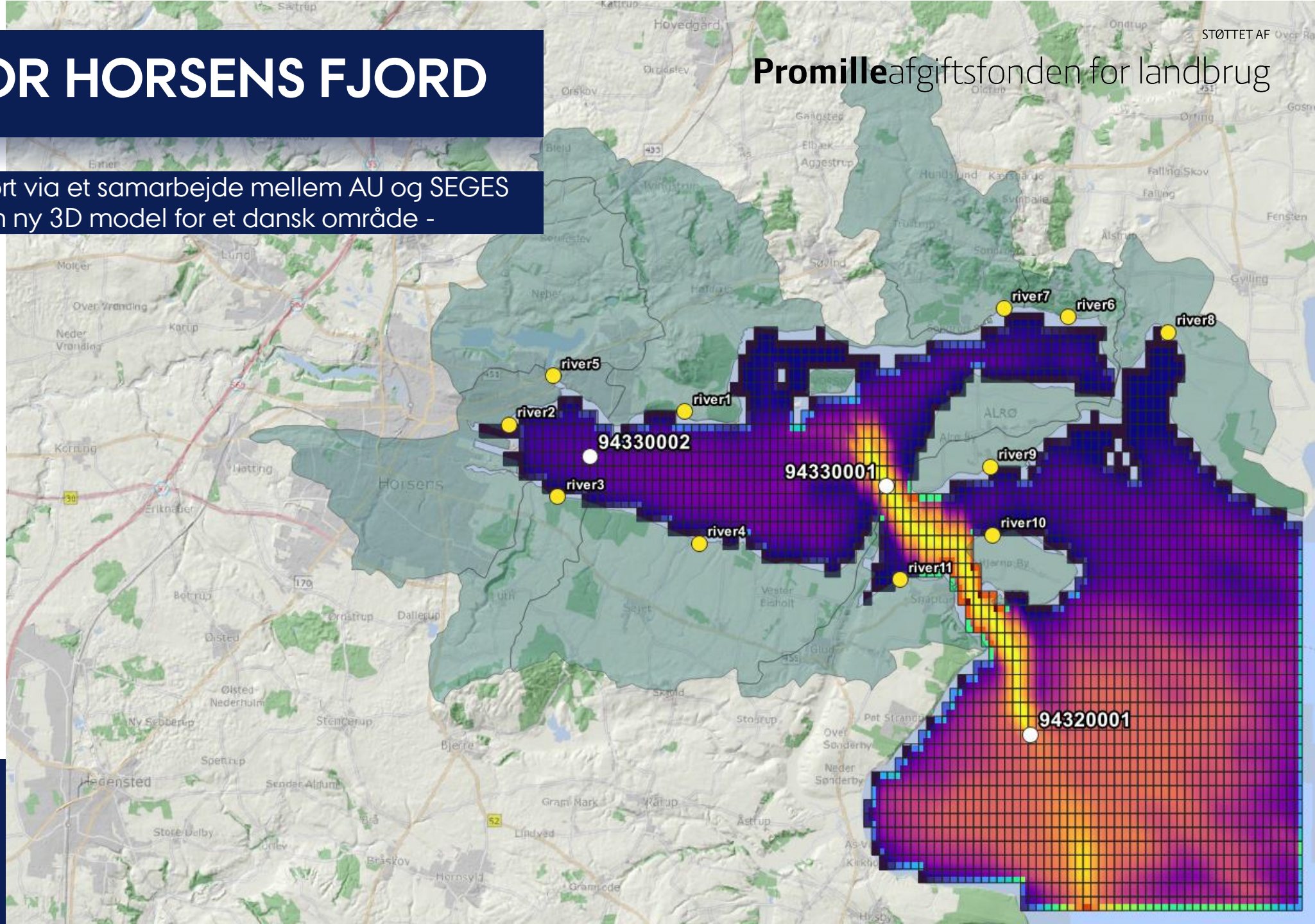


MODEL FOR HORSENS FJORD

Forskningsprojekt udført via et samarbejde mellem AU og SEGES
- første test af en ny 3D model for et dansk område -

Promilleafgiftsfonden for landbrug



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BAGGRUND

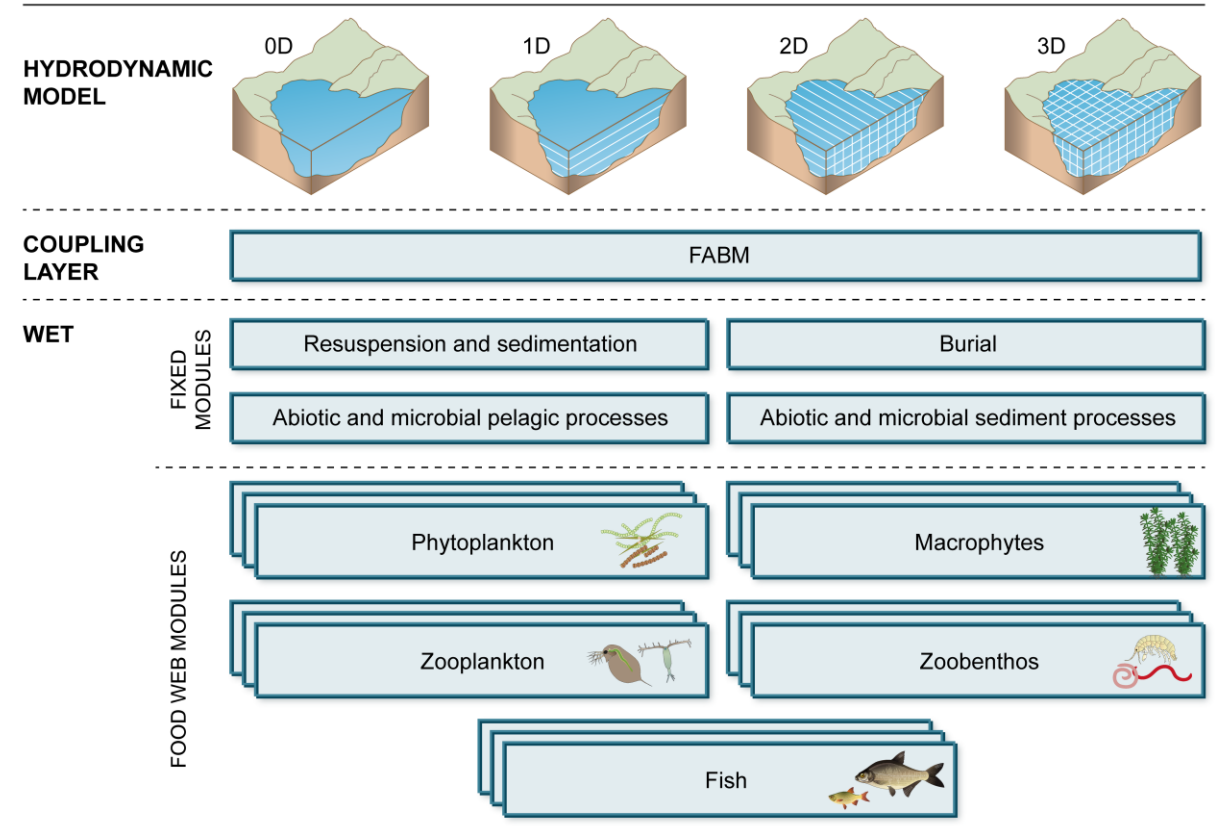
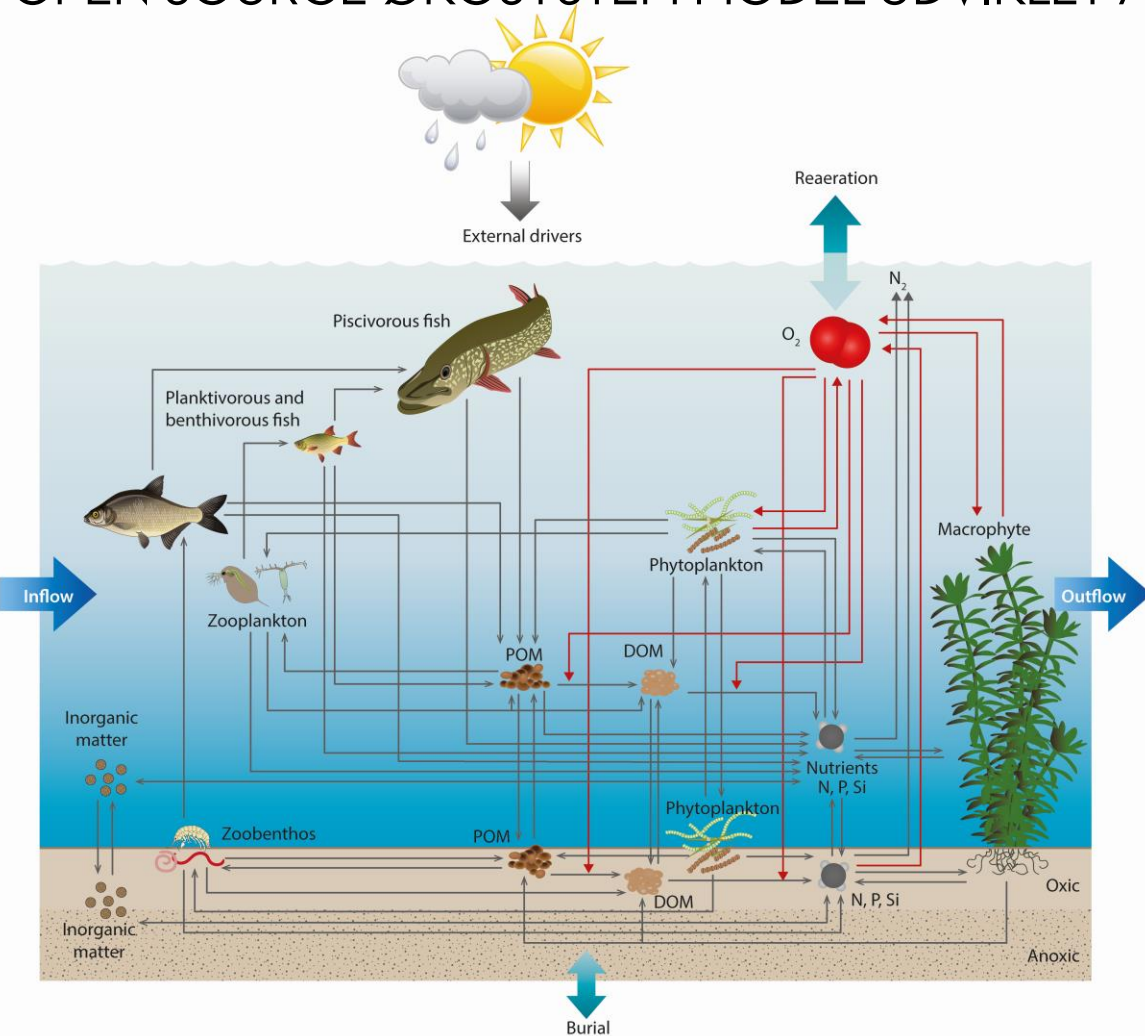
- ▶ Institut for Ecoscience (tidligere Bioscience, tidligere DMU) har igennem de seneste 15 år arbejdet med udvikling og anvendelse af vandkvalitetsmodeller med det formål at blive klogere på f.eks.:
 - ▶ Effekter af klimaforandringer
 - ▶ Effekter af ændringer i næringssalttilførsel (koblede oplands-vandkvalitetsmodeller)
 - ▶ Effekter af restaurering (f.eks. fjernelse af fisk, fjernelse af bundsediment, iltning)

