

Swedish MEWS Progress

Stakeholder Meeting

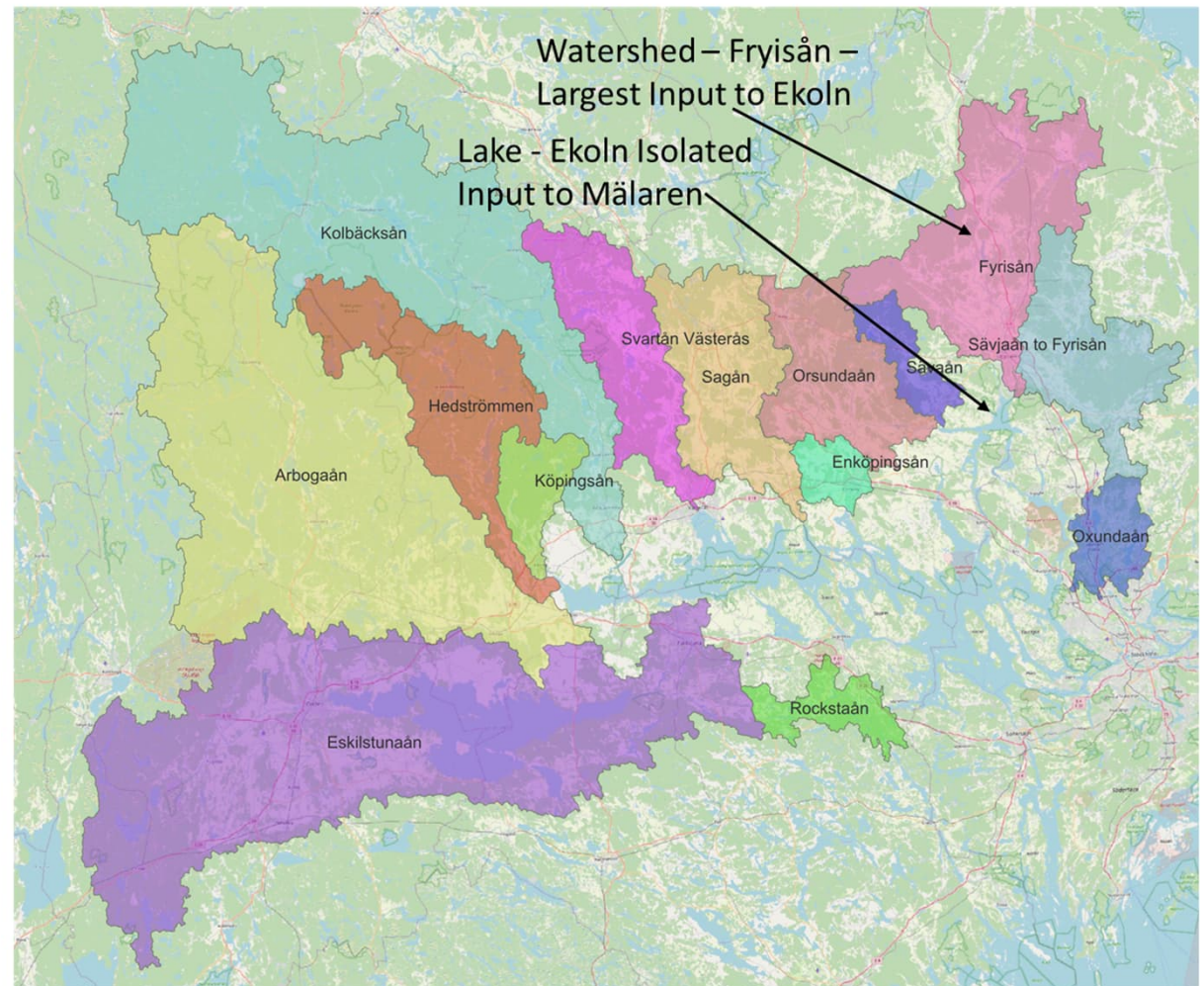
June 2 2026

Lake Erken

Progress on Watershed Modelling

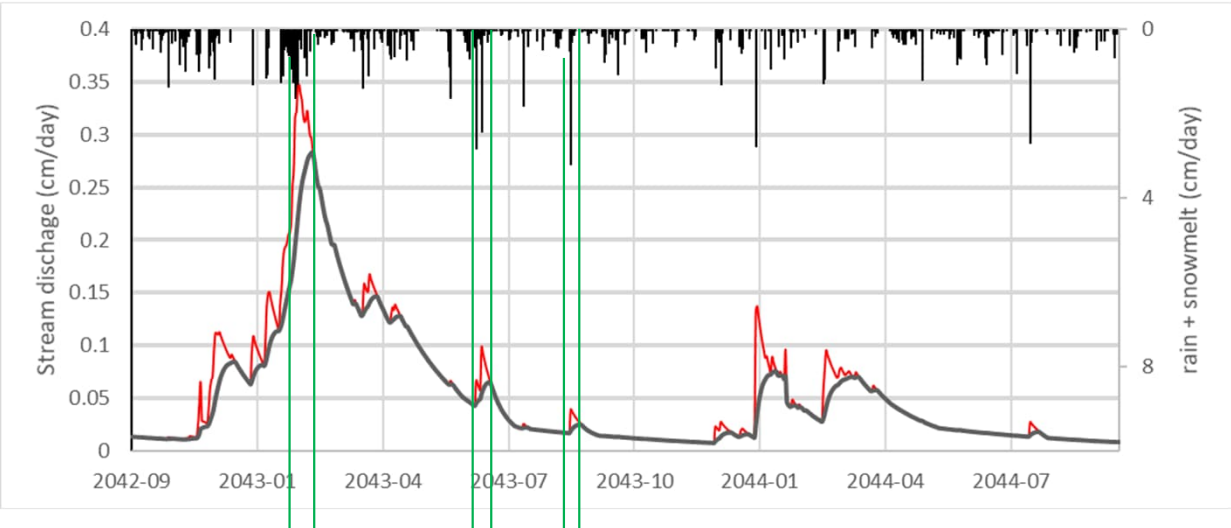
Hydrologic Events

Study Area



All major inputs to Mälaren are being studied by the MEWS project, which is evaluating the effects of hydroclimatic extreme events on Stockholm drinking water. We first tested evaluating events on the Ekoln basin.

