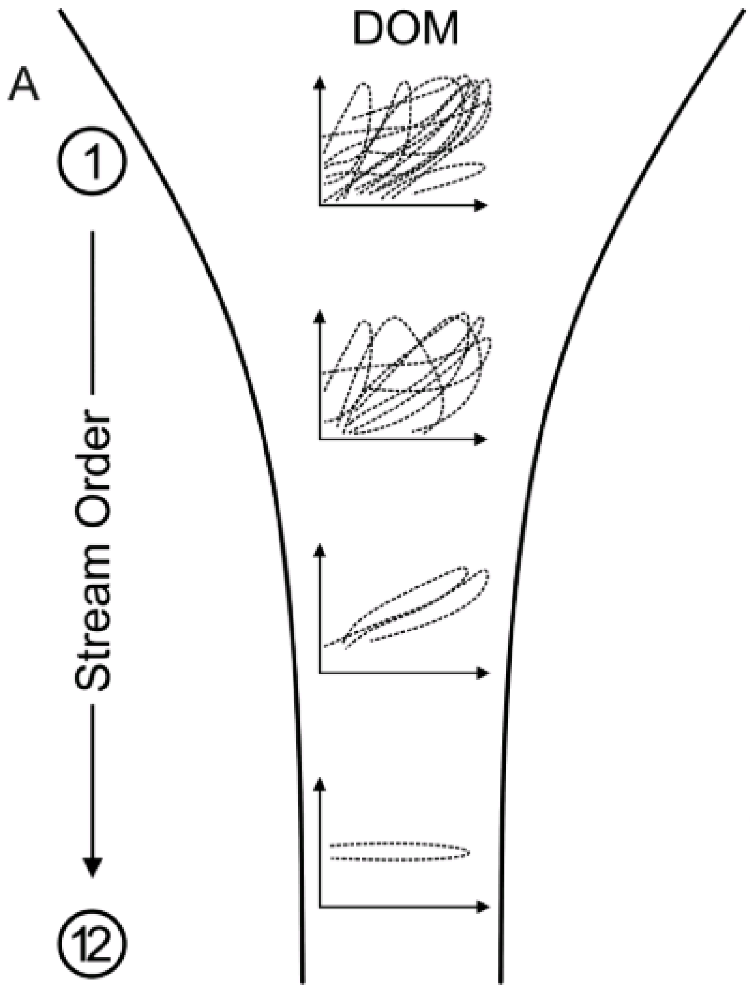
Dr Jonathan Ritson, Imperial College London

Adapting to changing catchments

- How will future changes in catchments impact upon our water supply systems?
- Can we advance current capabilities in catchment monitoring and modelling to predict organic concentrations, flux and treatability?
- Project partners: Imperial College, Exeter, Reading, Affinity Water and South West Water.

- Part 1 monitoring in the Exe catchment
- Part 2 Use of satellite data for water quality

