On the use of electrical conductivity (EC) to support water quality evaluations in rivers

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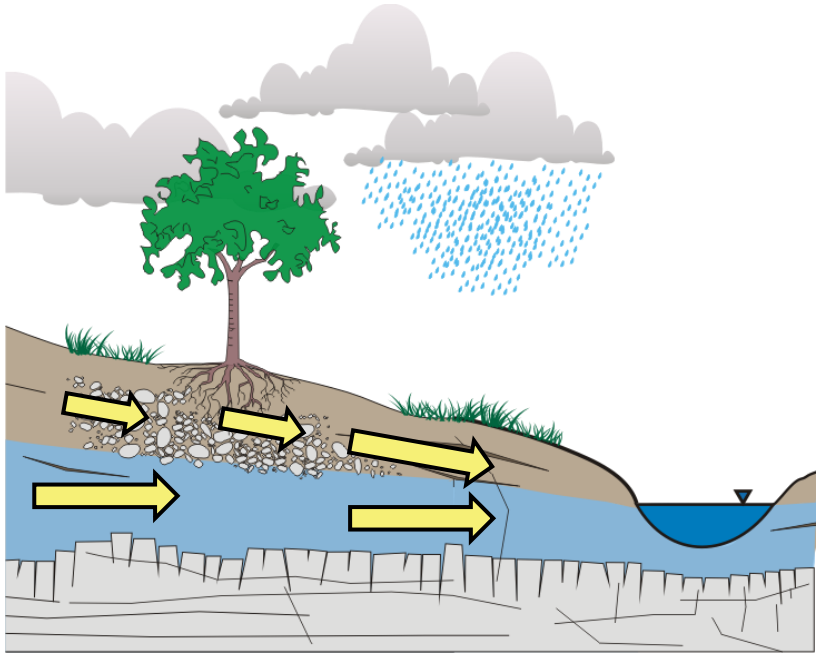
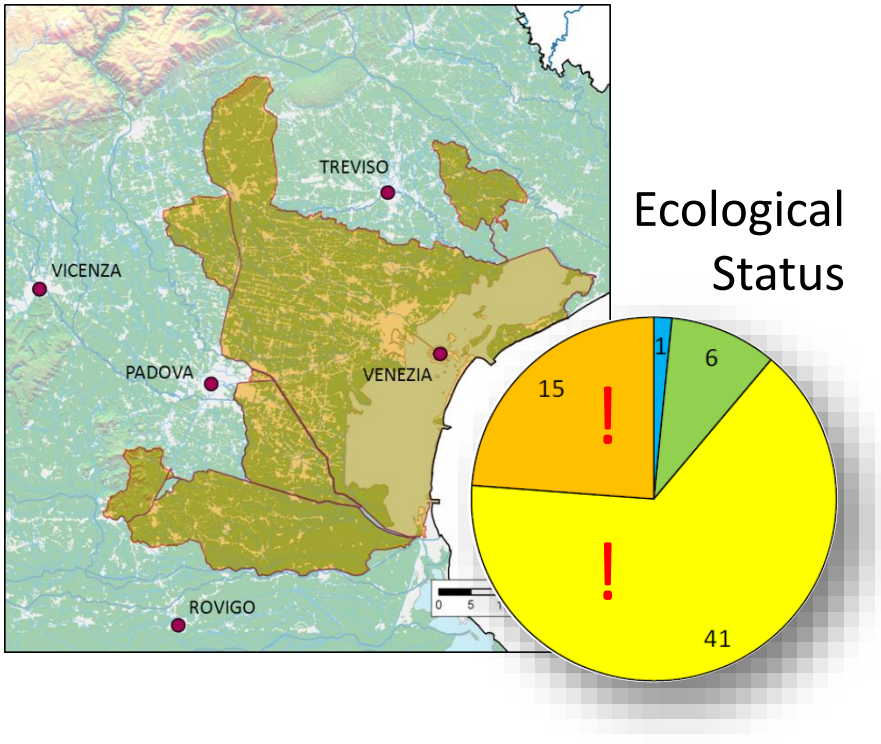
water quality at the catchment-scale