Watershed Antecedent Conditions - Event Identification using Hydrograph Separation



1. Lyne-Hollick Digital Filter

This is one of the most widely used recursive filters.

$$q_t = \alpha q_{t-1} + \frac{(1 + \alpha)}{2} (Q_t - Q_{t-1})$$

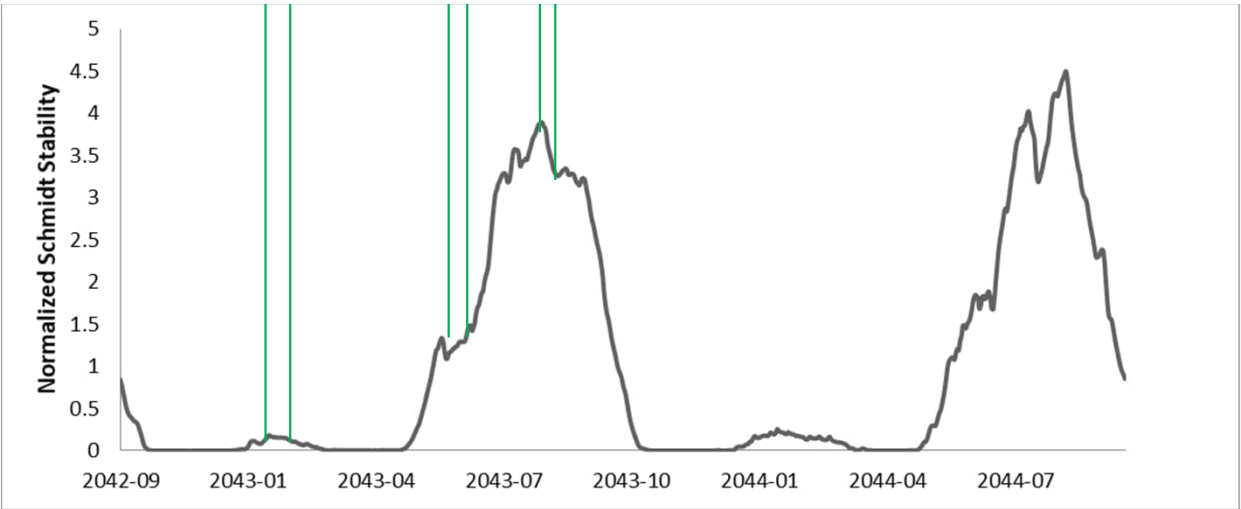
Where:

- q_t = quickflow at time t
- q_{t-1} = quickflow at previous time step
- Q_t = total streamflow at time t
- Q_{t-1} = total streamflow at previous time step
- α = filter parameter (typically 0.90–0.98)