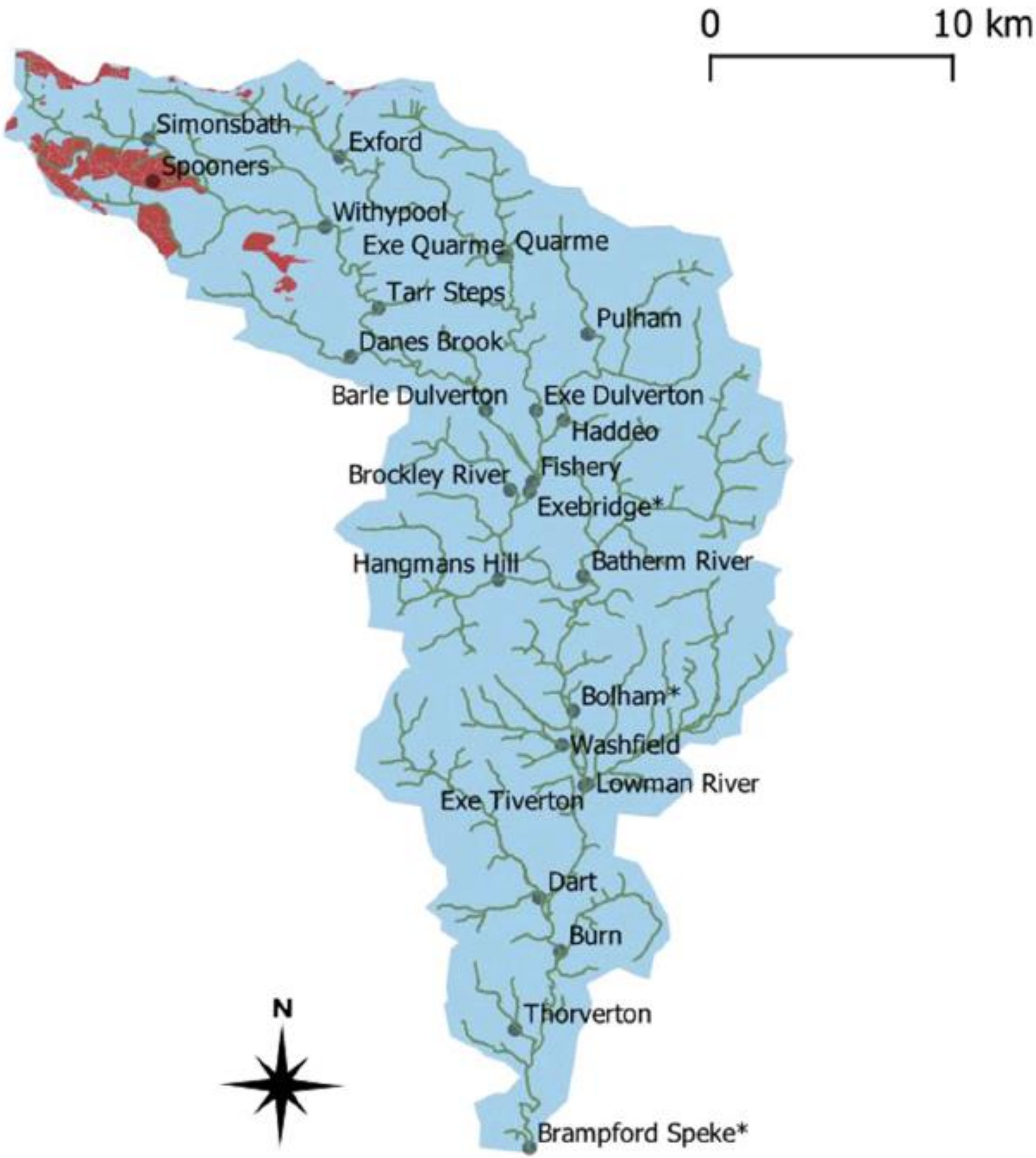
Part 1 monitoring in the Exe



- Dissolved organic matter (DOM) hysteresis
- Creed et al. 2015 The river as a chemostat : fresh perspectives on dissolved organic matter flowing down the river continuum

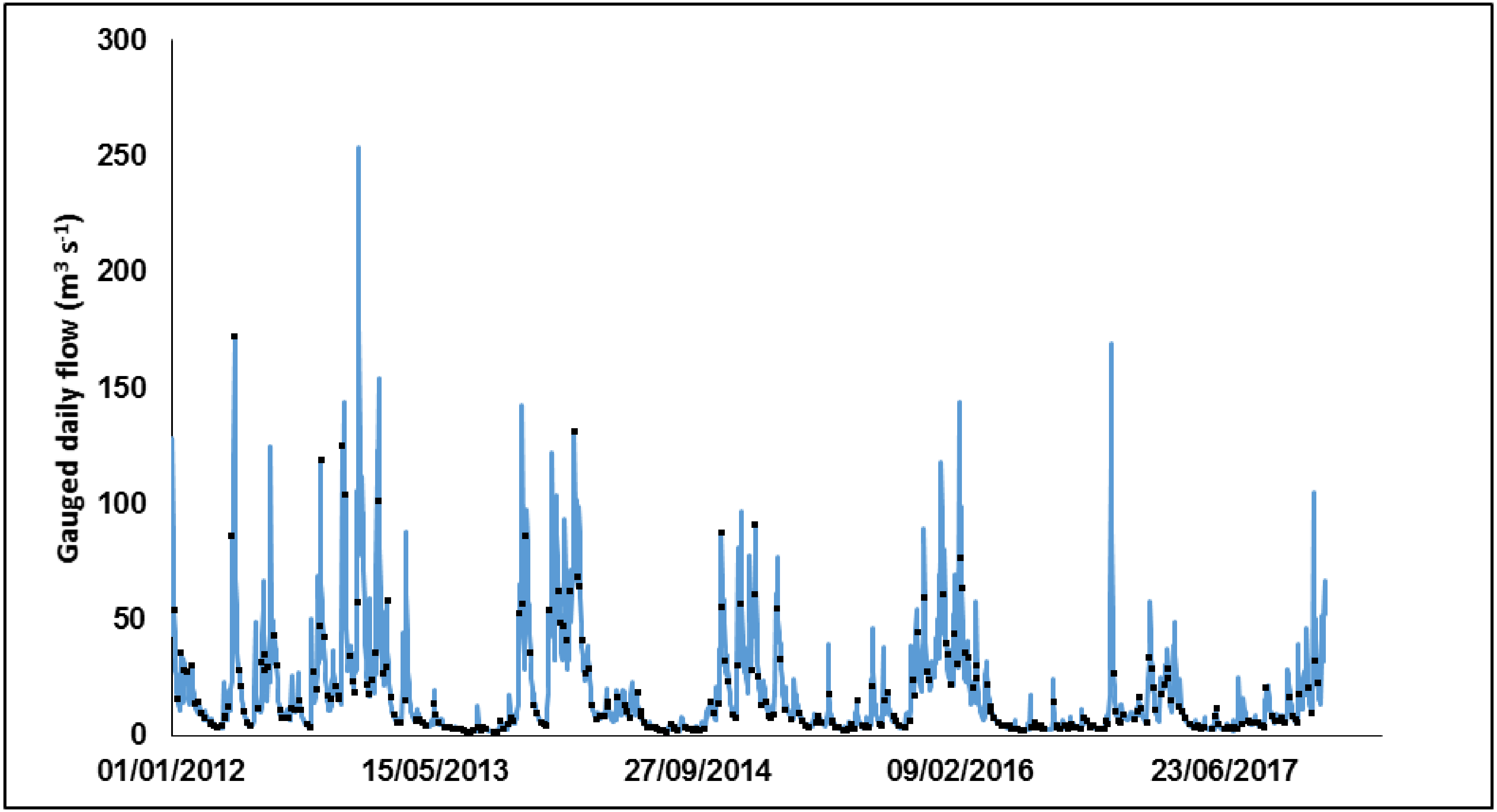
Sources of DOC in the catchment

- Analysis of 6 years of weekly grab sampling data (SWW) of Dissolved Organic Carbon (DOC)
- Monthly catchment survey of 25 sites
- Carbon stocks under different land uses