how water and solutes move through a watershed

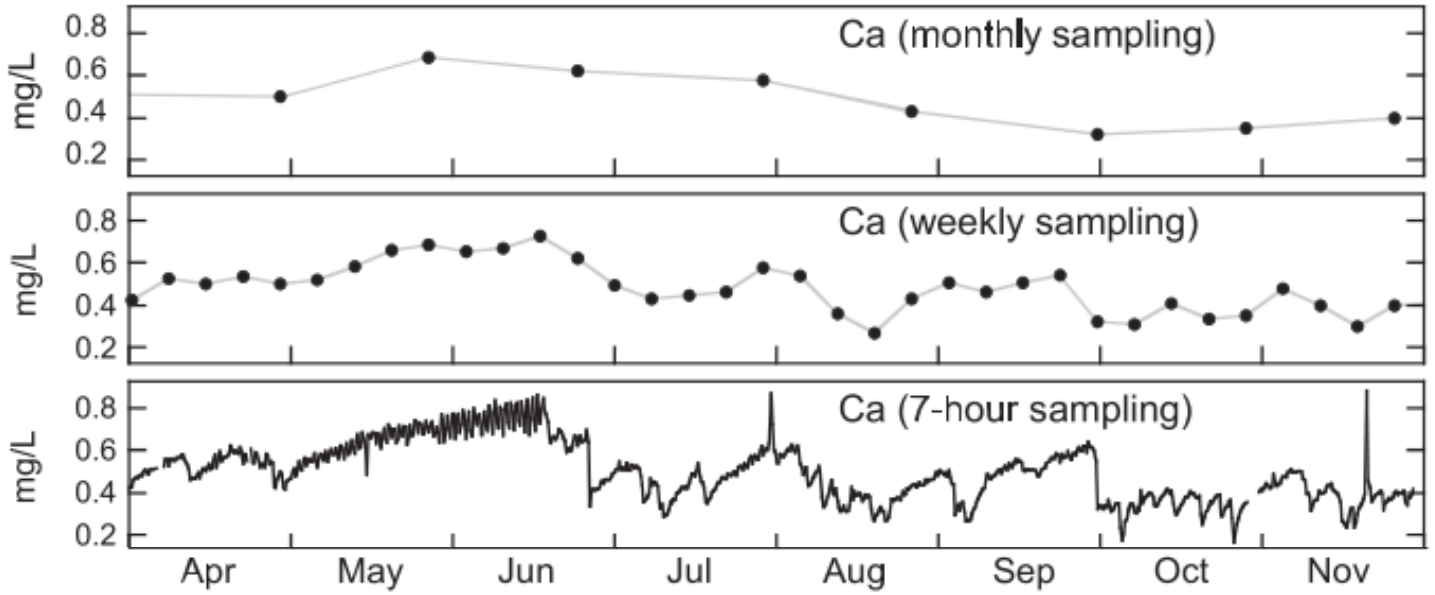




displacements + biogeochemical processes

measuring solute transport in catchments: some problematics

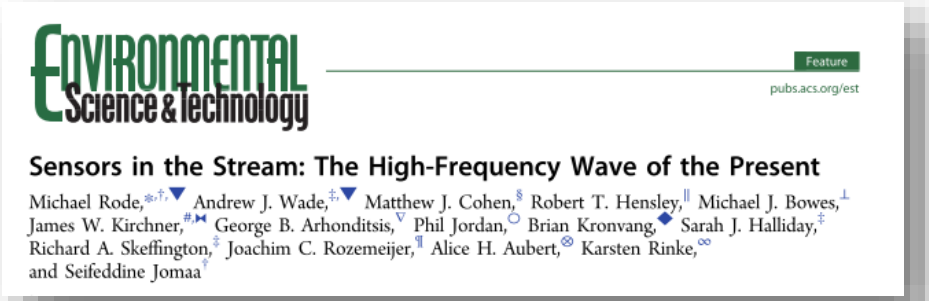
Revealing the structure of the hydrochemical response of a catchment: need for high frequency solute concentration measurements



