SWAT sediment & nutrient calibration and validation with a 6-year dataset of continuous data in a Finnish catchment

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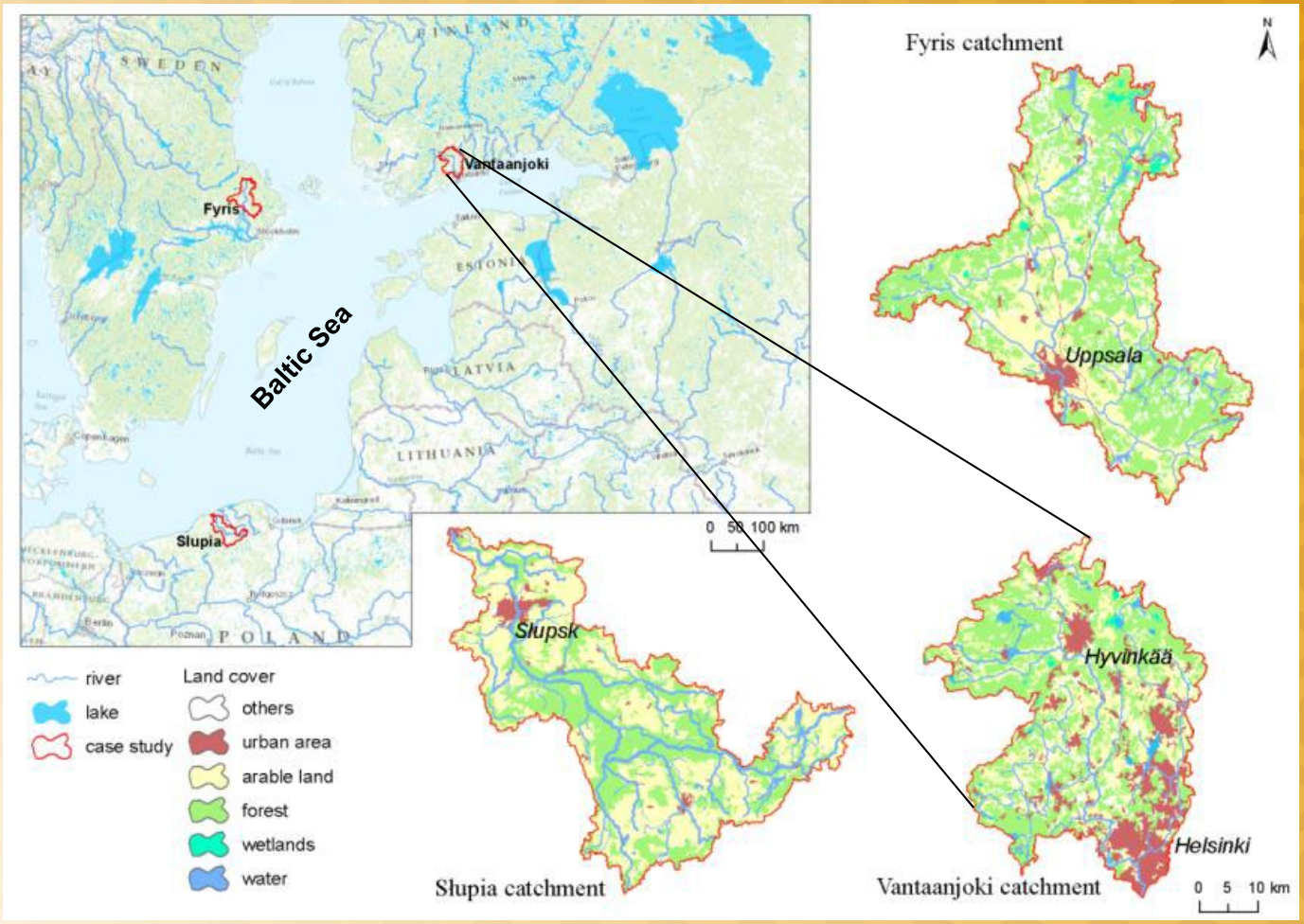
BONUS RETURN
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

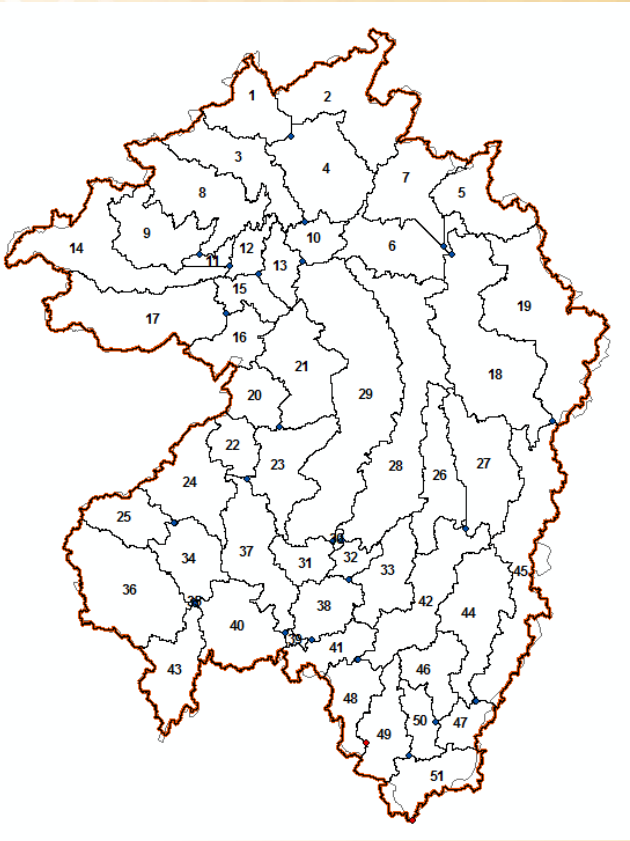
SWAT setup – case Vantaanjoki, Finland

Vantaanjoki catchment

- One of the case study catchments of the Bonus RETURN project (www.bonusreturn.com)
- The river flows through Helsinki metropolitan area of over 1 million people ➔ huge recreational value
- River was until 1970s heavily loaded and in poor state
- WWTPs improved the situation and now the river's ecological status is satisfactory
- A significant source of loading into the Gulf of Finland (on av. 60 tons P and 1000 tons N per year)