WET ECOSYSTEMS TOOL (WET)

OPEN SOURCE ØKOSYSTEM MODEL UDVIKLET AF AU

Moduler i WET

(Schnedler-Meyer et al. 2022)



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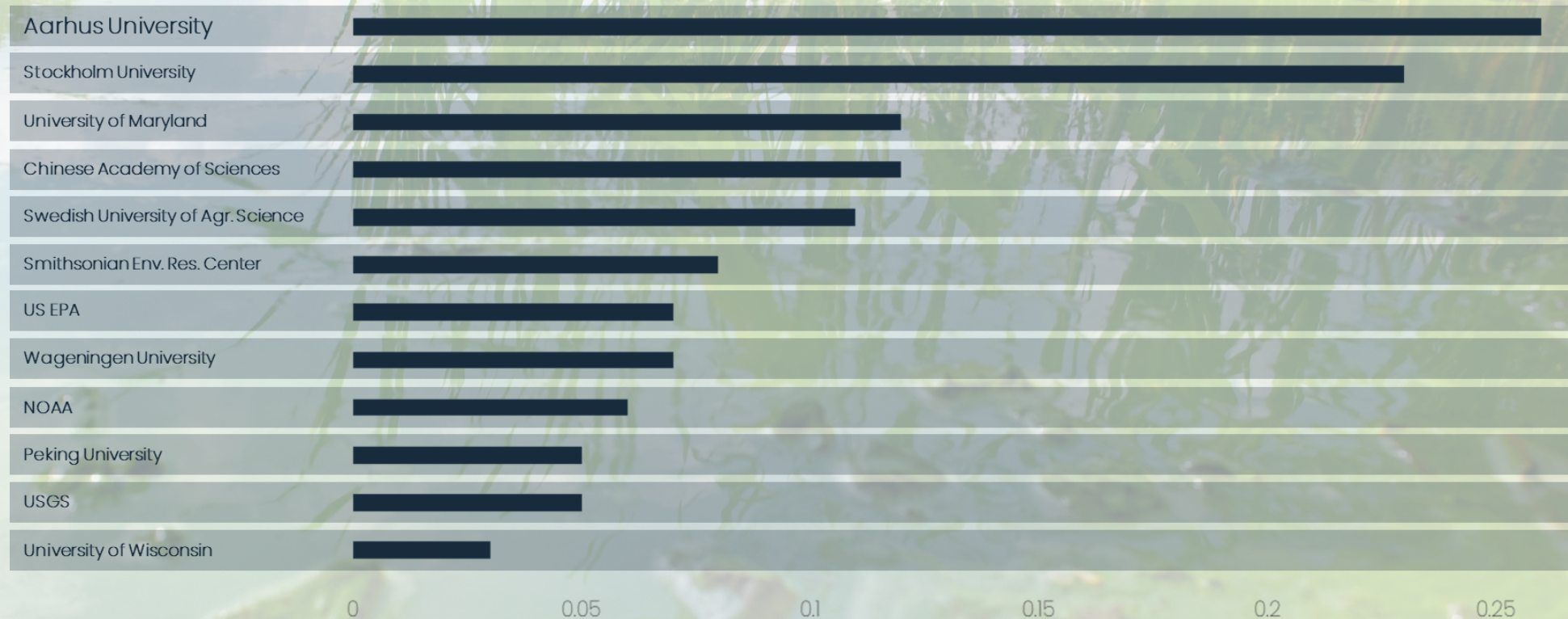
VI UNDERSØGER EFFEKTER AF KLIMAFORANDRINGER OG AREALANVENDELSE PÅ VANDSYSTEMER I HELE VERDEN



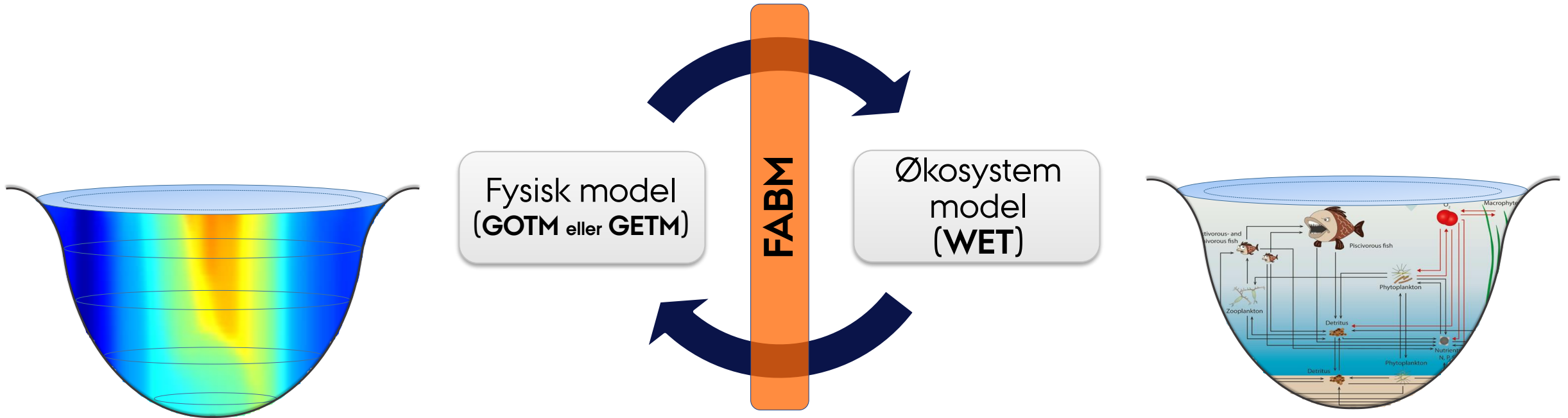
Forskningen bruges i stor stil

Vores gruppe er #1 i verden inden for vandkvalitetsmodellering (Hu et al. 2019)

