Norsk institutt for vannforskning
Norwegian Institute for Water Research

Norwegian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

NOM og klimaendringer - Status og fremtidsutsikter

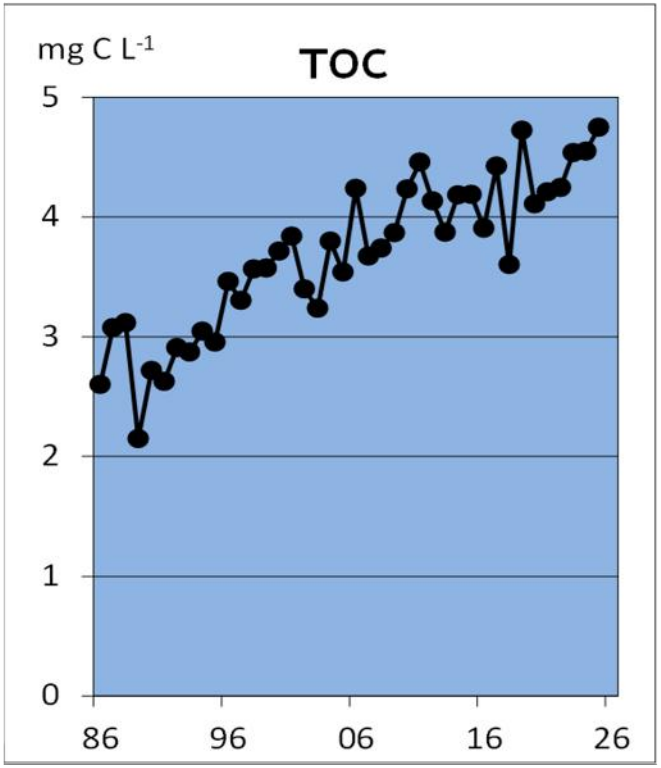
Vil råvannsfargen fortsatt øke?

Rolf D. Vogt, NIVA og Ståle Haaland, NMBU/NIBIO

Konsentrasjonen av naturlig organisk materiale (NOM) øker

- Vi ser dette som en økning i totalt organisk karbon i våre overvåkningsdata.



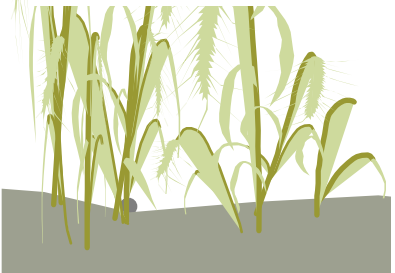


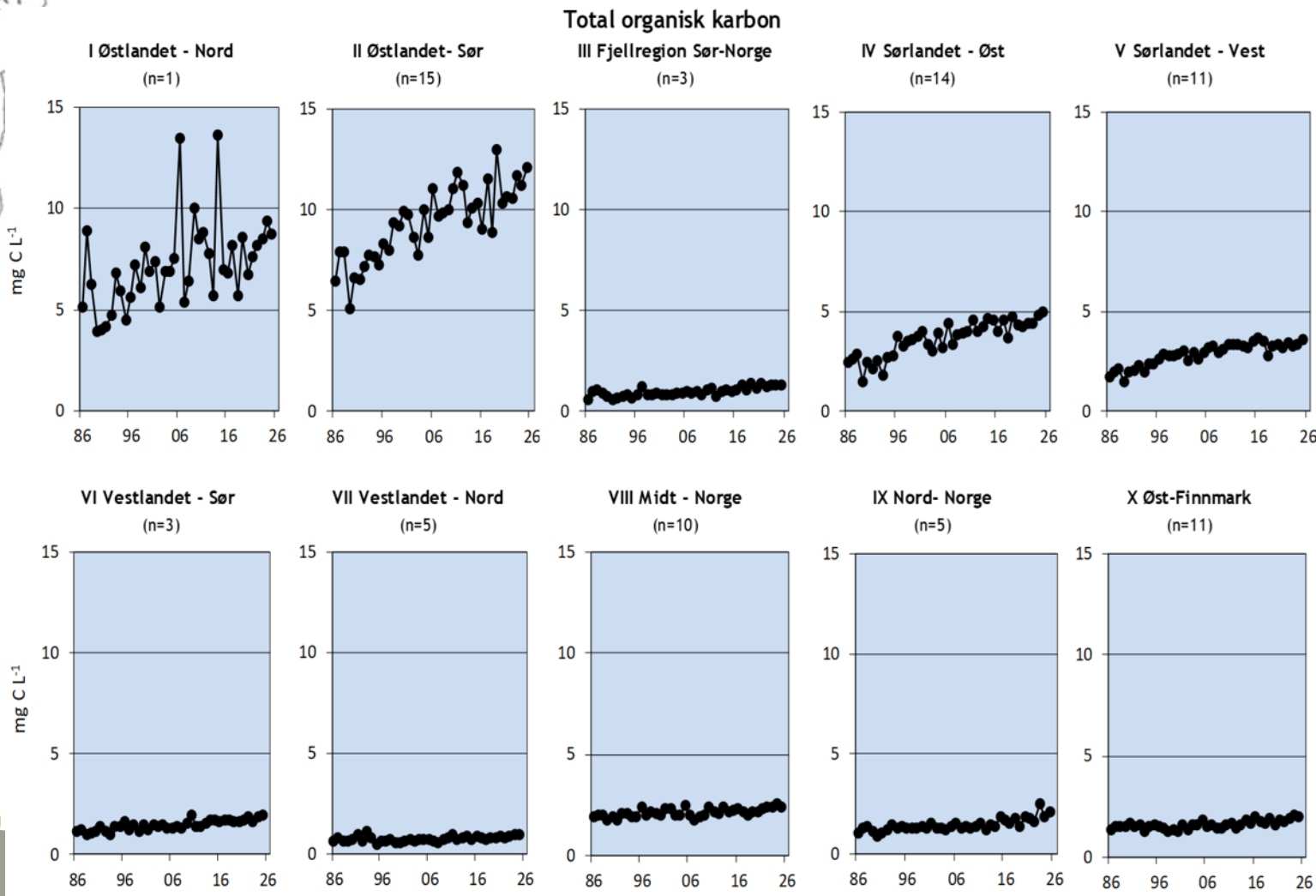


Årlige gjennomsnittskonsentrasjoner i 78 forsurings-følsomme tidstrendsjøer fordelt over hele landet.

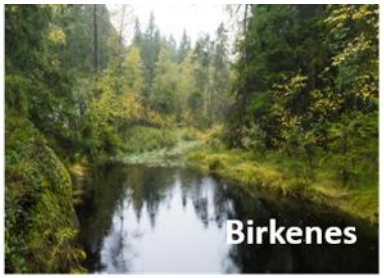


Årlige gjennomsnittskonsentrasjoner av NOM i de forsuringsfølsomme tidstrendsjøene, fordelt på 10 regioner