Then baseflow is:

$$B_t = Q_t - q_t$$

Lake Antecedent Conditions – GETM 3D >> GOTM 1D >> Lake Analyzer >> Schmidt Stability



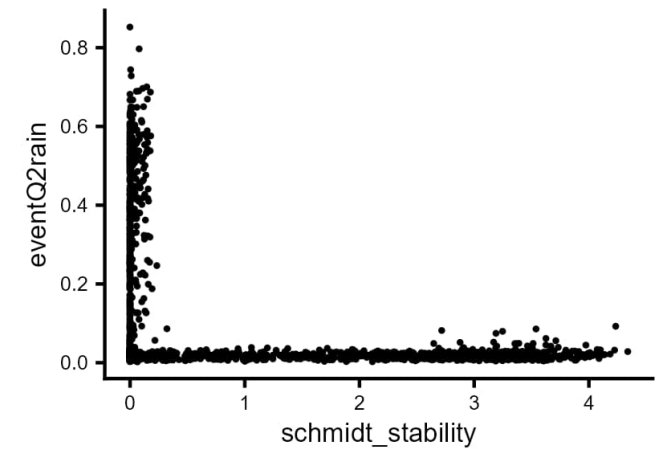
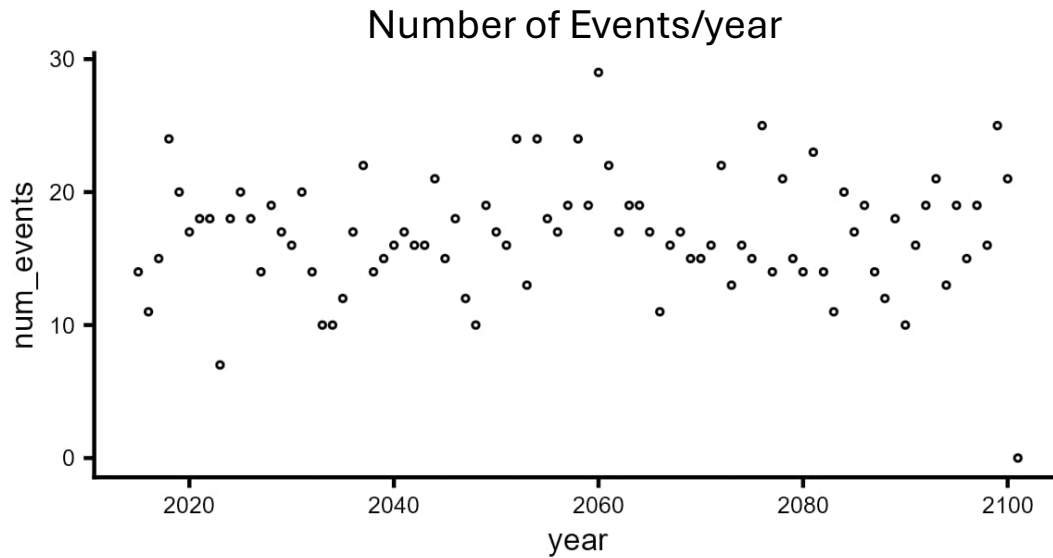
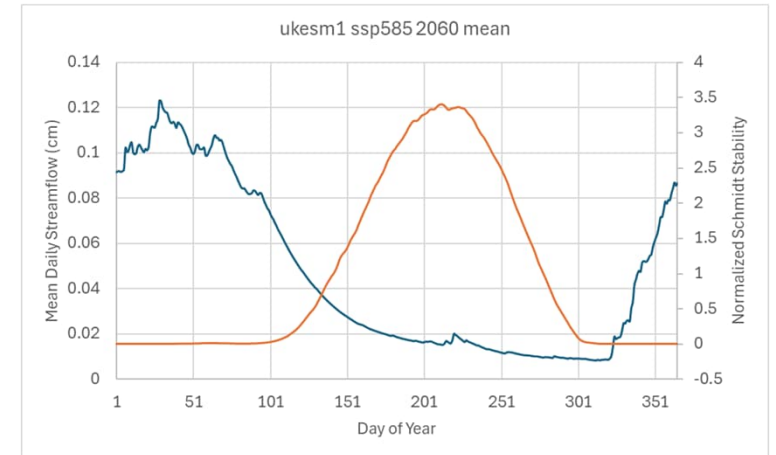
Winslow, L., J. Read, R. Woolway, J. Brentrup, T. Leach, J. Zwart, S. Albers, and D. Collinge. 2019. Package ‘rLakeAnalyzer’.

