



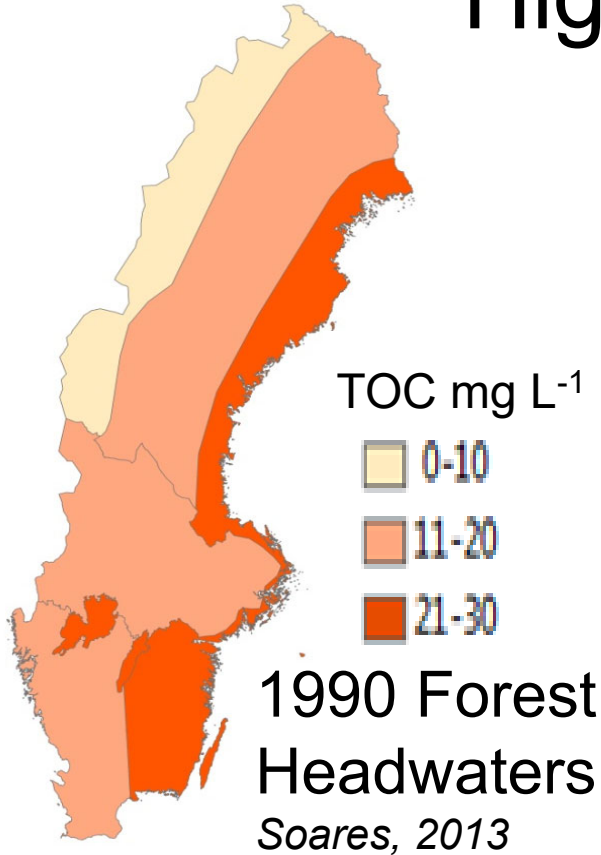
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Brunifierning av Sveriges vattendrag – klimat och andra påverkansfaktorer

Kevin Bishop, Karin Eklöf, Jens Fölster, Julia Hytteborn

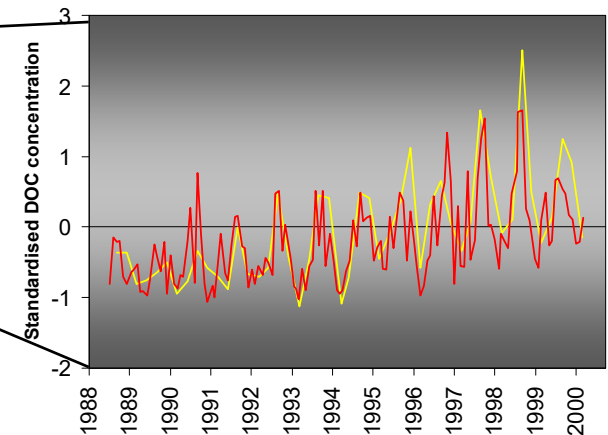


High DOC got higher! WHY??

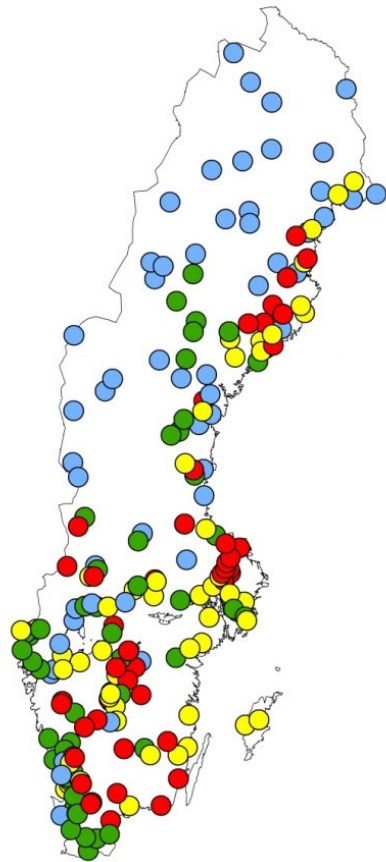
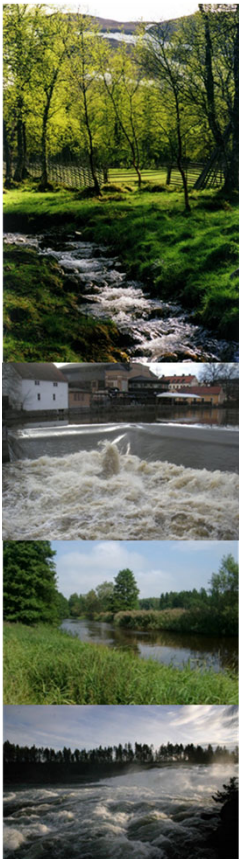


Freeman et al. *Nature* (2001)

- Climate?
- Acidification & Recovery?
- N-dep?
- CO₂ ?

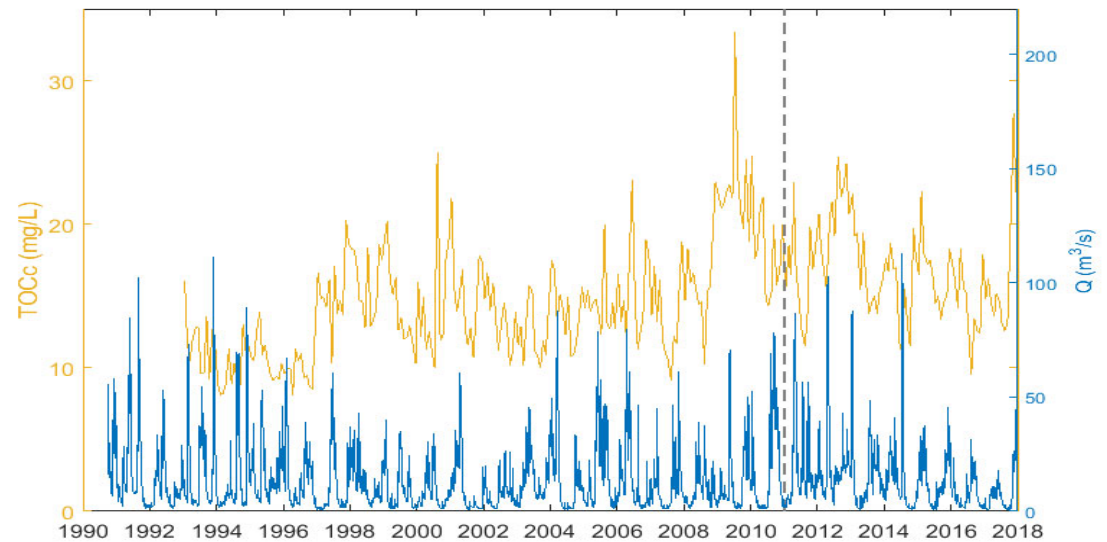


Miljöövervakning har koll sedan 1970s



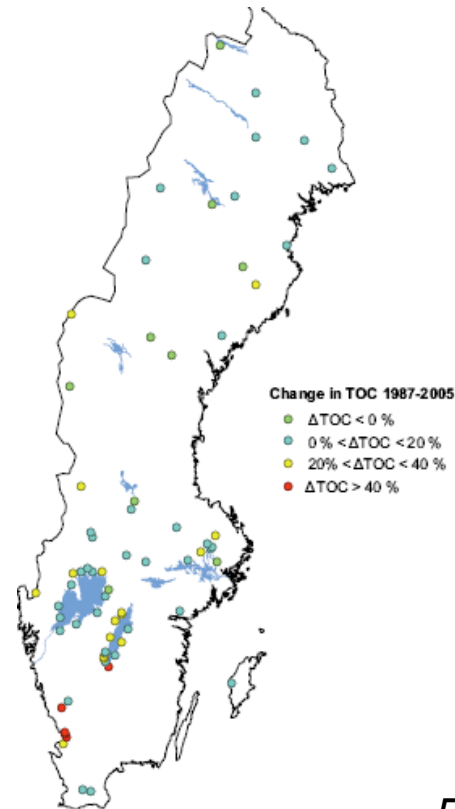
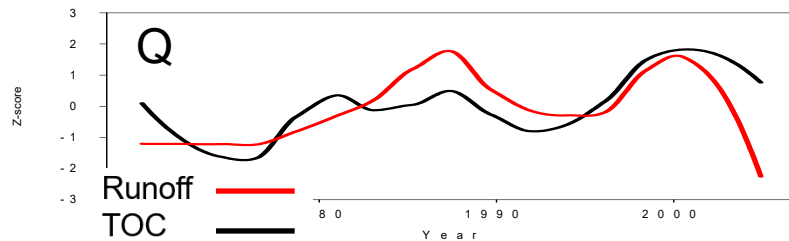
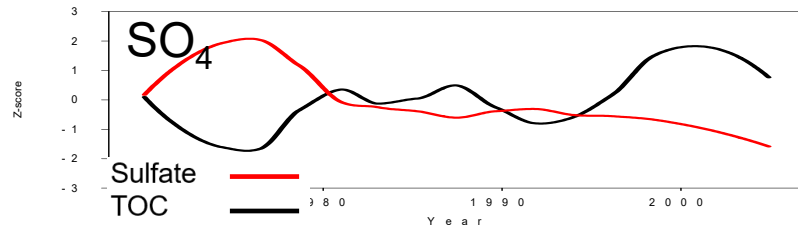
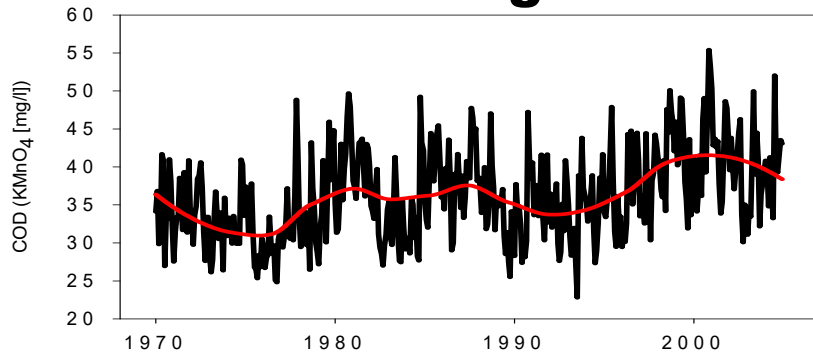
TOC, median (mg/l)