Sesongfluktuasjoner i NOM



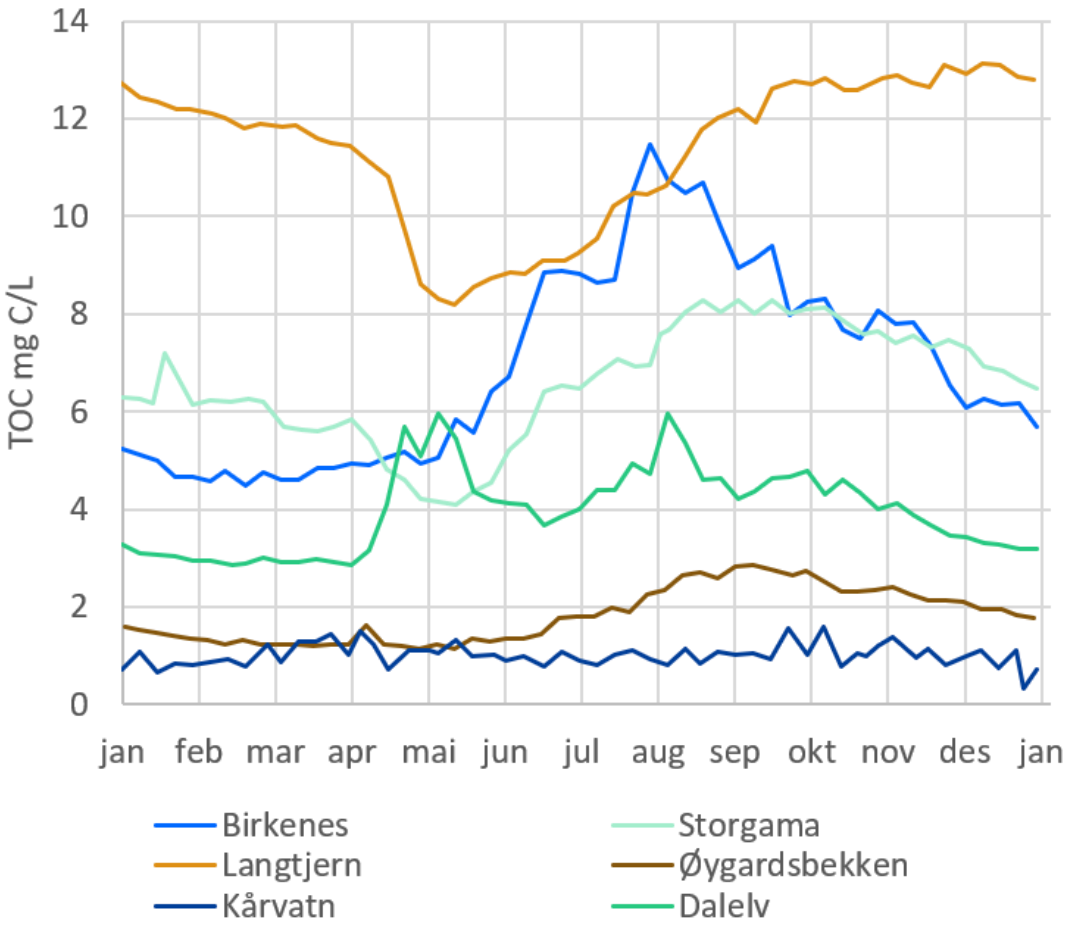


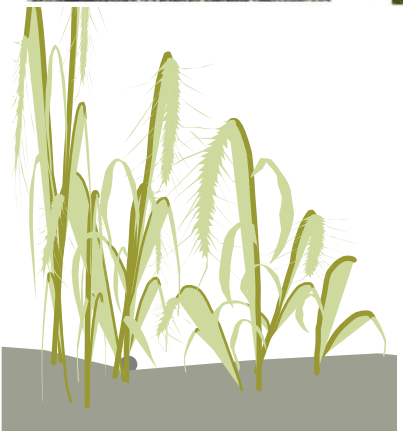












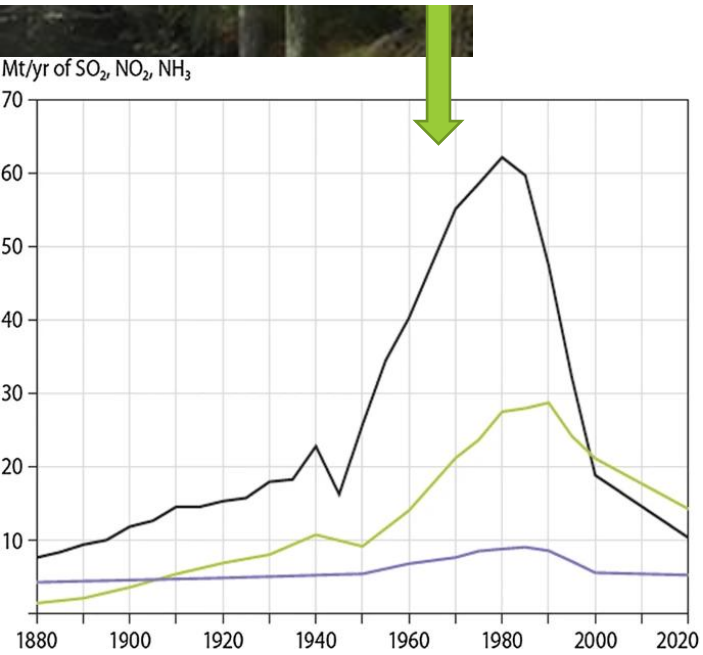
- Årlige gjennomsnittsverdier fra 2012 til 2015 av ukentlige prøver fra våre 6 feltforskningsstasjoner.
- Det er stor variasjon i sesongfluktuasjoner mellom forskningsstasjonene.
- Generelt lavest sent på våren og høyest på høsten.
- Variasjonen er mindre i større vassdrag.



Tilbakegang av sur nedbør og konsentrasjonen av sure komponenter i overflatevann

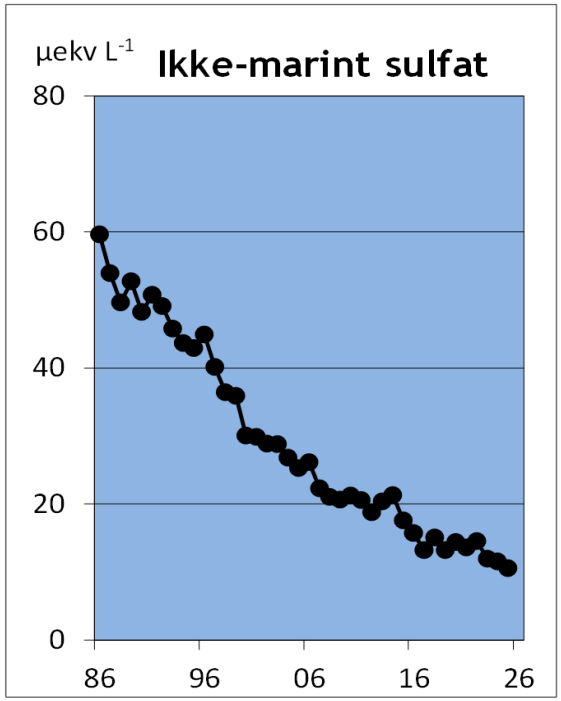
Norsk institutt for vannforskning
Norwegian Institute for Water Research

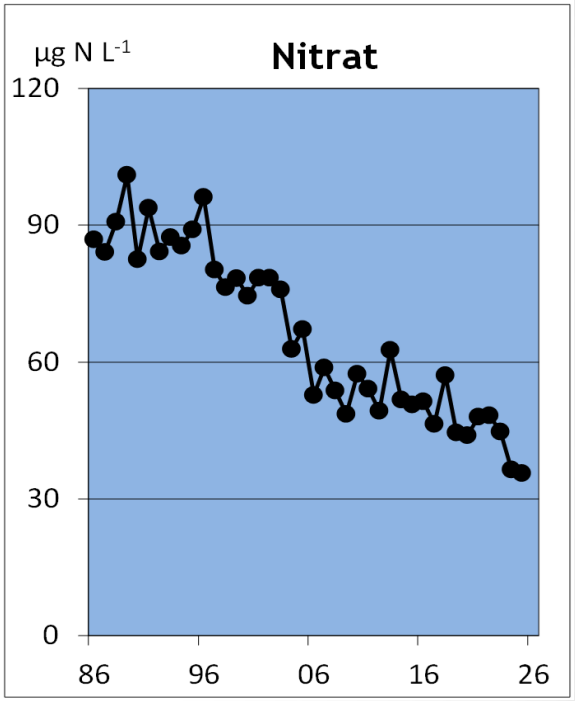
Bevisstheten om potensielle effekter av sur nedbør starter omtrent her!



Europeiske utslipp av svoveldioksid (SO_2—svart), nitrogenoksider (NO_x, beregnet som NO_2—grønn) og ammoniakk (NH_3—blå).

Fra Grennfelt et al. 2020



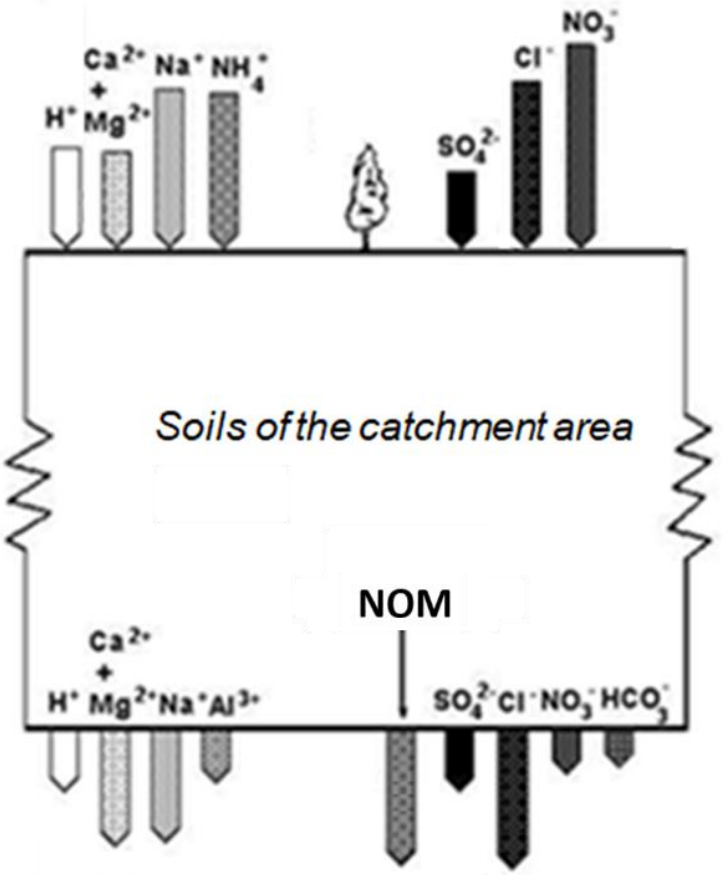


NIVA - ØkoFersk Trend overvåkningen. Konsentrasjoner i ferskvann.