1. HRU definition



- MULTIPLE HRUs LandUse/Soil/Slope OPTION
- THRESHOLDS : 4 / 4 / 4 [%]

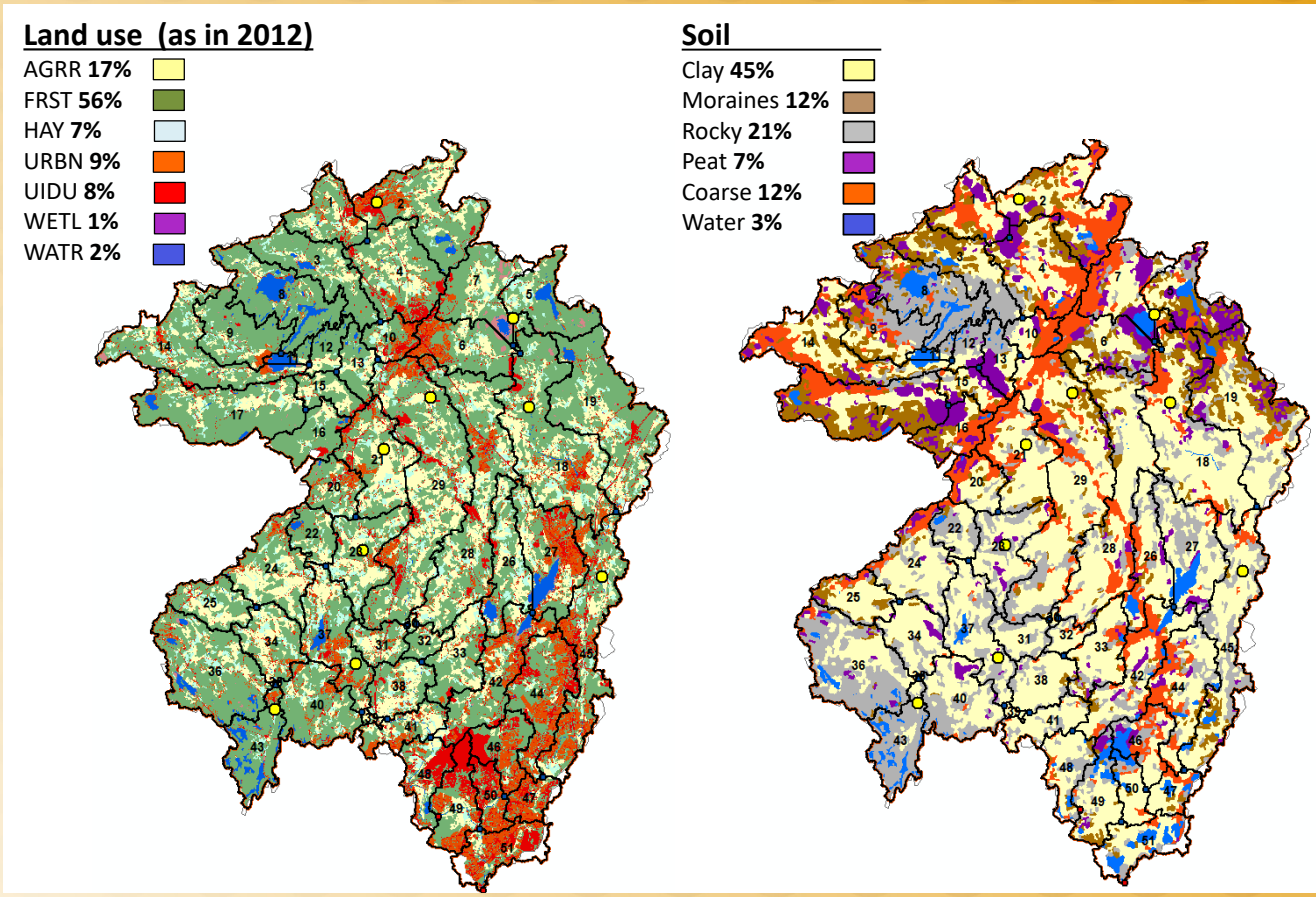
- Number of HRUs: **1760**
- Number of Subbasins: **51**

Land use type	ha	% of watershed	SWAT name
Autumn crops	2 078	1,2 %	AGRR
Spring crops	23 861	14,2 %	
Beets	68	0,04 %	
Gardens	239	0,1 %	
Other agricultural areas	2 908	1,7 %	
Grass	10 961	6,5 %	HAY
Pasture	8	0,0 %	
Residential areas	13 948	8,3 %	URBN
Recreational areas	1 768	1,0 %	
Industry & traffic areas	11 195	6,6 %	UIDU
Mines, landfills & construction sites	1 842	1,1 %	
Dense forest	78 445	46,6 %	FRST
Sparse forests, shrubs	16 497	9,8 %	
Rock outcrop	73	0,0 %	
Inland wetlands	878	0,5 %	WETL
Inland waters	3 684	2,2 %	WATR
Total	**168 454**	**100 %**	

3. Land use & soil maps

2. DEM & weather inputs

- DEM 10x10m resolution
- 3 weather stations: one in south and two in northern part of the watershed



