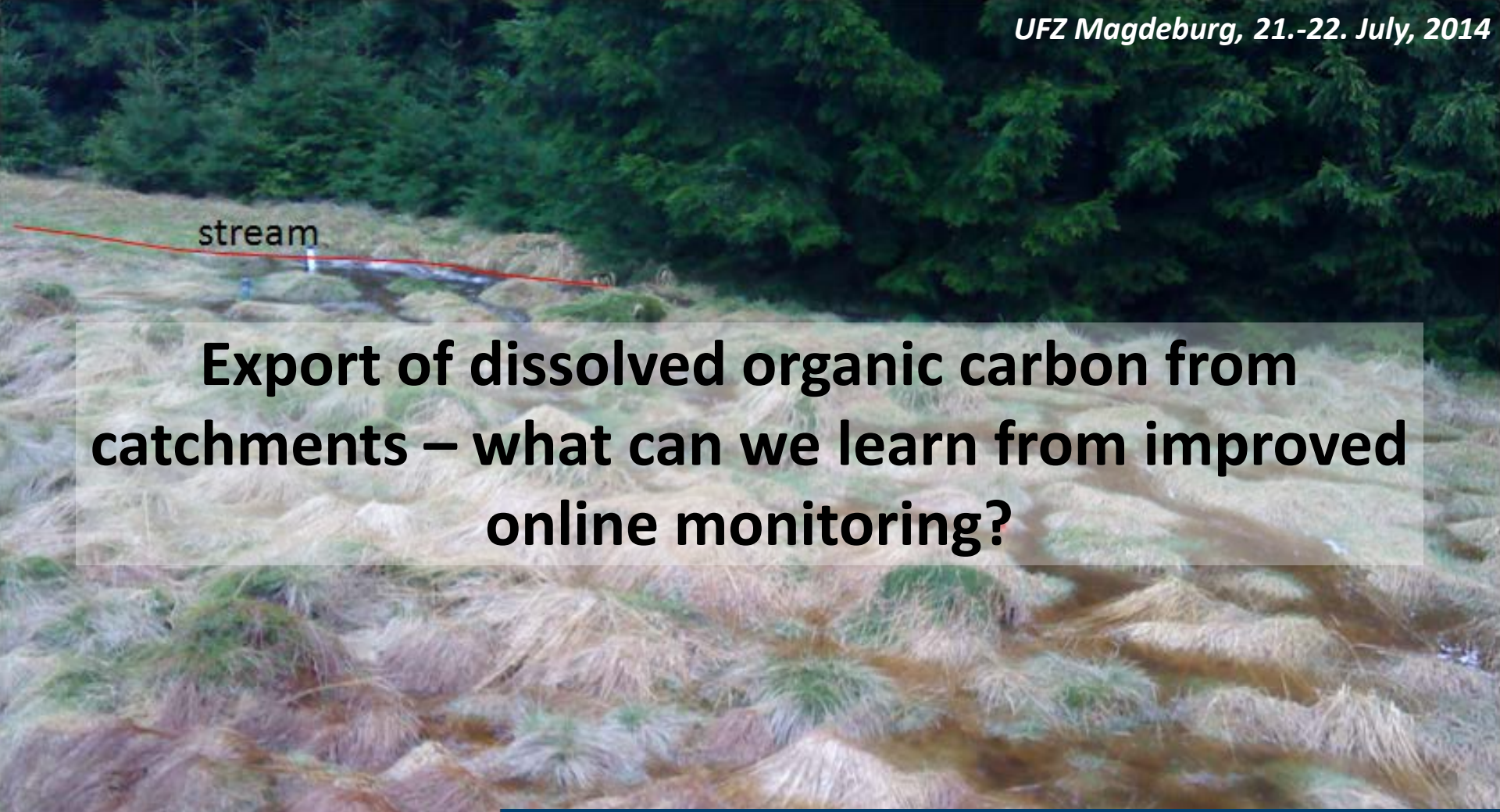
UFZ Magdeburg, 21.-22. July, 2014



Export of dissolved organic carbon from catchments – what can we learn from improved online monitoring?

J.H. Fleckenstein[4], M. Oosterwoud[4], S. Frei[2], K.H. Knorr[1], J.H. Park[3], M. Kurz[4], T. Keller[4]

[1] Westfälische Wilhelms-Universität Münster

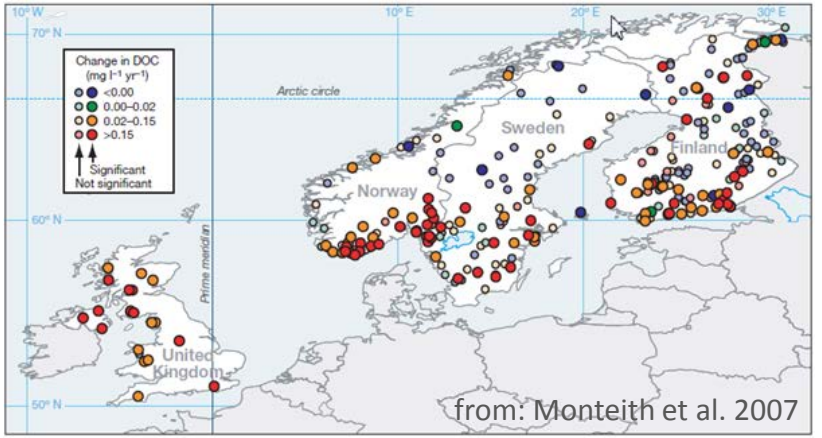
[2] Universität Bayreuth

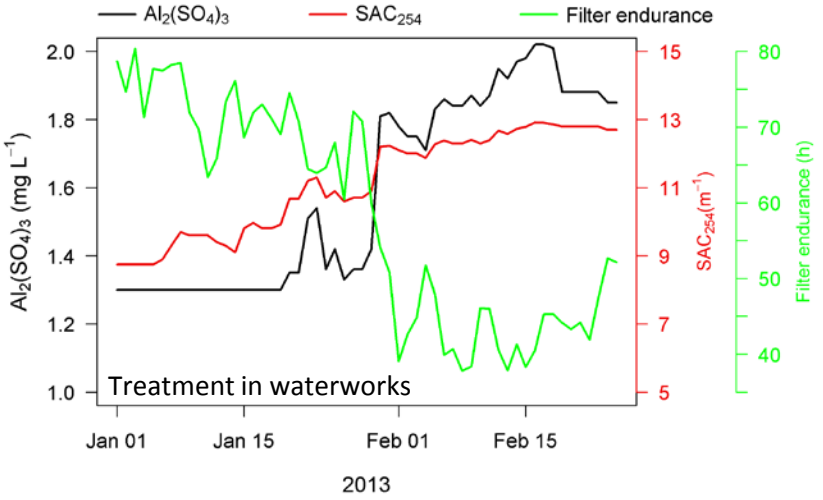
[3] Ewha Womans University

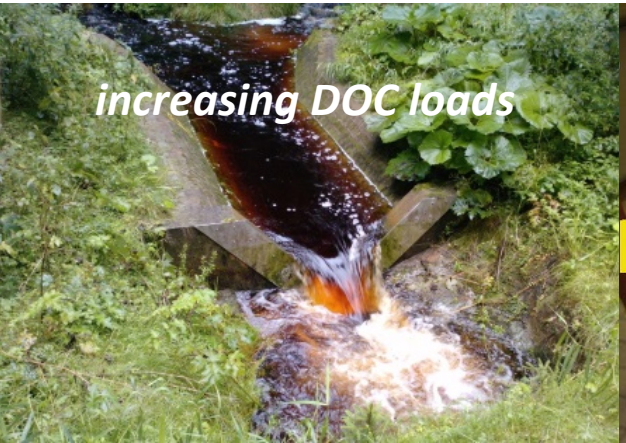
[4] Helmholtz Centre for Environmental Research – UFZ

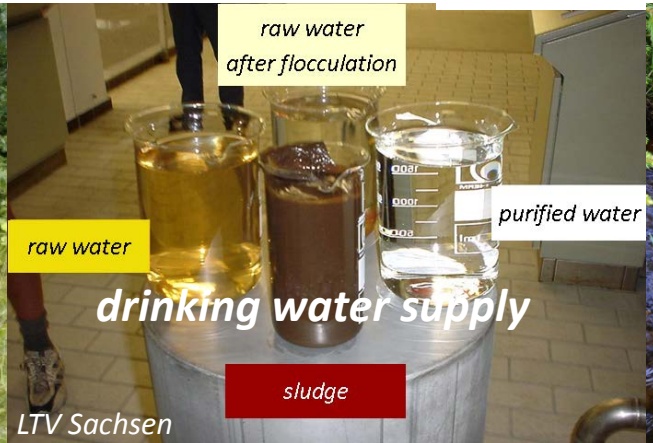
Background

- Increasing DOC loads → carbon cycle
- Impacts on drinking water supply
- New generation of online sensors
- What are the driving mechanisms ?
- Three examples (catchments)