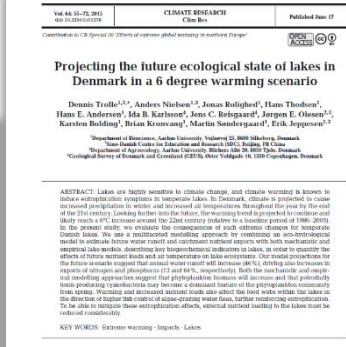
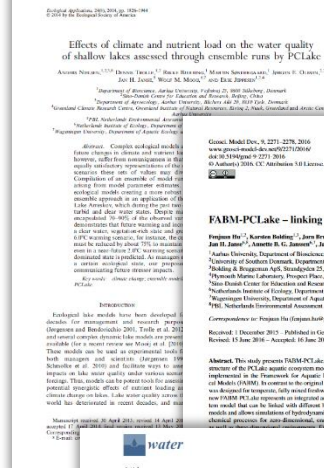
Aarhus University ranks #1 in the world in research centrality score for water quality modeling – a key indicator for impact and cooperation intensity.



WET KAN KOBLES TIL EN FYSISK MODEL VIA FABM



GOTM-VET (1D) - ER MEGET GODT TESTET OG DOKUMENTERET



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Water Ecosystems Tool (WET) 0.1.0 – a new generation of flexible aquatic ecosystem model

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Abstract. We present the Water Ecosystems Tool (WET) - a new generation of an open source, highly customizable aquatic ecosystem model. WET is a completely modularized aquatic ecosystem model, developed in the syntax of the Framework for Aquatic Biochemical Models (FABM), which enables coupling to multiple physical models ranging from zero to three dimensions, and is based on the FABM-PCLake model. The WET model has been extensively modularized, empowering users with flexibility of flow configurations, and also incorporates model features from other state-of-the-art models, with options for nitrogen fixation and vertical migration. With the new structure, features and flexible customization options, WET is suitable in a wide range of aquatic ecosystem applications. We demonstrate these new features and their impacts on model behavior for a temperate lake for which a model calibration of the FABM-PCLake model was previously published, and discuss the benefits of the new model.

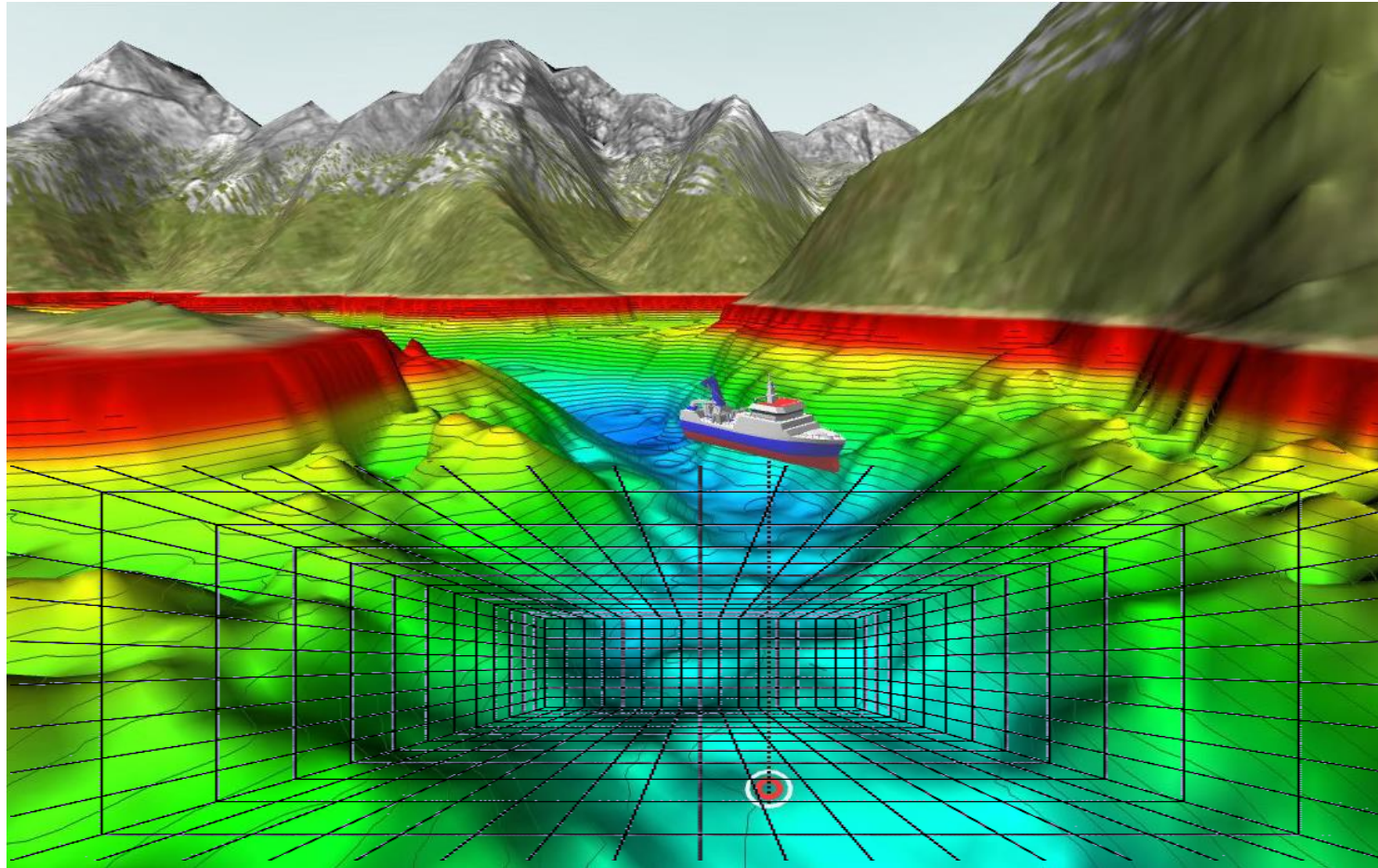
1 Introduction

The study and management of aquatic ecosystems have benefited widely from the ongoing development of various new model approaches to a host of ecological questions (Sørensen and Caljari, 2021). As the field matures, new and approaches and descriptions of individual ecological processes are formulated and improved upon, and management is continuously updated to reflect the current state-of-the-art. However, rather than building new models from scratch thus 're-inventing the wheel' over and over (Trolle et al., 2012), another way forward is to consolidate new developments into a few proven and well-established bioecological models, thereby improving their application and for the study of ecosystem-wide responses to environmental stressors. There is therefore a call for flexible and configurable models that contain various optional features, allowing them to be tailored to specific uses, without changing the model code or making a new version.

Among the most widely used lake ecosystem models in the world (Mooij et al., 2010; Trolle et al., 2012), the PCLake model was originally developed for the shallow Dutch lake Loosdrecht in the early 90s, under the name PCLoos (Jansen and Aldenberg,



GOTM-WET (1D) – ER MEGET GODT TESTET OG DOKUMENTERET



Fordele ved 1D:

- Hurtig beregningstid (minutter, hvor 3D typisk er timer eller flere dage)
- Muliggør mange test af betydning af økologiske parametre i model
- Muliggør simulering af lange tidsperioder (årtier eller mere)
- Gode erfaringer og dokumentation selv for store vandområder

Ulempe ved 1D:

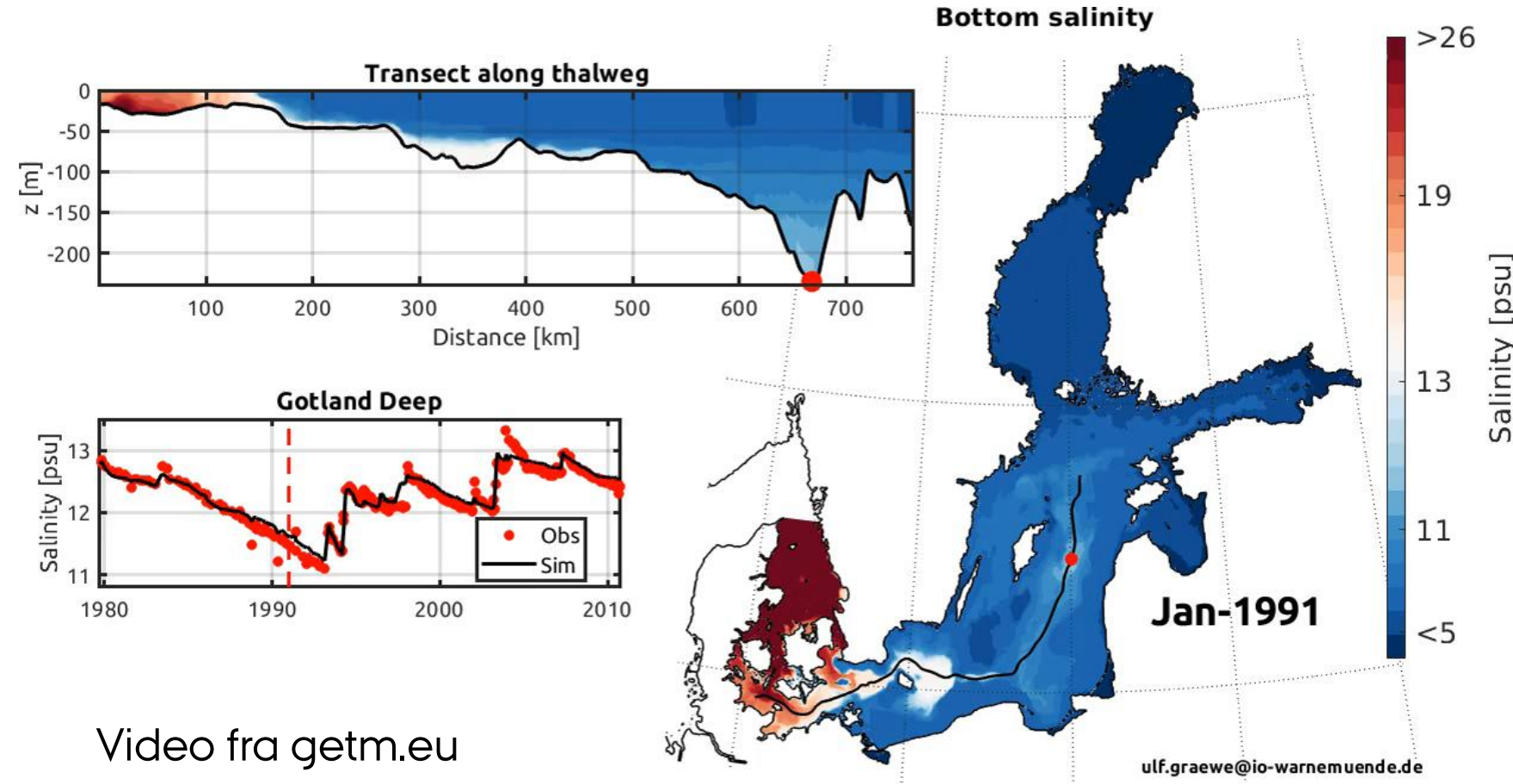
- Ignorerer horisontale gradienter

GETM (GENERAL ESTUARINE TRANSPORT MODEL)

– OPEN SOURCE 3D MODEL SOM ER KOMPATIBEL MED FABM OG DERMED WET

3D hydrodynamisk model

- Første version af Hans Burchard, Karsten Bolding m.fl. i start 00erne
- Anvendes bl.a. til sejladsudsigt fra Forsvarets Center for Operativ Oceanografi (FCOO)
- AU er interesseret i at kunne køre WET i et 3D setup
- Ny version (pyGETM) har været undervejs i godt 3 år af bl.a. Bolding&Bruggemann og AU.



pyGETM for Horsens Fjord

– første test af ny kode for et dansk område

Mål

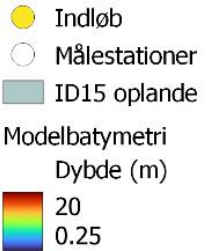
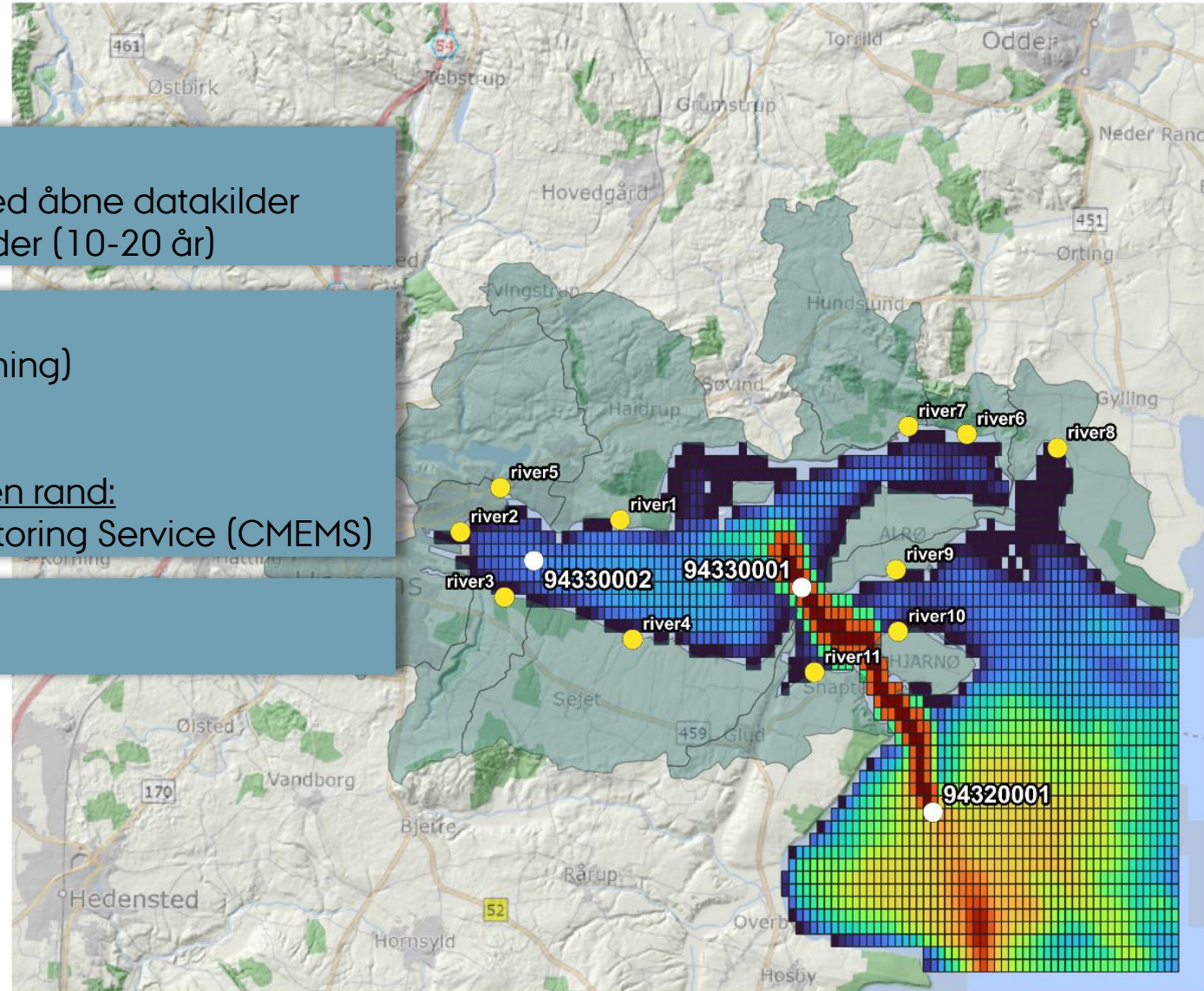
- Opsætning og test af ny modelkode med åbne datakilder
- Muliggøre simulering af lange tidsperioder (10-20 år)

Input data

1. Batymetri: EMODNet (ca. 115m opløsning)
2. Vejr: ERA5 reanalyseret grid data
3. Vand fra opland: ID15 dagligt data.
4. Vandstand, salt og temperatur fra åben rand: Copernicus Marine Environment Monitoring Service (CMEMS)