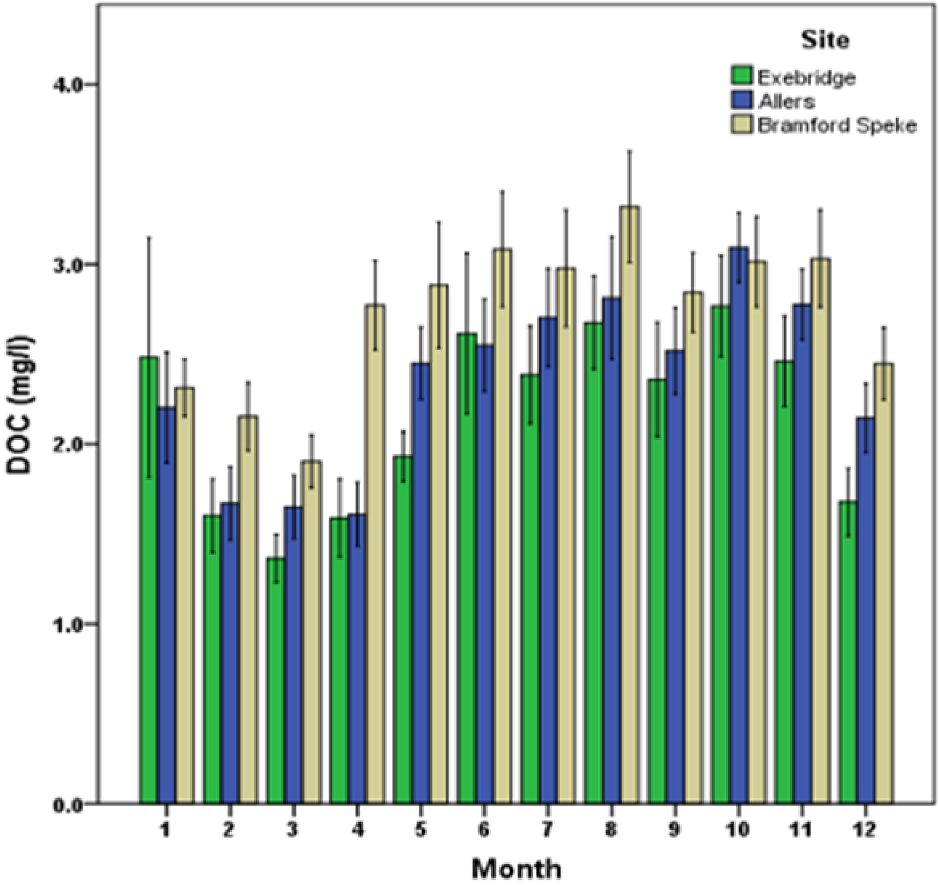


0
10 km
N
Simonsbath
Exford
Spooners
Withypool
Exe Quarme
Quarme
Tarr Steps
Pulham
Danes Brook
Barle Dulverton
Exe Dulverton
Haddeo
Brockley River
Fishery
Exebridge*
Hangmans Hill
Batherm River
Bolham*
Washfield
Lowman River
Exe Tiverton
Dart
Burn
Thorverton
Brampford Speke*