- 1.1 - 7.1
- 7.2 - 10.2
- 10.3 - 13.4
- 13.5 - 23.6



COD 1970-2005

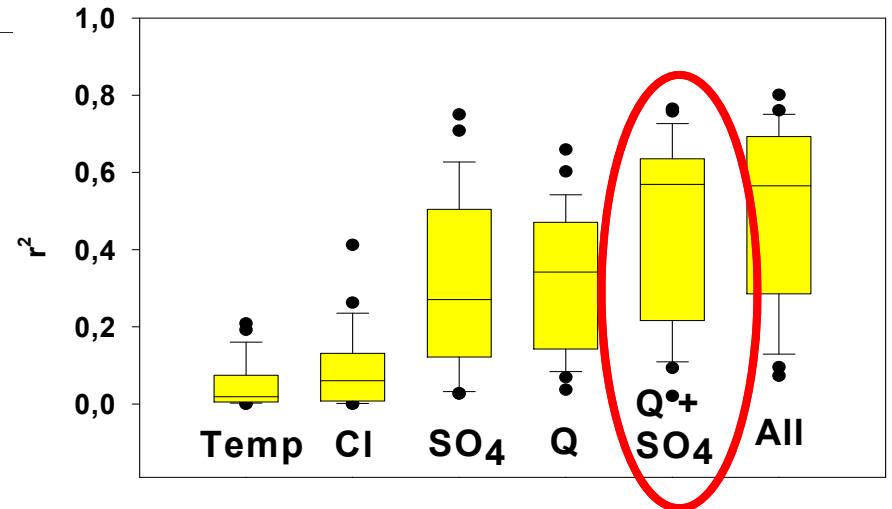
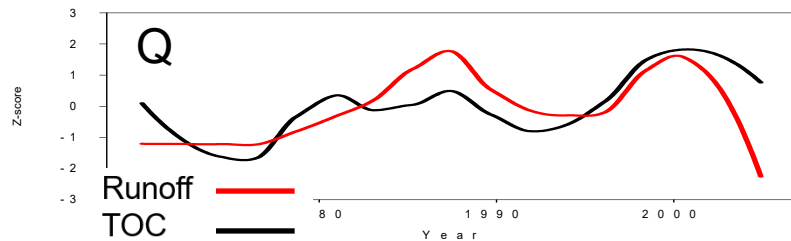
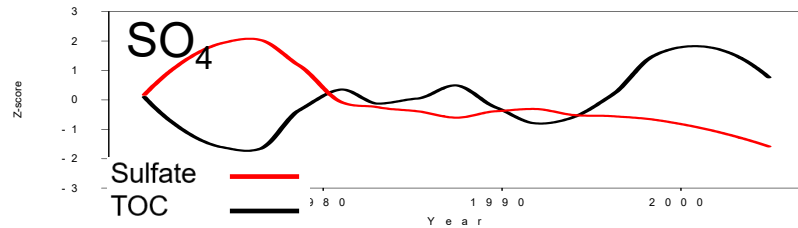
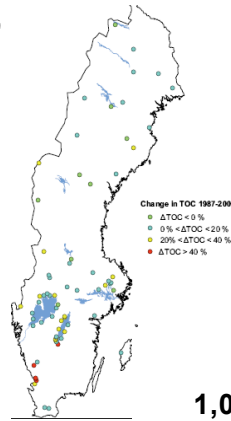
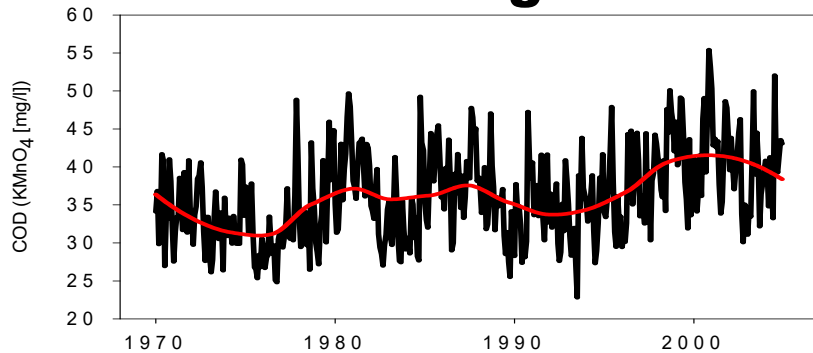
28 vattendrag



Erlandsson et al., (2007)
Global Change Biology

COD 1970-2005

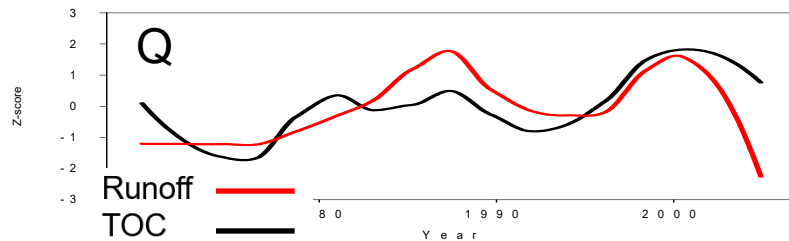
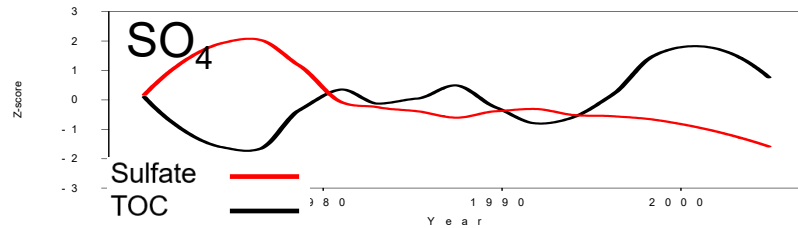
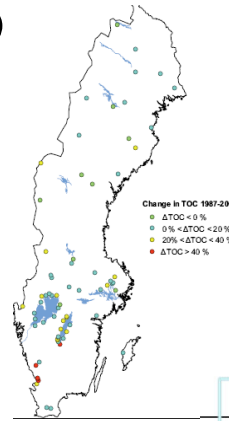
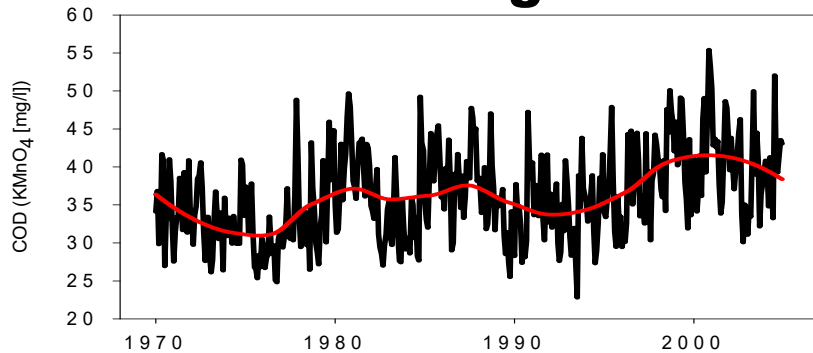
28 vattendrag



Erlandsson et al., (2007)
Global Change Biology

COD 1970-2005

28 vattendrag

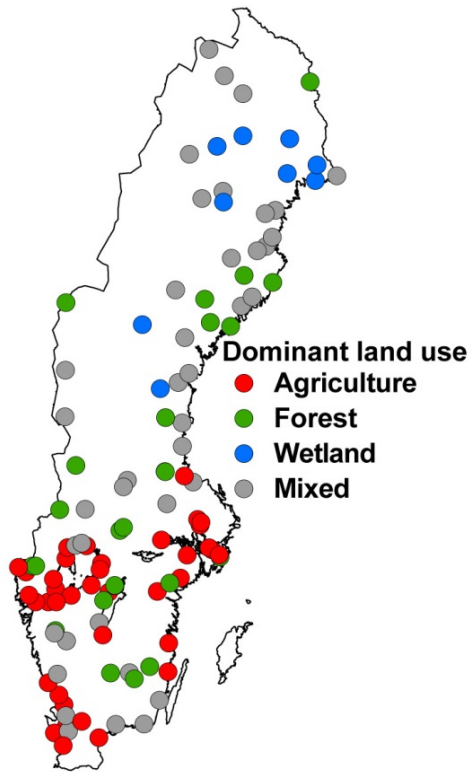


Future Climate:

25% increase in runoff
will give 6% higher
DOC concentrations

*Erlandsson et al., (2007)
Global Change Biology*

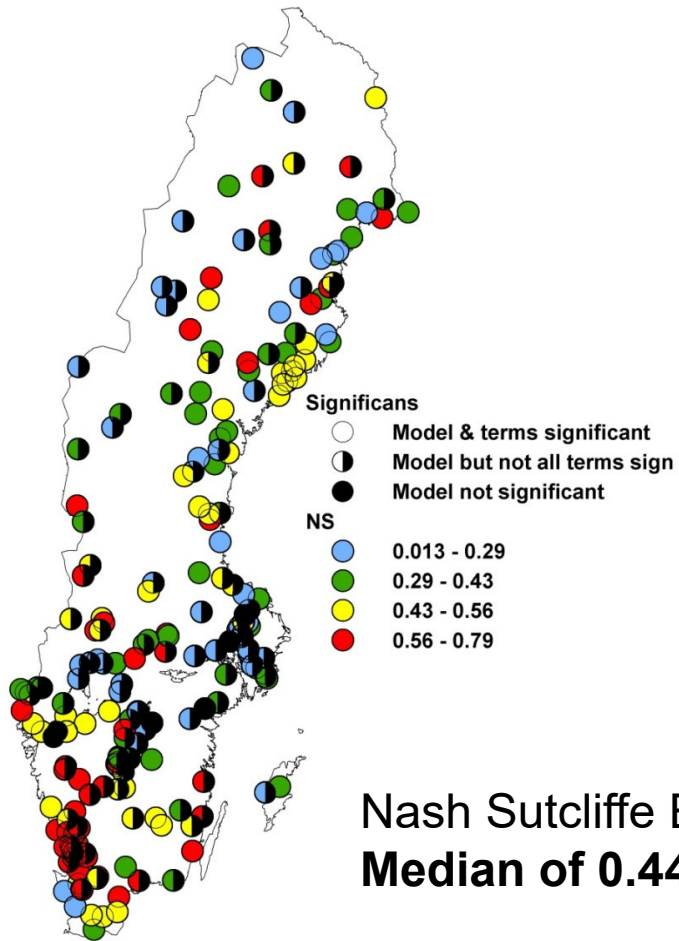
215 Water courses now monitored What do they say about trends and drivers?



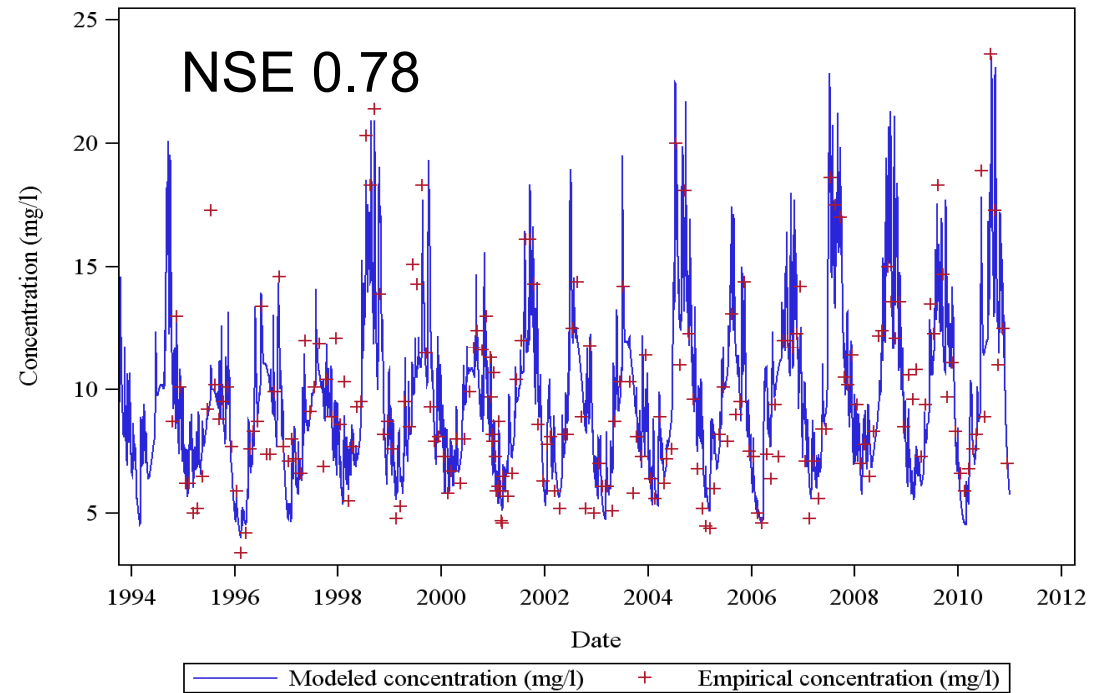
area 0.18 – 47,000 km²

Same model fitted to each
watercourse

$$TOC = \underbrace{e^{a_0}}_{\text{Constant (mean TOC)}} \cdot \underbrace{Q^{a_1}}_{\text{Discharge}} \cdot \underbrace{e^{A \cdot \sin(2\pi \cdot dtime + c)}}_{\text{Seasonality (Temperature)}} \cdot \underbrace{e^{a_4 dtime}}_{\text{Linear Trend}}$$