Lyne, V., and M. Hollick. 1979. Stochastic time-variable rainfall-runoff modelling. Pages 89-93 in Institute of engineers Australia national conference. Institute of Engineers Australia Barton, Australia.

Distribution of Events relative to Thermal Stratification

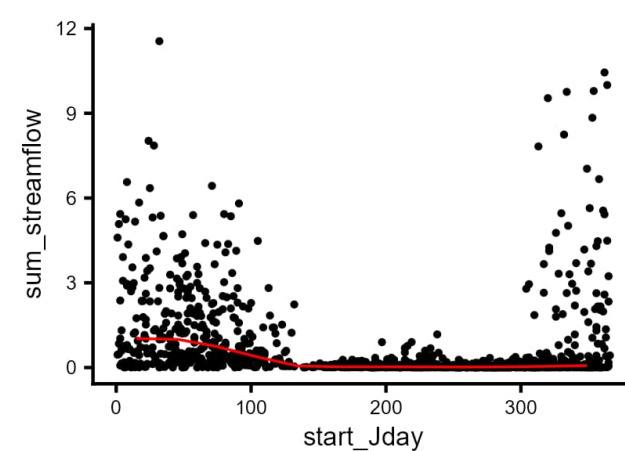
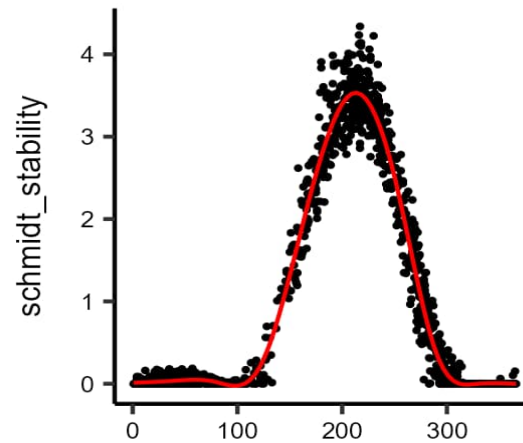
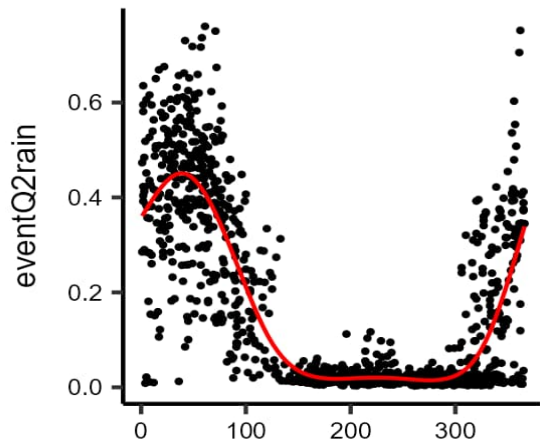
Coupling of Watersheds and Lakes

- The majority of streamflow enters the lake under isothermal conditions
Less favorable conditions for biology
- Streamflow during stratification is greatly constrained due to evaporation and soil moisture deficits, but some events of potential importance do occur
More favorable conditions for biology?

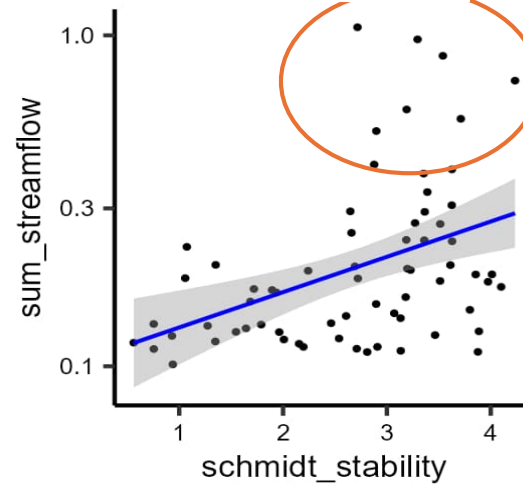
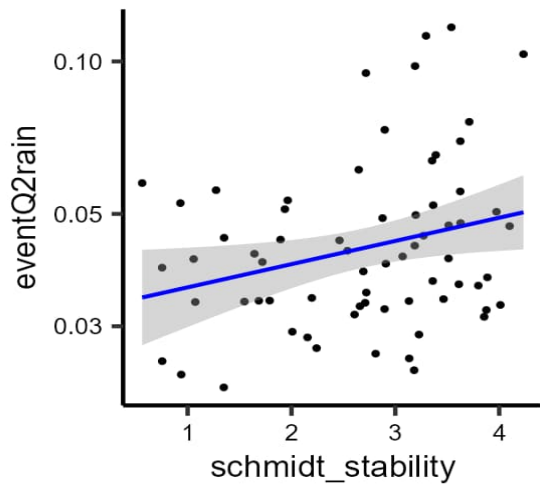