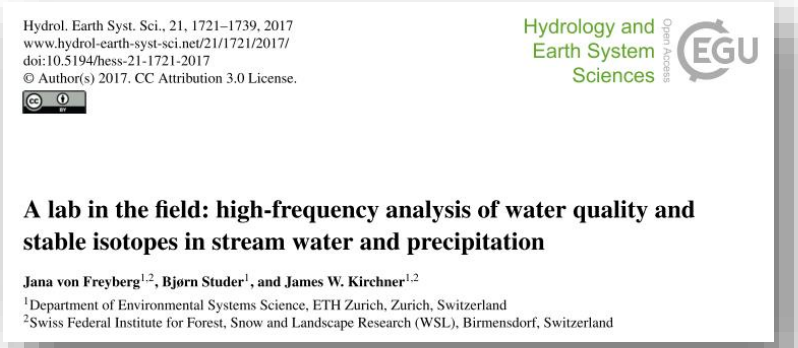
Neal et al., 2011, Sci. Tot. Environ.

measuring solute transport in catchments: some problematics

Technology is no longer a limiting factor



Rode et al., 2016, Envir. Sci. and Technol.



von Freyberg et al., 2017, HESS

but **economic and management efforts** can still be a barrier to high-resolution water quality instrumentation.

Some drawbacks of high-frequency instrumentation:

- high installation costs
- high maintainance costs
- need for special power supply
- (possibly difficult management of large amounts of raw data)