Måledata til test

- ODA: odaforalle.au.dk

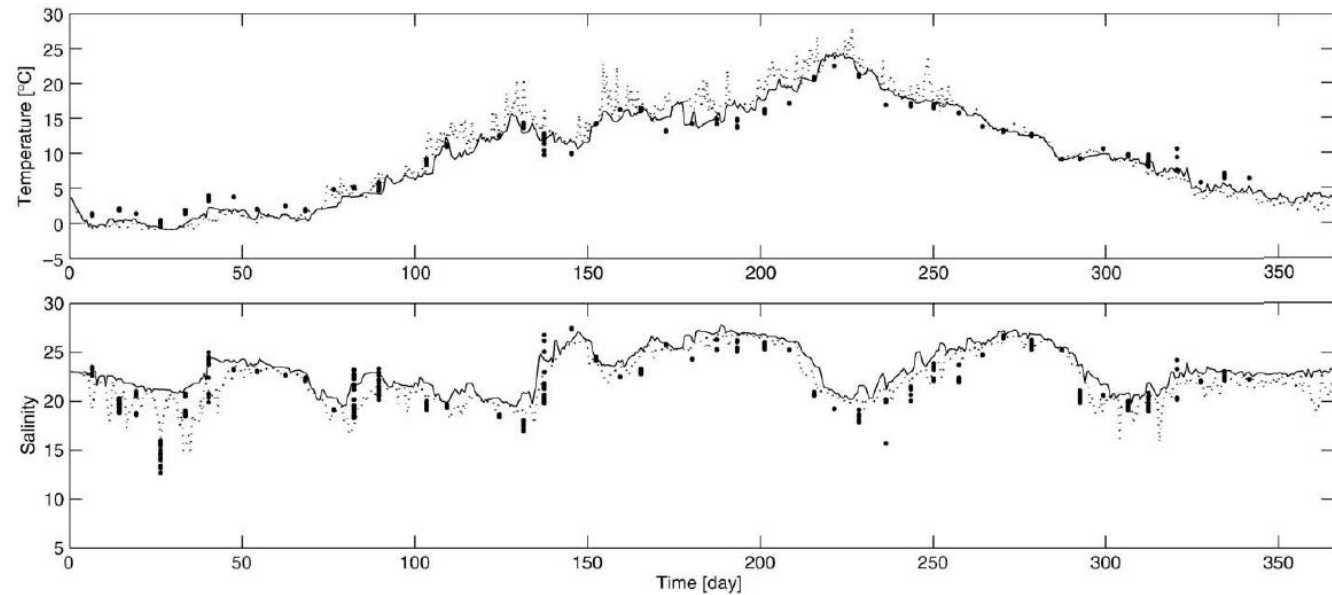


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Tidligere publicerede eksempler på 3D modellering af Horsens Fjord

COHERENS (Timmerman et al. 2010)

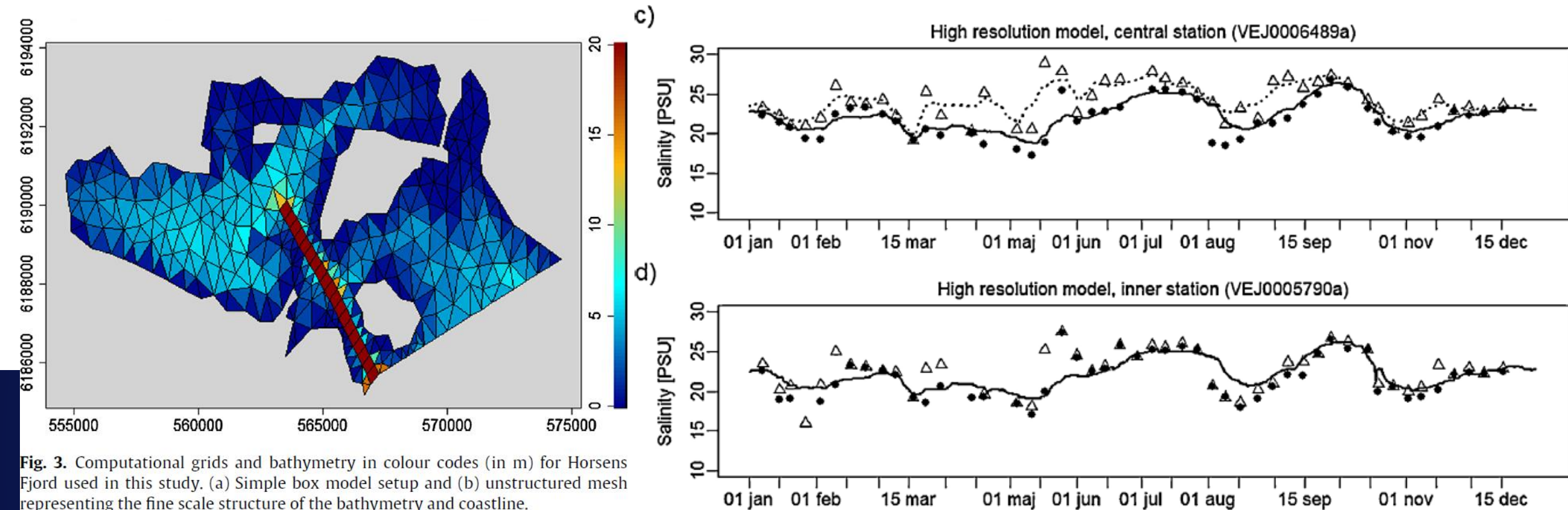
- Grid opløsning på 250 m, 15 lag
- Simuleringsperiode: 1 år (2004)
- Kun sammenlignet model med observationer fra indre fjord