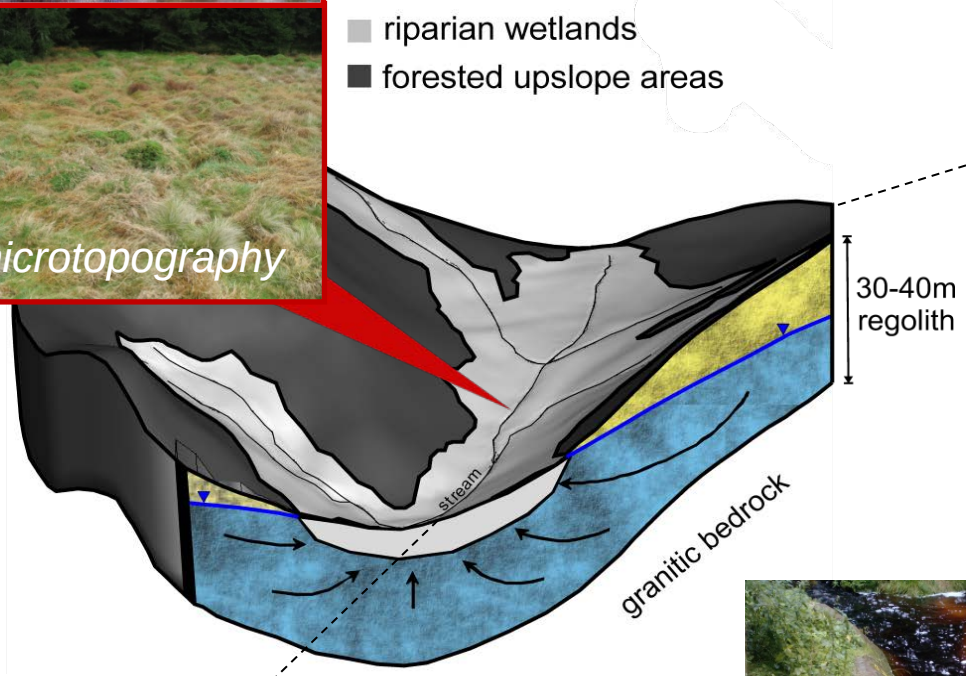


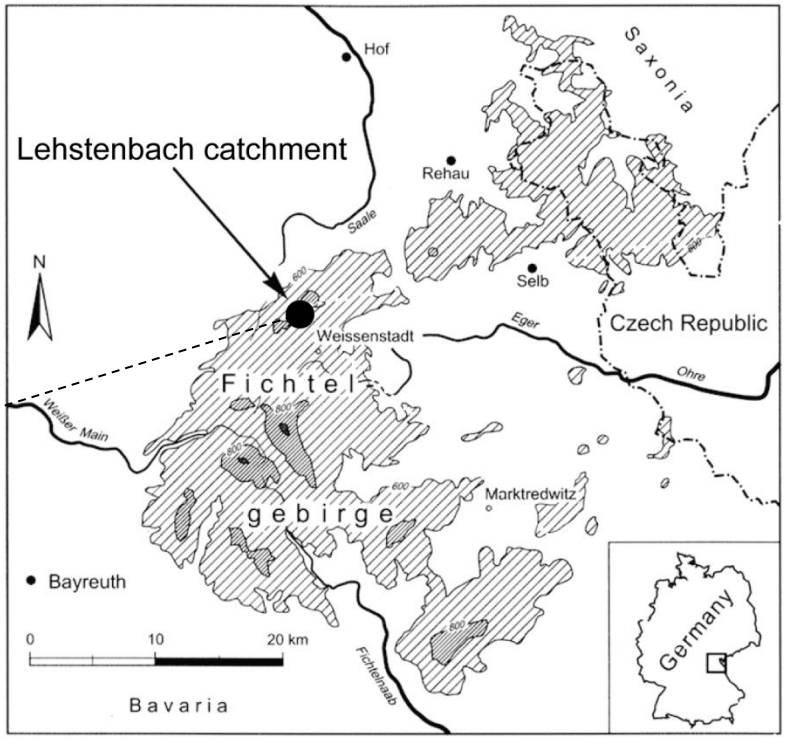


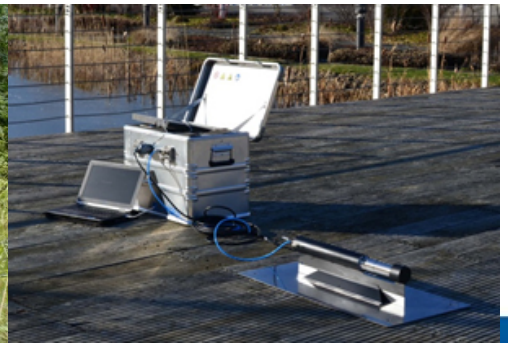




Example I – Lehstenbach Catchment (4.2 km²)





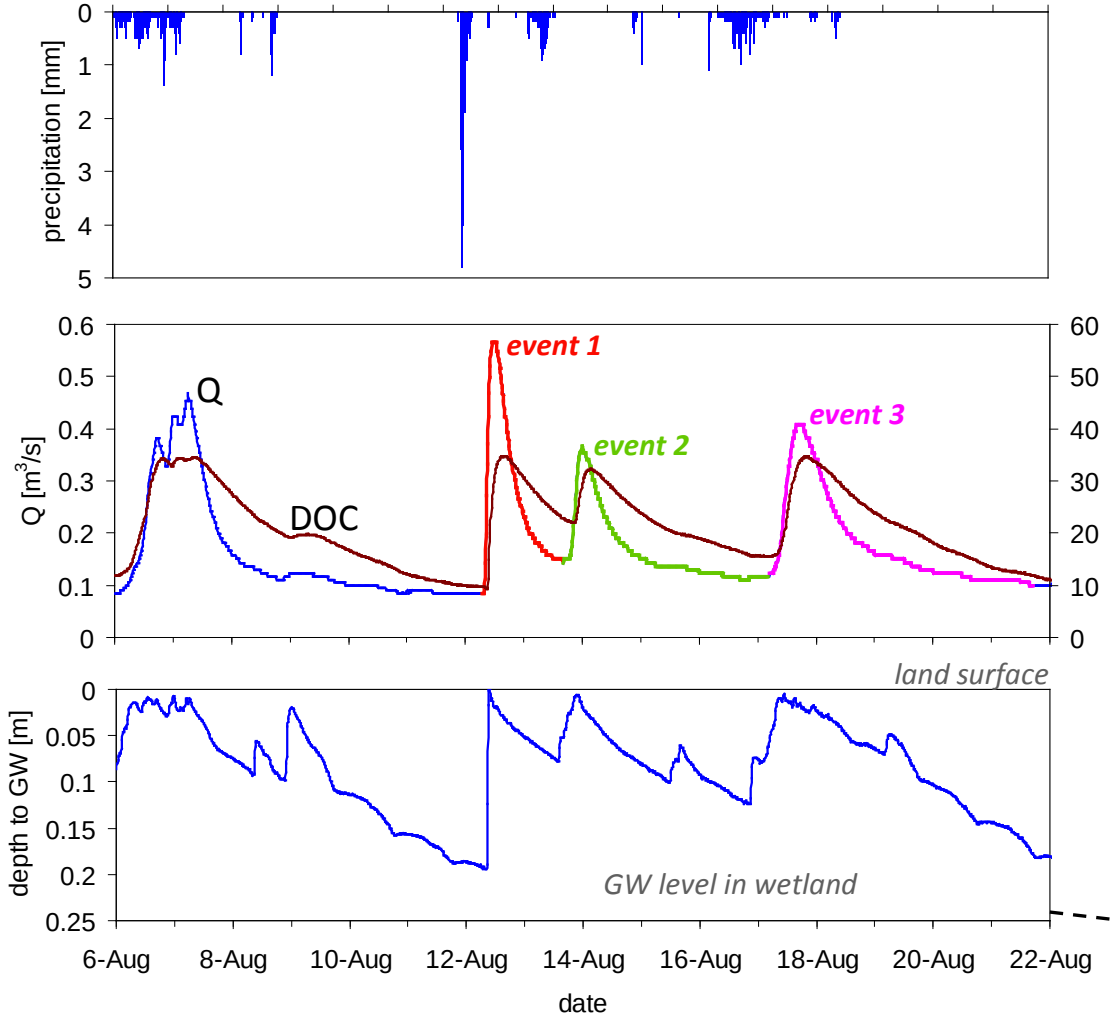


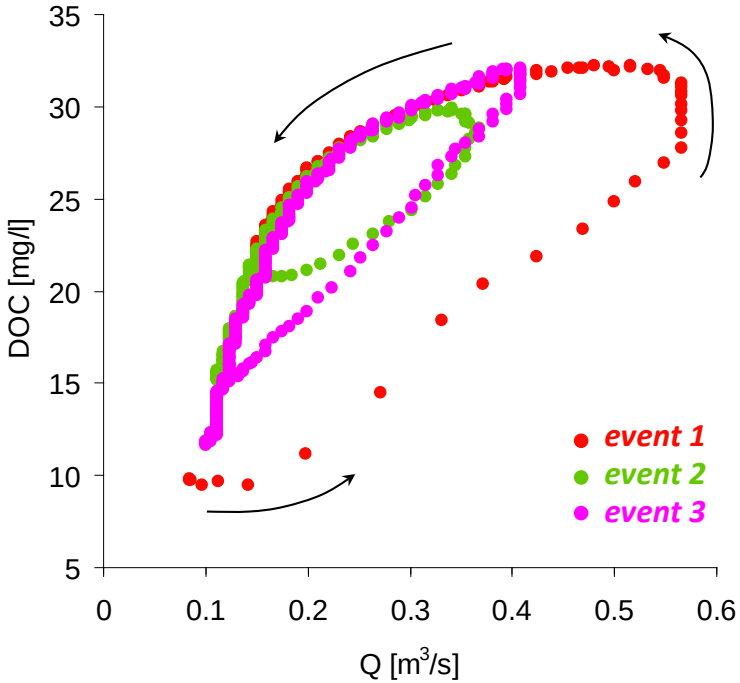
online DOC monitoring at catchment outlet →