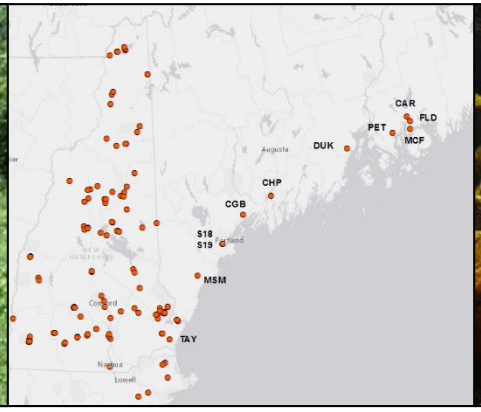
value of EC measurements

cheap + easy to use = hundreds of datasets from many places in the world

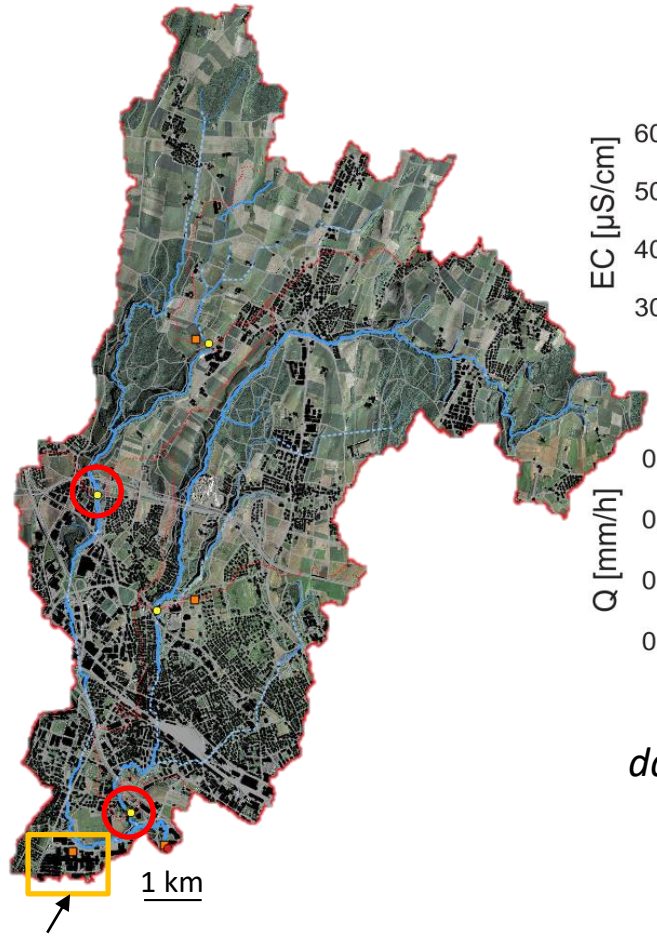
Examples

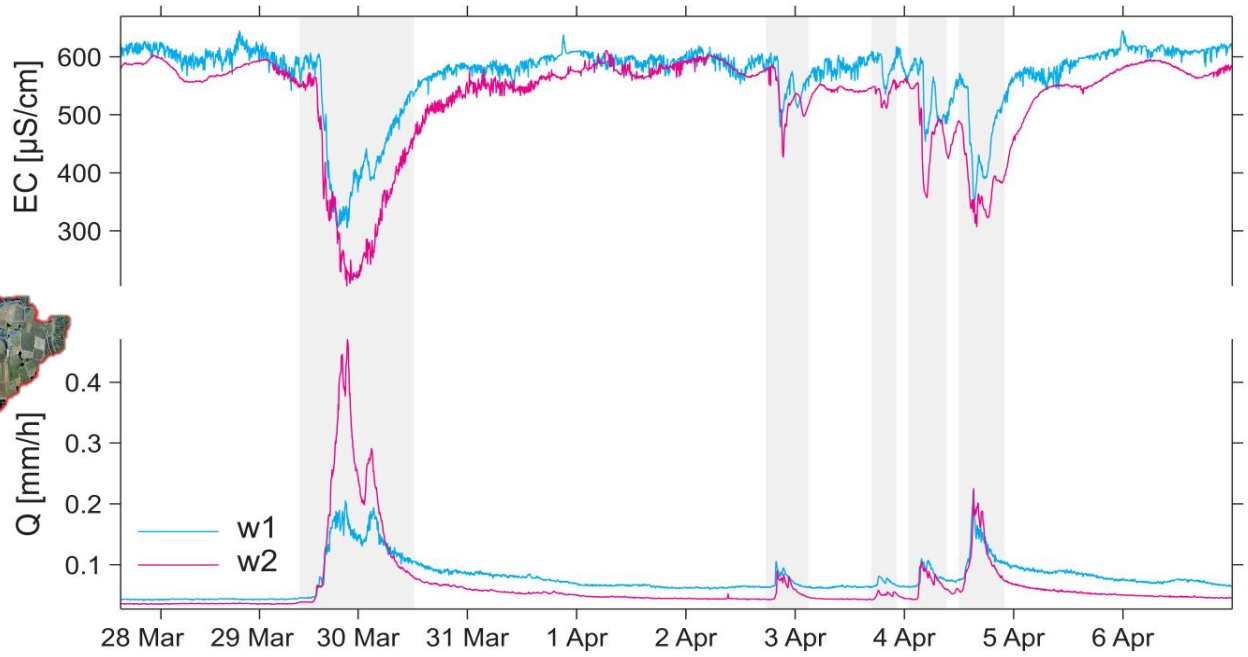
- NADUF program, CH
- LoVoTECS project, NH, USA
- CAOS project, Luxembourg
- USGS water quality surveys
- …

Traditionally used to estimate total dissolved solids (TDS)