- Weekly sampling gives reasonable coverage of flow conditions



Concentration and flux increase down catchment

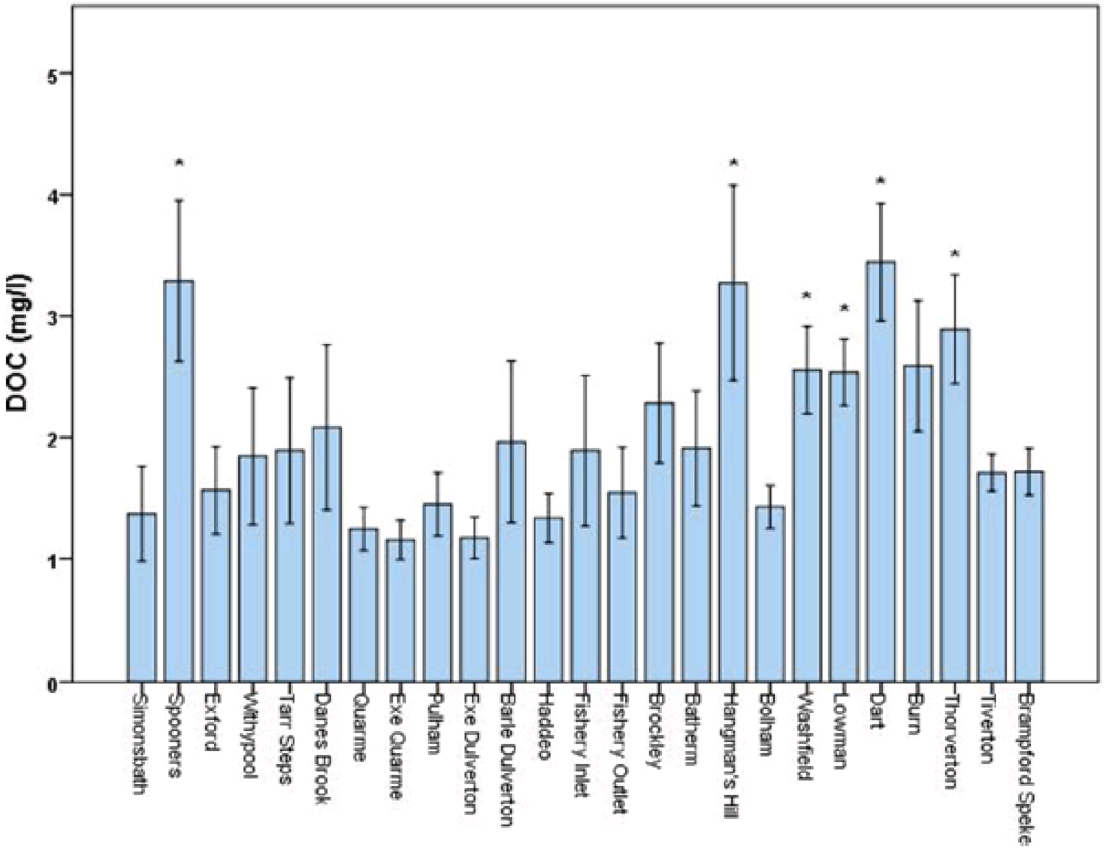


Site	Exebridge (kg ha^{-1} year^{-1})	Bolham (kg ha^{-1} year^{-1})	Brampford Speke (kg ha^{-1} year^{-1})
2012	47.89 ± 2.14	43.11 ± 1.36	55.34 ± 2.16
2013	18.53 ± 0.74	19.67 ± 0.82	26.73 ± 1.20
2014	16.53 ± 1.41	20.91 ± 0.97	25.93 ± 1.06
2015	31.98 ± 1.66	28.57 ± 1.07	28.13 ± 1.04
2016	33.60 ± 2.96	21.24 ± 0.79	21.42 ± 0.73
2017	15.87 ± 0.42	16.51 ± 0.27	17.13 ± 0.50

Explanations

- Underestimation of contribution from high flows
- Significant sources of DOC downstream
- Biodegradation limits impact of peaty headwaters

Monthly survey of 25 sites



Significantly higher DOC than the main channel from 6 sub-catchments.