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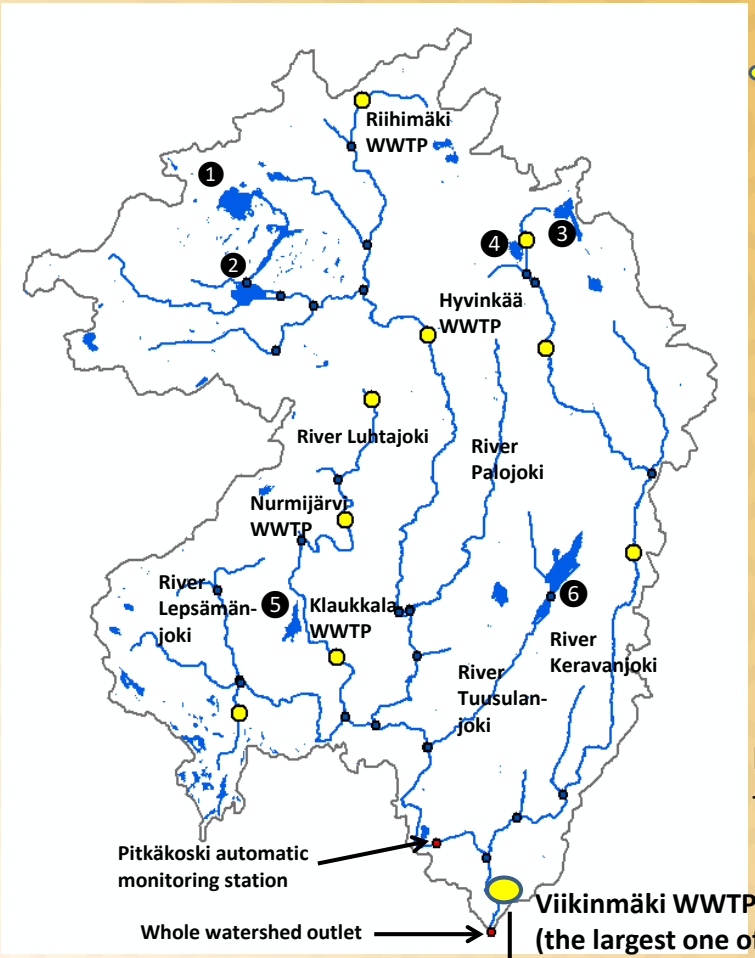
4. Major point sources, tributaries & lakes



- **Point source (WWTP)**

  Loading of nutrients and organic matter from WWTPs were obtained from their environmental permits

1. Lake Hirvijärvi
2. Lake Kytäjärvi
3. Lake Sykäri
4. Lake Ridasjärvi
5. Lake Valkjärvi
6. Lake Tuusulanjärvi

In SWAT, these six major lakes were taken into account as reservoirs

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Pitkäkoski automatic monitoring station

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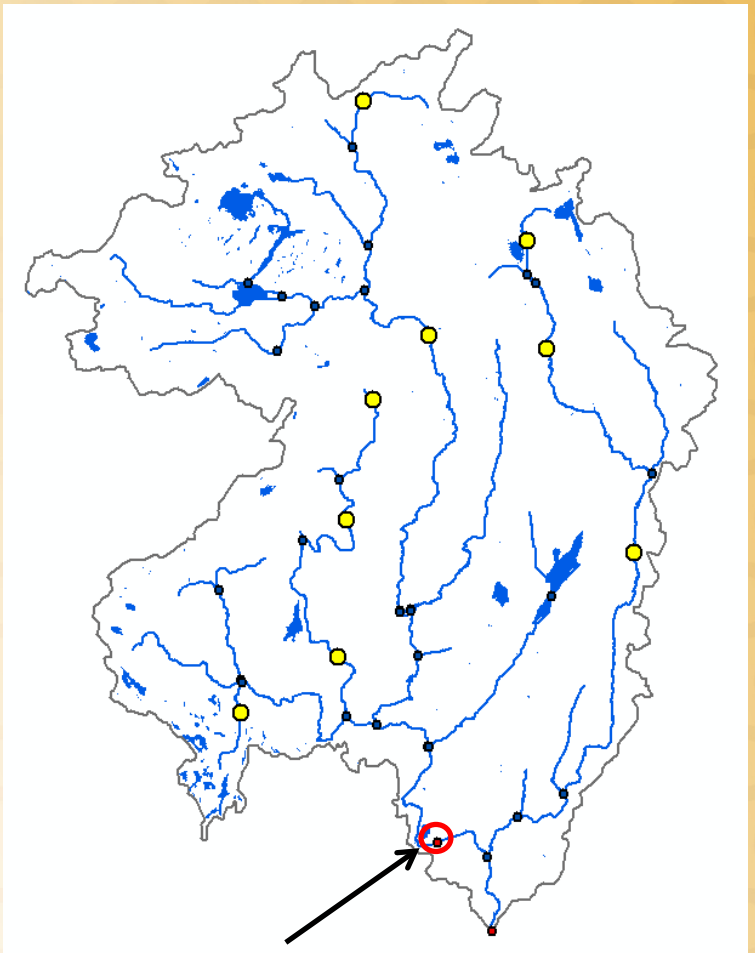
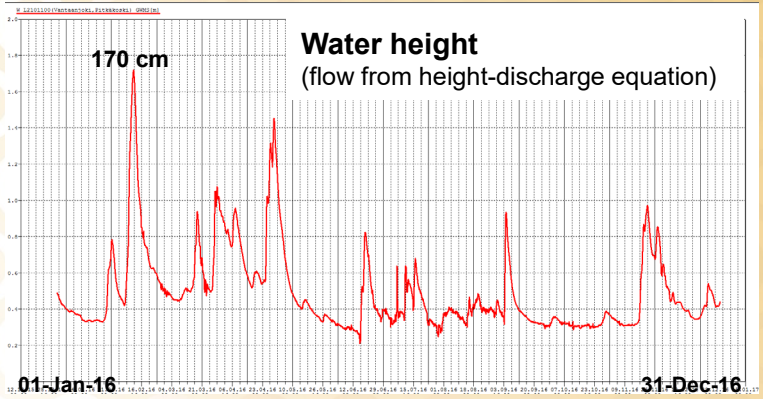
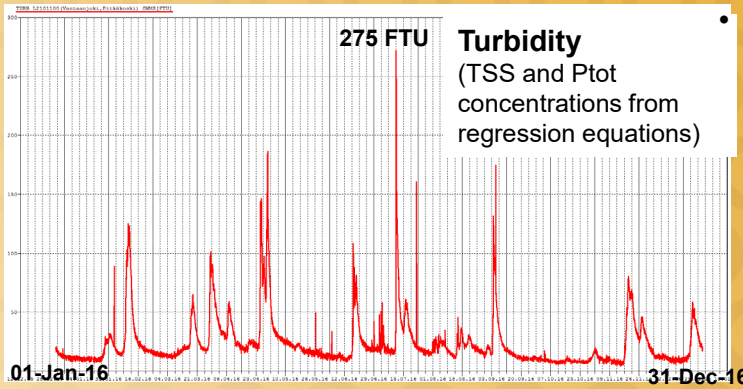
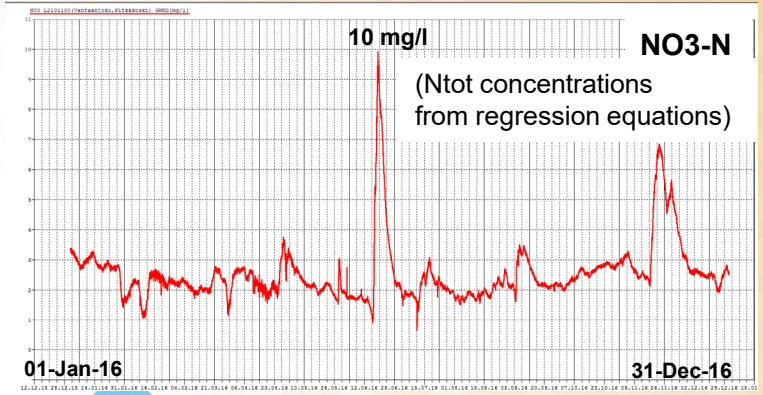