EC measurements at the Chamberonne stations





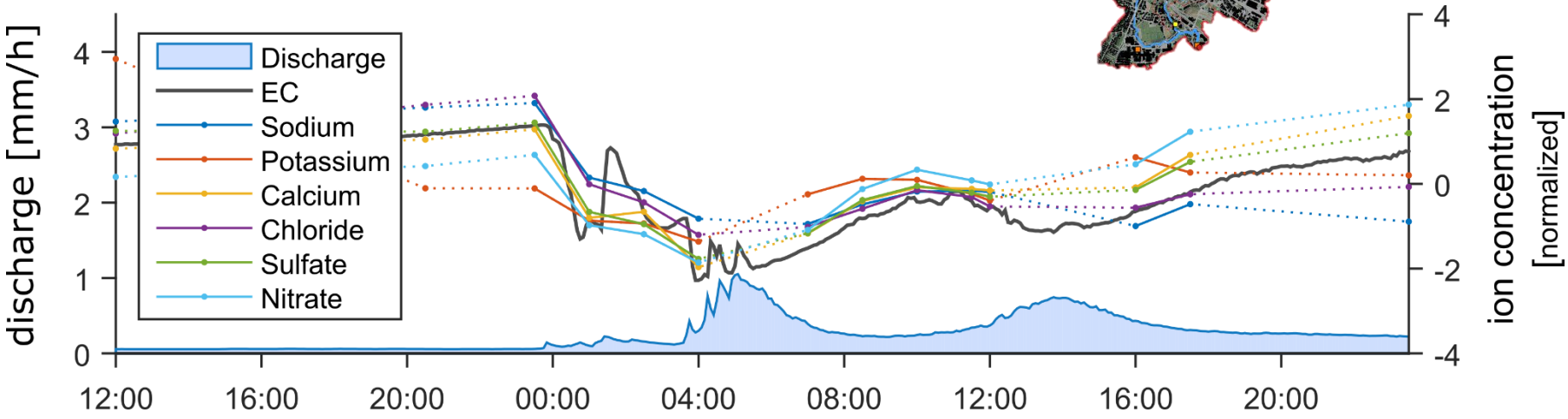
data from the Chamberonne river, Lausanne

Large variations in TDS during storm events

EC measurements at the Chamberonne

Evident links between EC and solute concentration

Chamberonne Sorge
storm event 26.10.2016
solute frequency: 90 min



can we make **EC** useful for active solute monitoring and modeling?

methods: decomposing EC into ion contributions

Classic interpretation of EC:

$$EC = \sum_i EC_i = \sum_i (\Lambda^0 m\, \gamma_{EC})_i$$

Λ^0 molar conductivity
m molar concentration
γ_{EC} electrochemical activity coeff.

Reformulation:

$$EC(t_k) = \sum_i a_i\, C_i(t_k)$$

$$f_i(t_k) = \frac{EC_i(t_k)}{EC(t_k)} \xrightarrow{\text{algorithm}} \boldsymbol{f_i}(t)$$