One peaty, one woodland and three agricultural areas, one agri+urban

No impact from small-scale aquaculture

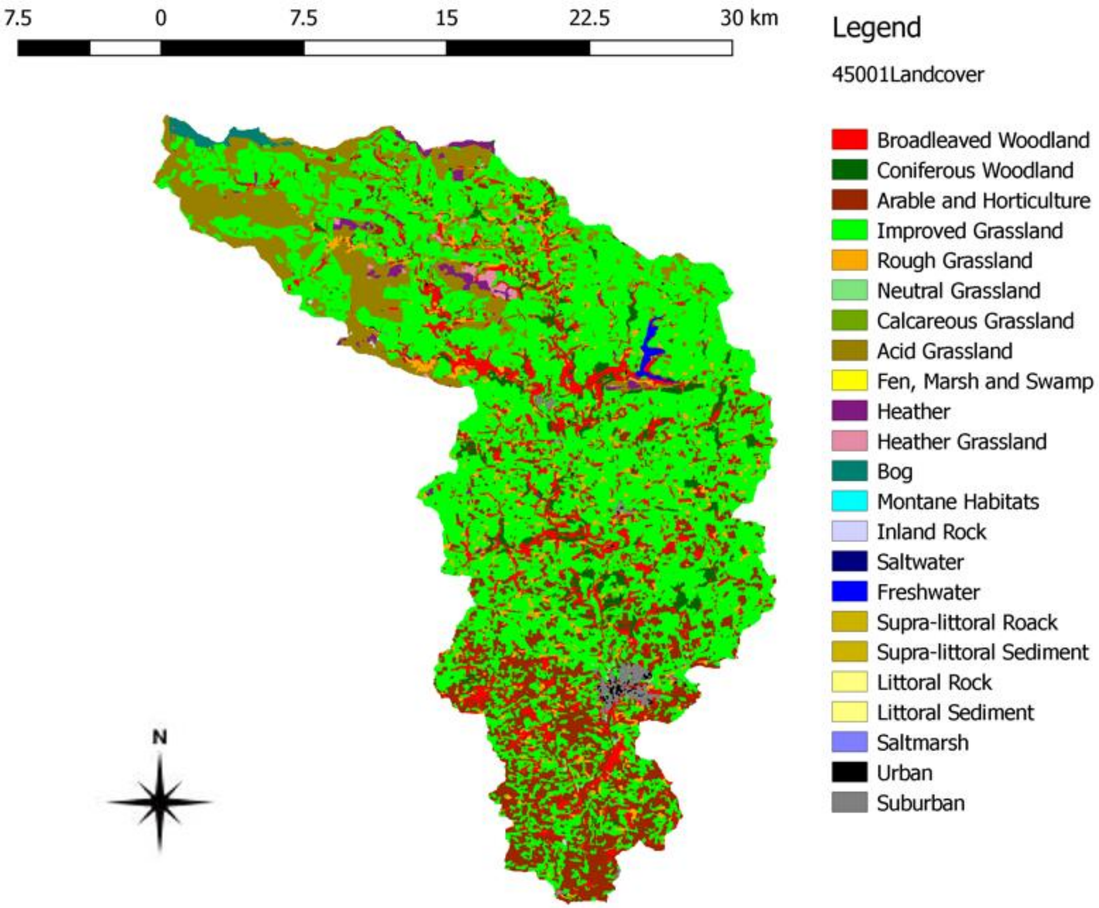
Modelling effect of land use

- Automated linear modelling (ALM) for DOC concentration in the (n = 15) sub-catchments

- $F= 6.232$, $p =0.011$, adjusted $r^2=0.692$

- Broadleaved woodland, Arable, Acid Grassland, Improved grassland, Sub-urban

Catchment land use



Litter sources of DOC

Peatland site		Woodland site
1,212 ± 161 g m^{-2} litter biomass	≈	961 ± 180 g m^{-2} litter biomass
		
↓		↓
10.65 ± 3.31 mg persistent DOC m^{-2}	<	20.50 ± 3.73 mg persistent DOC m^{-2}

Soil carbon sources

- SOC woodland:

28.3 (± 15.6) t ha^{-1} 0 – 10 cm depth

12.0 (± 2.5) t ha^{-1} 10 – 20 cm depth

- SOC peatland: 714.6 (± 32.6) t ha^{-1}

Biodegradability

- Peat headwater ~5.30 mg l^{-1} at 45.0% degradable
- Woodland stream ~1.43mg l^{-1} at 25.7% degradable

Explanations

- Underestimation of contribution from high flows
- Significant sources of DOC downstream
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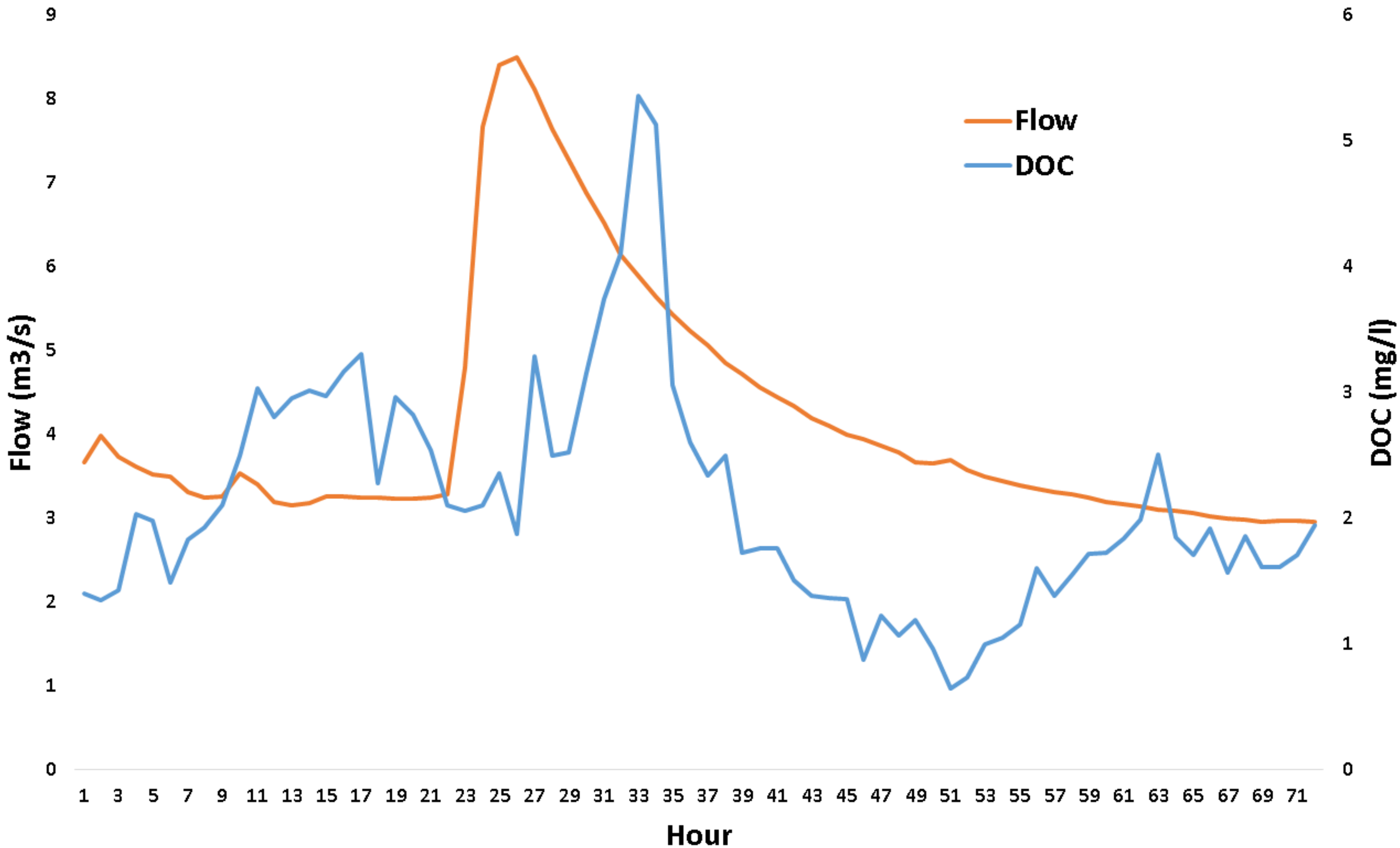
UV-Vis sensors