Event Screening Tool – Events During Stratification

ukesm1-0-ll-ssp585



Filtered to Remove Isothermal Conditions



- Have recalibrated Watershed model and re-run analysis
- Evaluation of events shows hydrologic effect, but nutrient and phytoplankton?
- Although the events measured are relatively large during stratification they are a small component of the seasonal flow.

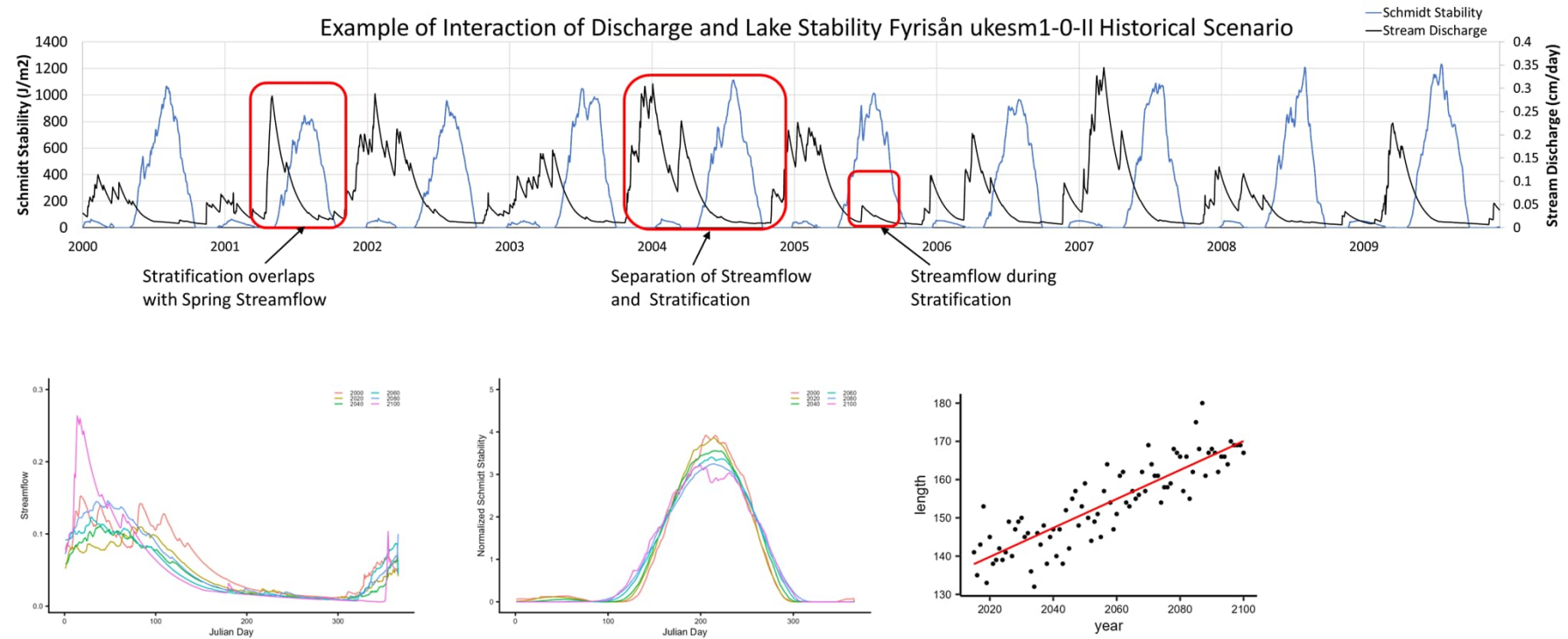
Summary

- Have good information on events
 - Most events occur during isothermal conditions.
 - Largest events are during isothermal conditions
 - Not clear of the relative importance of events during isothermal vs stratified conditions
 - There is fairly large annual and seasonal variations in the
 - Number of events
 - Event discharge
- Present Problem – Apparent lack of nutrient limitation

