Managing Events and Extremes in Water Supplies (MEWS)

3D modelling in Mälaren

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Introduction

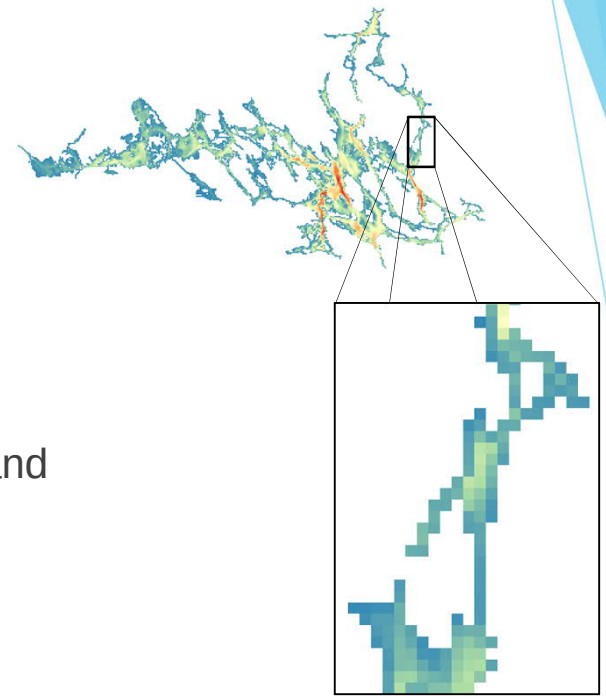
- Managing Events and Extremes in Water Supplies
  - https://mews-water.com/
  - Water4All funding source
- Extreme hydrological events in drinking water reservoirs
  - Coupling of watershed and lake
  - Importance of in-lake processes
- Development of modelling tools
- Three case studies:
  - Mälaren (Sweden)
  - Lake Kinneret (Israel)
  - Ohra Reservoir (Germany)

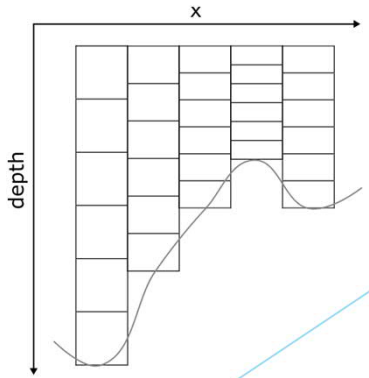
Outline

- Explanation of the 3D model
- Calibration and model performance
- Example application: PFAS transport modelling
- Future Work & Summary