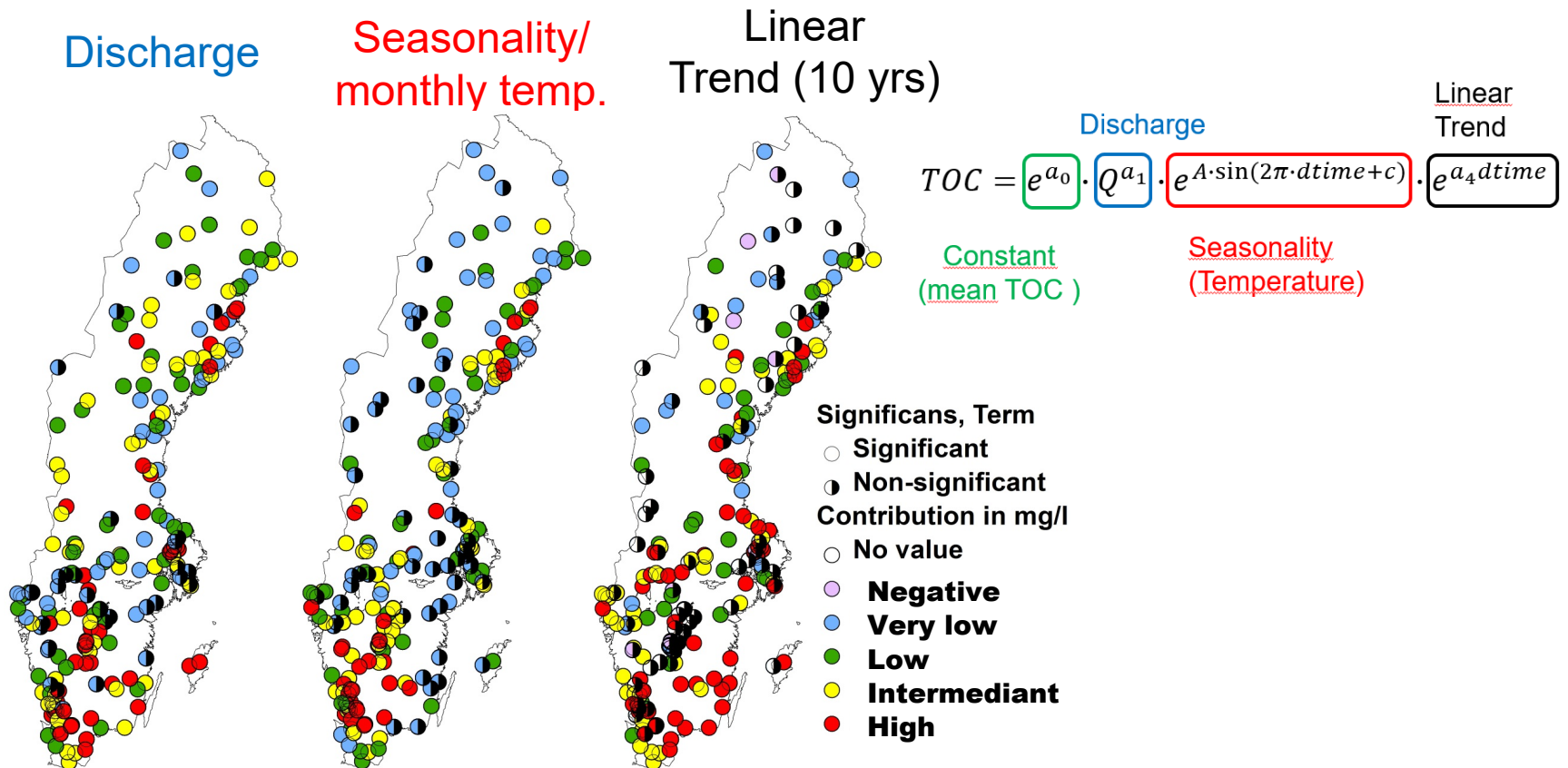


Nash Sutcliffe Efficiency (NSE)
Median of 0.44



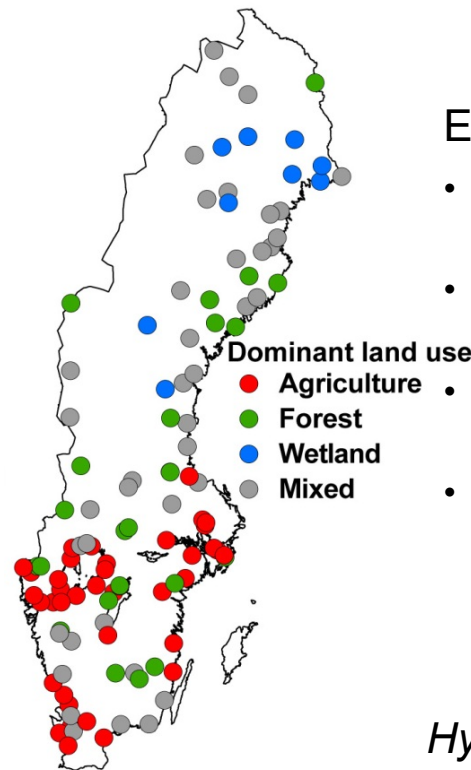
Hytteborn et al., (2015)
Sci. Tot. Env.

Influence on the TOC concentration



What controls the control of Flow, Season and Trend?

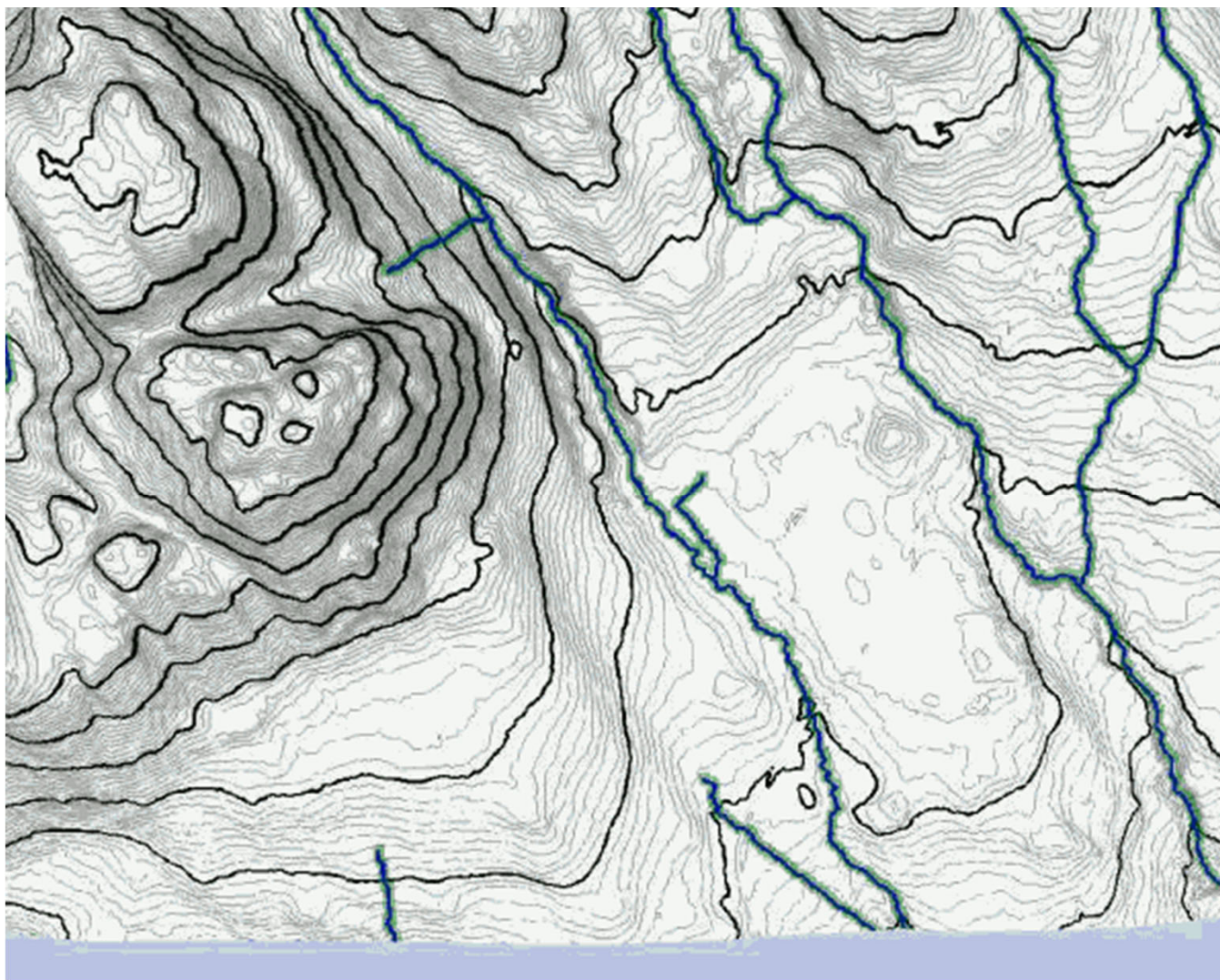
- Model correlations with map info didn't explain much ($\sim 0.2r^2$)
- **No correlation with the trend coefficient**
- Flow and Seasonality understandable