Example of Event Variability ukesm1-0-ll-ssp585

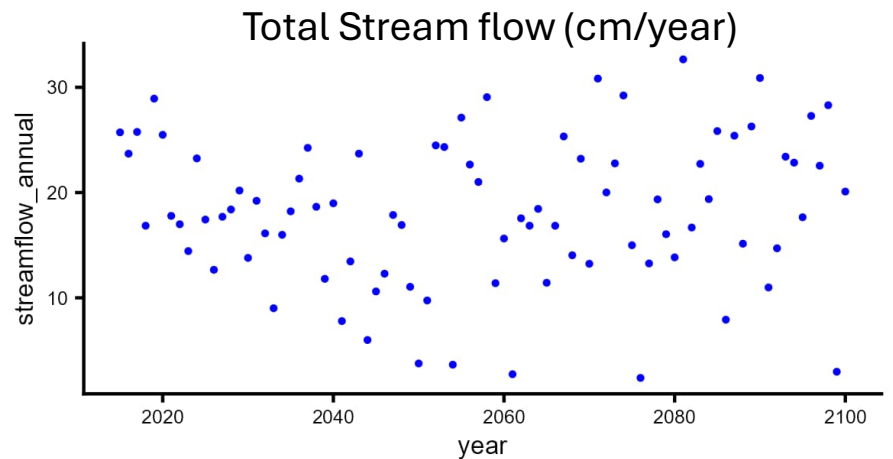
All Events	Isothermal Conditions	Stratified Conditions
Event length Mean = 8 d Max = 82 d	Event length Mean = 11.3 d Max = 82 d	Event length Mean = 4.1 d Max = 41 d
Event Discharge Mean = 0.56 cm/d Max = 11.6 cm/d	Event Discharge Mean = 1.0 cm/d Max = 11.6 cm/d	Event Discharge Mean = 0.057 cm/d Max = 1.17 cm/d
Event Discharge/Rain Mean = 0.124 Max = 0.852	Event Discharge/Rain Mean = 0.215 Max = 0.852	Event Discharge/Rain Mean = 0.019 Max = 0.093

Distribution of Streamflow Between Stratified and Isothermal Lake Conditions



Are there trends in changing amounts of discharge occurring during stratified and isothermal conditions?

Analysis of the amount of streamflow during stratified and isothermal conditions



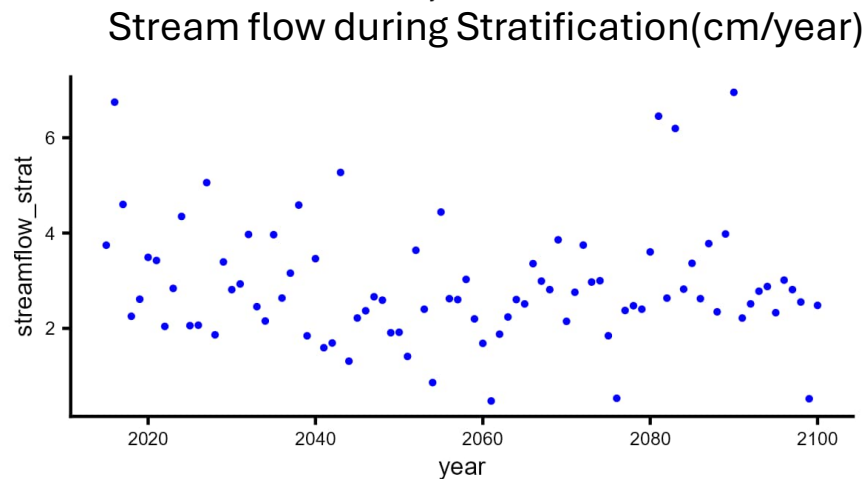
No clear trend

Large inter-annual variability

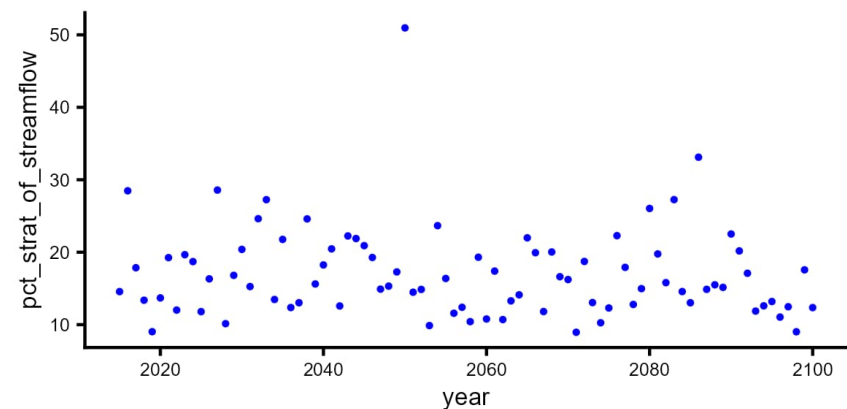
Potential problem with model not correctly simulating the largest events.