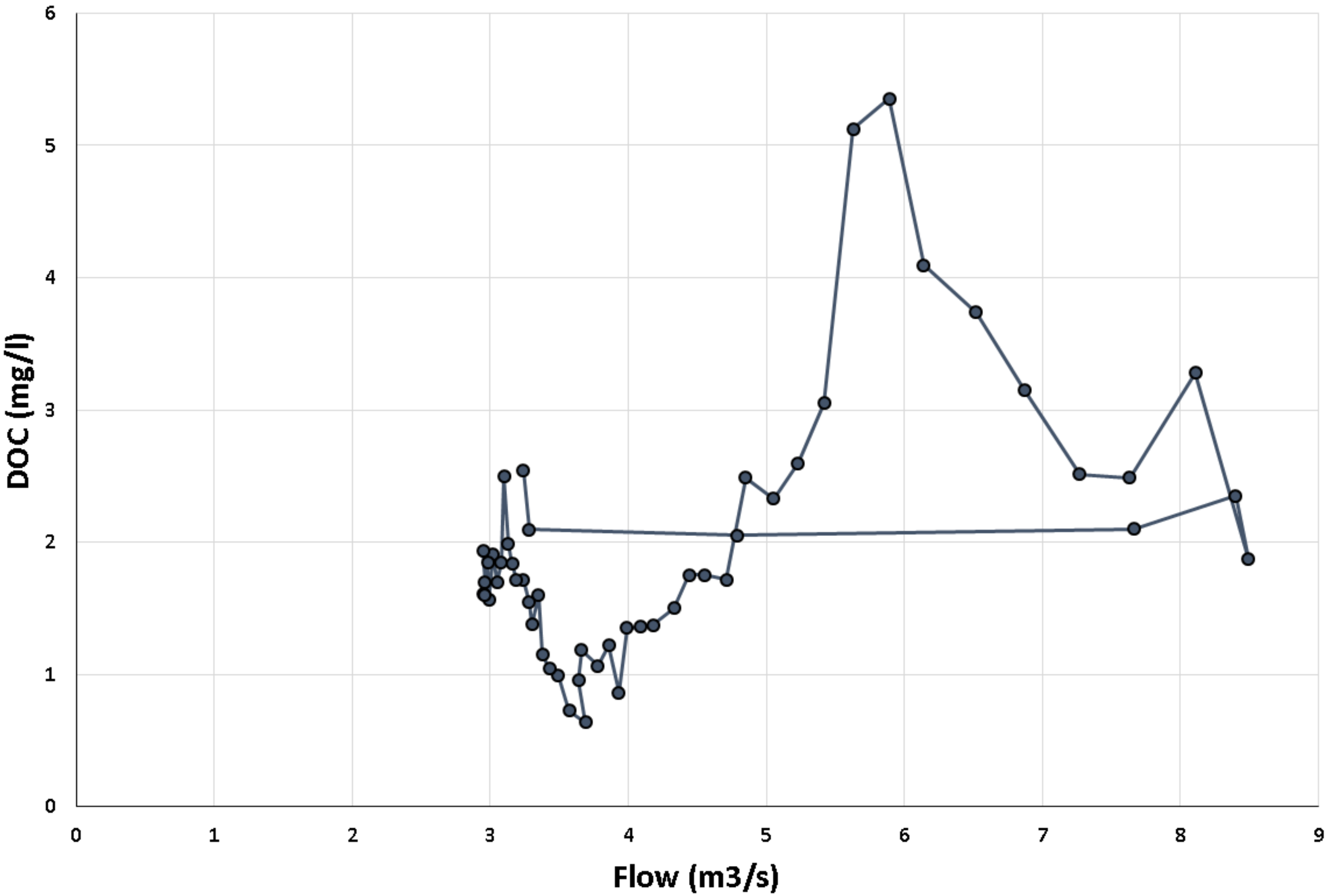
- Scanning 200 -720 nm, hourly data
- DOC calibration (n=65) :
  - Single wavelength adj. r^2=0.705
  - Multiple wavelengths adj. r^2=0.948

High flow event July 2017



3.59% of annual DOC load during the event

DOC – Flow hysteresis



- Graph shows flow-DOC relationship during the high flow event
- Anti-clockwise hysteresis, initially flushing followed by dilution

Part 2 remote sensing

- UKWIR Satellite Remote Sensing for Proactive Catchment Management 2015 – forestry changes, land use, pesticide risk, erosion risk, colour risk (peat, drainage), detect and site buffer strips

- Report states: Possible to map clarity, suspended solids, chlorophyll concentration, CDOM and phycocyanin concentration. Currently, no freely available software tools or routine operational uptake of these methods exist, and as such these approaches are still in the R&D domain.

- This work has been funded by the Twenty-65 leverage and development fund with contributions from South West Water, Welsh Water, Yorkshire Water, United Utilities and Wessex Water.