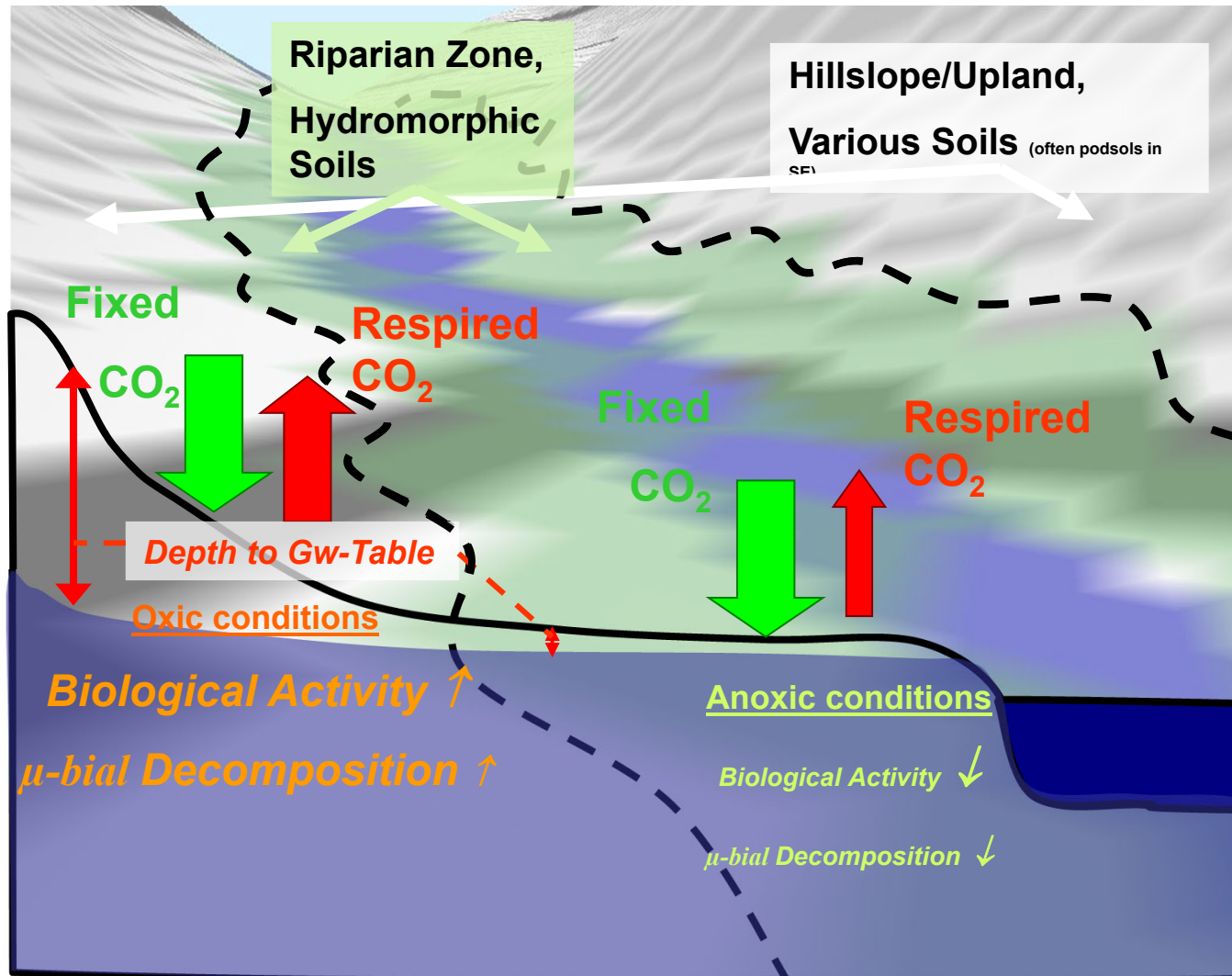


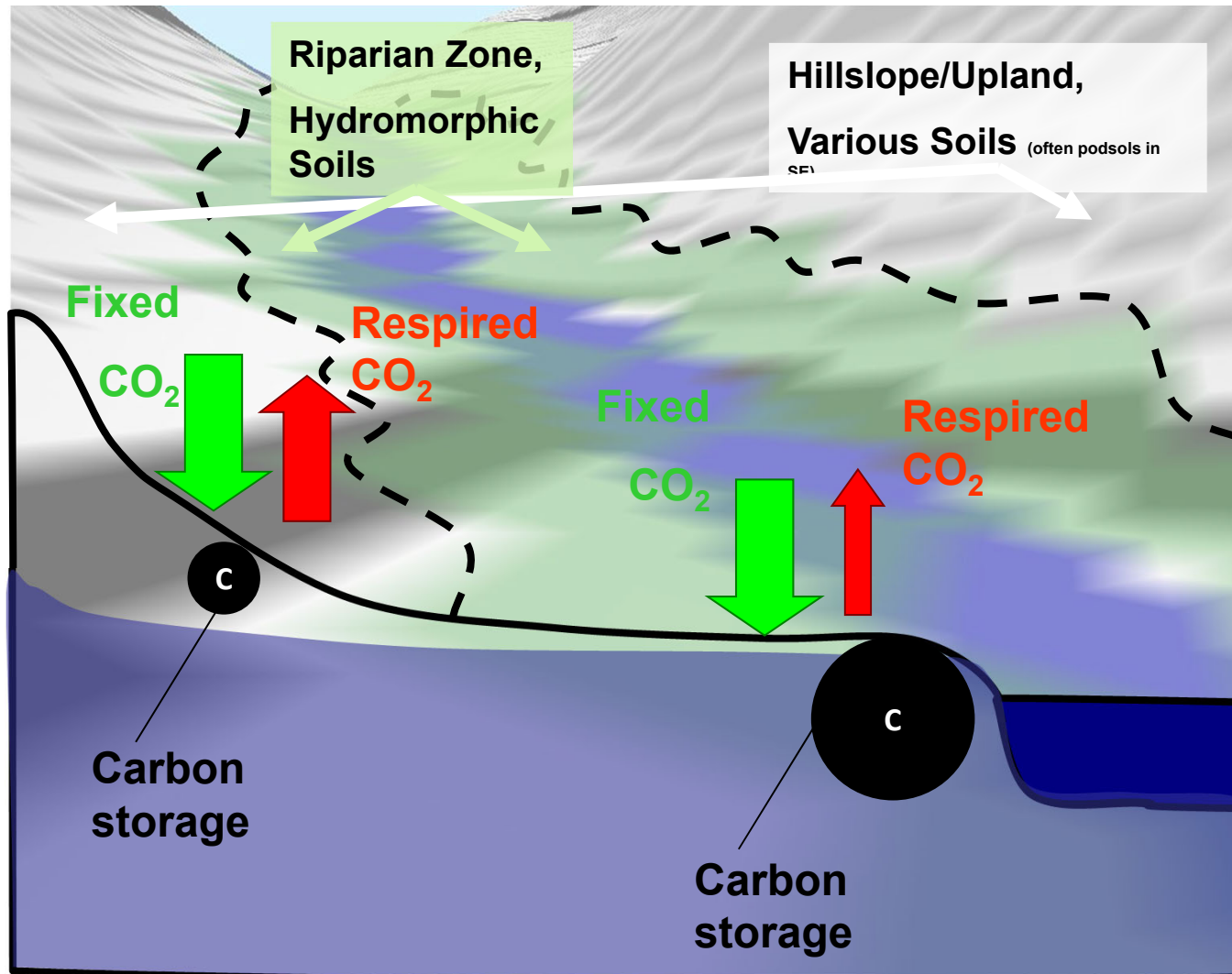
Evaluation data:

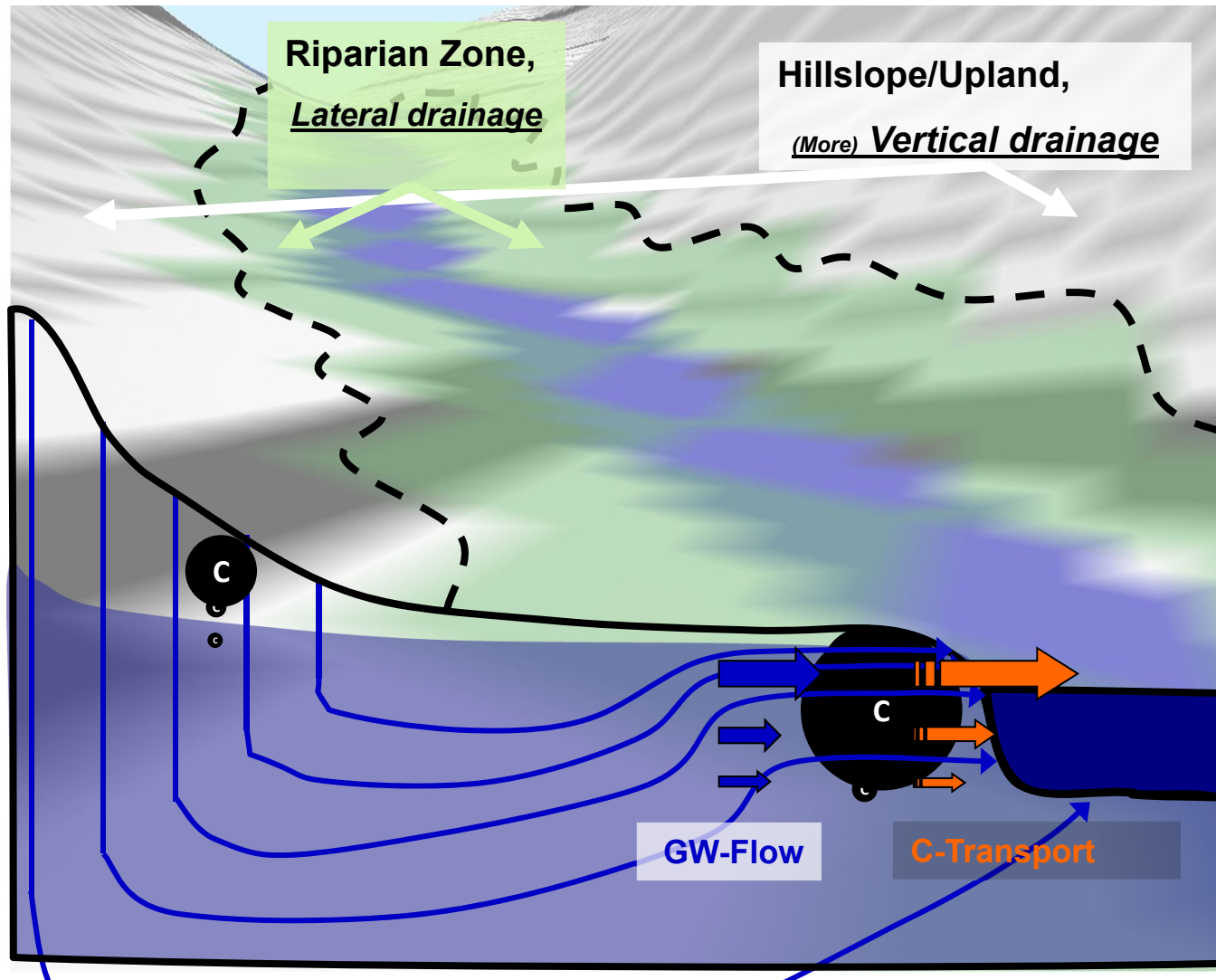
- Spatial data (area, elevation etc)
- Precipitation and Temperature
- Land use, Soil type and kNN data
- Water residence time in upstream lakes