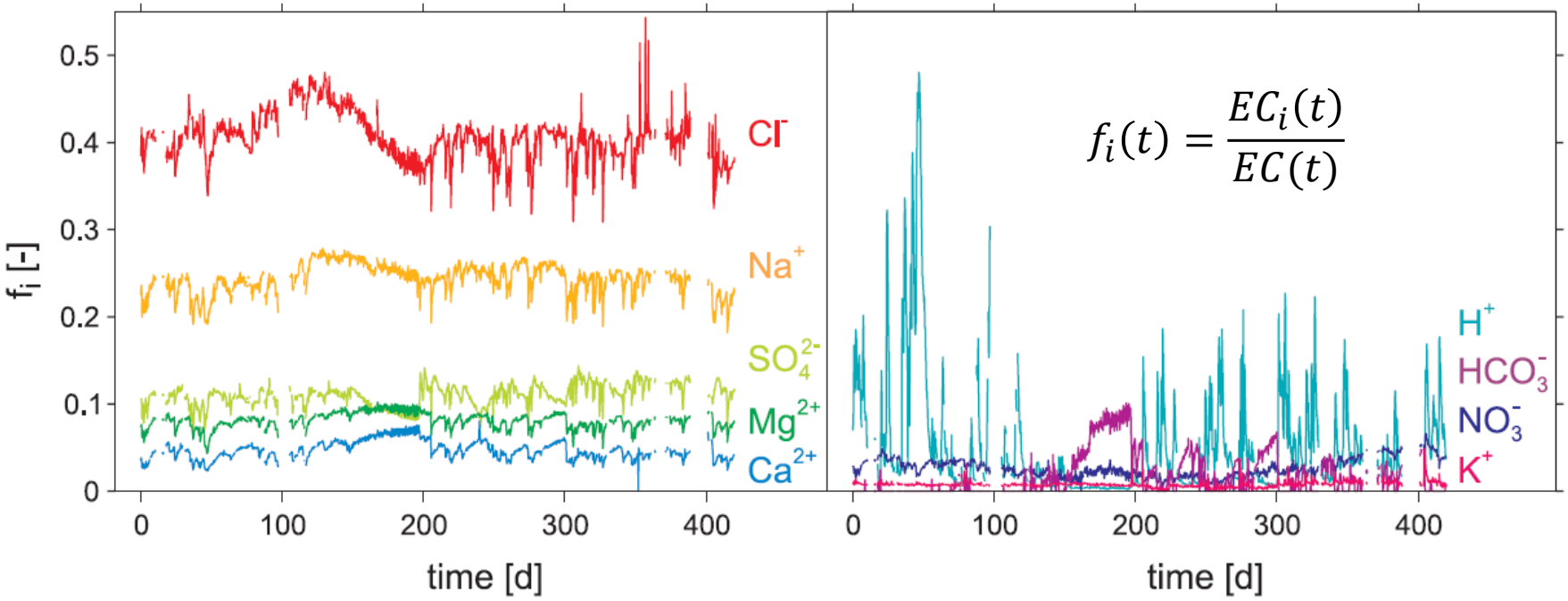
$$C_i(t) = \frac{\boldsymbol{f_i}(t)}{a_i} EC(t)$$

estimate of solute concentration at high frequency starting from continuous EC measurements