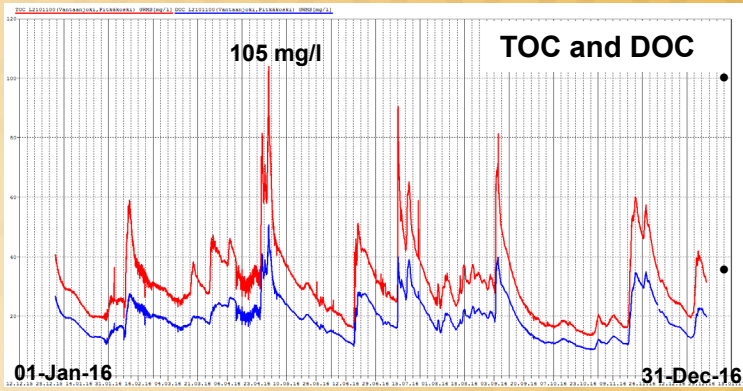
- S::can nitro-lyser sensor (www.s-can.at/products/spectrometer-probes#)
- Hourly data from years 2011–2016, virtually without breaks
- Turbidity (FNU)
- NO_3-N (mg/l)
- TOC & DOC (mg/l)
- High correlation between turbidity and water-sampled total P (and sediment) ➔ conversions with linear relationships
- The area upstream the station covers 76% of the Vantaanjoki catchment (only the eastern river Keravanjoki is outside)

Example raw data of 2016 from the Pitkäkoski station









Sensor-measured turbidity (raw data) was converted to suspended solids (TSS) and total phosphorus (Ptot) concentrations by linear regression equations derived from the water-sampled TSS/Ptot concentrations and simultaneous recordings of raw turbidity.

Similar datasets were derived for NO3-N and Ntot concentrations from NO3-N raw sensor data.

For the sake of calibration and validation in SWAT-CUP SUFI-2 programme, hourly concentration and flow data were aggregated into **daily loads** of Ntot, NO_3-N, TSS and Ptot.

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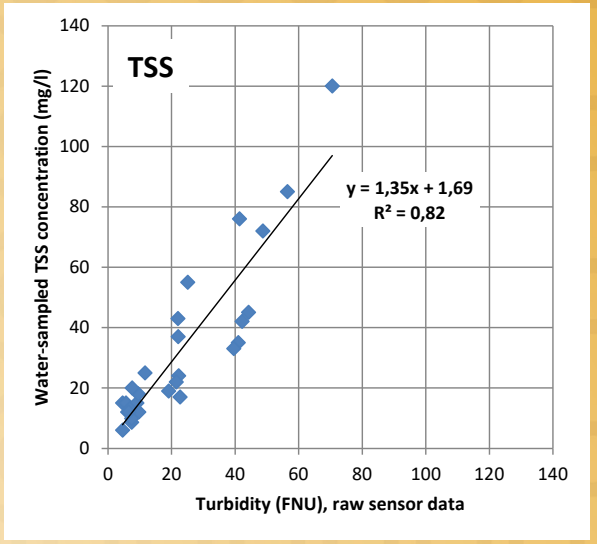
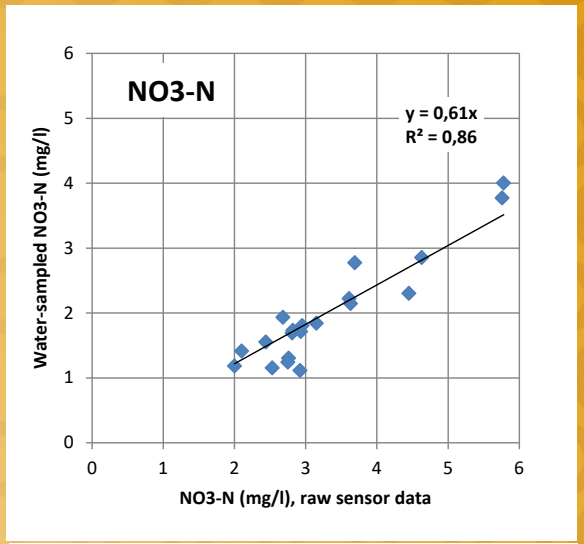
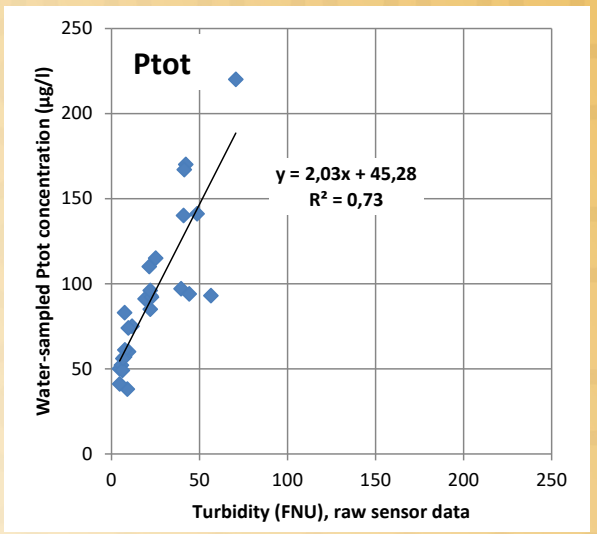
Raw sensor data vs. water samples