Photo: Ståle Haaland

Nedbørfeltet er kilden til NOM

Atmosfærisk deposisjon (input)



Utvasking fra jord (output)

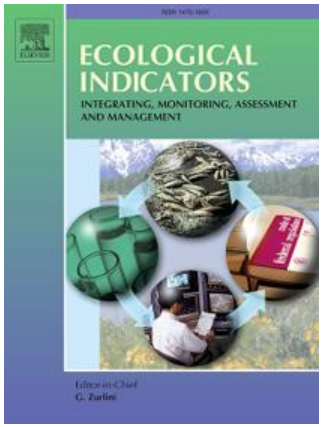
Figur (modifisert) fra Rosenquist (1977) / Grøterud (2000)

- *Alloktont NOM i overflatevann kommer i all hovedsak fra nedbørfeltets jordsmonn, ikke fra atmosfærisk avsetning*.

Norsk institutt for vannforskning
Norwegian Institute for Water Research

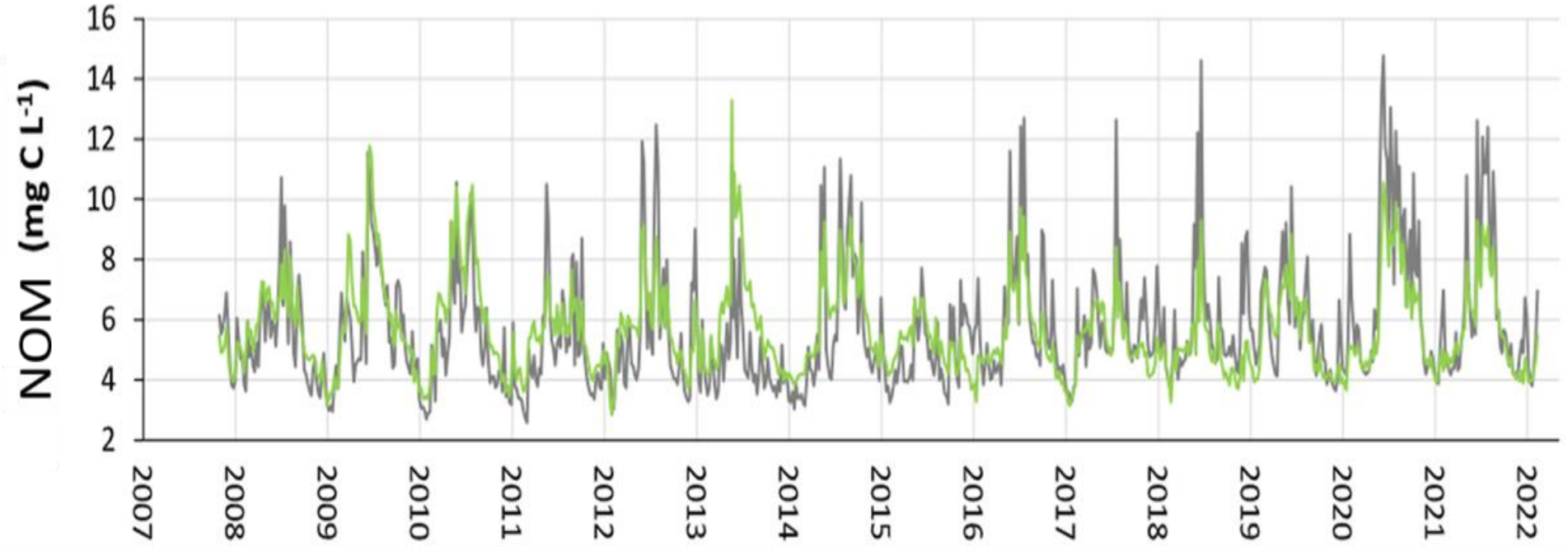
Norwegian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH



Våre modeller er relativt gode, men presisjonen varierer i tid og rom

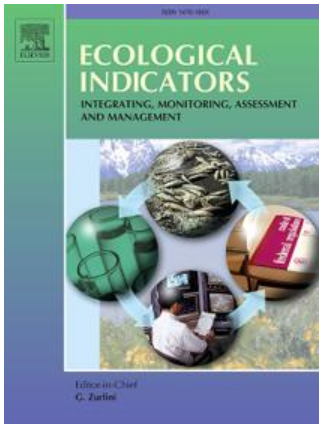
Lange, gode dataserier for NOM-utvikling og farge får vi ofte fra vannbehandlingsanlegg.



Norsk institutt for vannforskning
Norwegian Institute for Water Research

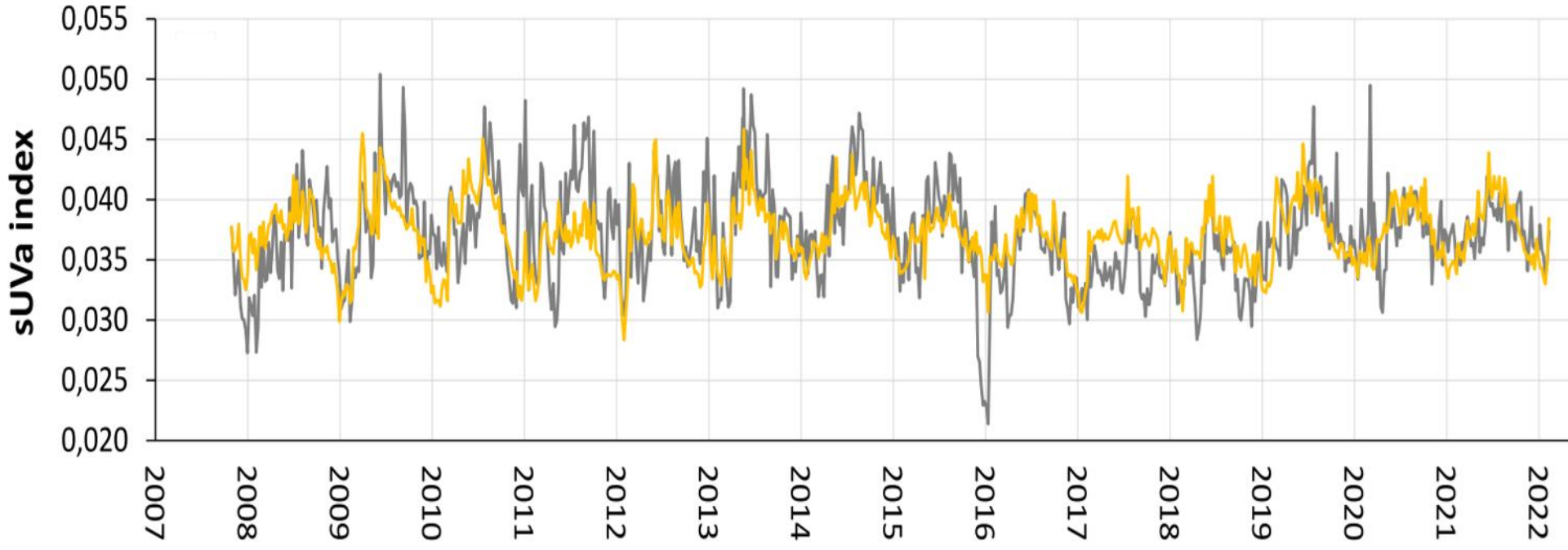
Norwegian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH



Man har i større grad modellert kvantitative endringer av NOM (TOC) over tid framfor kvalitative endringer.

Modellene benytter blant annet klimaparametere, men også info om nedbørfeltets beskaffenhet, etc.