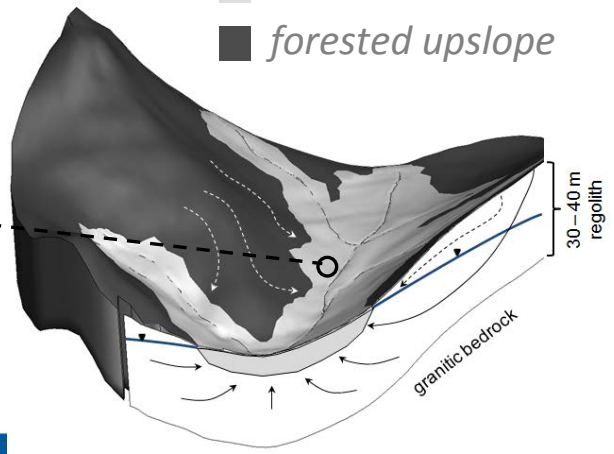
+ routine monitoring (e.g. Q, GW-levels, chemistry)

Time series of DOC, Q & riparian GW-head

summer rain events in 2010



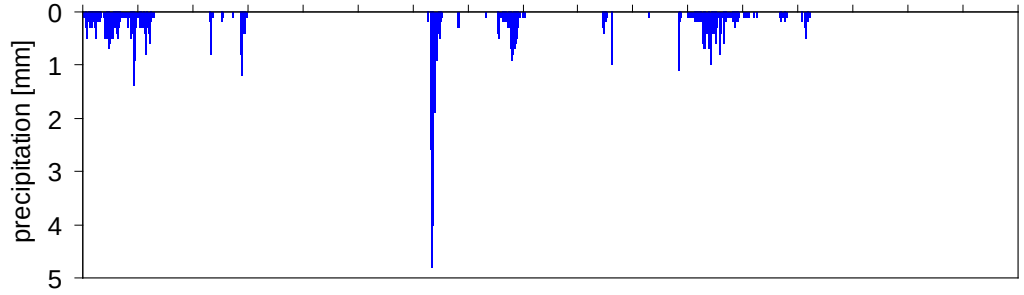


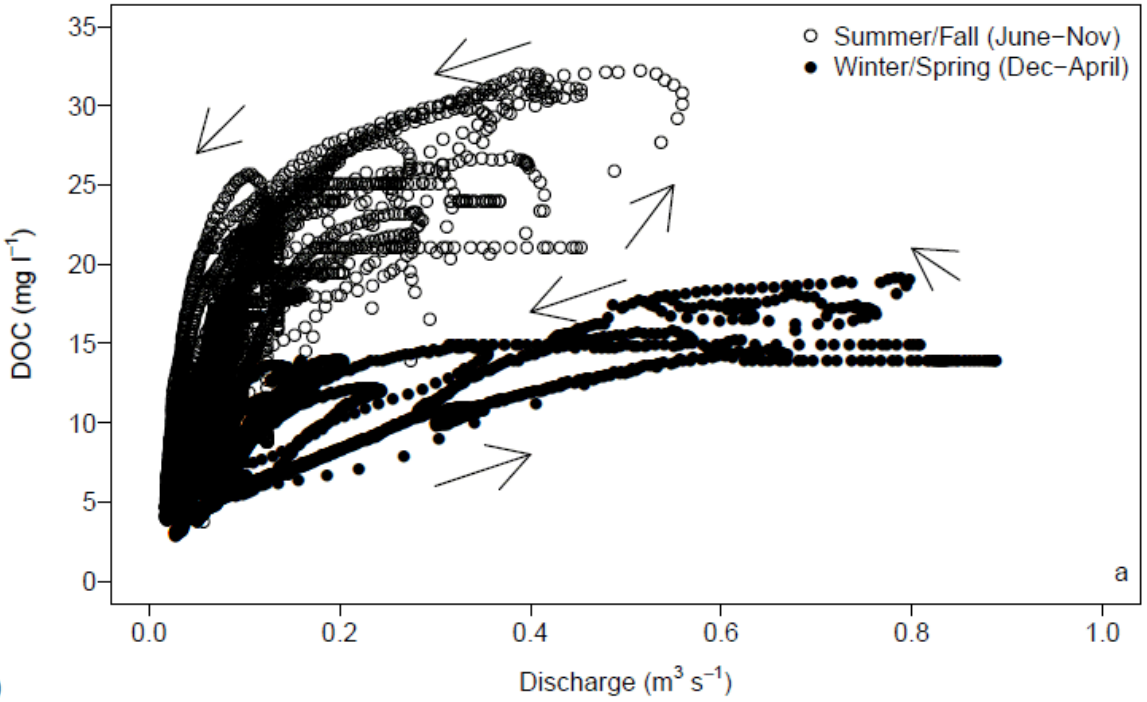


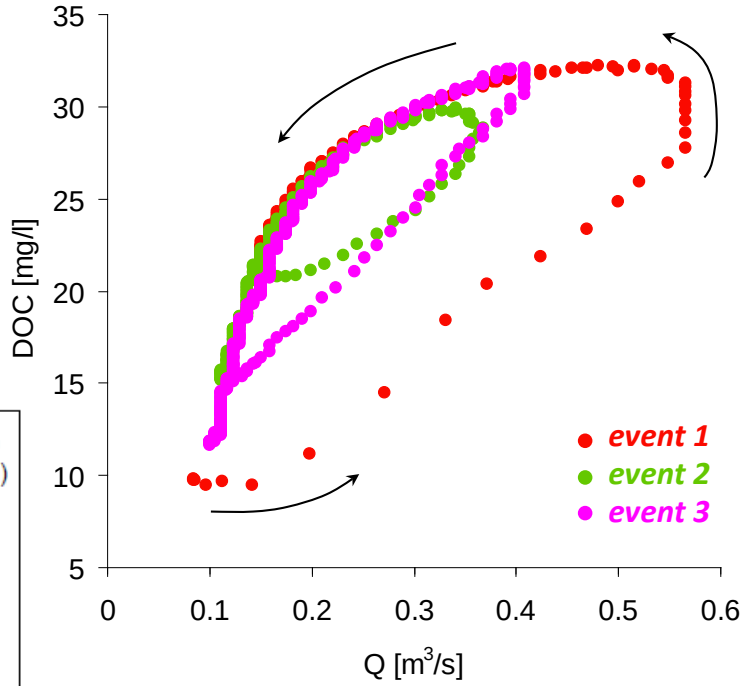
Strohmeier, et al. 2013, Biogeosciences, 10, 905–916

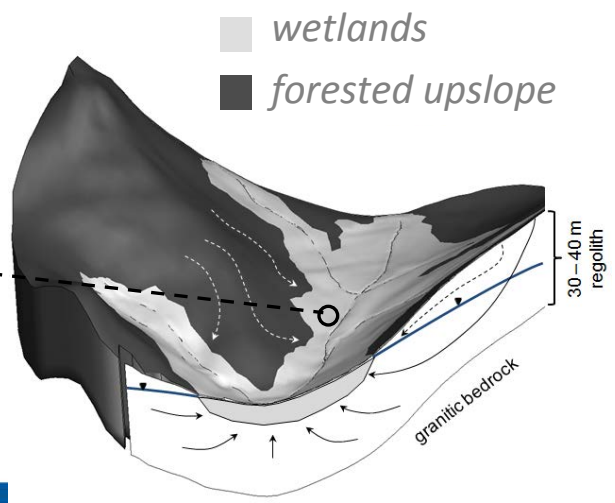
Time series of DOC, Q & riparian GW-head