PyGETM

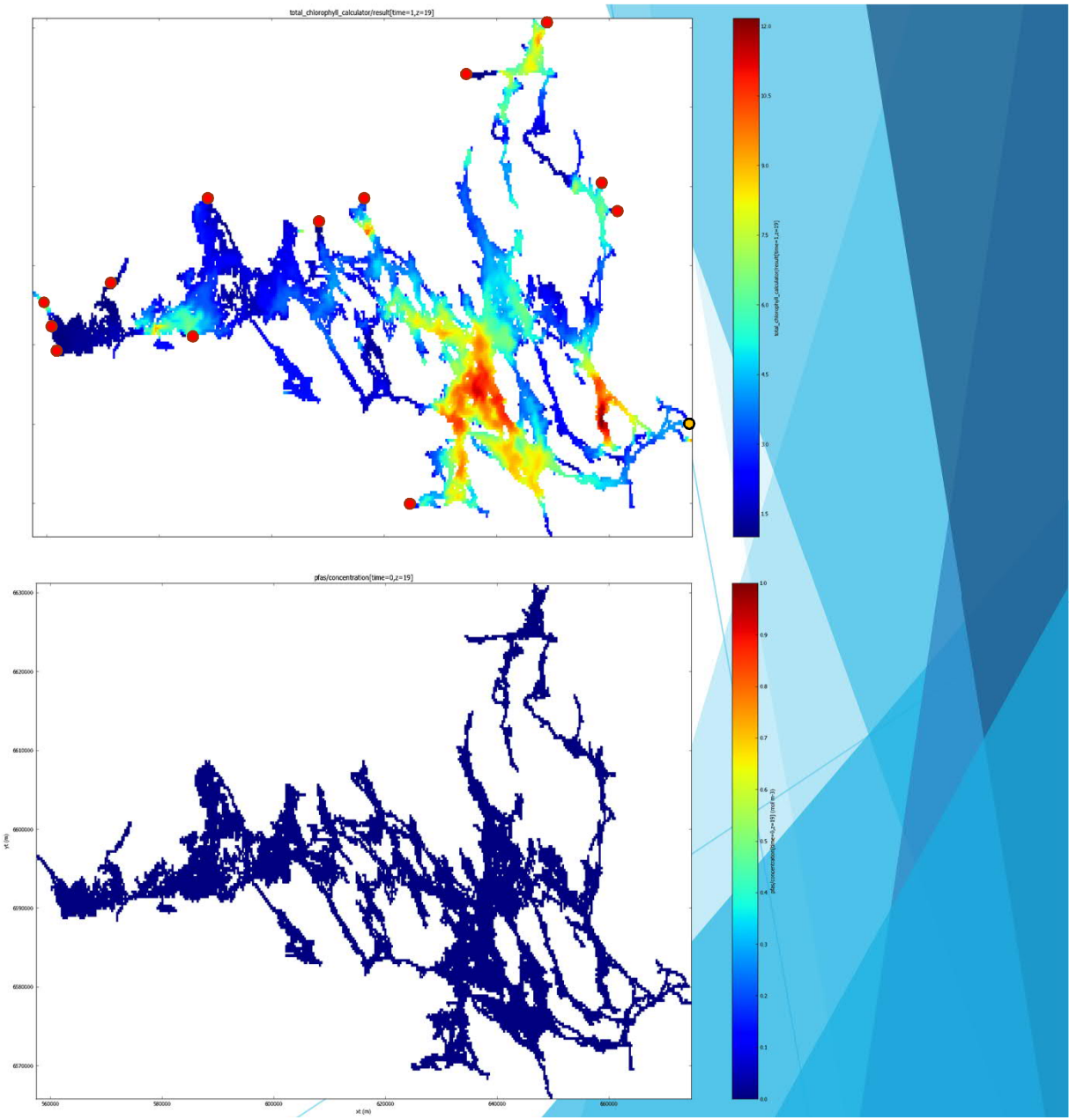
- PyGETM is a rewrite of the GETM model (General Estuarine Transport Model)
- Meant as a middle ground between fast 1D models and slow flexible-grid 3D models
- Regular grid, sigma layers
- Mälaren:
  - 300 x 300 m bathymetry, smoothed
  - 20 vertical layers