Tidligere publicerede eksempler på 3D modellering af Horsens Fjord

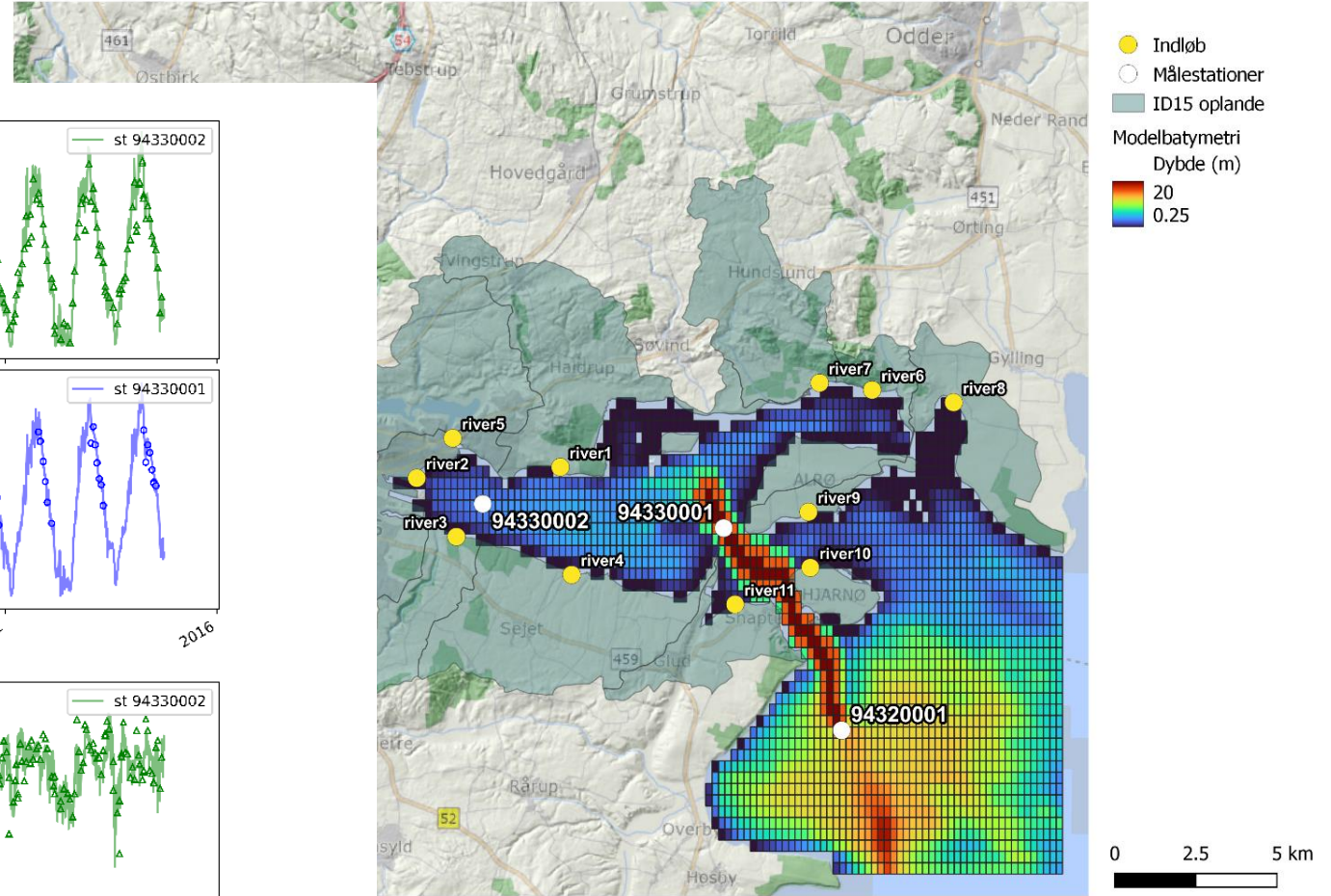
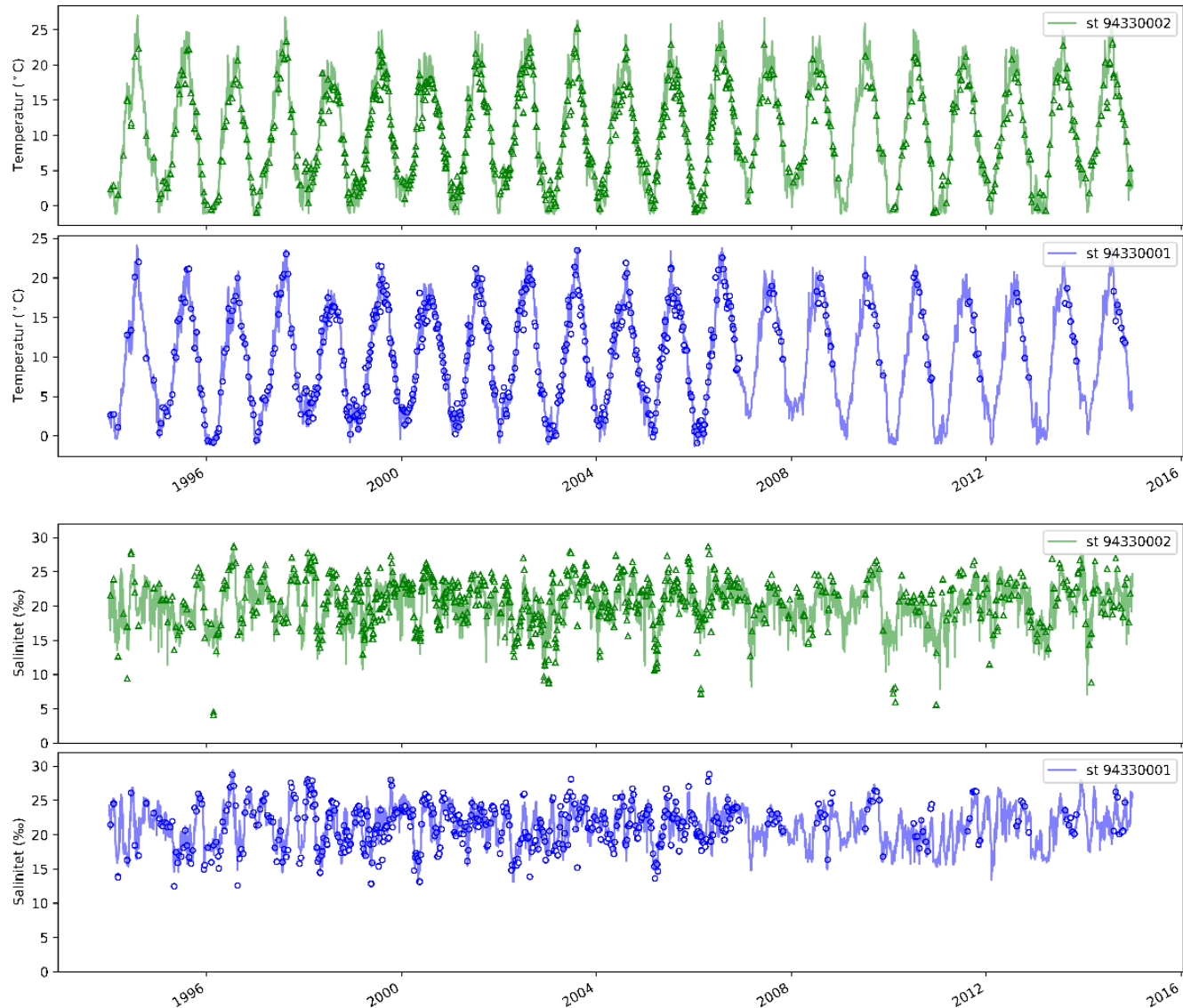
Flexsem (Larsen et al. 2013)

- Mesh interpoleret fra 50 m grid, 5 lag
- Simuleringsperiode: 1 år (2004)



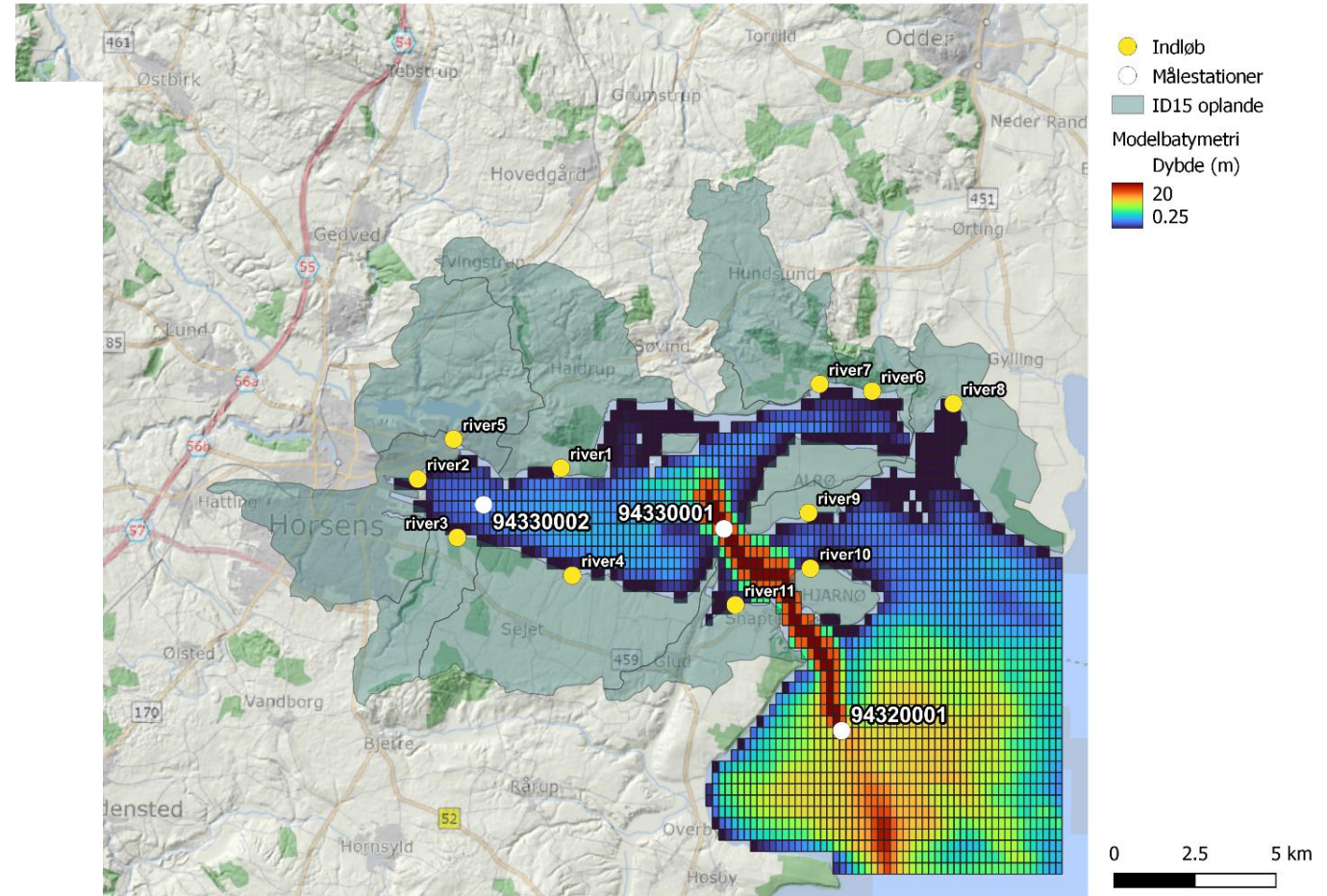
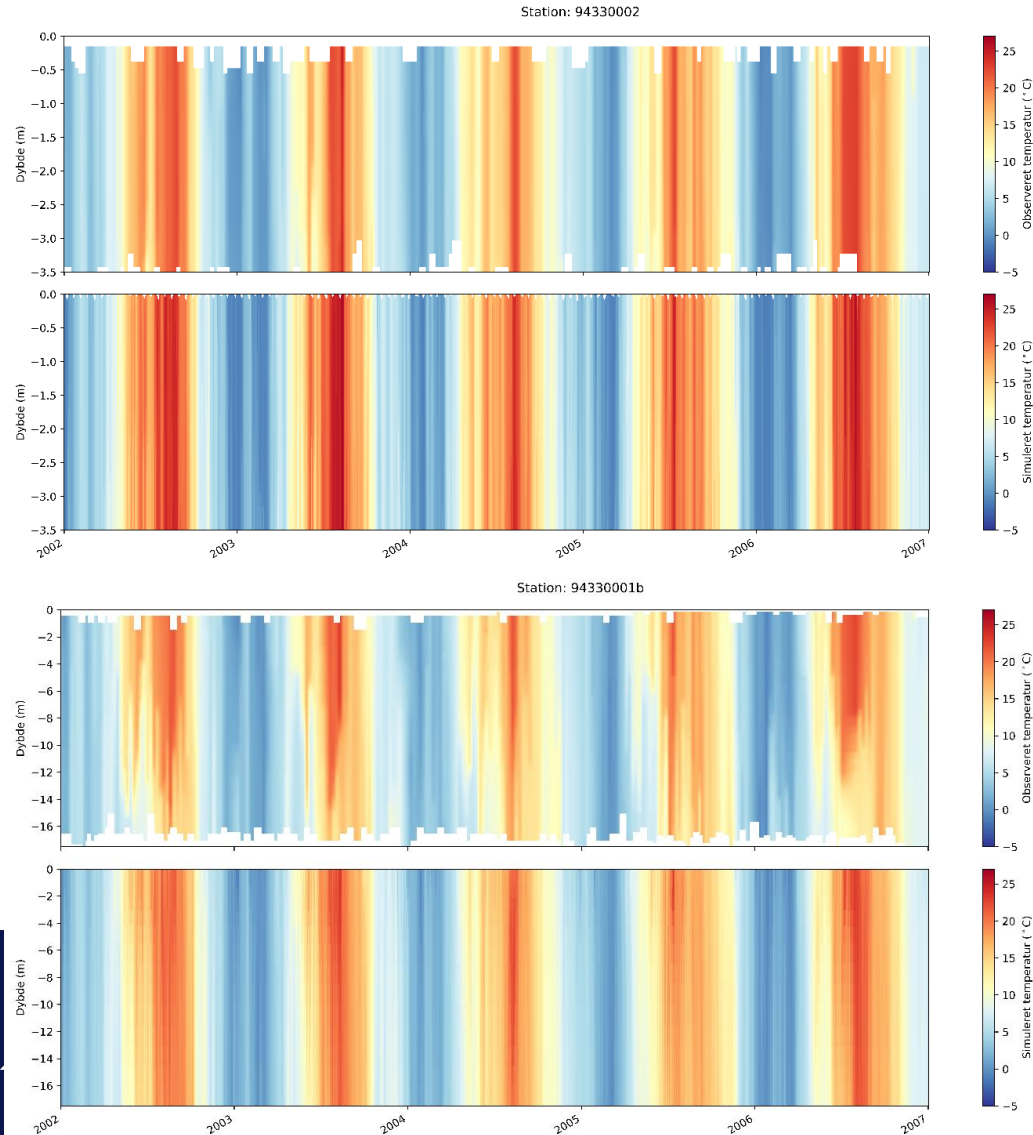
pyGETM for Horsens Fjord