summer rain events in 2010



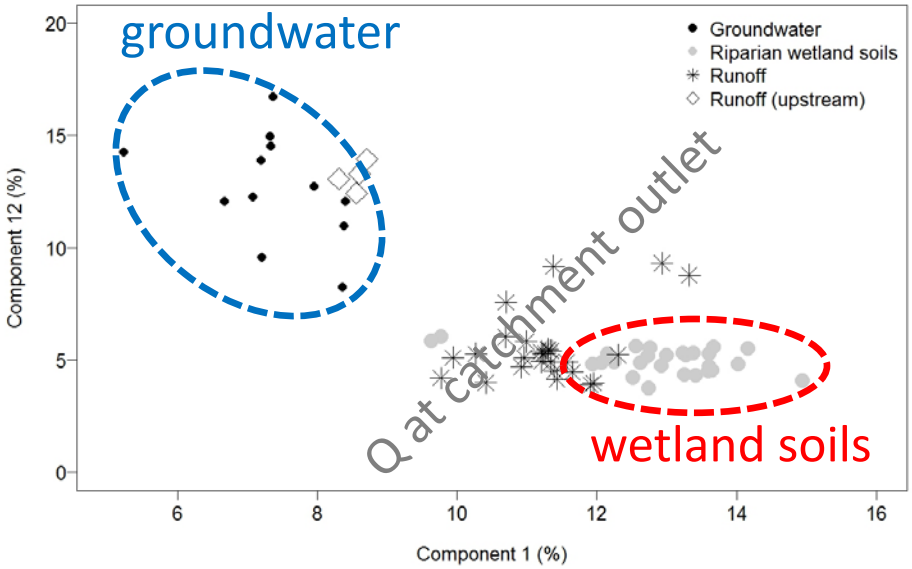


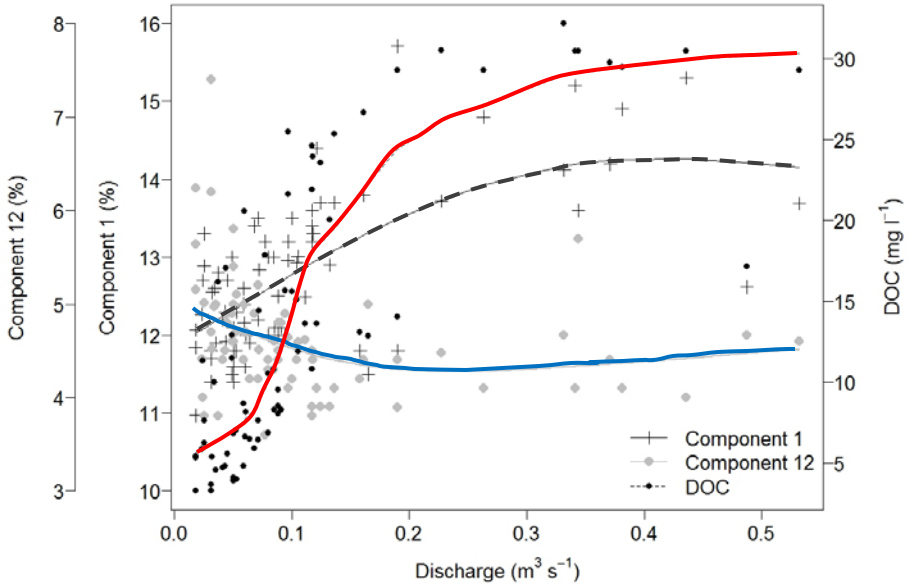




Strohmeier, et al. 2013, Biogeosciences, 10, 905–916

Fingerprinting of DOC components





fluorescence excitation-emission matrices & parallel factor analysis (PARAFAC)

Strohmeier, et al. 2013, Biogeosciences, 10, 905–916

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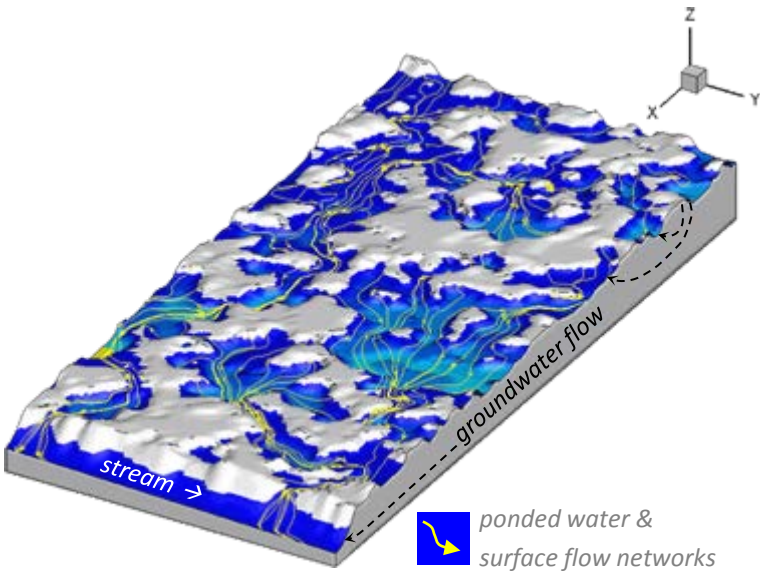
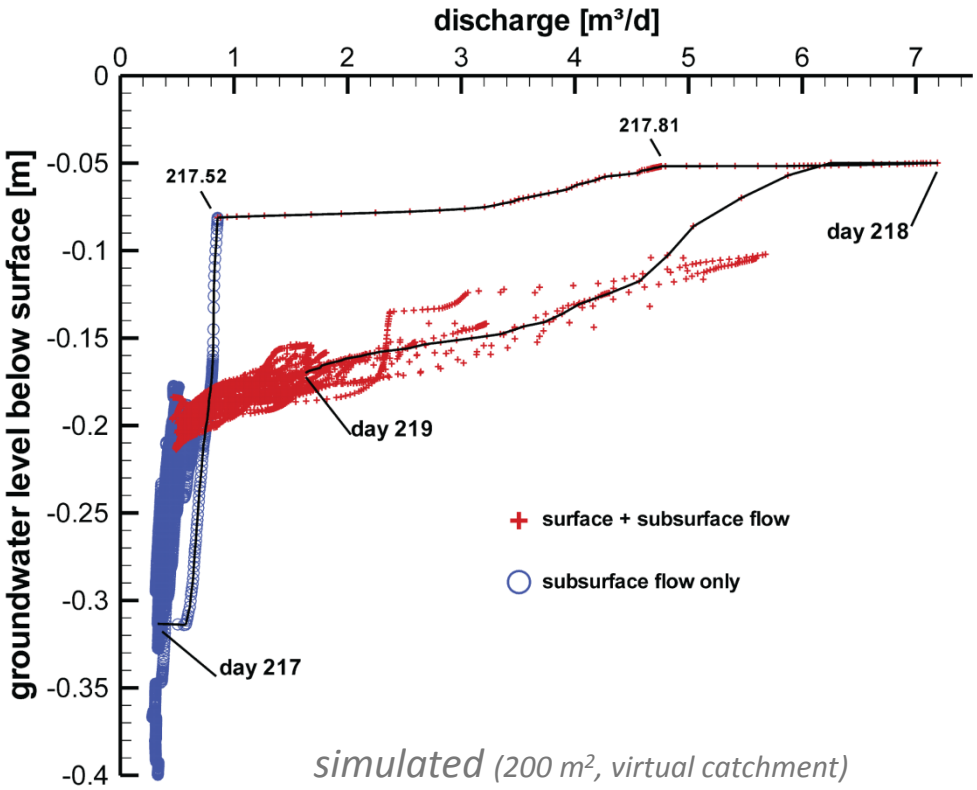
Hydrologic dynamics → runoff generation

threshold-type runoff generation→



200 m², virtual catchment

hysteretic GW-Q relationship



simulated (200 m², virtual catchment)

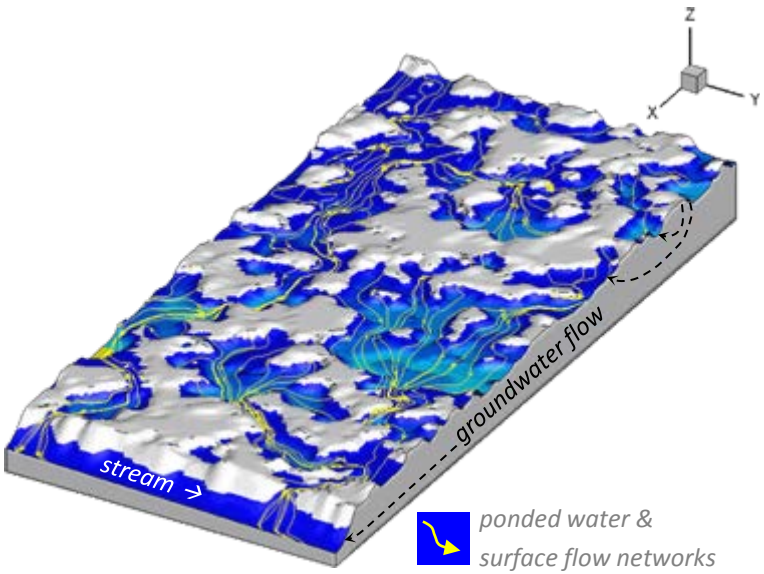
Frei et al. 2010, Advances in Water Resources, 33, 1388-1401