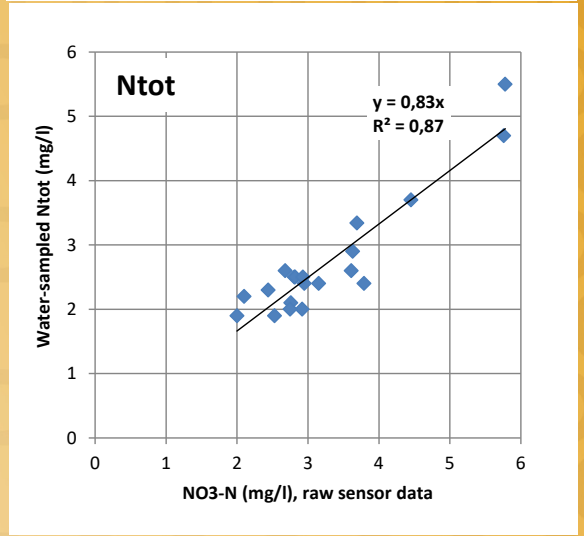
➔

conversions to TSS, Ptot and Ntot concentrations by linear regression equations









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Flow calibration against daily gauged flow records (2011-2016)

TSS calibration against sensor-based, high-frequency data (2011-2013)

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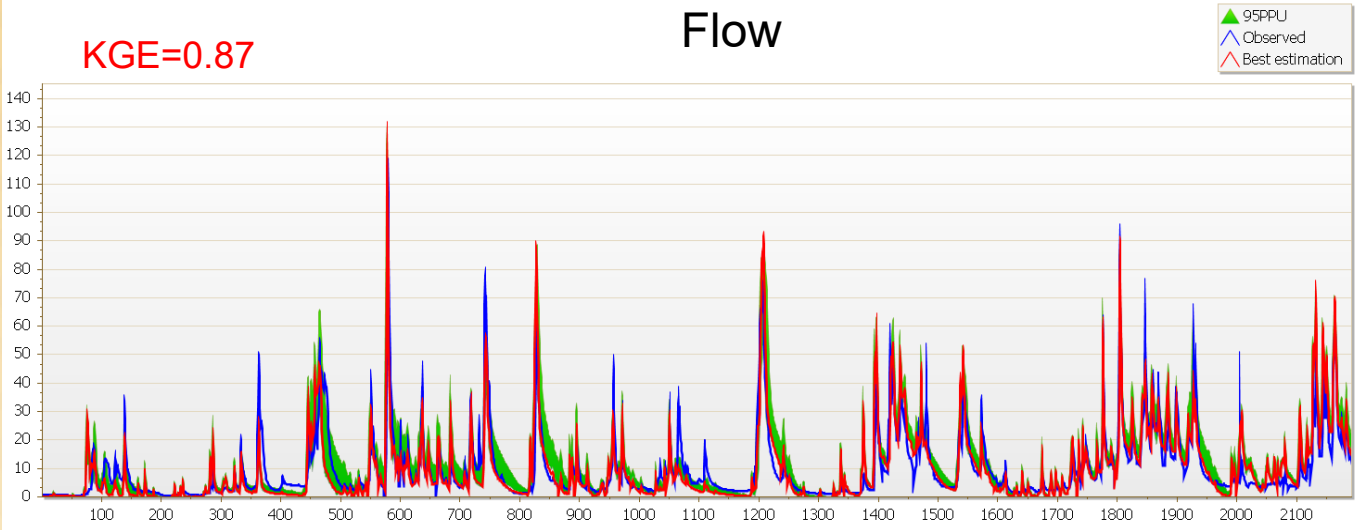