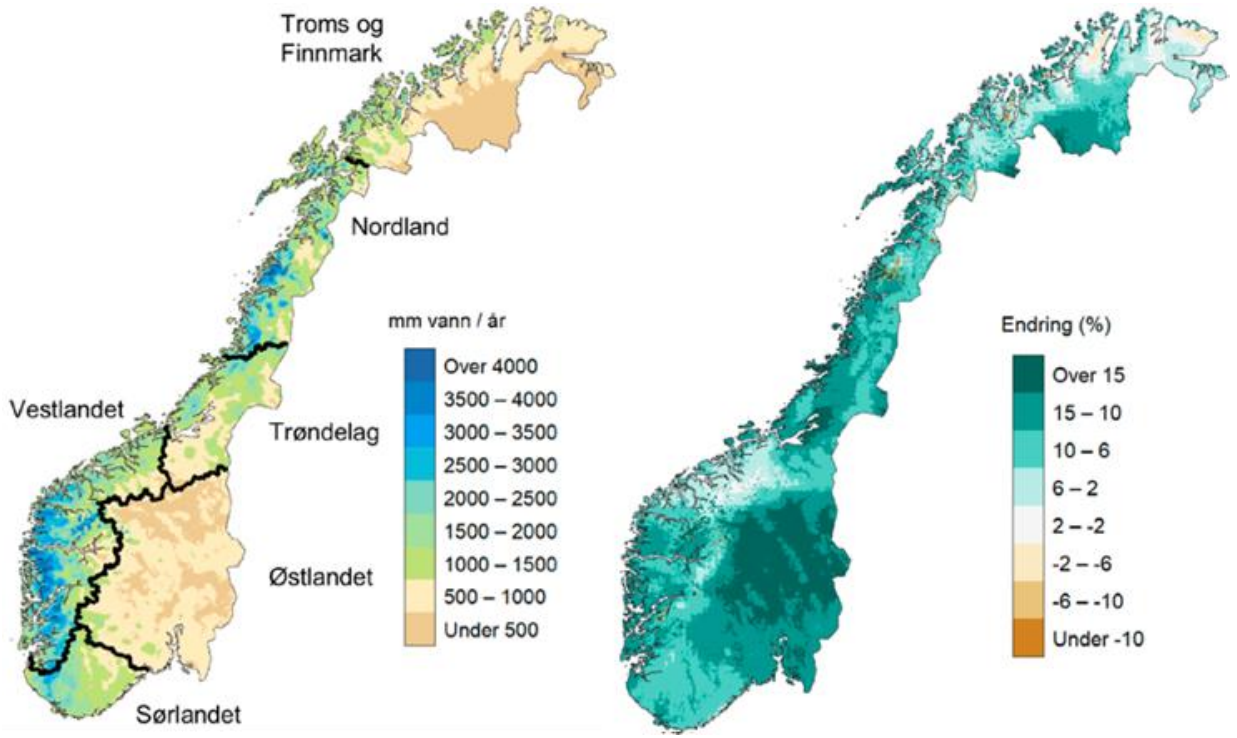






Avrenning, nå vs yr 2100

Norges miljø- og biovitenskapelige universitet



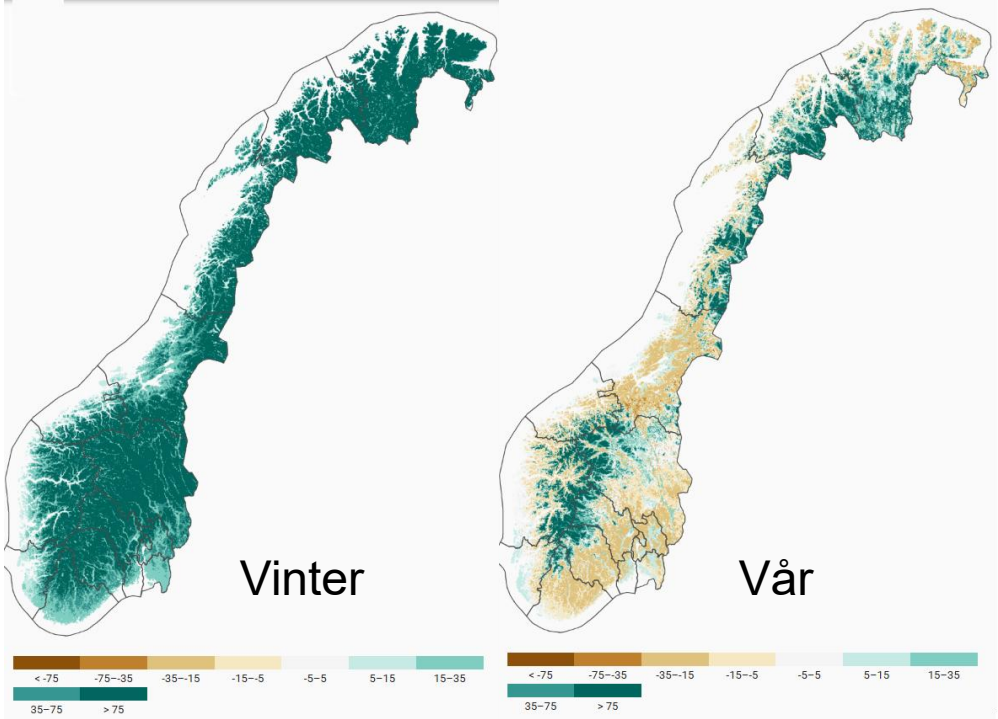
- ***Venstre*** *gjennomsnittlig avrenning (mm/år) i perioden 1991–2020. Sorte linjer markerer avrenningsområder i Norge.*
- ***Høyre*** *Relative endringer (%) i årlig avrenning fra 1991–2020 til 2071–2100 for scenarioet SSP3-7.0. Den estimerte endringen er gjennomsnittet av 20 ulike modellsimuleringer (distHBV–COR-BA-2025).*

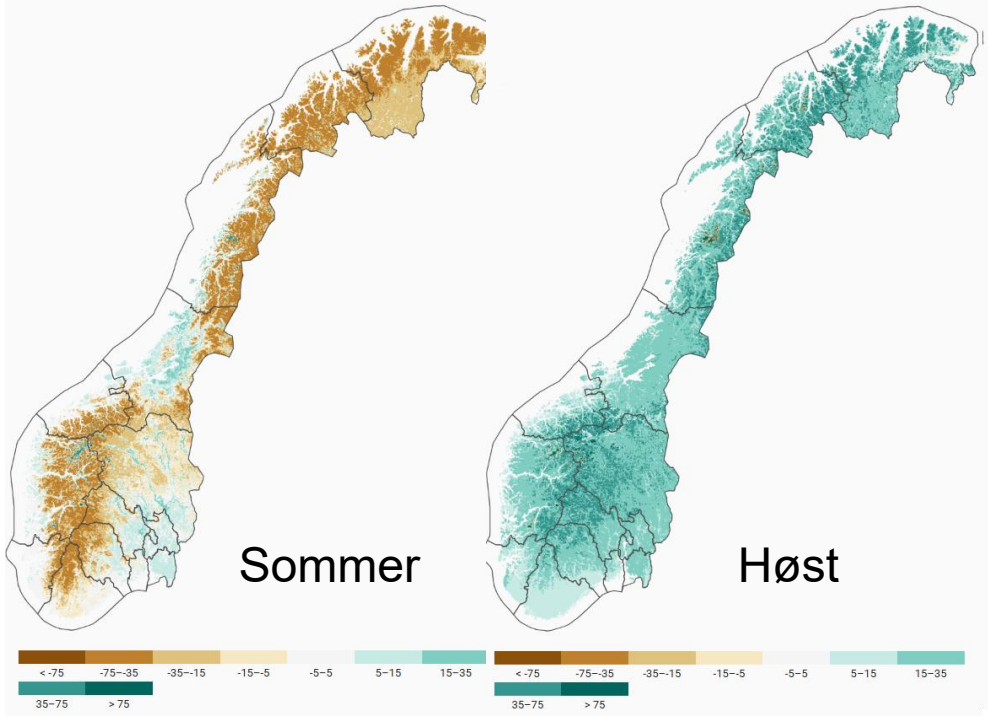
Norsk klimaservicesenter (NCCS, 2025)





Photo: Ståle Haaland





Norges miljø- og biovitenskapelige universitet

Avrenning, nå vs yr 2100

Årstider.

Generelt mer om høsten og vinterstid.

Regionale forskjeller vår og sommer.

Norsk klimaservicesenter (NCCS, 2025)



Norwegian University of Life Sciences

Nedbørepisoder.
Romlig fordeling over ulike deler av nedbørfeltet..