Frei et al. 2012 Journal of Geophysical Research – Biogeosciences, 117, G00N12

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

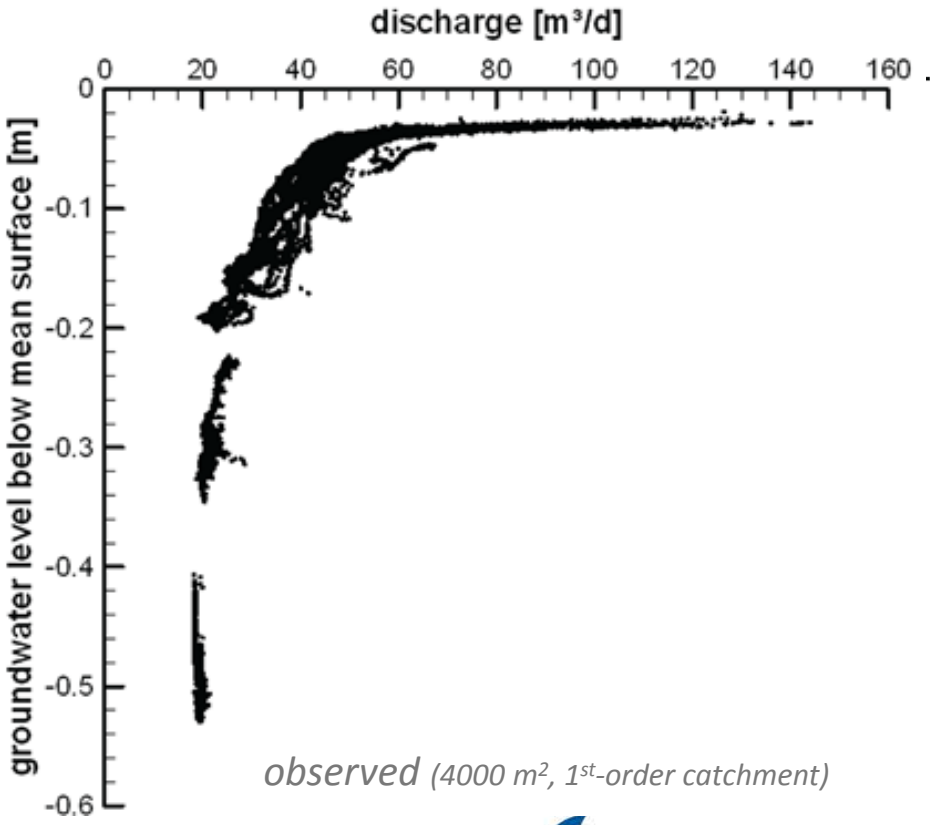
Hydrologic dynamics → runoff generation

threshold-type runoff generation→



200 m², virtual catchment

hysteretic GW-Q relationship



observed (4000 m², 1st-order catchment)

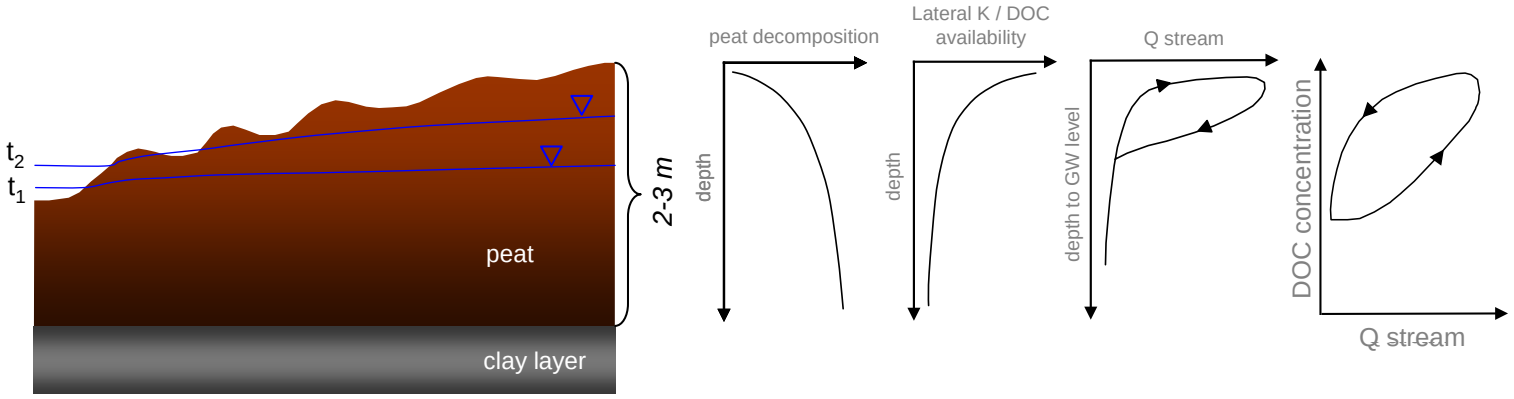
Frei et al. 2010, Advances in Water Resources, 33, 1388-1401

Frei et al. 2012 Journal of Geophysical Research – Biogeosciences, 117, G00N12

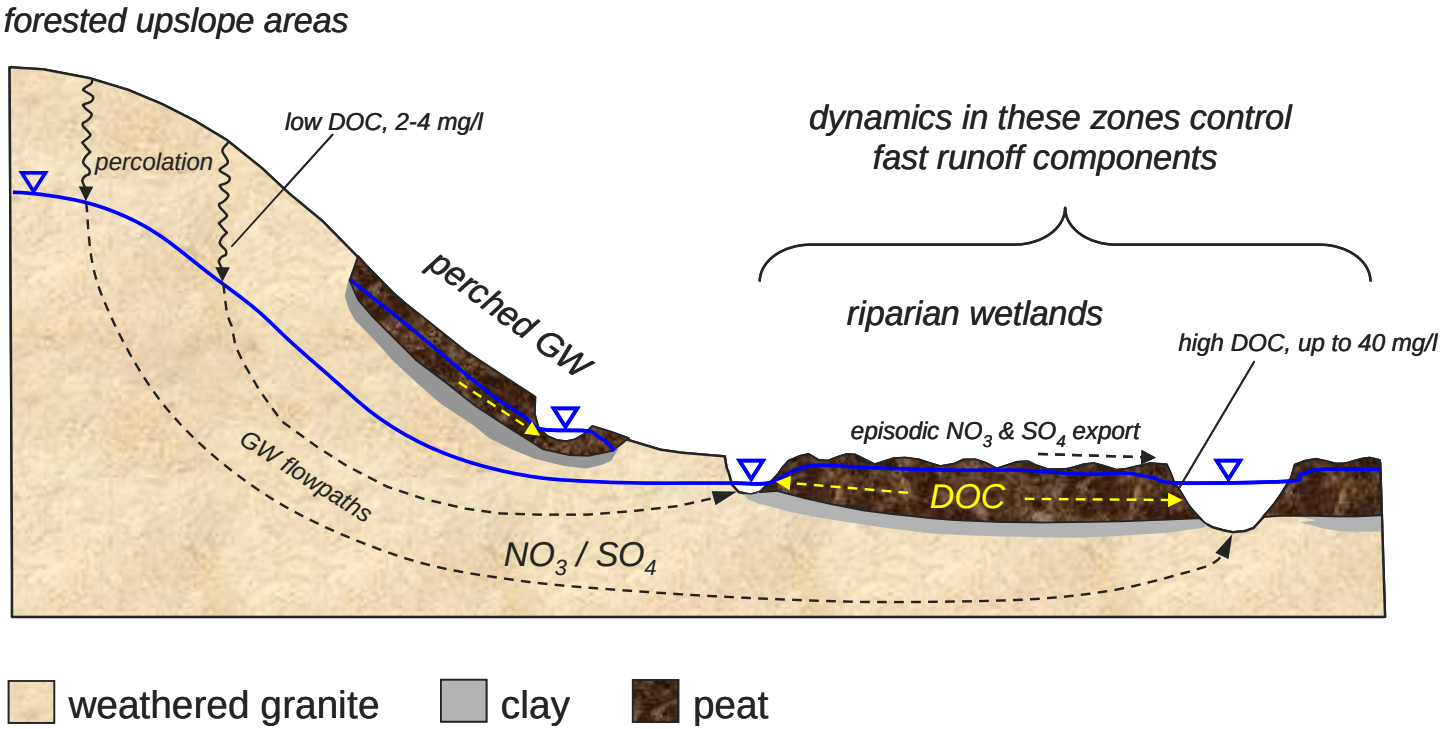
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Conceptual model of DOC export – Lehstenbach