Trying with measured data

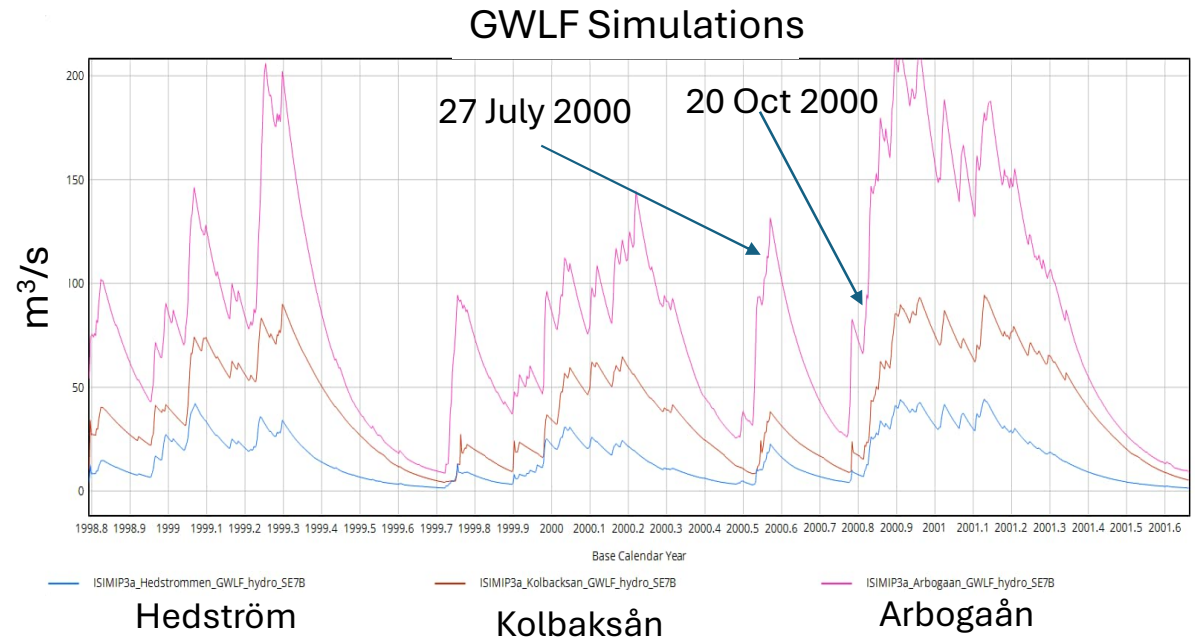
Test identifying events with frequency distribution method



Stream flow during Stratification as percent of total

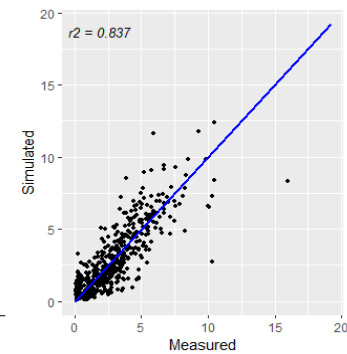
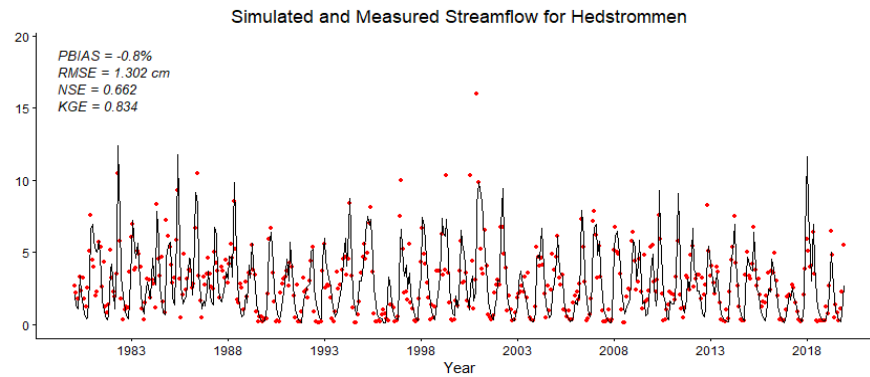
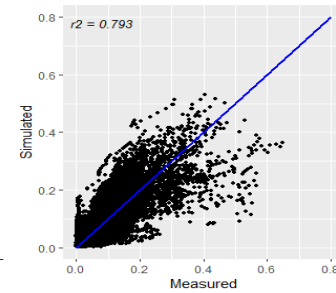
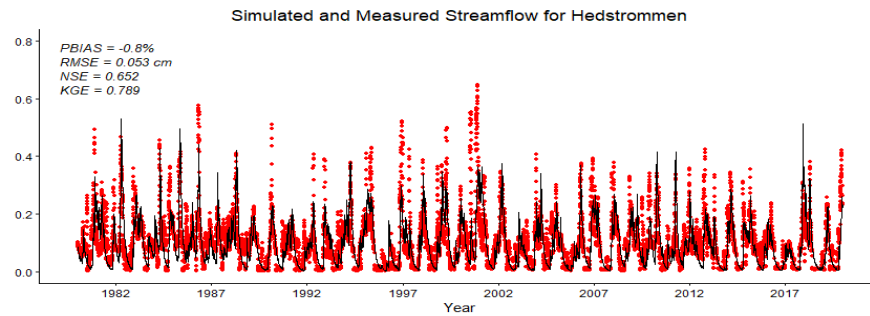