Why it should work and why its getting better

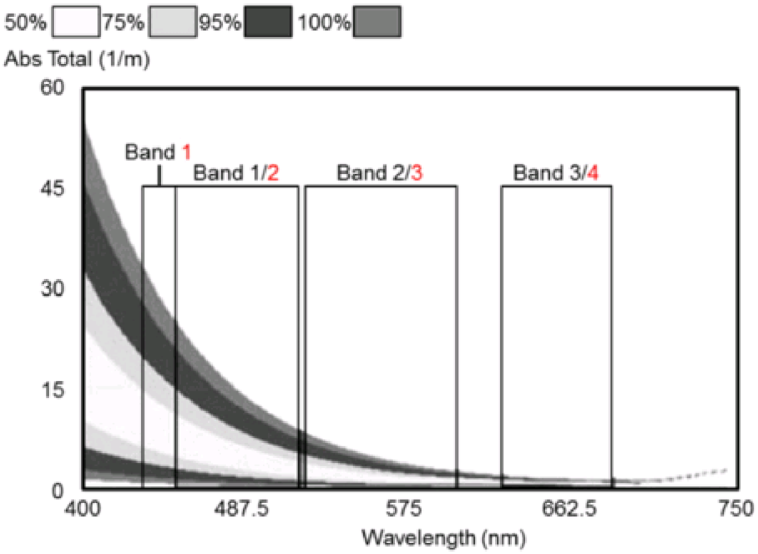


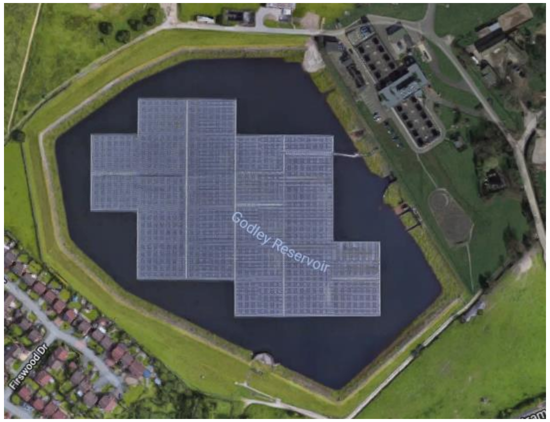
Fig. 1. The gradually decreasing absorbance of CDOM in the electromagnetic spectrum and the band location of typical multispectral satellite sensors. Dark numbers represent earlier Landsat sensors and red numbers indicate Landsat 8 bands and the improvement of Band 1 relative to the available energy. The shaded intervals represent typical ranges of 500 simulations.
(After Kutser et al., 2005b).

CDOM absorbs in the regions commonly used in satellite reflectance instruments

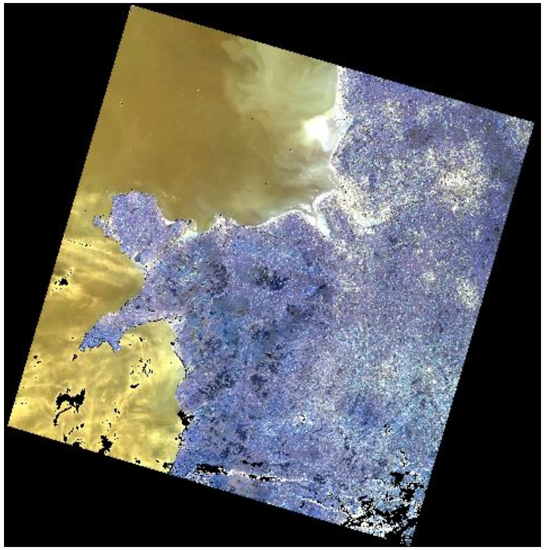
Spatial and spectral resolution is improving. In the last 10 years we've gone from 30 m to 3 m spatial.

Processing of images is becoming more standardised and less on the user side.