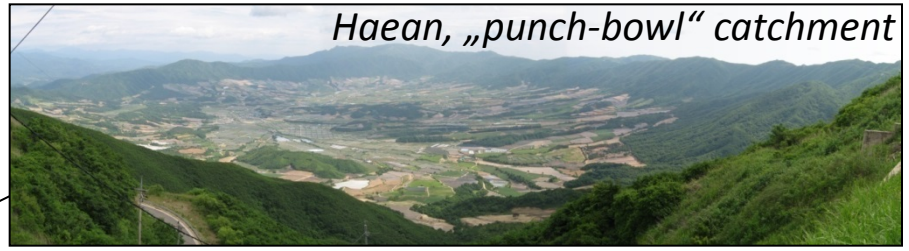
DOC mobilization in riparian wetlands



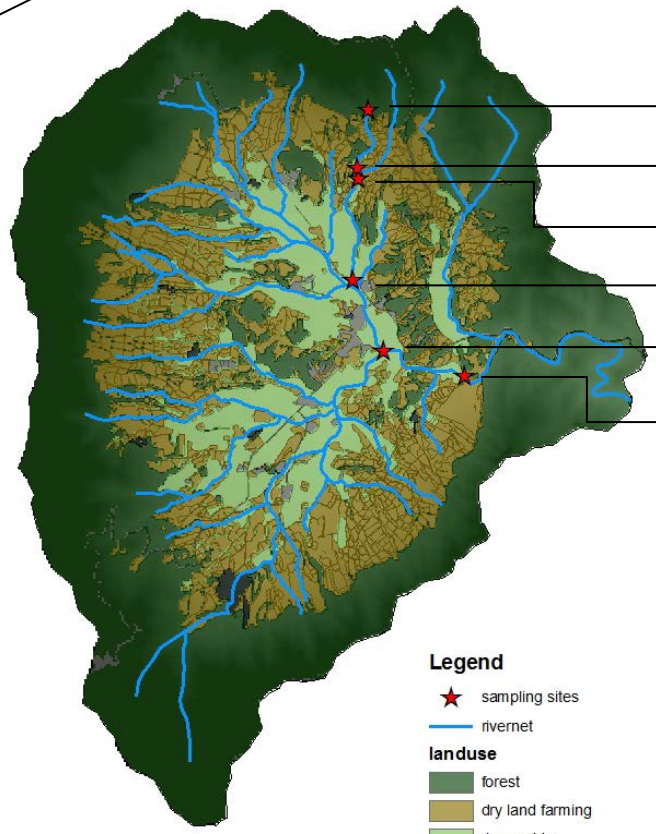
catchment-scale flowpaths



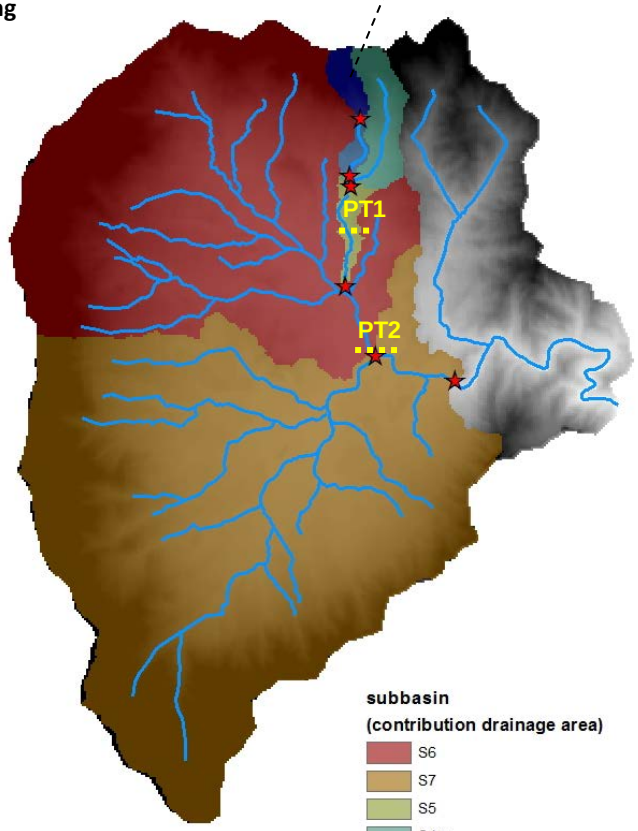
Example II – DOC mobilization under monsoonal climate



Subcatchment S1
(0.4 km²)



Sampling Sites
S1
S3
S4w
S5
S6
S7



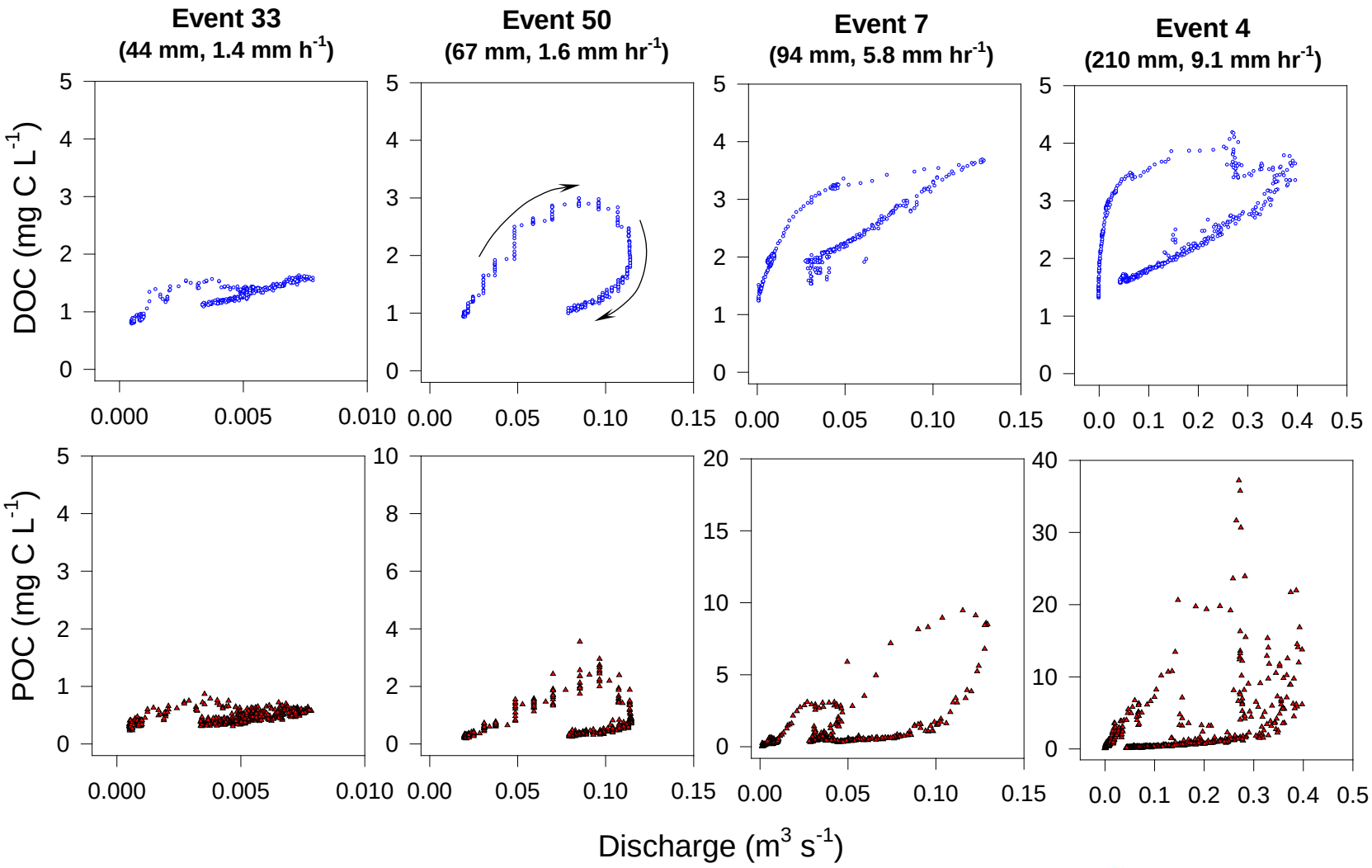
Legend
sampling sites
rivernet
landuse
forest
dry land farming
rice paddy
urban
others

0 0.5 1 2 3 4 Kilometers

subbasin
(contribution drainage area)
S6
S7
S5
S4w
S3
S1

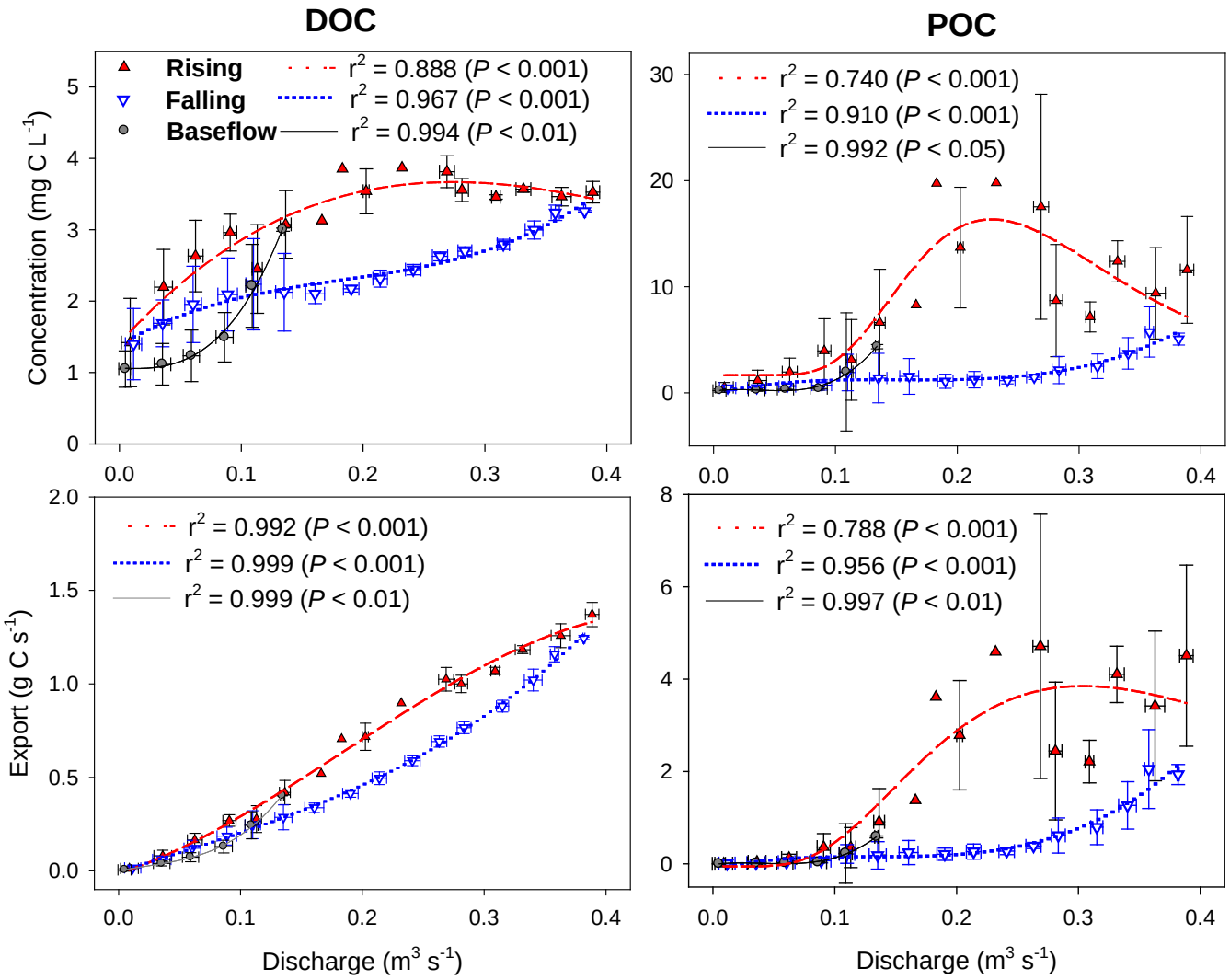
Haean, 1st-order catchment (0.4 km^2)