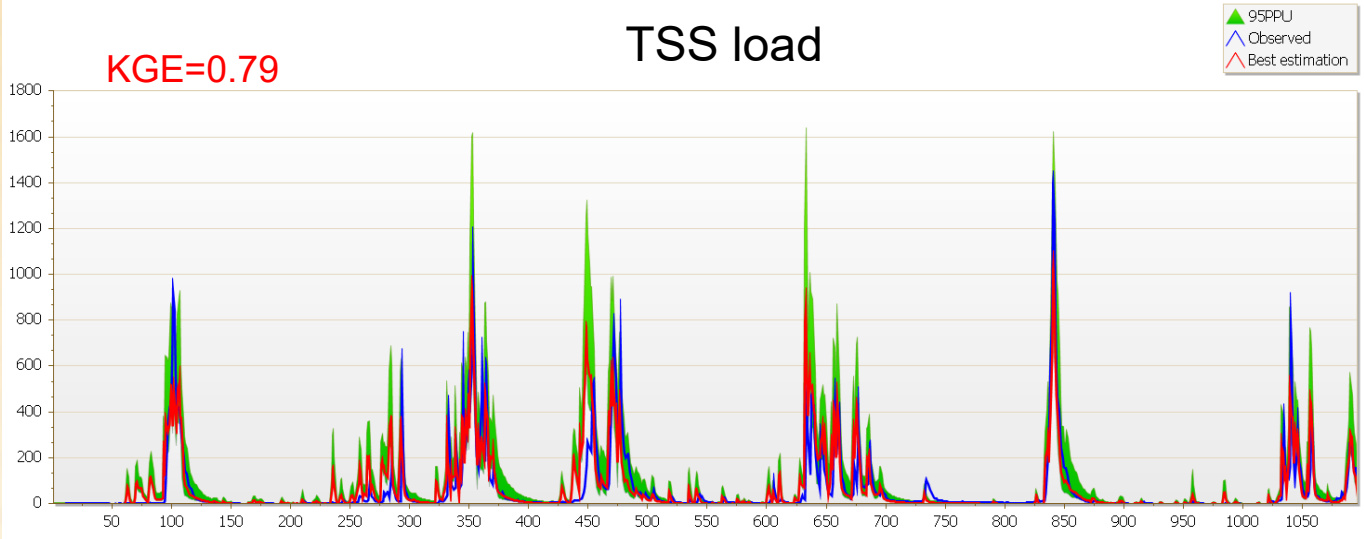
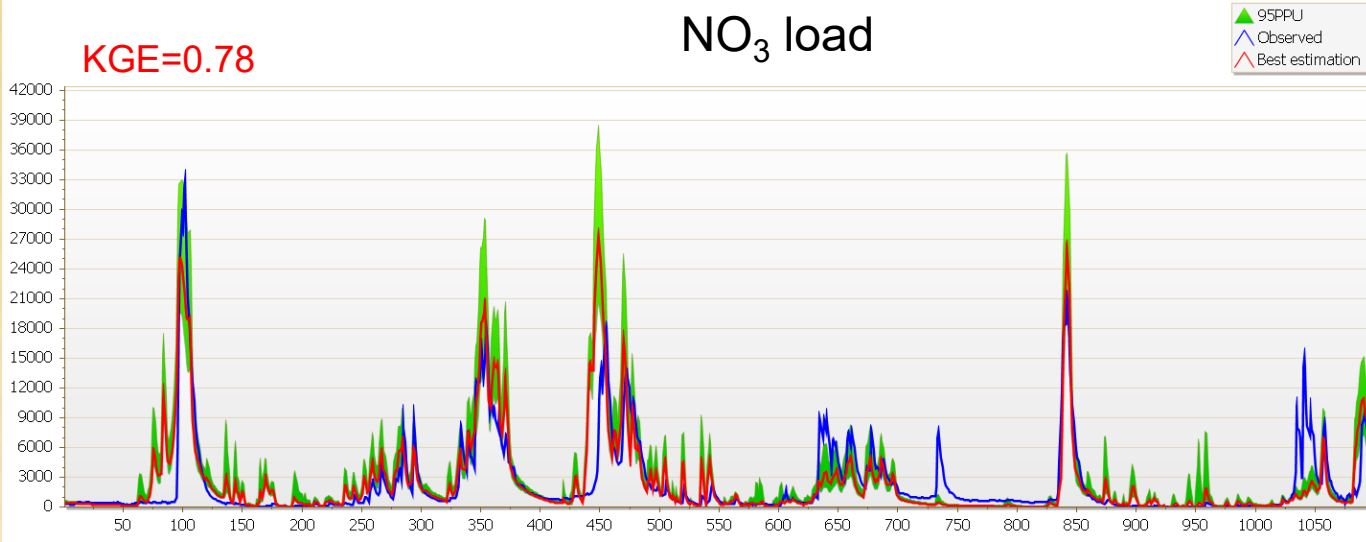
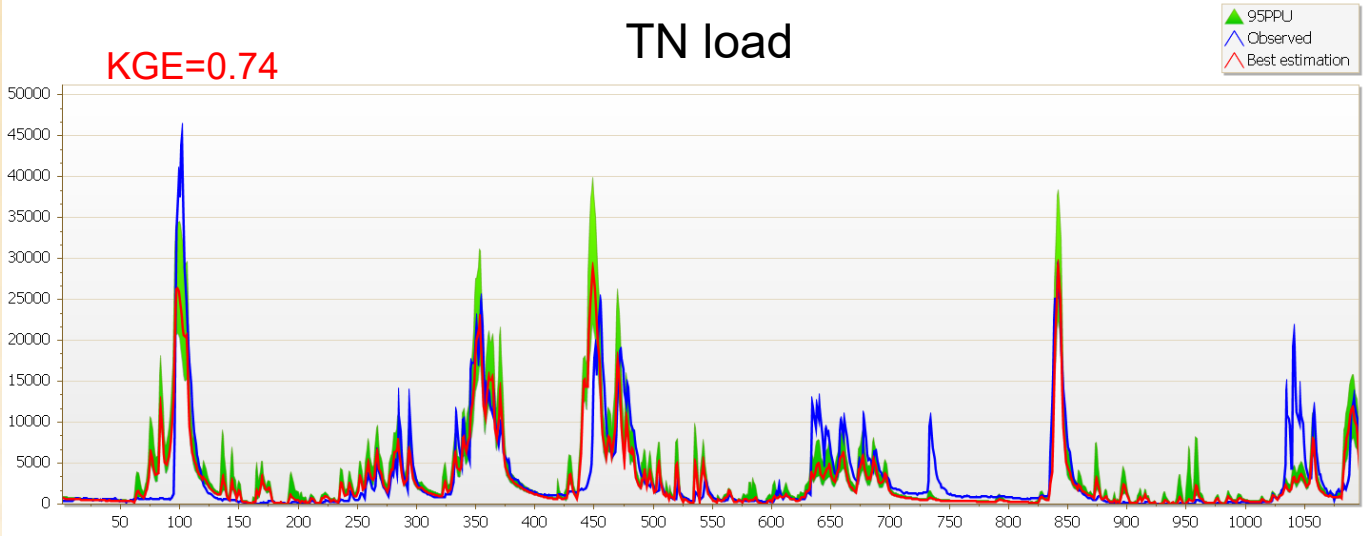




NO_3 / TN calibration against sensor-based, high-frequency data (2011-2013)





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Sub-sampling scenarios: does sampling frequency and strategy matter for SWAT calibration?