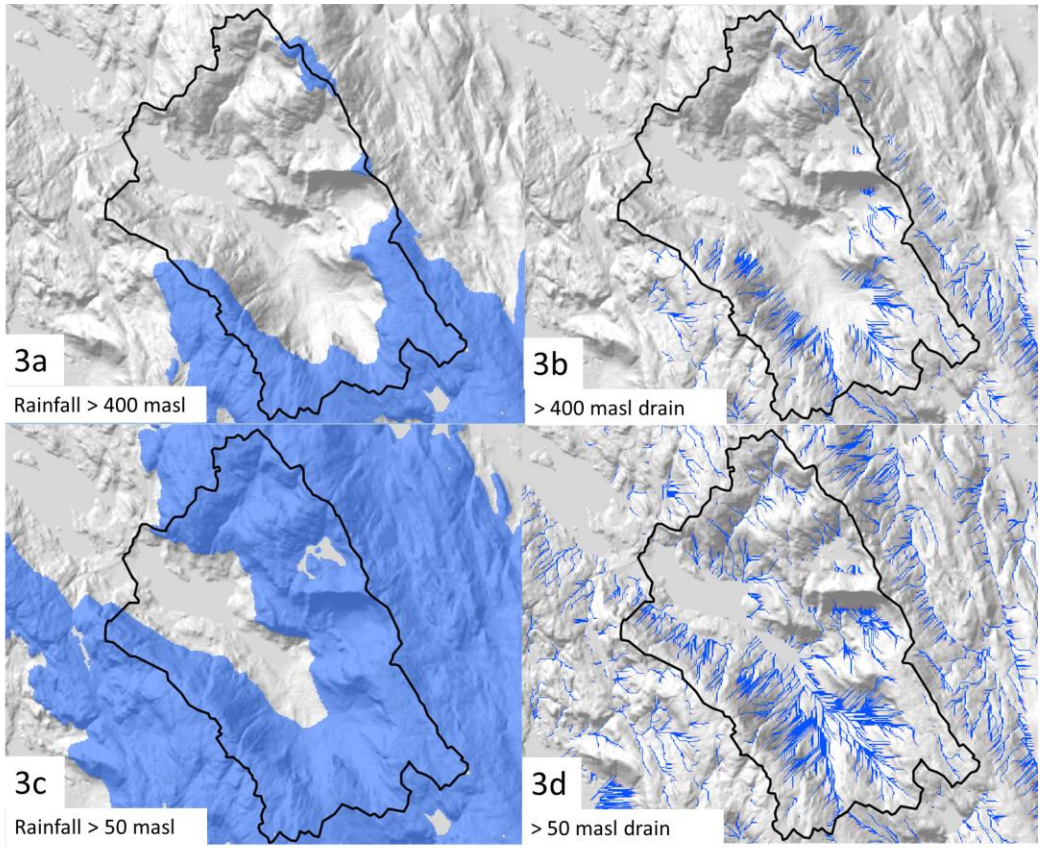


Figure 3. Spatial distributed precipitation and the following surface drainage (24 hrs simulation).

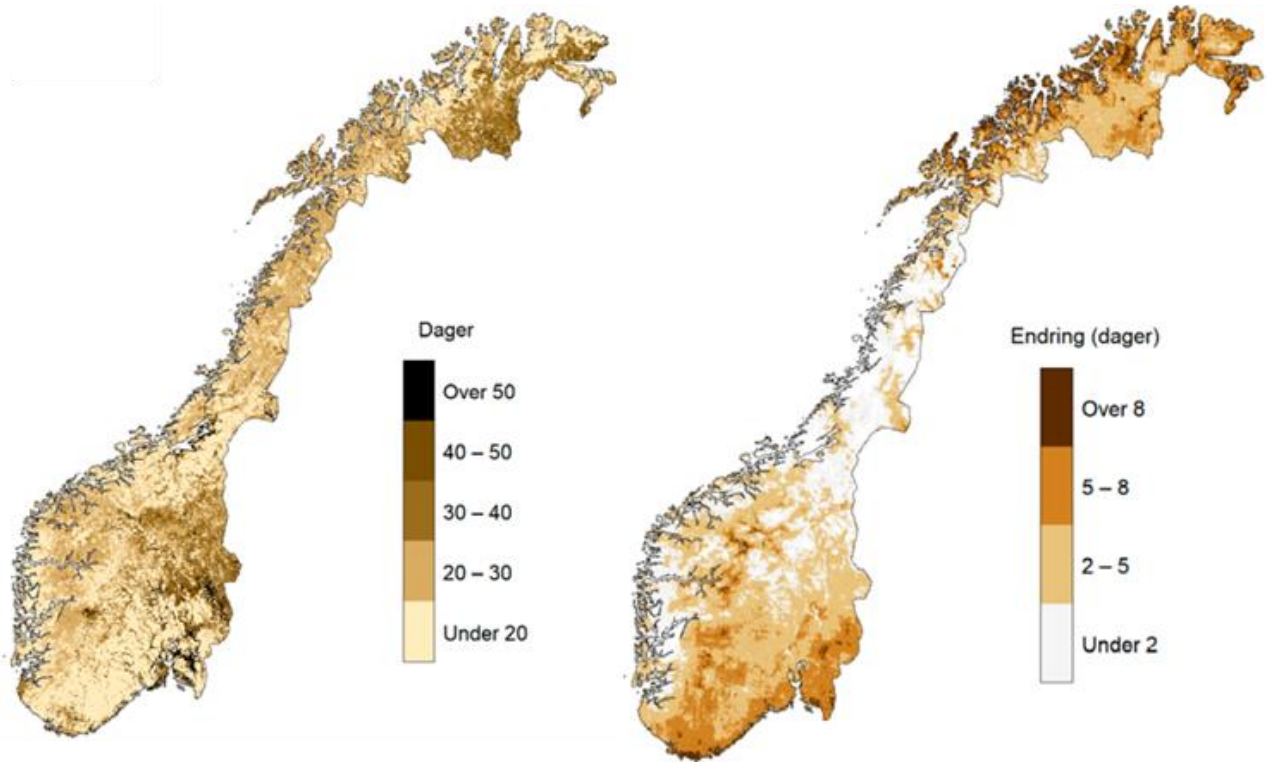
Based on Haaland et al., NOMiNOR (2016)

- *Det kan være interessant å hente romlige data for å vurdere avrenning fra hele nedbørfeltet over tid etter en nedbør/avrenningsepisode. Dette vil gi oss informasjon om hvordan NOM i nedbørfeltet vil transporteres til overflatevann.*
- *Ulike deler av nedbørfeltet har ofte ulike egenskaper, noe som påvirker konsentrasjonen og kvaliteten av NOM i avrenning.*



Photo: Ståle Haaland

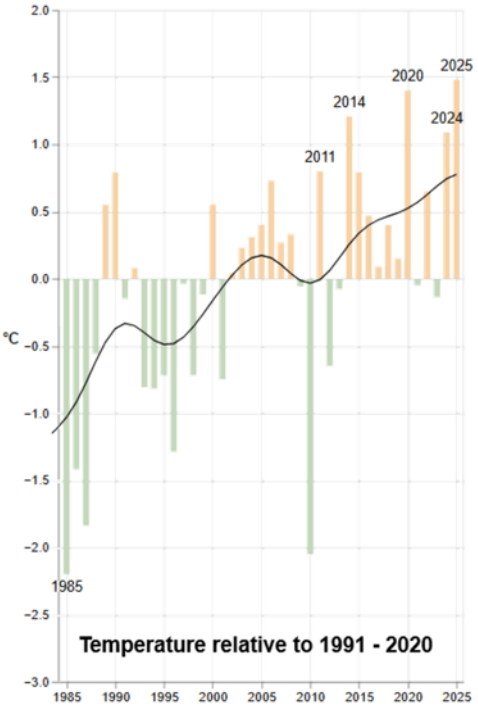
Tørke, nå vs år 2100



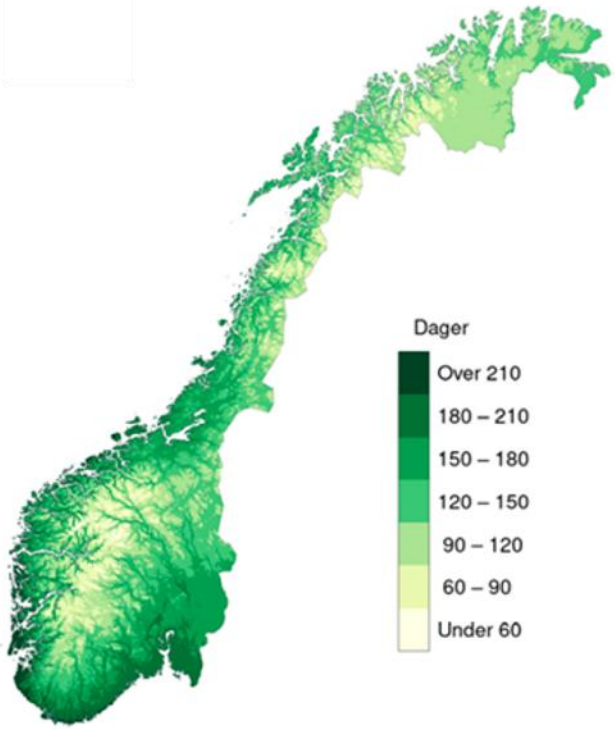
- ***Venstre:*** *Gjennomsnittlig tørkevarighet mellom 15. juni og 15. oktober i perioden 1991–2020.*
- ***Høyre:*** *Endring i antall dager mellom mai og september med alvorlig meteorologisk tørke (langvarig periode med mindre enn gjennomsnittlig nedbør) i perioden 2071–2100. Den estimerte endringen er gjennomsnittet av 20 ulike modellsimuleringer (distCOR-BA-2025).*