Hysteretic solute dynamics – DOC & POC



from: Jeong, et al. 2012, Journal of Geophysical Research - Biogeosciences, 117, G03013

Hysteretic solute dynamics – pooled data

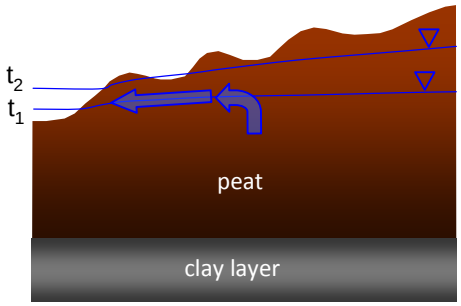


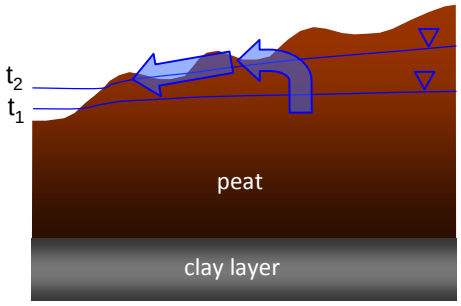
from: Jeong, et al. 2012, Journal of Geophysical Research - Biogeosciences, 117, G03013

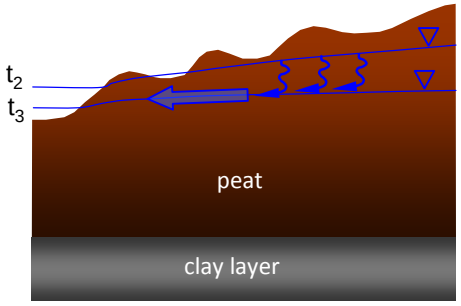
Conceptual models of DOC export – Lehstenbach vs. Haean

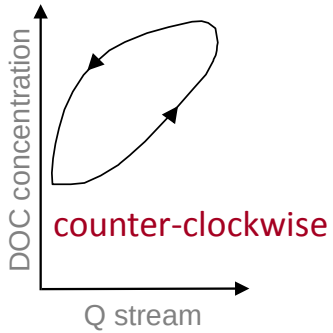
rising hydrograph *peak flow* *falling hydrograph* *DOC-Q hysteresis*

Lehstenbach



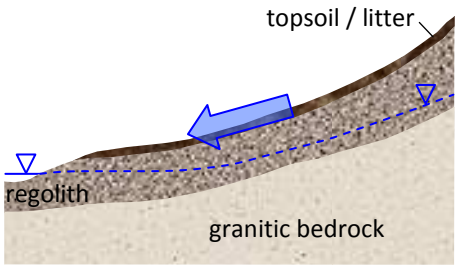


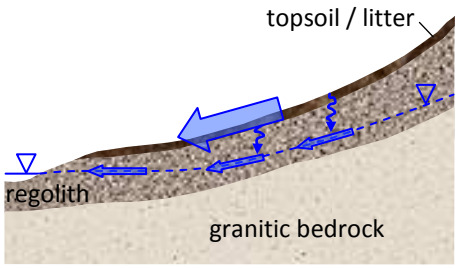


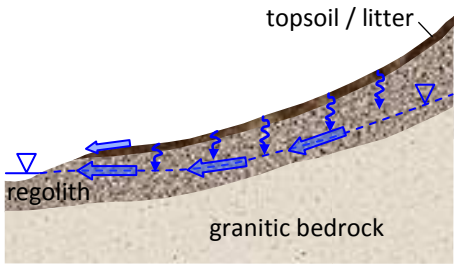


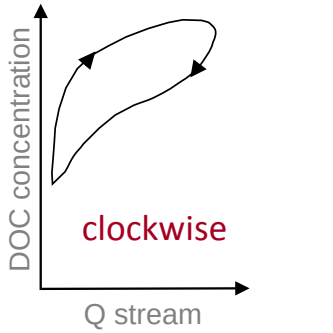
dominant flow routes (width = magnitude) fresh peat (high DOC) decomposed peat (low DOC)