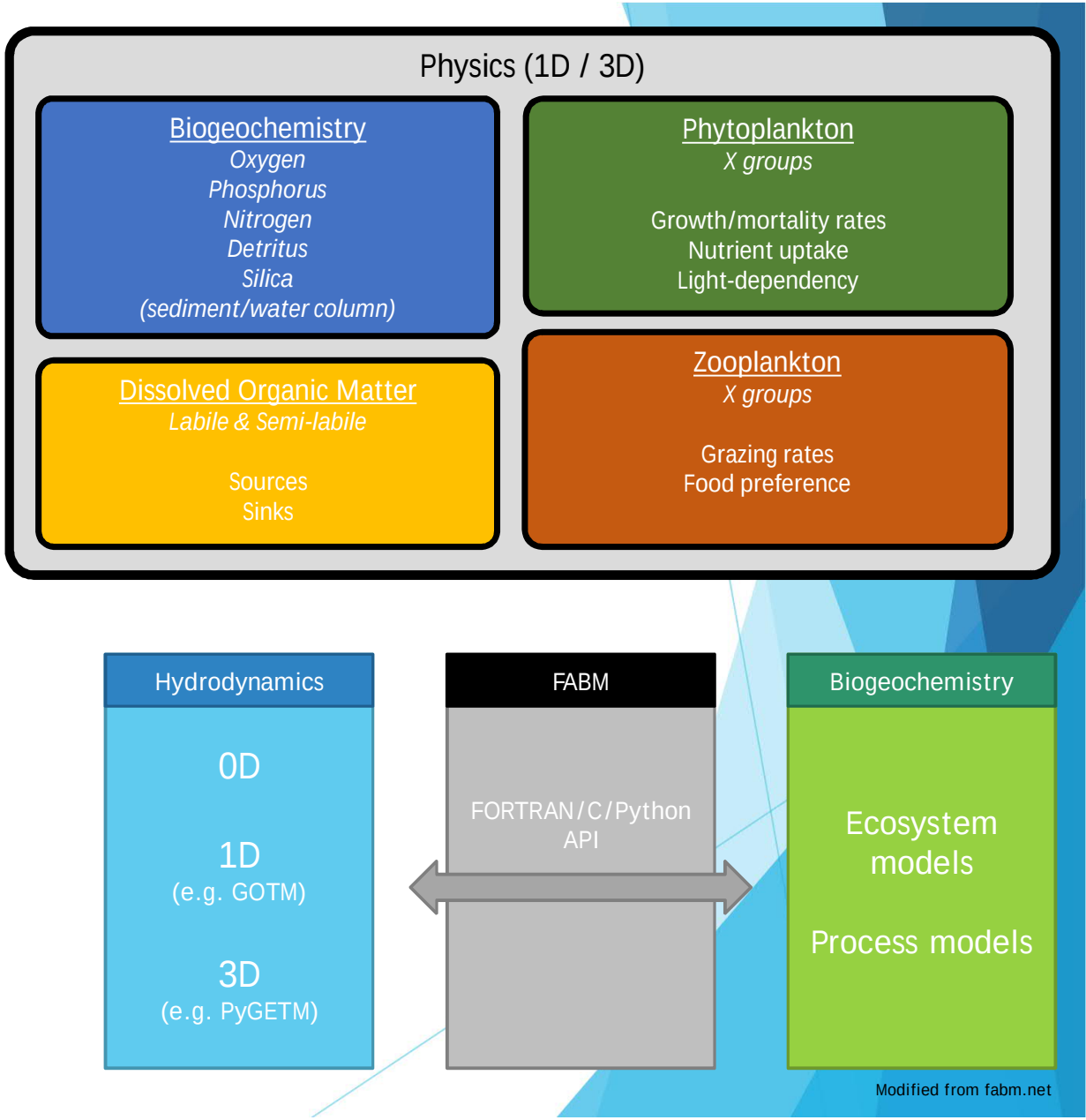
PyGETM

- Potential outputs:
  - Temperature and salinity profiles
  - Water level
  - Transport
  - *Biogeochemistry & Tracers*
- Rivers:
  - Main river inflows
  - Using discharge from SMHI discharge stations
- Runtime
  - 30-core run, ≈ 1 hour per simulated month