Benettin and van Breukelen, 2017, ES&TL

a proof of concept

Solutes can be **RANKED** according to their relative contribution to EC

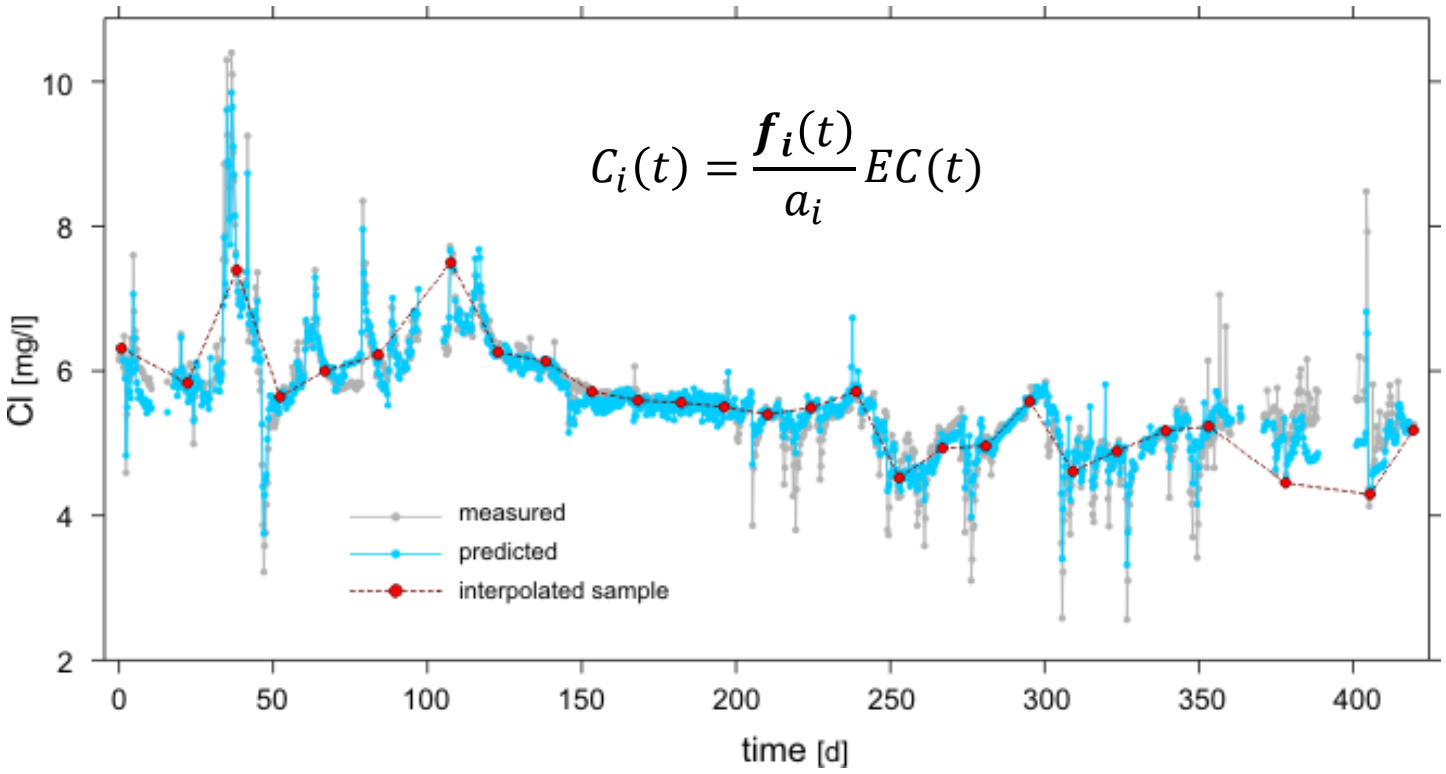


→ search for patterns in individual solute contribution

data from Plynlimon UHF, UK

a proof of concept

ACTIVE use of EC to reconstruct higher-frequency solute behavior



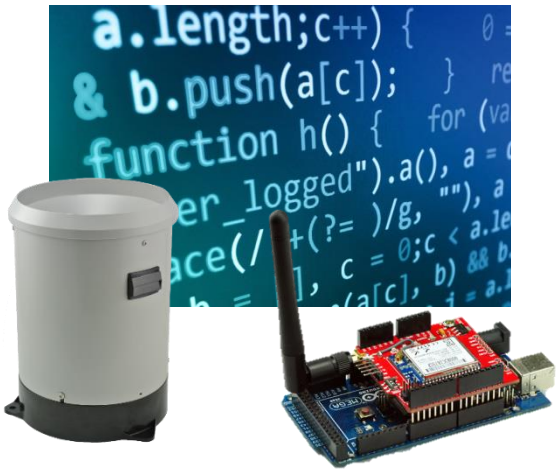
...deploying networks of EC probes? measuring EC of precipitation?
...can EC be integrated in transport models?

application to Plynlimon UHF dataset, UK

future developments

Innovation

Generating new Algorithms, Developing Sensors for streamflow, precipitation (and more?)

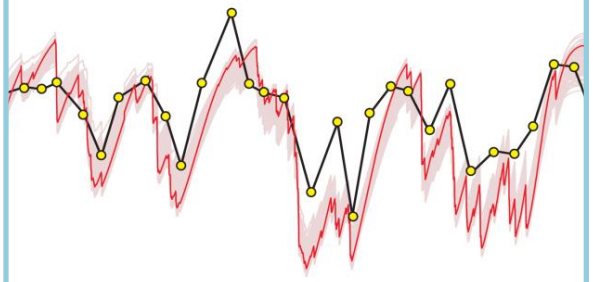


Monitoring

Creating a protocol for the routine use of EC to complement water quality monitoring programs

Modeling

Developing a methodology to use EC in the calibration of transport models



discussion and conclusions

- EC embeds a lot of information (besides this particular approach)
- early application is promising
- many opportunities for further development
- low-cost technology

- applications are likely to be site-specific
- applications are likely to be solute-specific
- need to ‘train’ the algorithm
- EC sensors: durable, but maintanance is still required
- EC signal easily clouded by point sources (road salting, sewage discharge...)

still need for extensive testing in diverse environments