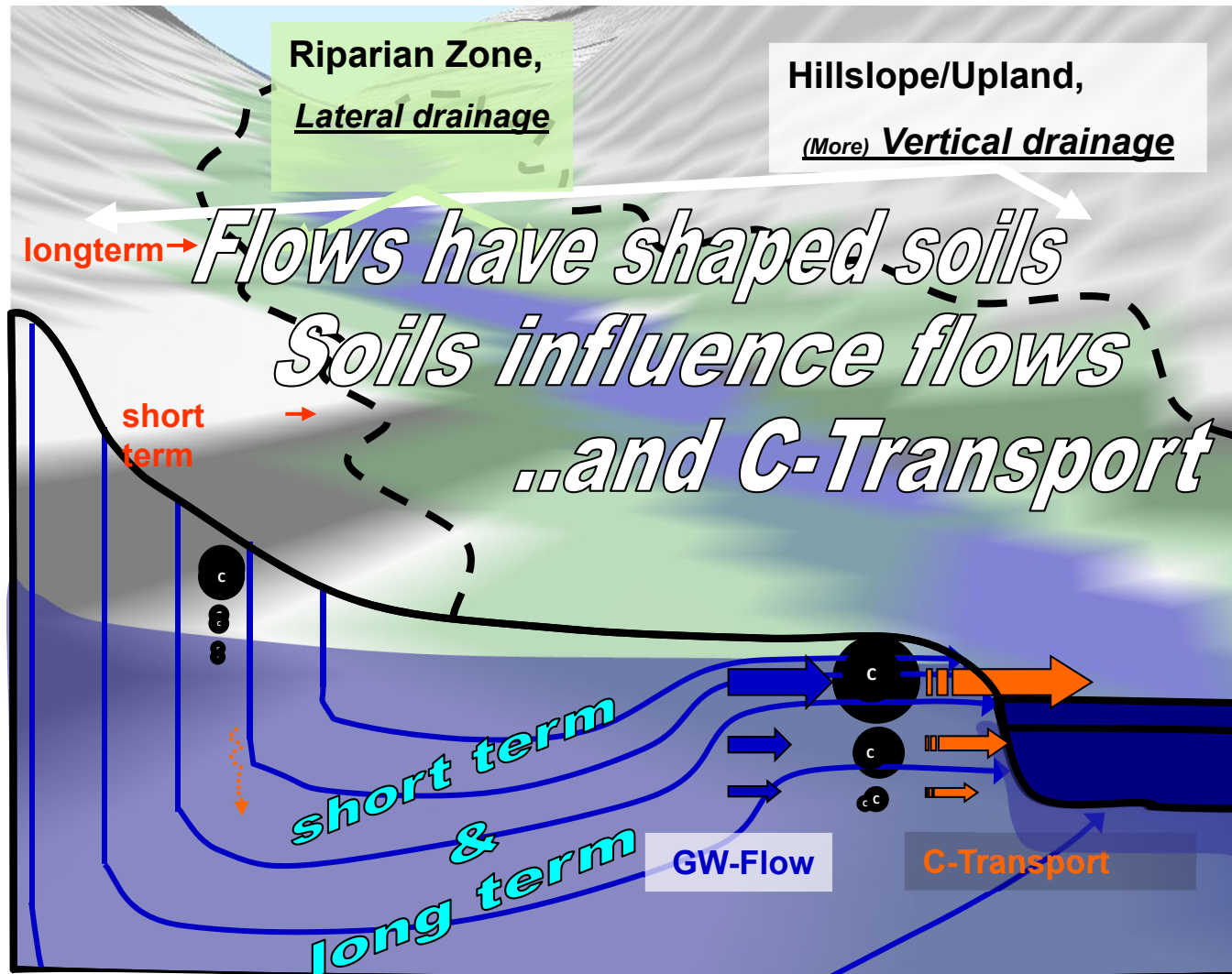
*Hytteborn et al., (2015)
Sci. Tot. Env.*











The background of the slide is a topographic map with brown contour lines and blue stream networks. A red oval highlights the first line of text, and several pink arrows point from the text lines to the corresponding features on the map: from "Terrain shapes flows" to a contour line, from "Flows have shaped soils" to a stream, from "Soils influence flows" to a stream, and from "...and C-Transport & key aspects of water quality" to a stream.

Terrain shapes flows

Flows have shaped soils

Soils influence flows

***...and C-Transport
& key aspects of water quality***

The "Riparian Hypothesis"



Seasonality?:

Swedish stream carbon is modern
(much C-fixed during growing season)

atmospheric ^{14}C -CO₂

*Campeau et al.,
(in review)*

What does the future hold??

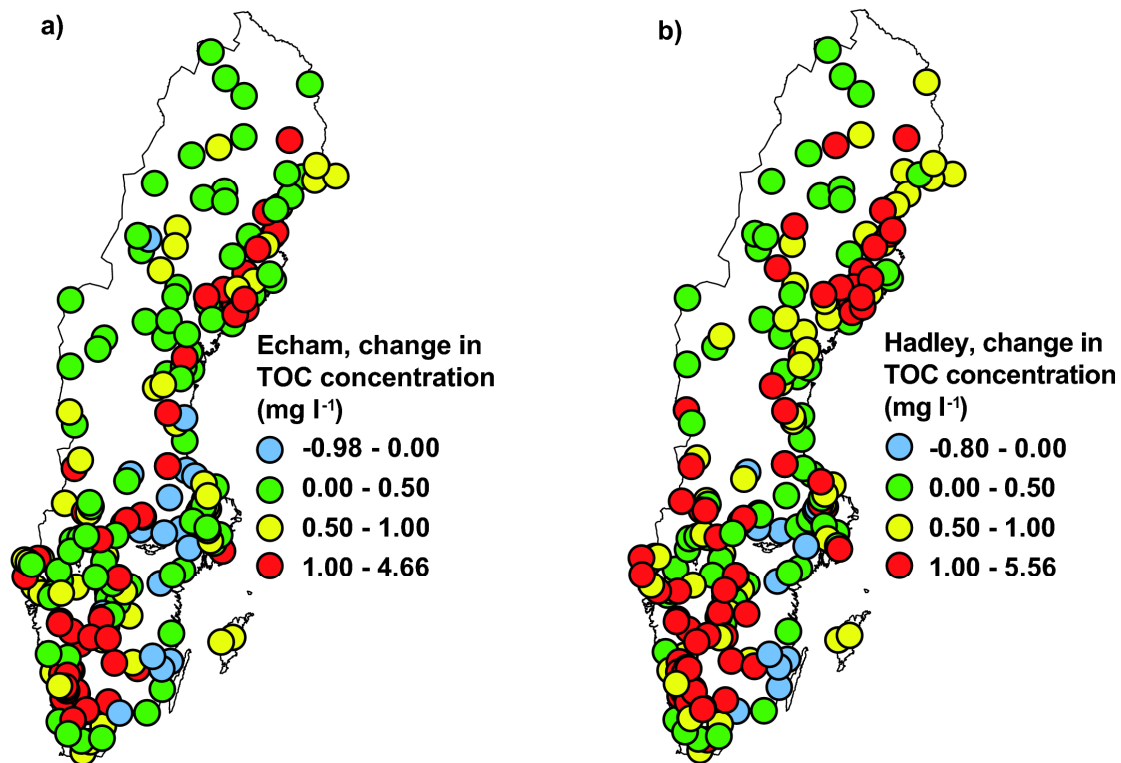
- Temperature and Discharge predictable
- Use two climate predictions (Hadley and Eacham) with IPCC Scenario of emissions
- Trend? – Assume that DOC increase stopped in 2010

Evaluation data:

- Spatial data (area, elevation etc)
- Precipitation and Temperature
- Land use, Soil type and kNN data
- Water residence time in upstream lakes

*Hytteborn et al., (2015)
Sci. Tot. Env.*

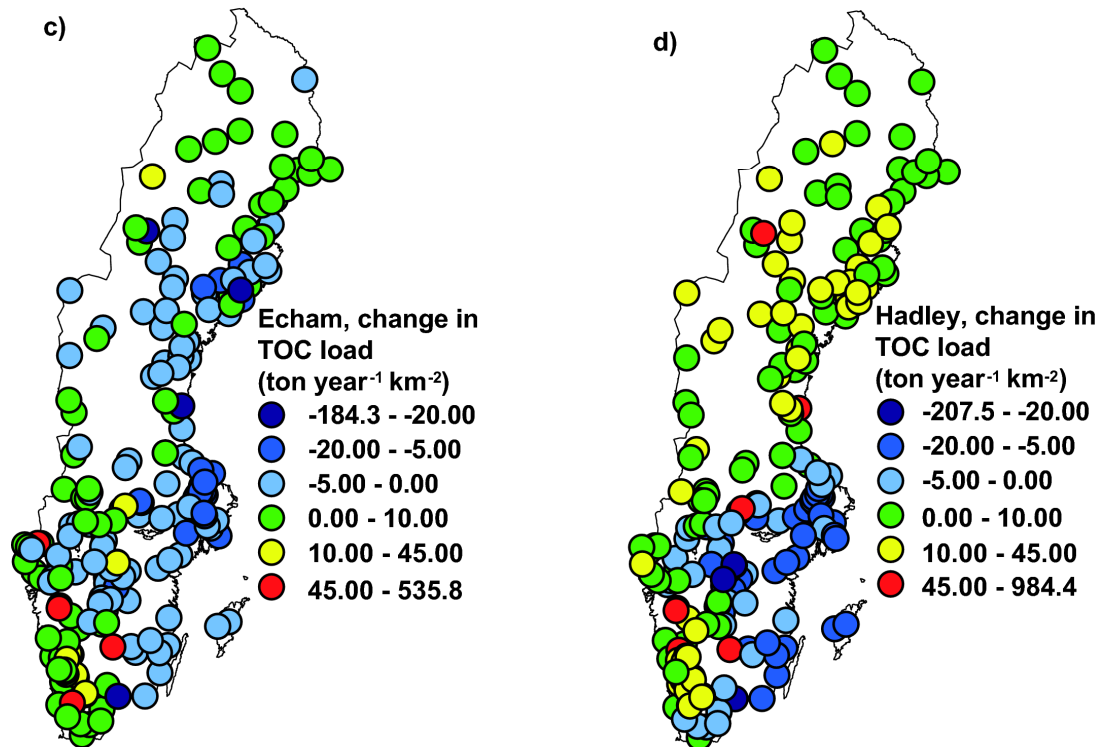
TOC concentration 2071-2100 (change relative to 2000)