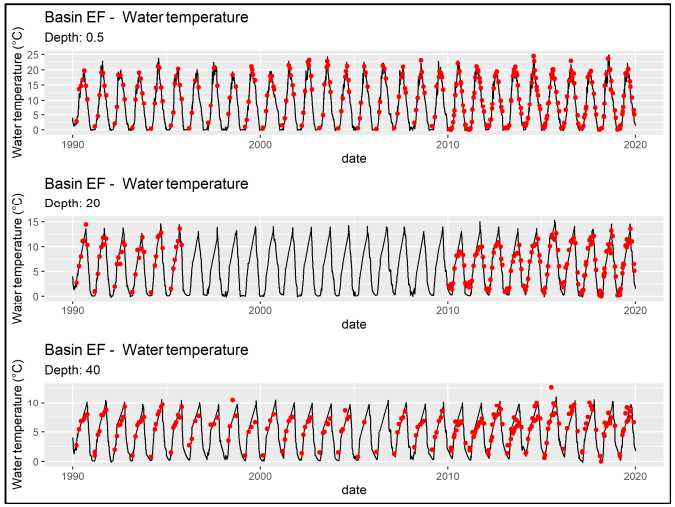
Selmaprotbas

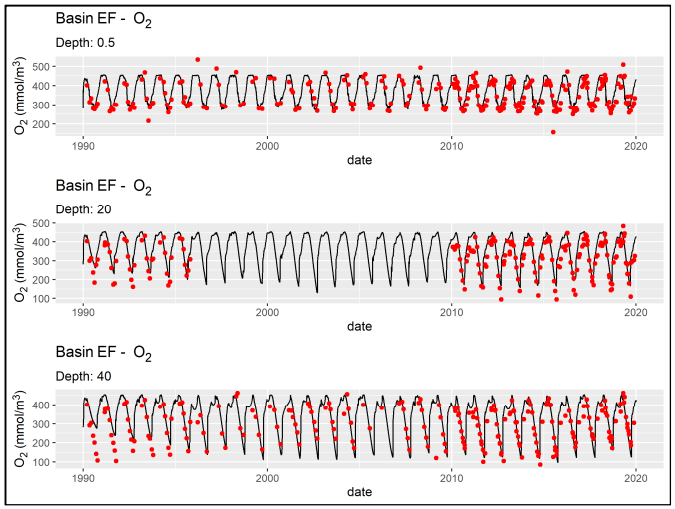
- Intermediate complexity
- Modules
  - Biogeochemistry (O_2, NO_3, NH_4, PO_4, Si)
  - Dissolved Organic Matter
  - Phytoplankton
  - Zooplankton
- FABM (Framework for Aquatic Biogeochemical Models)
  - Transport is handled by FABM coupling
  - Switching between 1D and 3D or combining different biogeochemical models

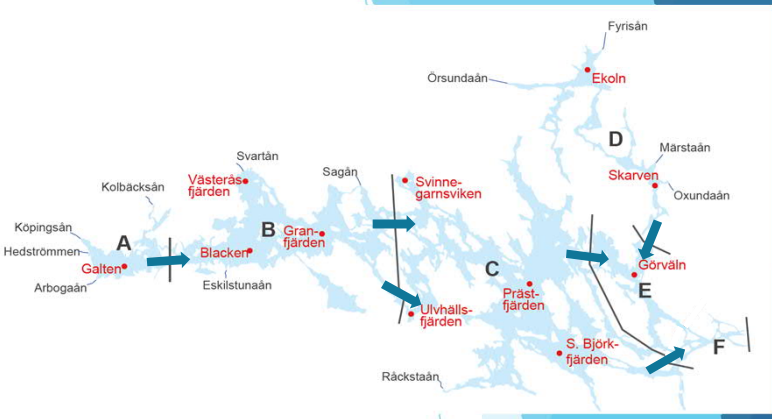


Calibration

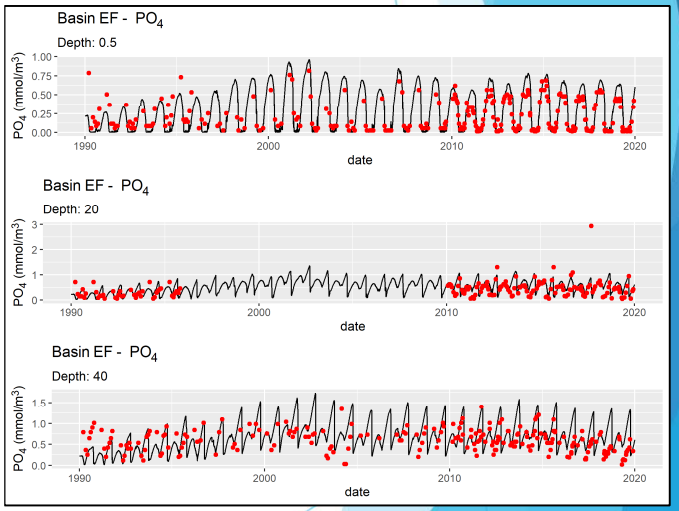
- The 1D GOTM (General Ocean Turbulence Model) is also coupled to FABM, and used for calibration
- Five basins, one-way exchange
- Relatively good performance