- The model calibrated against high-frequency data => '**reference**'
- Sub-sampling of HF data to mimic real-world grab sampling **frequencies** and **strategies** commonly used by WQ monitoring agencies
- Frequency: monthly (the most common by monitoring agencies) or weekly
- Strategy: regular (easy to implement) vs. random (with some constraints; the most common) vs. flow-proportional sampling
- Only regular monthly sampling scenarios completed so far, for TSS and TN/NO3

Frequency / Strategy	Regular	Random	Flow-proportional
Monthly	X		
Weekly			

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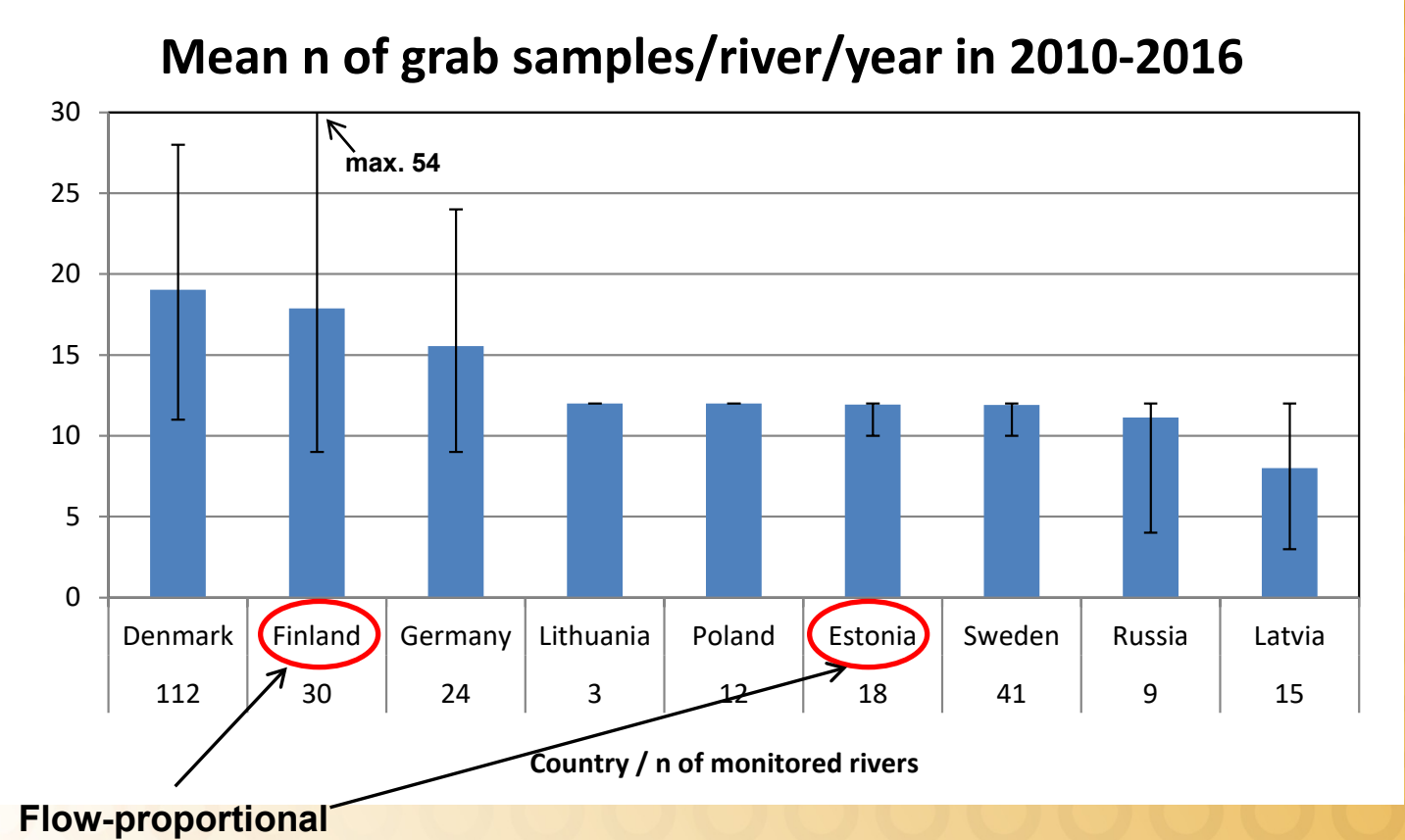
Riverine monitoring in Baltic Sea Region (BSR) countries as reported in HELCOM Pollution Load Compilation