IPCC A1b
Scenario

*Hytteborn et al., (2015)
PhD Thesis*

TOC load 2071-2100 (change relative to 2000)

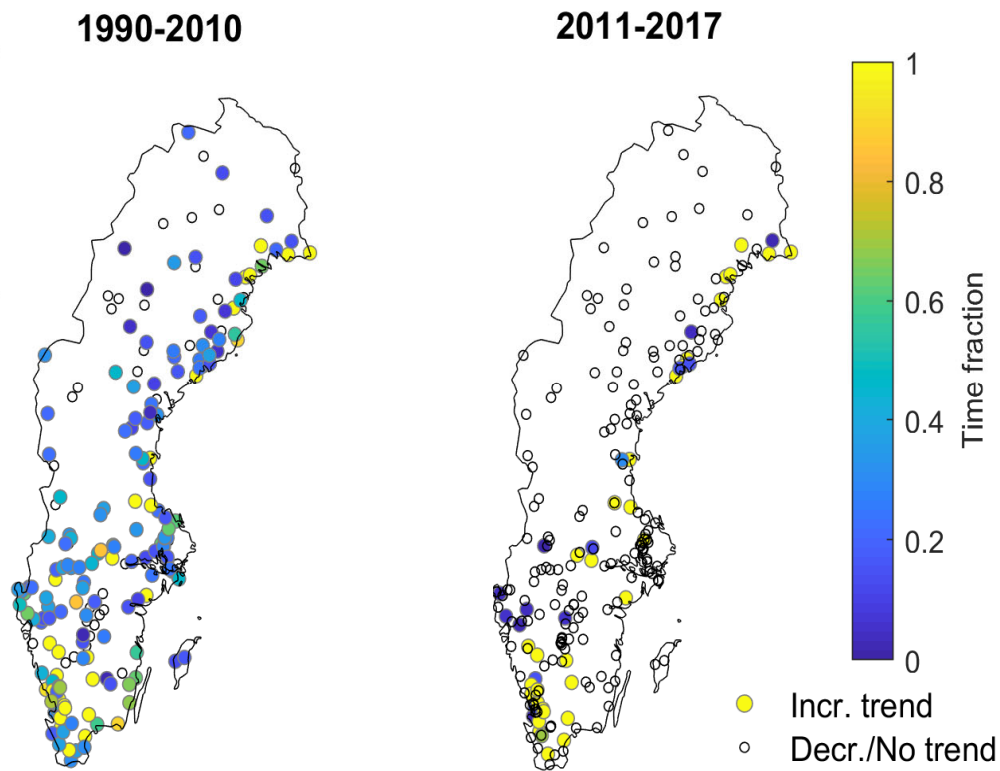


IPCC A1b
Scenario

*Hytteborn et al., (2015)
PhD Thesis*

What did the future hold? ...since 2010

Recovery from acidification slowing...



Increasing TOC
% of watercourses

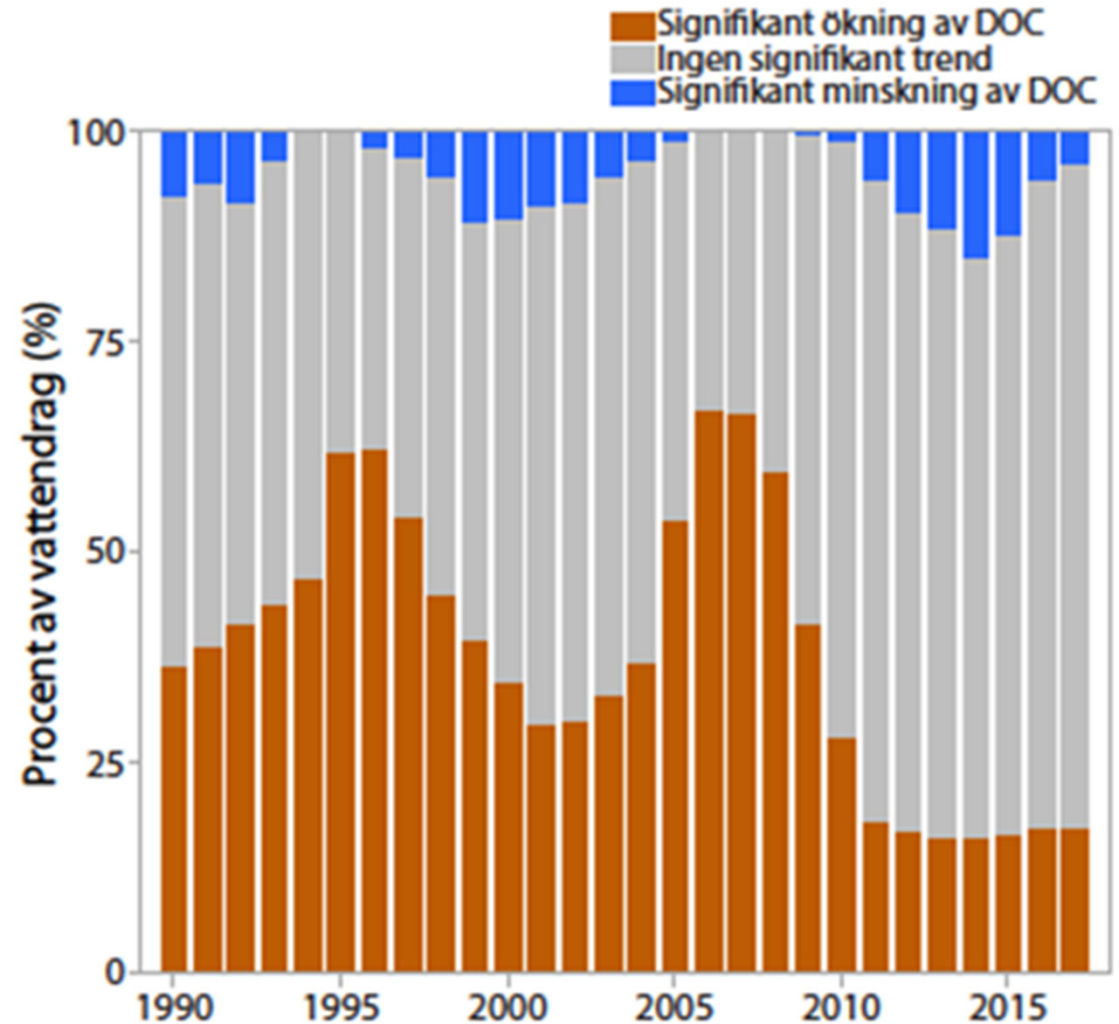
1990-2010: 74%

2010-2017: 17%

Eklöf et al., (2018)
SLU Report to Swedish EPA

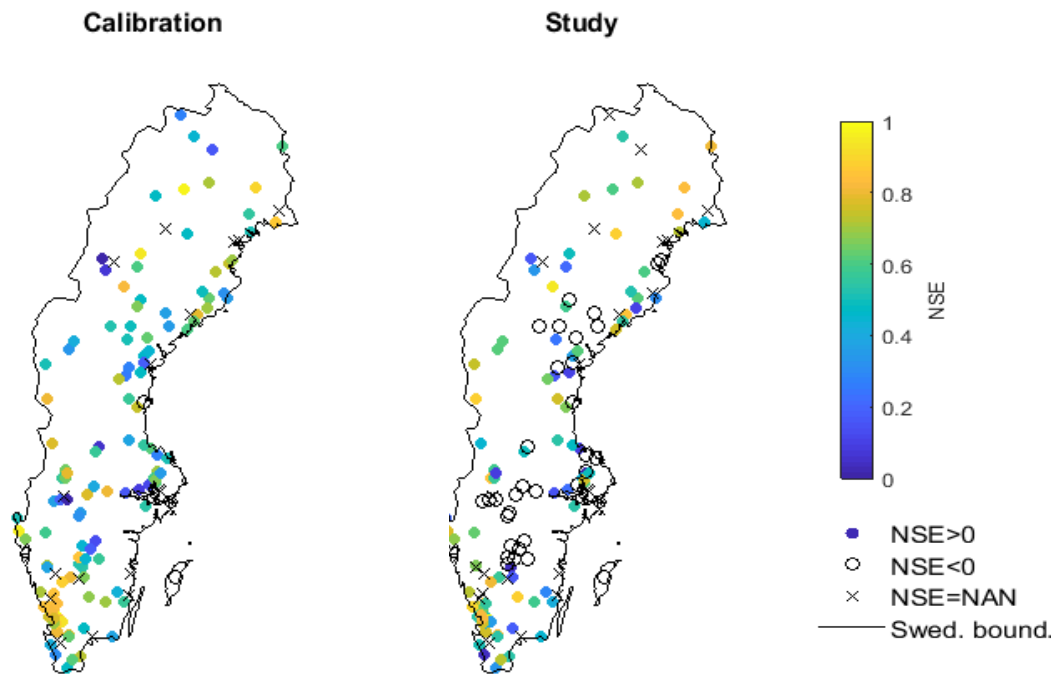
ökande respektive minskande trend av TOC