– Simulering af lang tidsperiode (1994-2014)



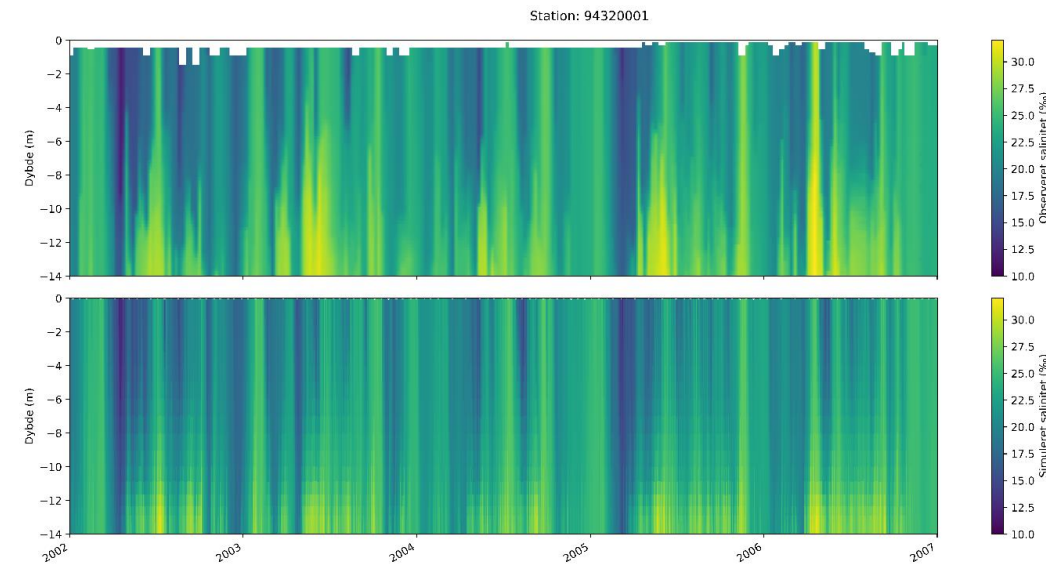
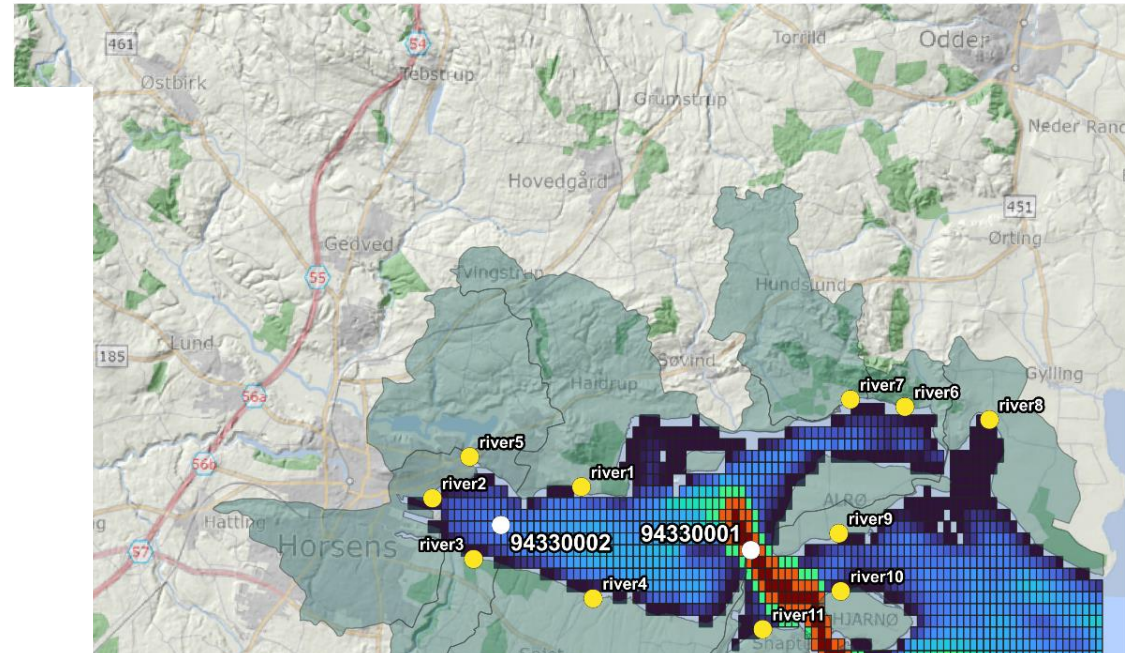
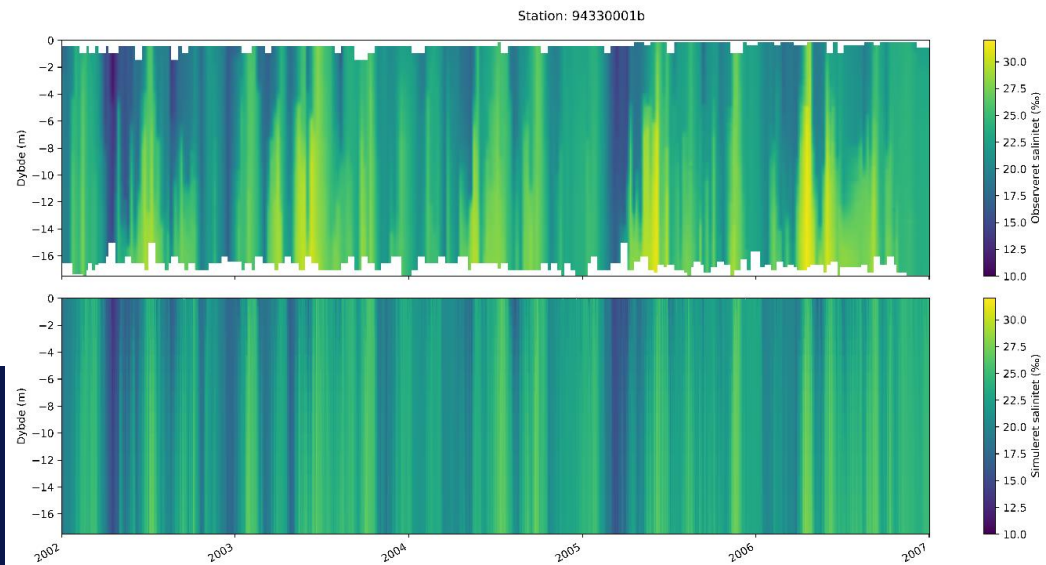
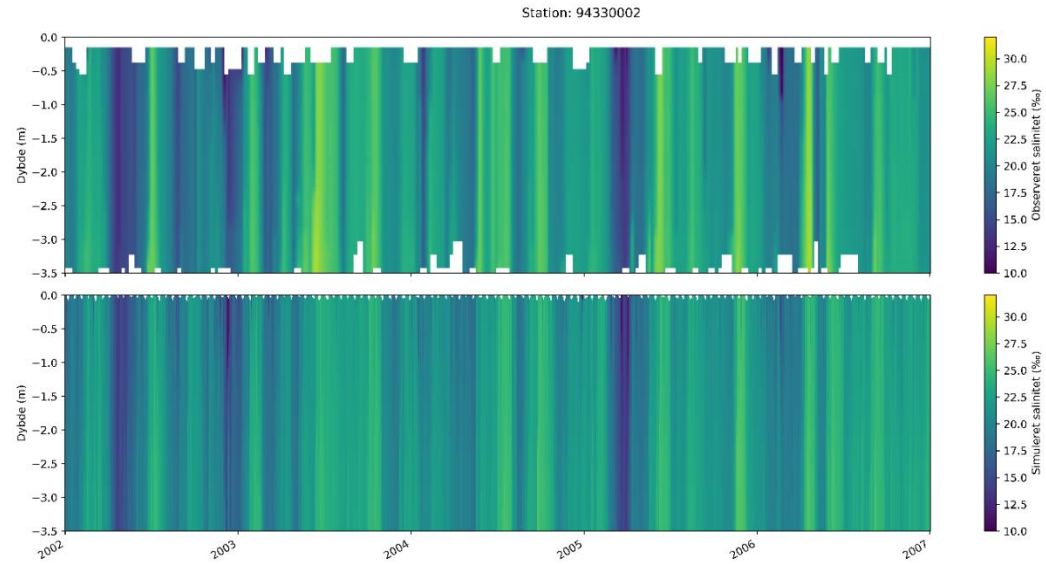
pyGETM for Horsens Fjord