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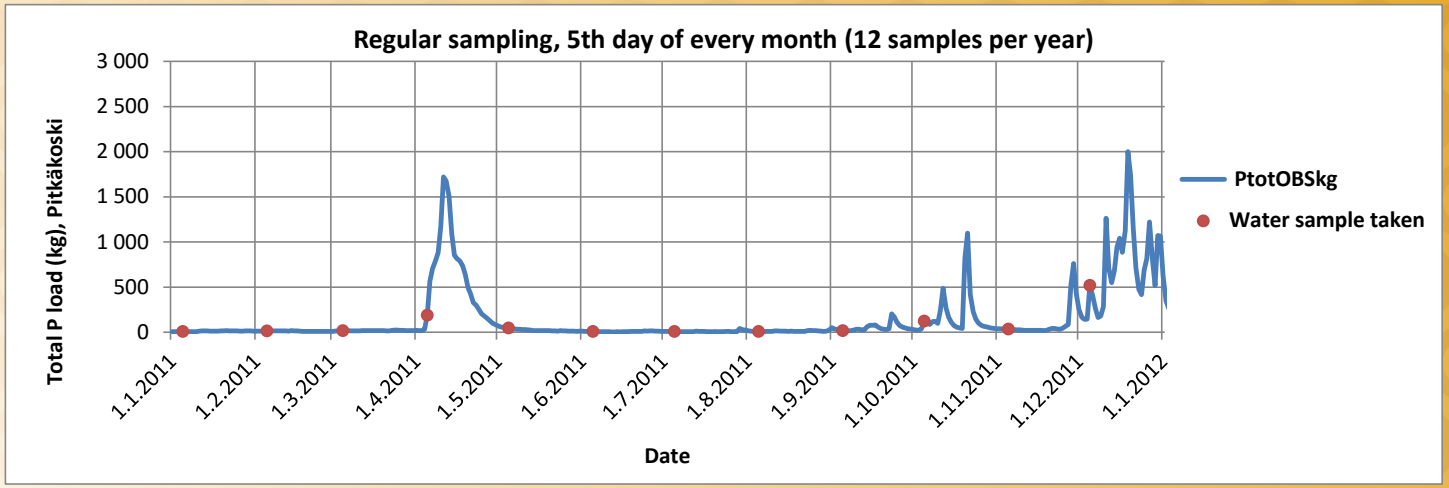
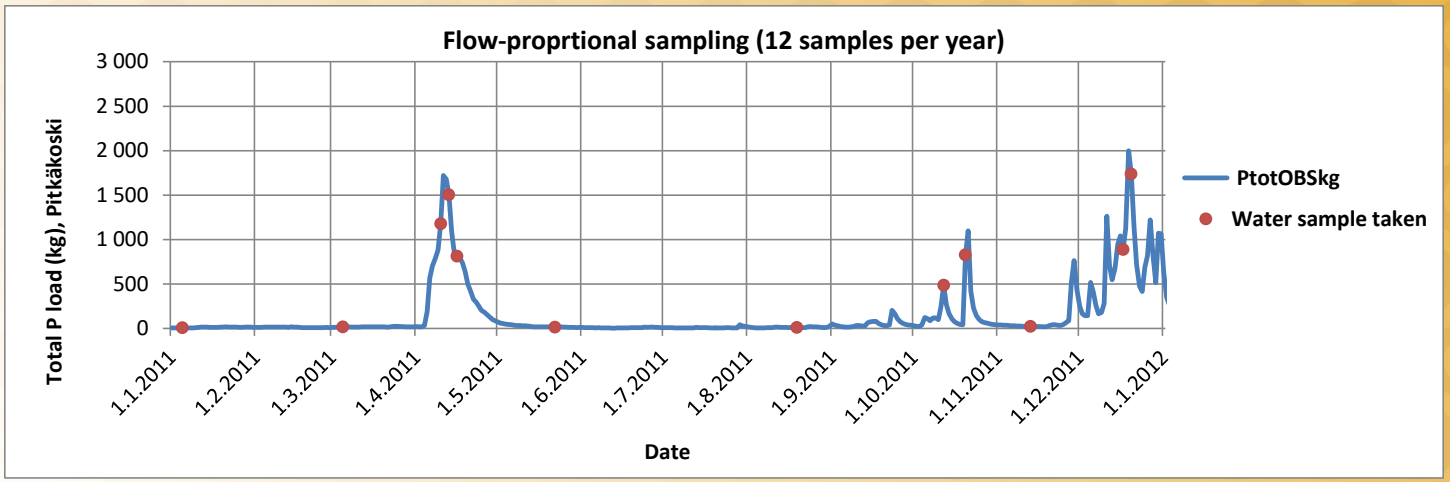
Examples of sampling strategies





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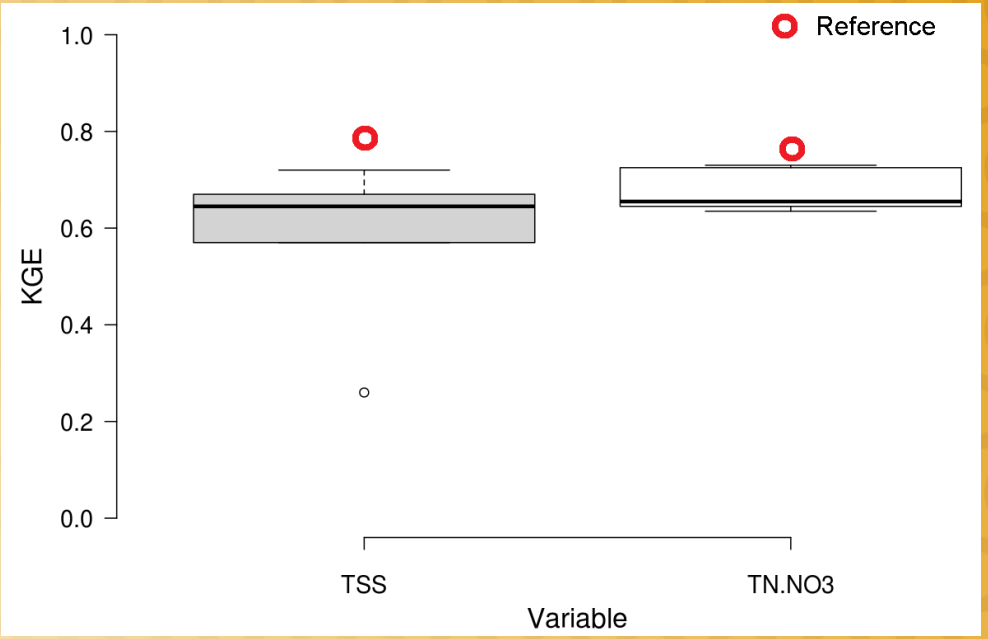
Comparison of KGE between the models calibrated against high-frequency data and monthly sub-sampled data

- So far six realizations of 'regular monthly' scenario (measurements on the 5th, 10th, 15th, 20th, 25th and 30th of each month => box plots)
- In sub-sampling scenarios, the models were first calibrated against monthly sub-sampled data and then evaluated against high-frequency data (reference)
- Comparisons are based on the 'best' parameter sets obtained using SUFI2



Mean reduction in KGE: 0.21 for TSS and 0.09 for TN/NO_3

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Discussion

- Our results are so far preliminary
- As compared with traditional water sampling data, high-frequency data do not only increase the reliability of load estimates, but also reveal differences between traditional sampling strategies and improve model calibration (goodness-of-fit)
- Crockford et al. (2017)*: ”One of the benefits of using higher-resolution environmental data is the ability to assess the limitations of existing empirical models that are often employed for river catchment management”
- Perhaps there are possibilities to extend this approach to process-based modeling as well?

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*Crockford, L., O’Riordain, S., Taylor, D., Melland, A.R., Shortle, G. & Jordan, P. 2017. The application of high temporal resolution data in river catchment modelling and management strategies. *Environ. Monit. Assess.* 189: 461

THANK YOU!

Photo: Simo Räsänen

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