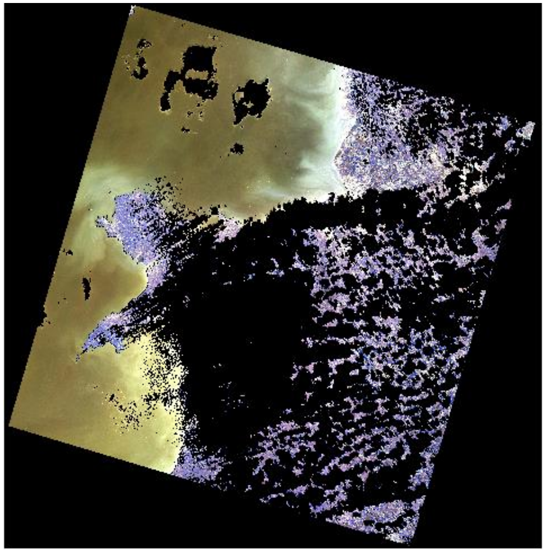
Why it doesn't always work



1. Google Earth image of Godley reservoir



2. Landsat 8 image of Wales on a clear day

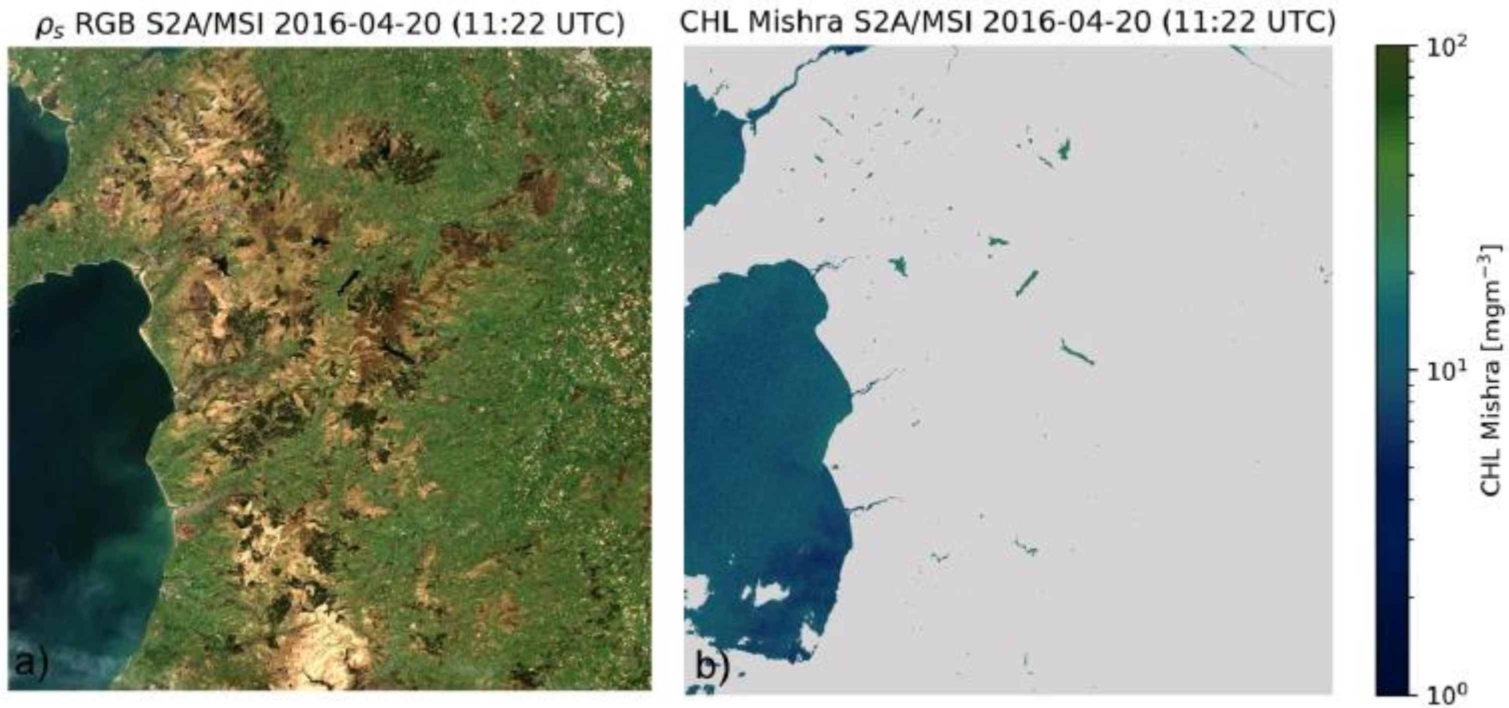


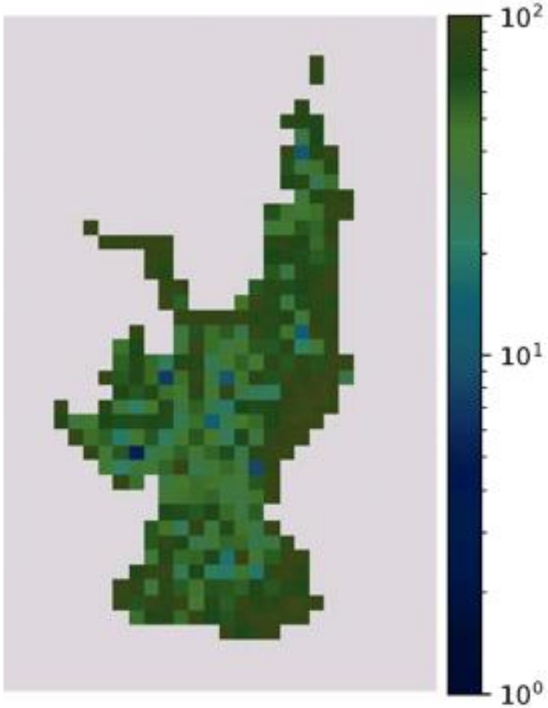
3. Landsat 8 image of Wales on a cloudy day

Monitoring DOC vs algae

- DOC possible, however empirical relationships and site/time specific. Trends in DOC/Colour relationship.

- Algae works across sites (ρ=0.738, p=0.003, n=14)





- Spatial variation in algae across Llyn Brenig
- Potential to automate via Google Earth Engine
- Data and processing tools freely available
- SEPA trialling for WFD monitoring
- Cloud cover!

Conclusions

- Peat important source of DOC but woodland, urban and agriculture also significant
- UV-Vis sensors offer opportunity to understand flow events missed by grab samples and improve modelling (INCA-C)
- Satellite data can offer warnings of algal blooms as well as mapping

Acknowledgments

TWENTY65

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