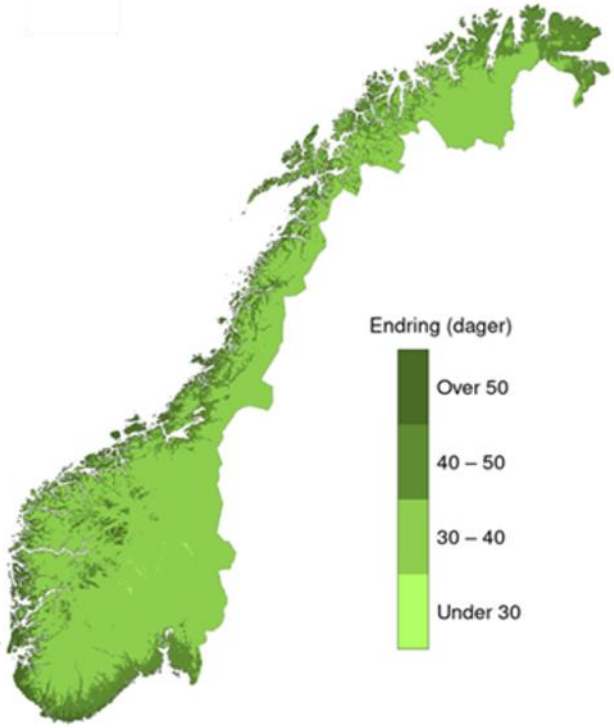
Norsk klimaservicesenter (NCCS, 2025)





Vekstsesong, nå vs år 2100





- ***Venstre:*** *Lengden på vekstsesongen (antall dager per år) i referanseperioden 1991–2020.*
- ***Høyre:*** *Estimert endring (antall dager per år) fra perioden 1991–2020 til 2071–2100 under et høyutslippsscenario (SSP3-7.0). Den estimerte endringen er gjennomsnittet av 20 ulike modellsimuleringer (COR-BA-2025).*

Norsk klimaservicesenter (NCCS, 2025)



NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Utvikling av stående volum (kubikkbiomasse u.b.) i Norge

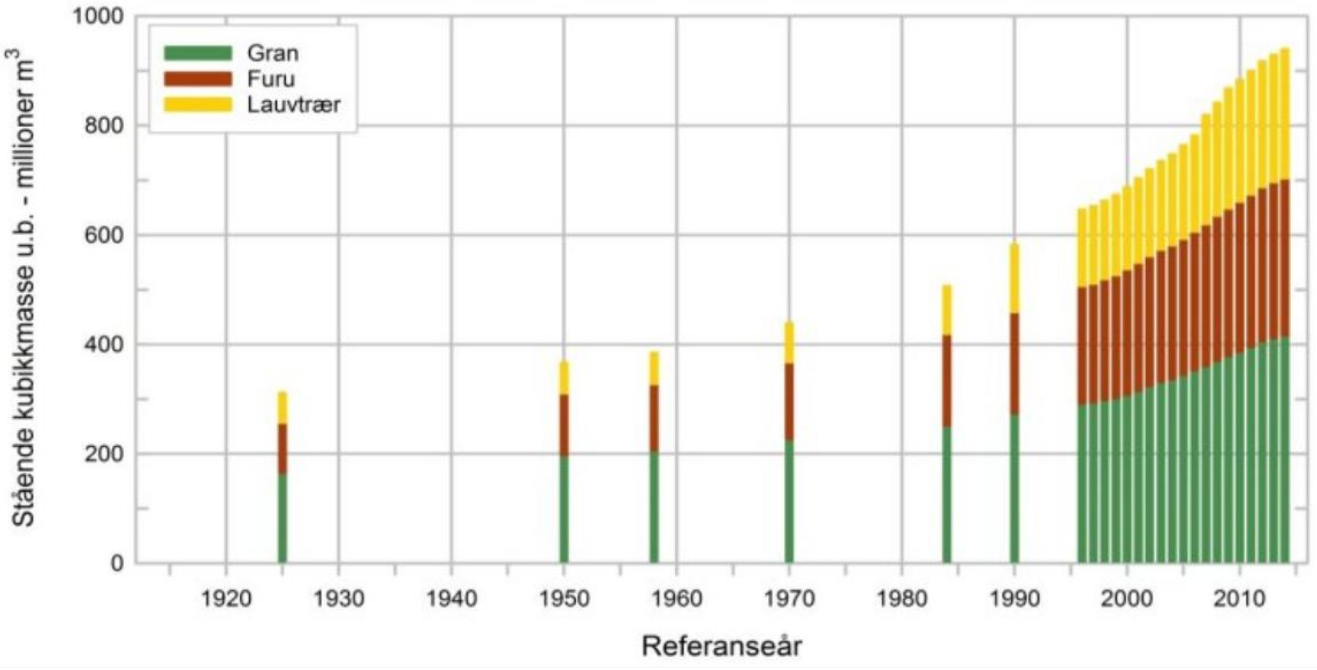




From greening to browning: Catchment vegetation development and reduced S-deposition promote organic carbon load on decadal time scales in Nordic lakes

NIBIO – Landsskogtakseringen

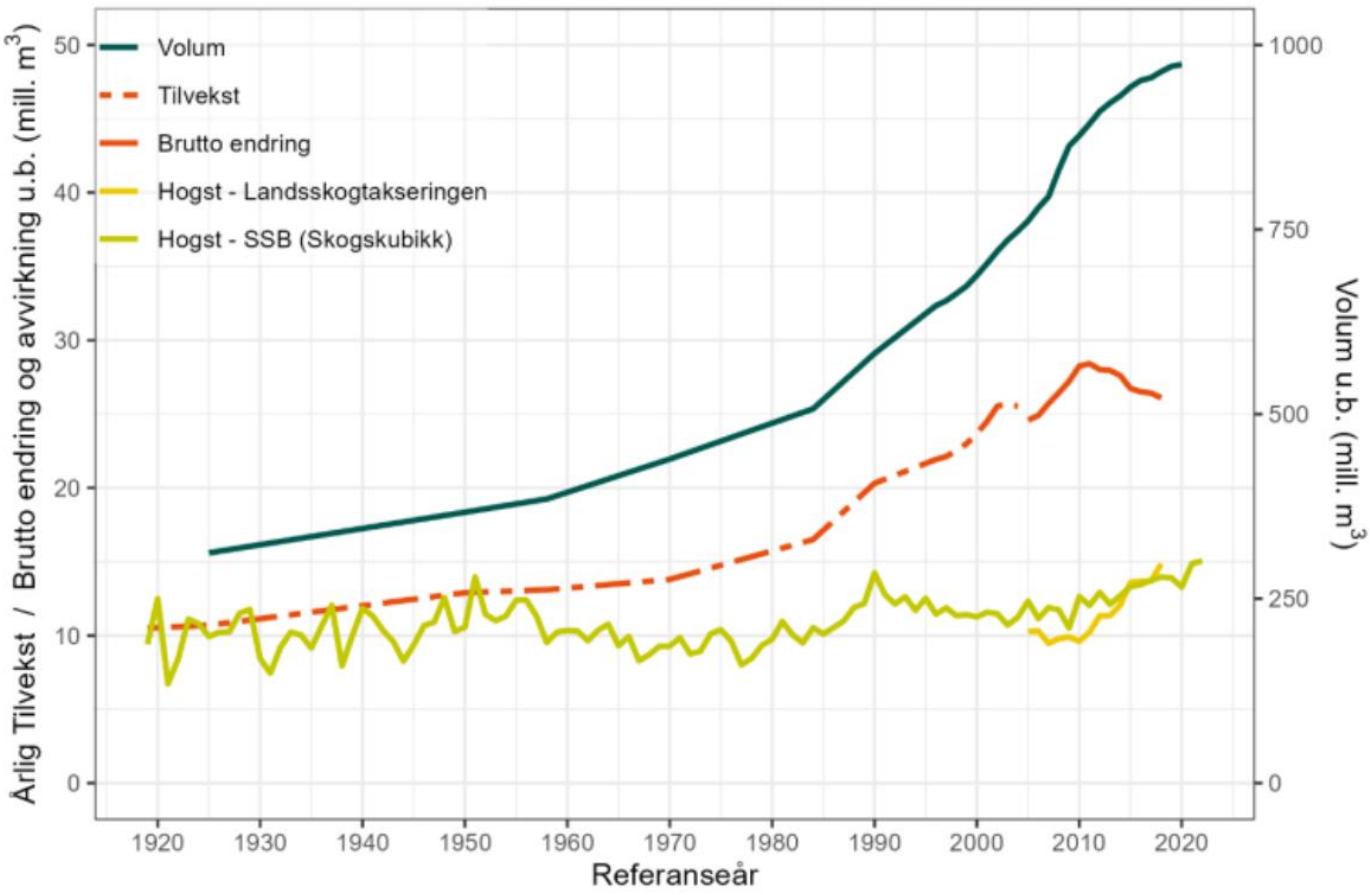
Anders G. Finstad, Tom Andersen, Søren Larsen, Koji Tominaga, Stefan Blumentrath, Heleen A. de Wit, Hans Tømmervik & Dag Olav Hessen





NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Mer hogst enn tilvekst fremover



- *Veksten har sluttet å øke, mens hogst og naturlig dødelighet har økt betydelig de siste årene, noe som har ført til en reduksjon i volumet av stående gran. Dette representerer en betydelig endring fra den langsiktige trenden over flere tiår, hvor granvolumet har økt markant. Breidenbach 2024 (NIBIO).*



Norwegian University of Life Sciences

Alger og NOM

Limnologica 84 (2020) 125818

Contents lists available at ScienceDirect

Limnologica

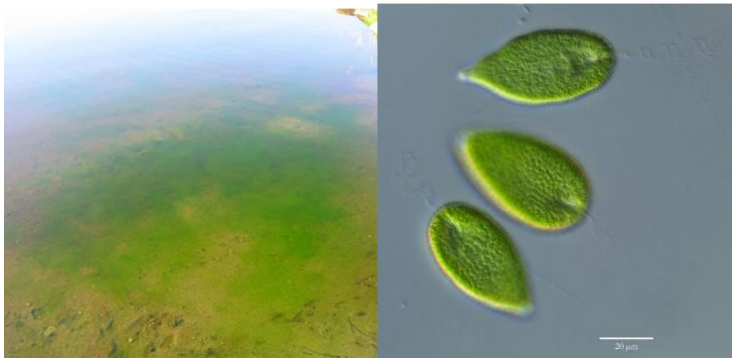
journal homepage: www.elsevier.com/locate/limno

The success of *Gonyostomum semen* (Raphidophyceae) in a boreal lake is due to environmental changes rather than a recent invasion

Camilla Hedlund Corneliussen Hagman *, Thomas Rohrlack, Gunnhild Riise

Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432, Ås, Norway





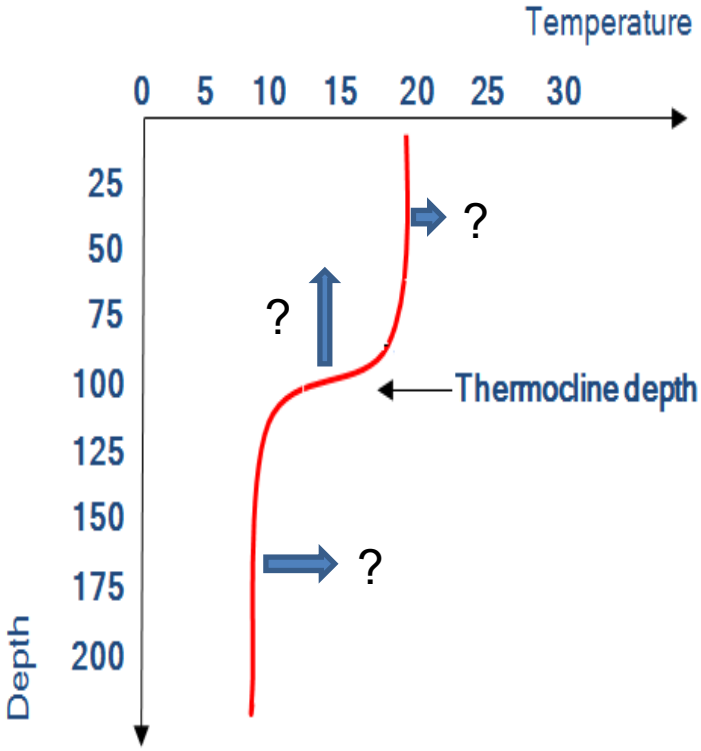
- Enkelte alger har trolig et fortrinn når det gjelder økte konsentrasjoner av NOM.

Eksempel; slimalgen G. semen



Innsjøers respons på et endret klima

Innsjøer (og nedbørfelt) kan få kortere perioder med isdekke eller fravær av isdekke, noe som vil påvirke innsjøens sirkulasjonsmønster, lysforhold og omsetning av NOM (sedimentasjon, bleking, etc,). Mye kan påvirkes av dette.



- *Det vil også her være forskjeller i respons mellom innsjøer, og her er for eksempel innsjøers <u>oppholdstid</u> viktig å skue til i vår NOM kontekst.*

Figur fra Haaland, 2014

Norsk institutt for vannforskning
Norwegian Institute for Water Research

Norwegian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Råvannskilder i Østmarka naturreservat

De blå estimatene fikk du av oss i 2010, Bjørnar



Quantifying the Drivers of the Increasing Colored Organic Matter in Boreal Surface Waters

S. HAALAND,*,† D. HONGVE,‡ H. LAUDON,§ G. RIISE,∥ AND R. D. VOGT⊥

Norwegian Institute for Agricultural and Environmental Research, Bioforsk, Fr. A. Dahls vei 20, NO-1432 Ås, Norway, Norwegian Institute of Public Health, P.O. Box 4404 Nydalen, NO-0403 Oslo, Norway, Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, SLU, SE-901 83 Umeå, Sweden, Department of Plant- and Environmental Sciences, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway, and Department of Chemistry, University of Oslo, P.O. Box 1033, NO-0315 Oslo, Norway

Received October 20, 2009. Revised manuscript received March 07, 2010. Accepted March 10, 2010.

Long-term monitoring of surface water quality has shown increasing concentrations of colored dissolved organic matter (CDOM) across large parts of the northern latitudes. This has increased purification costs for domestic water works. Appropriate abatement actions require better knowledge of the governing factors for the increase, and this has motivated a growing scientific interest in understanding the factors and mechanisms promoting the CDOM increase. A proposed water color model for an important raw water source for Oslo, Norway, is based on the precipitation's amount and mobile ion concentration. The model explained more than 93% of the temporal variation in CDOM between 1983 and 2008. The model structure was also tested on three adjacent raw water sources and was found to explain 75−82% of the CDOM development throughout the same period. The long-term trend of increasing CDOM was closely related to the decline in sulfate and chloride concentrations in precipitation. Furthermore, interannual fluctuations in CDOM were explained by variation in predominant water flow paths, depending on amounts and intensity of precipitation, both of which are predicted to increase in several parts of the northern latitudes according to climate change scenarios.

Introduction

Concentrations of CDOM in northern European and northeastern American lakes have increased significantly over the past 2−3 decades (*1*−*5*). SO_2 emissions peaked in northern Europe and North America from the mid 1960s to the mid-1970s (*6*), and in southern Norway there has been a decline in the concentration of acid rain components of about 70% during the past two decades (*7*). In the early 1980s, it was hypothesized that increased inputs of strong mineral acids possibly could explain the decline in CDOM (*8*), which in the previous decades had been observed in several lakes on the northern hemisphere. At present, the increase in CDOM concentrations in northern Europe and North America has been linked to the decreasing acid rain depositions (*1*, *9*). Some studies have also pointed out a similar effect caused by sea-salt in precipitation as for the acid rain deposition (*1*, *10*, *11*). Several authors also mention fluctuations in rainfall amount and intensity, air temperature, and sunlight radiation as regionally important factors, along with the impact of climate change, for the seasonal and interannual variation in CDOM concentration and quality (*12*−*20*). In addition, the importance of catchment characteristics such as soil acidity on CDOM has been recognized (*1*, *11*). Catchment runoff chemistry has also been found to be highly influenced by hydrology (*21*). In particular, headwater streams show elevated CDOM concentrations and changes in the quality of CDOM during periods of high runoff (*16*−*20*, *22*−*24*). Hence, the predicted changes in precipitation patterns, causing annual flooding in southern Norway (*22*), will further affect the amount and characteristics of CDOM leaching from the soil to surface waters in the future.