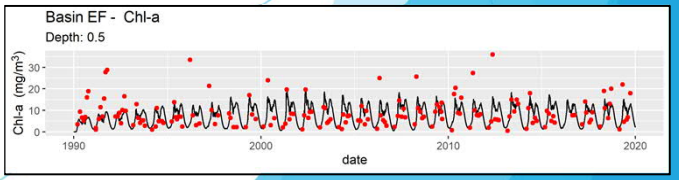




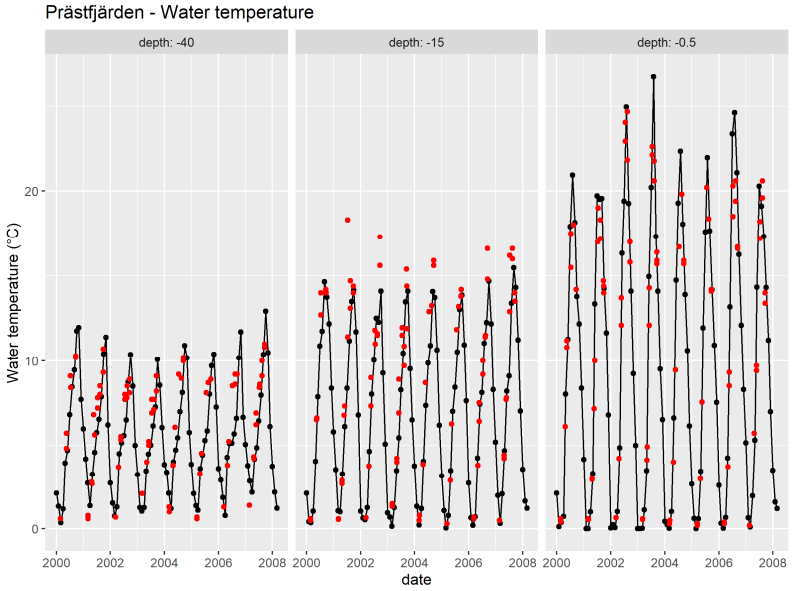


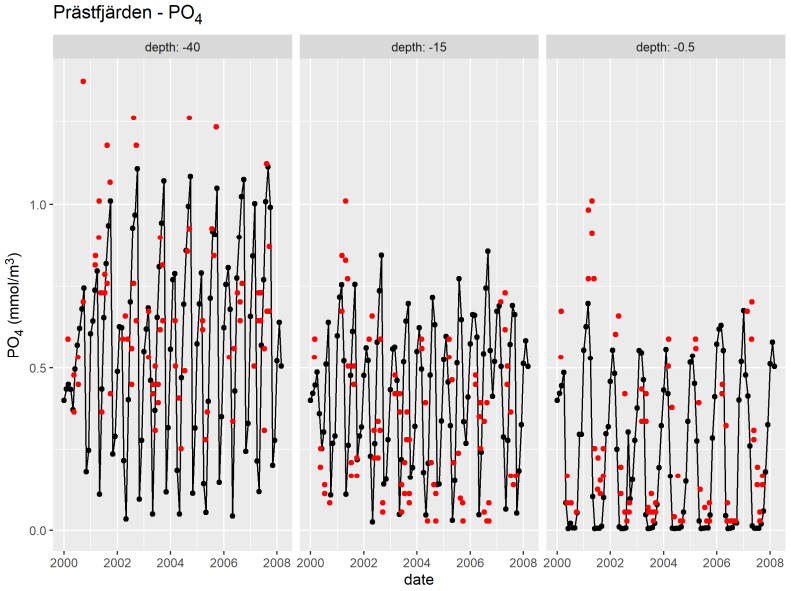
Modified from Sonesten et al. 2013

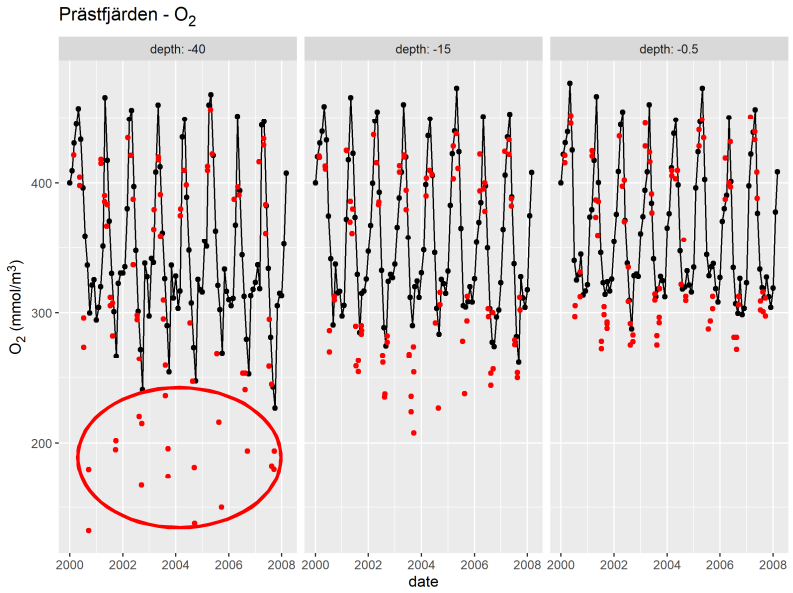


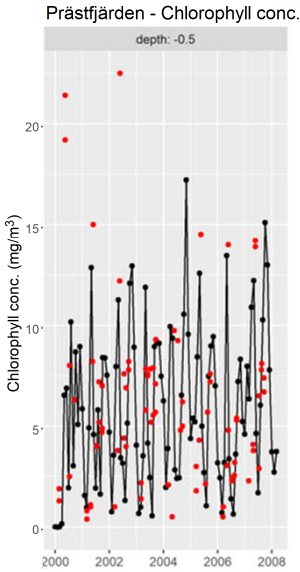