Haean

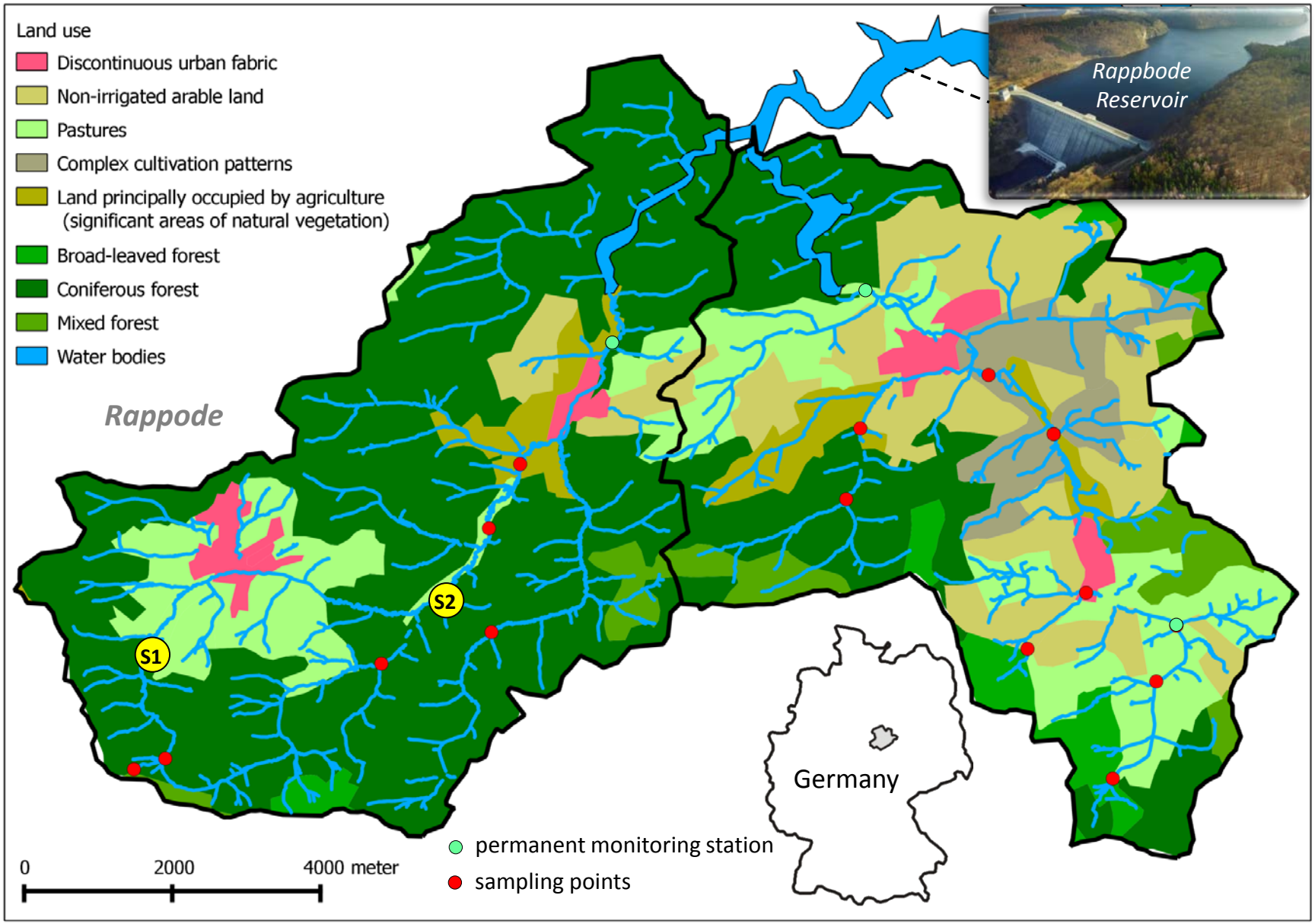




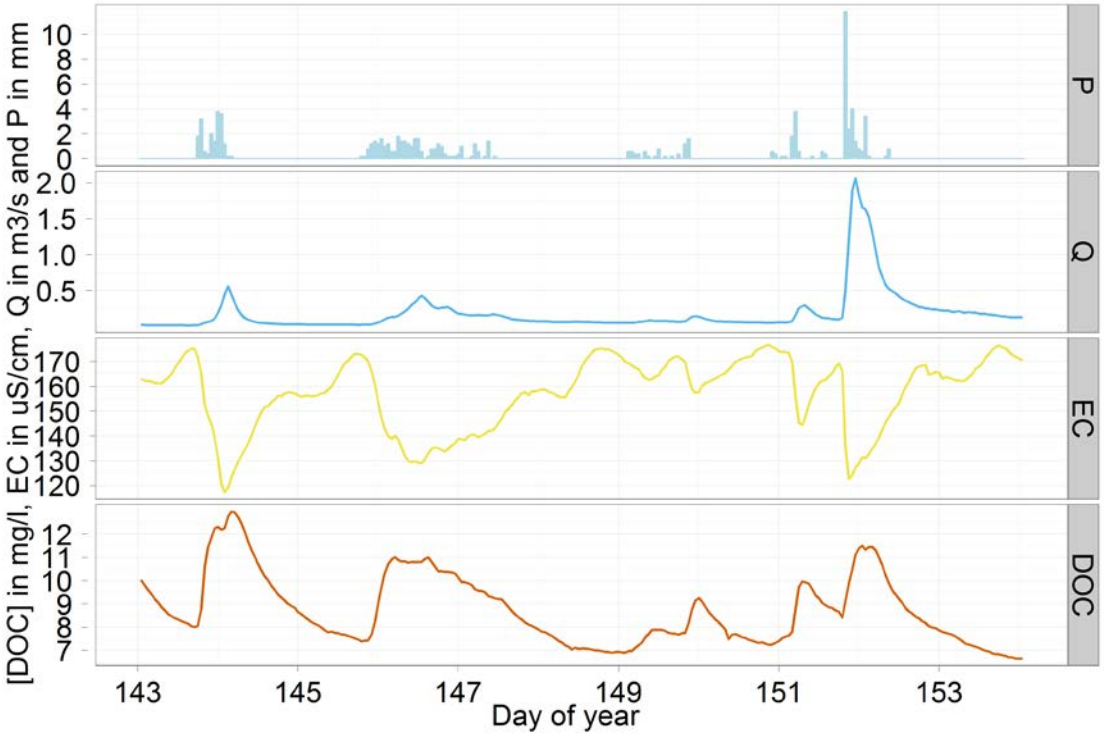


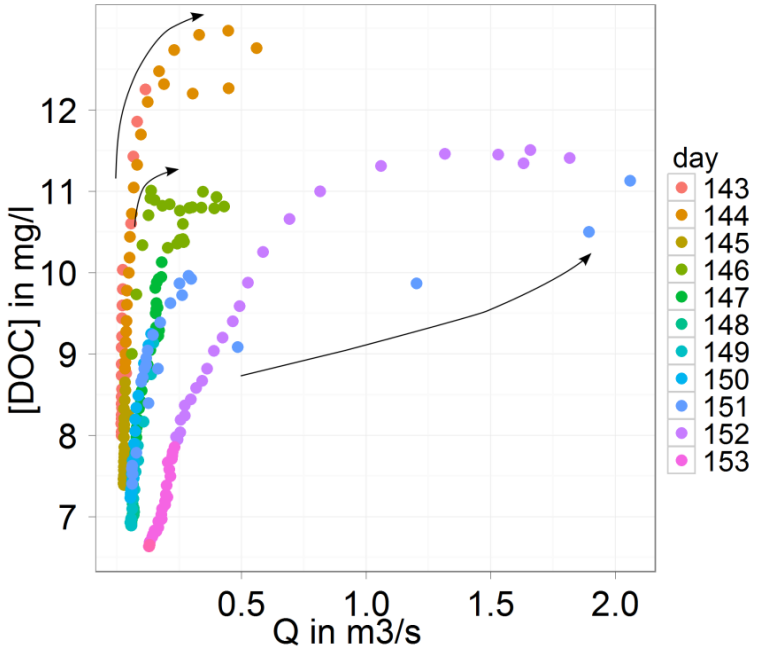


Example III – DOC export from the Rappbode system



Q, EC & DOC at UV-VIS sensor S1 – subcatchment 3.7 km²





initial fast flushing followed by delayed reponse as system wets up

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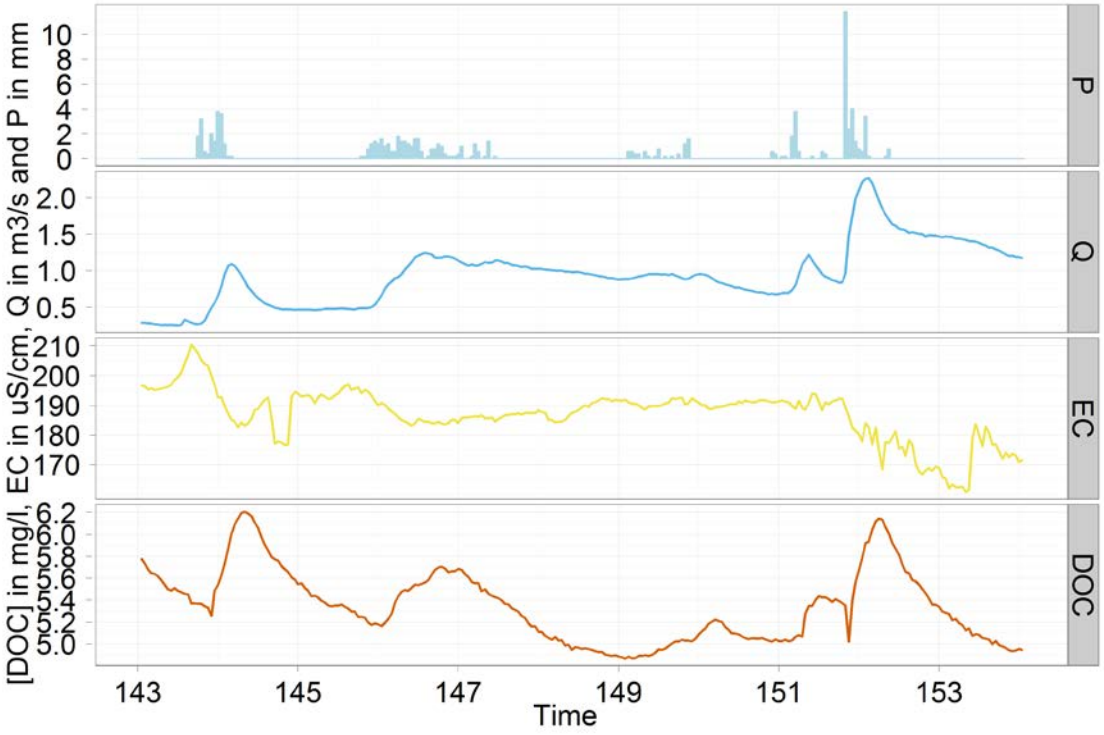
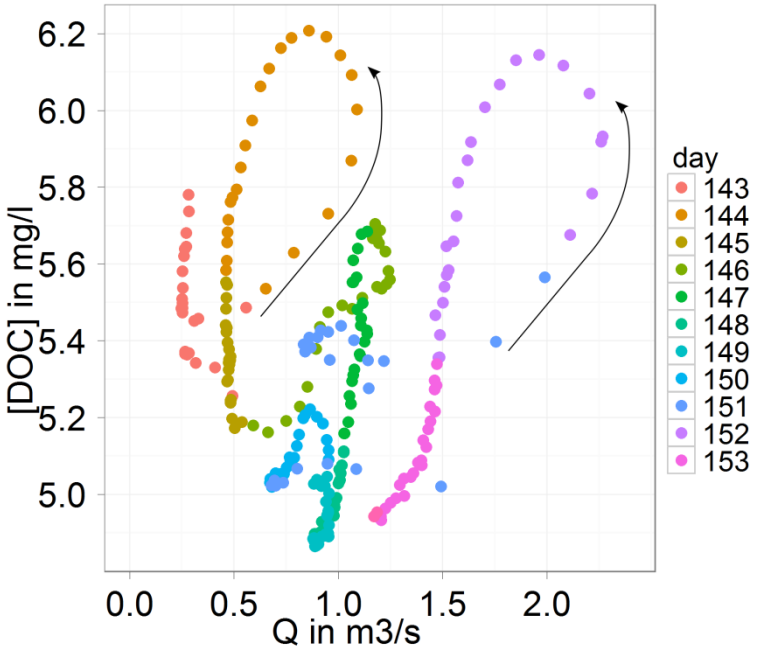
Q, EC & DOC at UV-VIS sensor S2 – subcatchment 17.6 km²





delayed response, dynamic source areas, no depletion of sources ?

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Conclusions

- Improved sensing capabilities provide new insights into DOC dynamics
- Distinct hysteretic relationships between DOC & Q
- Relationships indicative of mobilization mechanisms
- Climatic drivers + catchment structure control export dynamics
- Larger catchment size/complexity → more complex C-Q relationships
- Low frequency monitoring → important dynamics may be missed

  → significant underestimation of loads

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Frei S., Knorr K.-H., Peiffer S. and Fleckenstein J.H. (2012) Surface micro-topography can cause hot-spots of biogeochemical activity in wetland systems, Journal of Geophysical Research – Biogeosciences, 117, G00N12

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Strohmeier S., Reichert M., Frei S., Knorr K.-H., Fleckenstein J.H., Peiffer S., Matzner E. (2013) Concentrations and fluxes of dissolved organic carbon in runoff from a forested catchment: insights from high frequency measurements, Biogeosciences,10:905-916

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Photo: André Künzelmann, UFZ

Hydrogeology
UFZ Leipzig

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J. Jeong — Kangwon National University, South Korea

Fin!