Eklöf et al., (2018)
SLU Report to Swedish EPA
Generalized Additive Modeling (GAM)
by C. von Brömssen



What did the future hold? (since 2010)

predictions 2011-2017 with no linear trend



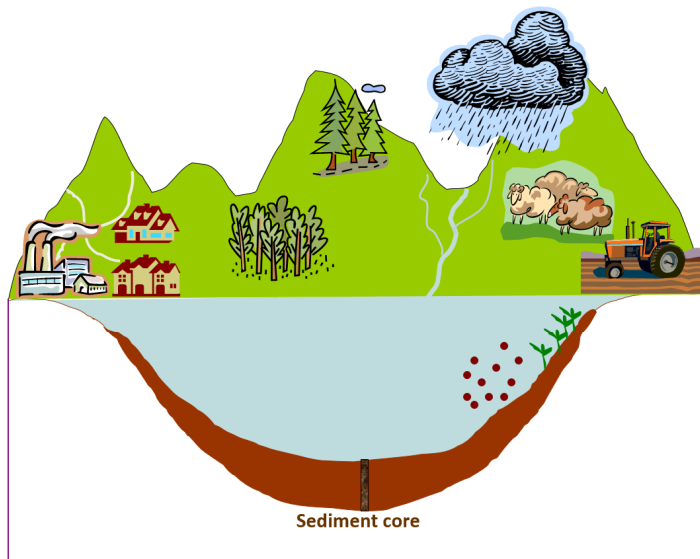
Statistical model
performance
(median NSE)

1990-2010: 0.44

2010-2017: 0.34

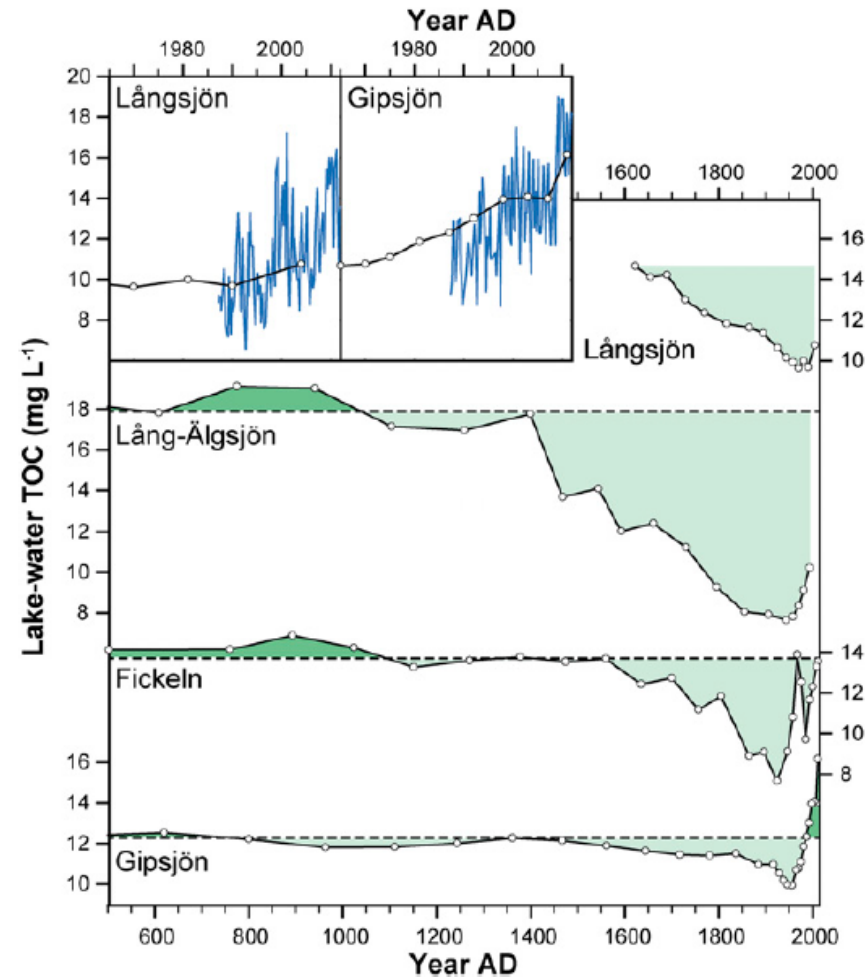
What can the past tell us?

Pre-Industrial TOC often higher
(drainage, acidification...)

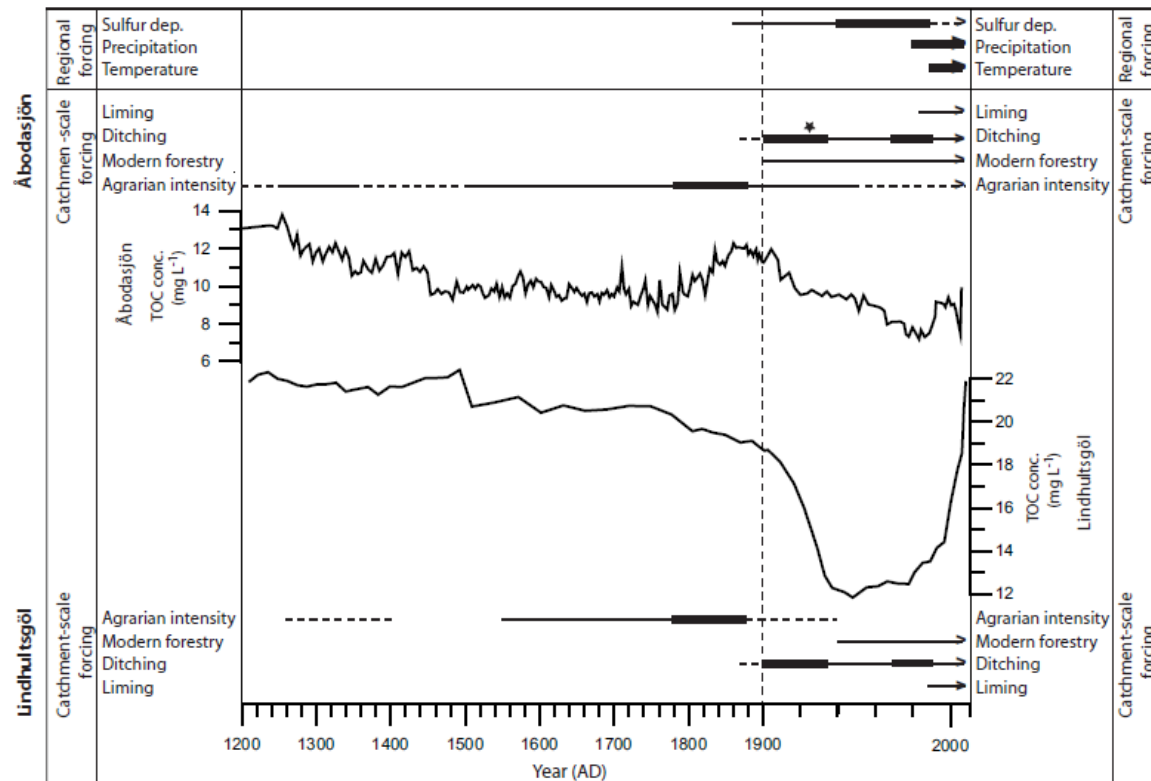


The lake sediment record

Meyer-Jacob et al. 2015 "PNAS₆



“Historical TOC concentration minima during peak sulfur deposition” *Bragée et al. 2015*





Brunifierning av Sveriges vattendrag – klimat och andra påverkansfaktorer

- Climate itself not likely to push median DOC much higher
- DOC increases have leveled off across much of Sweden
- Increases continue in south and northeast
- Acidification recovery part of the story – but not the whole story
- Decades of observations answer many questions
- Observations of land use change effects will answer more questions! (continued monitoring and more sediment records)
- **Use interventions (forest management shifts, wetland restoration) as learning opportunities!**



SCIENCE AND
EDUCATION **FOR**
SUSTAINABLE
LIFE