The main objective of this study was to assess more directly how temporal trends in CDOM concentrations in boreal lakes of low ionic strength are related to changes in precipitation quality and quantity. This was made possible by long time series of color intensity measurements on raw water for drinking water purposes, conducted by the Oslo Water and Sewerage Works (WSW) where land use within the catchment is heavily restricted, and where the average annual, growing season and winter air temperatures have not changed significantly ($p > 0.05$) throughout the past two decades.

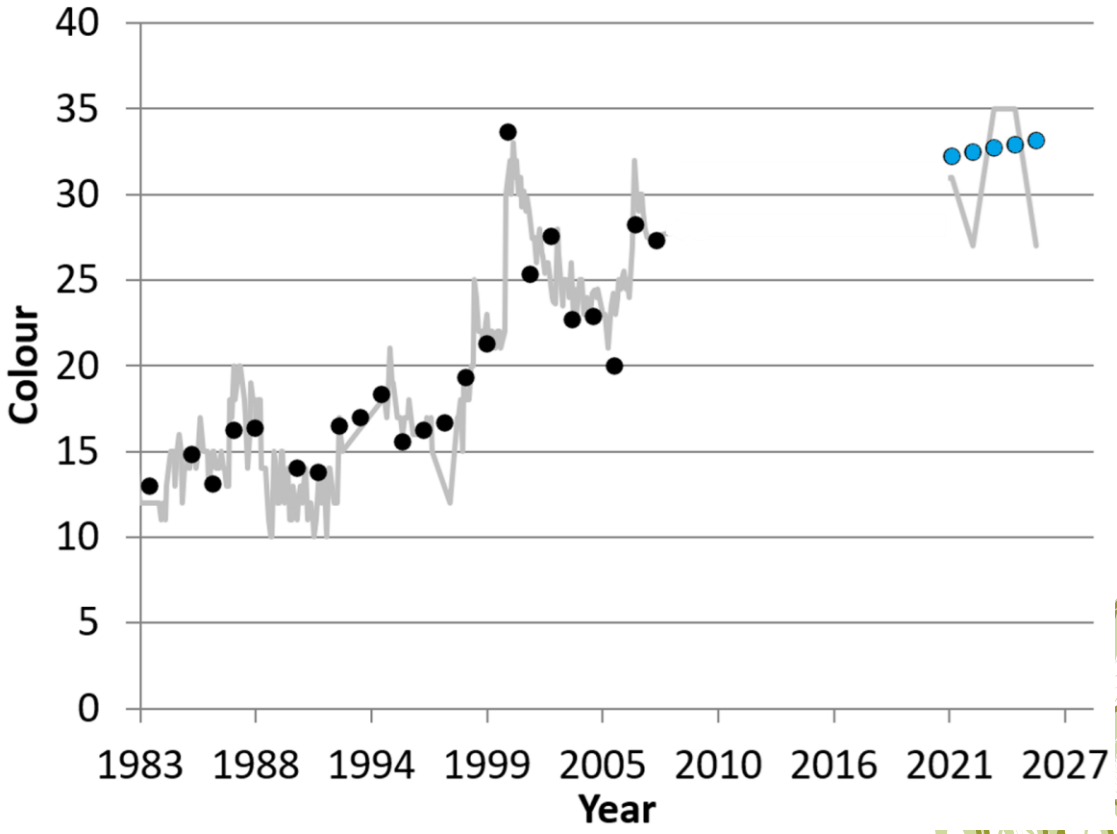
Methods

Study Sites. Four adjacent lakes, which cover the municipal drinking water demand in Oslo, Norway (Figure 1), were included in the study: Elvåga (59°53′N, 10°54′E, 196 m a.s.l.), Maridalsvatnet (59°59′N, 10°47′E, 150 m a.s.l.), Langlivatnet (59°05′N, 10°34′E, 320 m a.s.l.), and Alunsjøen (59°57′N, 10°51′E, 239 m a.s.l.). The catchment bedrock for all lakes

* Corresponding author phone: + 47 40 60 41 00; fax: + 47 63 00 92 10; e-mail: staale.haaland@bioforsk.no.
† Norwegian Institute for Agricultural and Environmental Research.
‡ Norwegian Institute of Public Health.
§ Swedish University of Agricultural Sciences.
∥ Norwegian University of Life Sciences.
⊥ University of Oslo.

FIGURE 1. Norway and location of the studied raw water sources.

10.1021/es903179j © XXXX American Chemical Society



Dissolved organic matter charge dynamics over three decades

under review

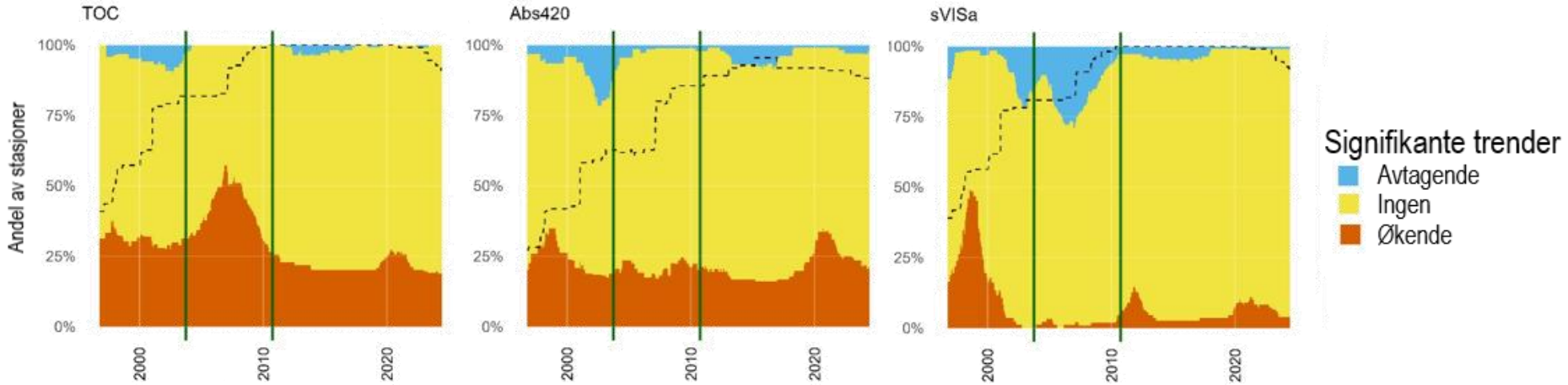
Anna Lackner*[1], Rolf David Vogt[2], Carin Sjöstedt[3], Jon Petter Gustafsson[3], Kevin Bishop[1]

[1]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden. [2]Norwegian Institute for Water Research, Oslo, Norway. [3]Department of Soil and Environment, Swedish University of Agricultural Sciences, Sweden.

Hva kan vi lære av de Svenske miljødataene?



- 31 000 vannprøver fra 110 nedbørsfelt overvåket fra 1995 til 2024.
- Antallet stasjoner med en økning i TOC og farge er mellom 20 – 30%, unntatt en TOC topp i 2005, der nesten 50% viste en signifikant økning.





- Avtagede trend for TOC.
- sVISa viser få signifikante trender.
- I 1998 var det imidlertid en økning i 50% av stasjonene
- **Det vil si at økningen i NOM og endring i ikke er monotone og varierer fra sted til sted.**

Norsk institutt for vannforskning
Norwegian Institute for Water Research

Norwegian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Hva kan vi forvente i Norge?

- **Deposisjonen av sur nedbør er nesten borte, og nedgangen flater ut.**
  - Økningen i NOM på grunn av nedgang i sur nedbør forventes derfor å stoppe
- **Vi har økende temperatur og nedbørmengder.**
  - Det kan gi ulike effekter på NOM.
- **Felling av trær og tilvekst krysser hverandre, noe som bryter med en hundreårs lang periode med mer tilvekst enn uttak.**
  - Økningen i NOM på grunn av mer skog kan derfor stoppe opp i fremtiden.

Klimaendringer kan føre til økte konsentrasjoner av NOM, men med betydelige variasjoner mellom nedbørfelt.