3D Model performance







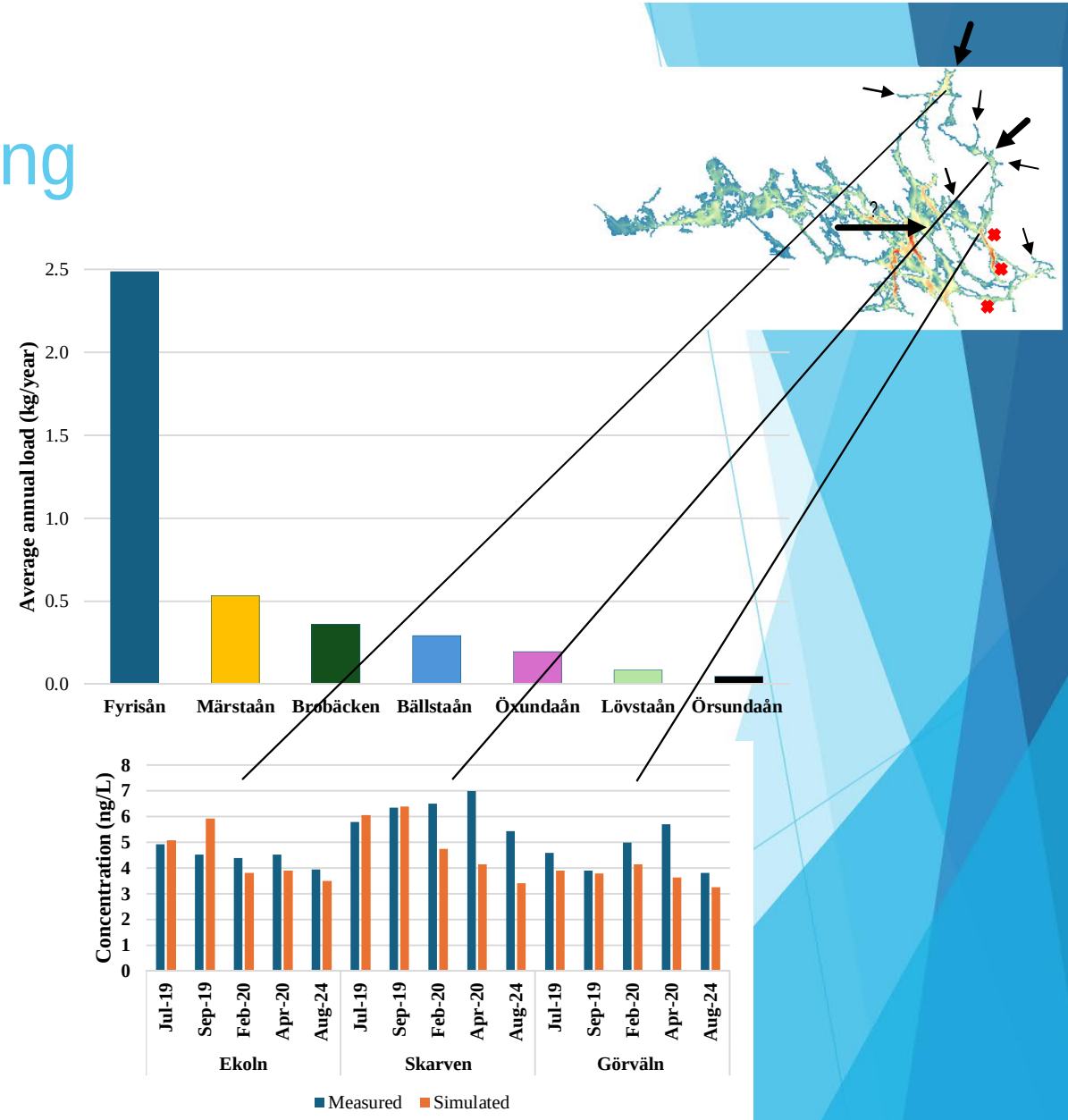


Ongoing work

PFAS transport modelling

Thesis project by Aiswarya Susan John

- Estimate $PFAS_4$ loads from rivers in Eastern Mälaren
  - Due to lack of data, concentration from rivers in western part was assumed to be 3.06 ng/l, based on in-lake measurements
- Which watershed poses the biggest problems?
- Moderately well agreement with observations
  - Temporal variation largely unknown
  - Some underestimation of PFAS inputs Märstaån / Oxundaån