– simulering af temperaturprofiler



pyGETM for Horsens Fjord

– simulering af salinitetsprofiler



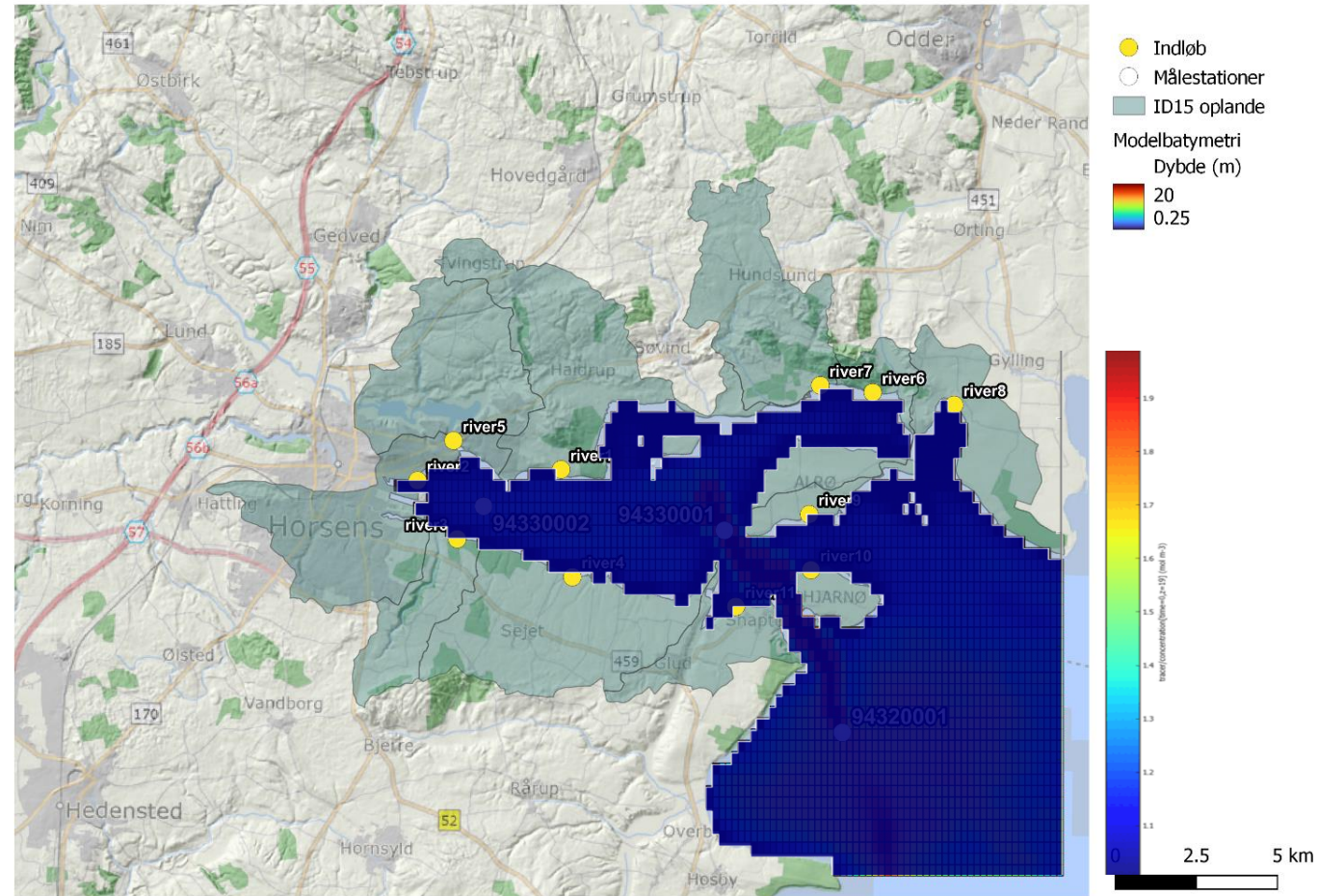
2.5 5 km

pyGETM for Horsens Fjord

– simulering af tracer eksperiment

Tracer i alle tilløb

- Giver indikation af spredning af vand fra de enkelte tilløb



pyGETM for Horsens Fjord

– afrunding og anbefalinger

- Det er lykkedes at opsætte en **pyGETM** model for Horsens Fjord, som kan simulere meget lange tidsperioder på en workstation (20 år tager ca. 60 timer)
- Modellen kan i høj grad simulere temperatur og saltdynamikkerne i den indre del af fjorden, men har lidt sværere ved at ramme den stærke lokale lagdeling i salt og temperatur i sejlrenden
- Flere test af batymetri (tydeliggørelse af sejlrende og/eller en finere gridopløsning) kan sandsynligvis forbedre modellen yderligere)
- Bedre randbetingelser ved åben rand (f.eks. kobling til større model-setup for Nordsø-Østersø området) kan muligvis også forbedre modellen's evne til at simulere lagdelingen i sejlrenden