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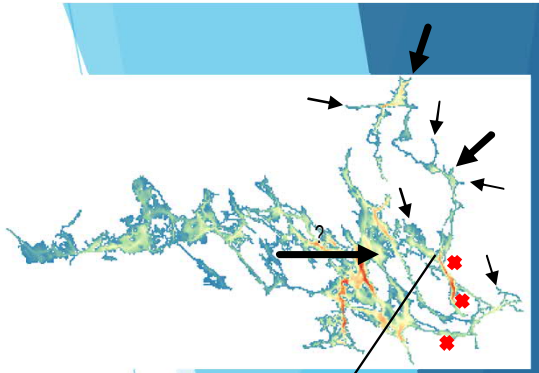
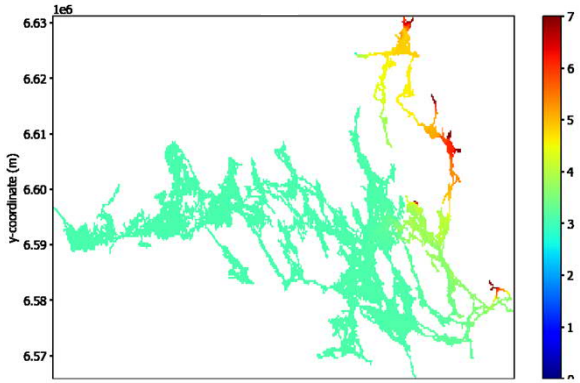
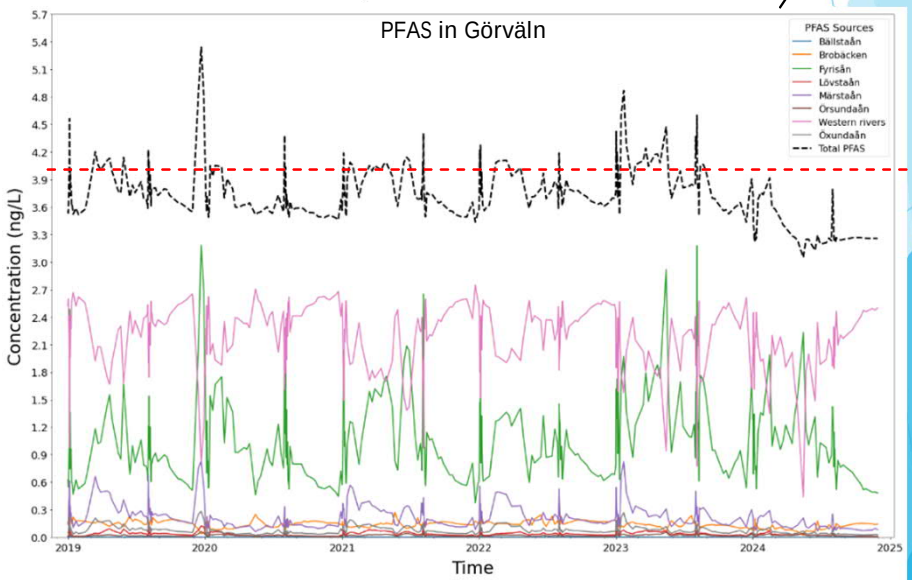
- Görväln / Lovö; at times close to or exceeding the 4 ng/l limit





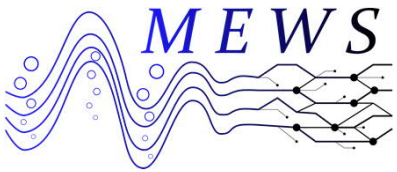
July 2019



Future work

- Further improvements to model setup
  - Better coverage of the watershed
  - More realistic outflow dynamics
- PFAS and pharmaceutical transport (thesis)
- DOM transport and transformation in Mälaren
- Biogeochemical and transport processes during extreme events

Summary



- Work in progress, but model has reached stage where it can be a useful tool to investigate specific topics
- Runtime is a major challenge and limits scope, but coupling to a parallel 1D setup means that events can be identified
  - Long-term climate projections are not an option with the 3D model
- Interaction with drinking water providers enables a much more focussed development of scenarios

Thank you for your attention!

Co-funded by the European Union

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References

- Models & Software:
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  - GOTM: https://github.com/gotm-model/code/tree/lake
  - Selmaprotbas: https://github.com/jorritmesman/selmaprotbas
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  - Abbasi, M., Peacock, M., Drakare, S., Hawkes, J., Jakobsson, E., Kothawala, D., 2024. Water residence time is an important predictor of dissolved organic matter composition and drinking water treatability. Water research 260 121910 doi:10.1016/j.watres.2024.121910.
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