Stakholder Identified Event Large DOC inputs During the Late summer and Fall of 2000

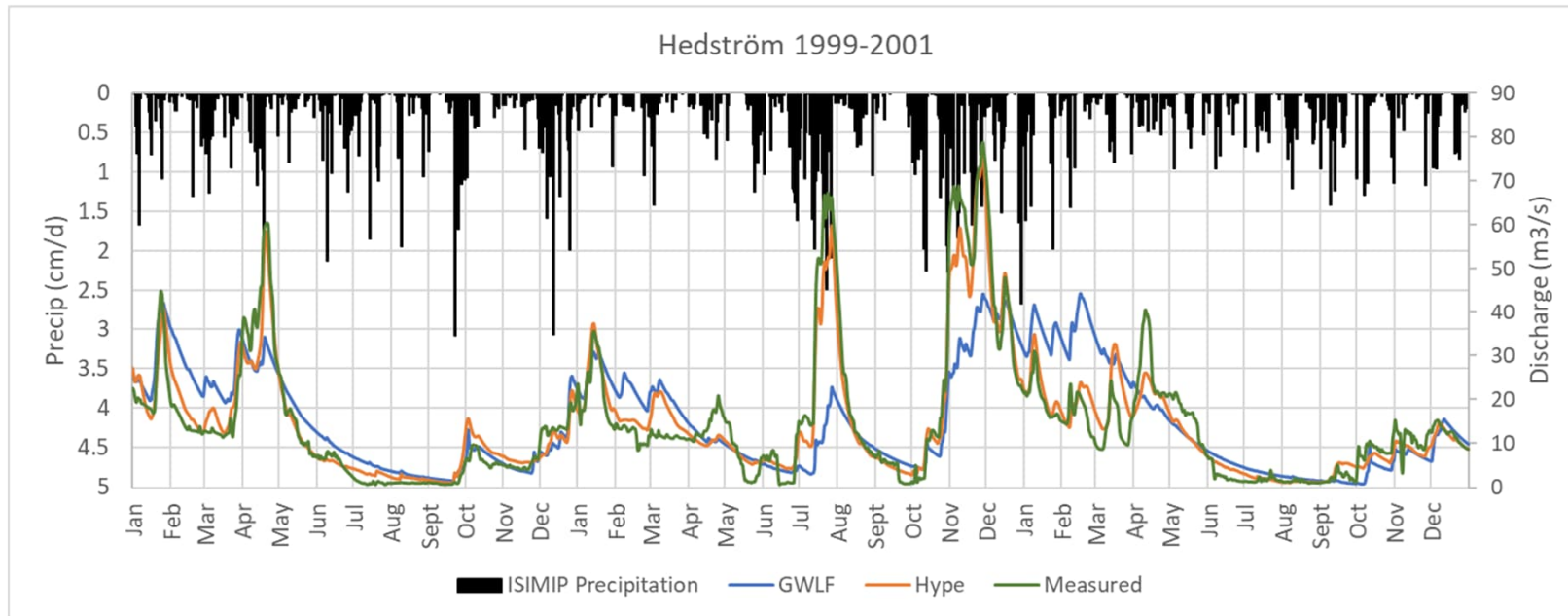


- This event led to highly elevated DOC concentrations at the Stockholm drinking water intakes – with a large delay time
- The first peak would be during stratified conditions downstream of Galten
- The second peak is during Isothermal conditions

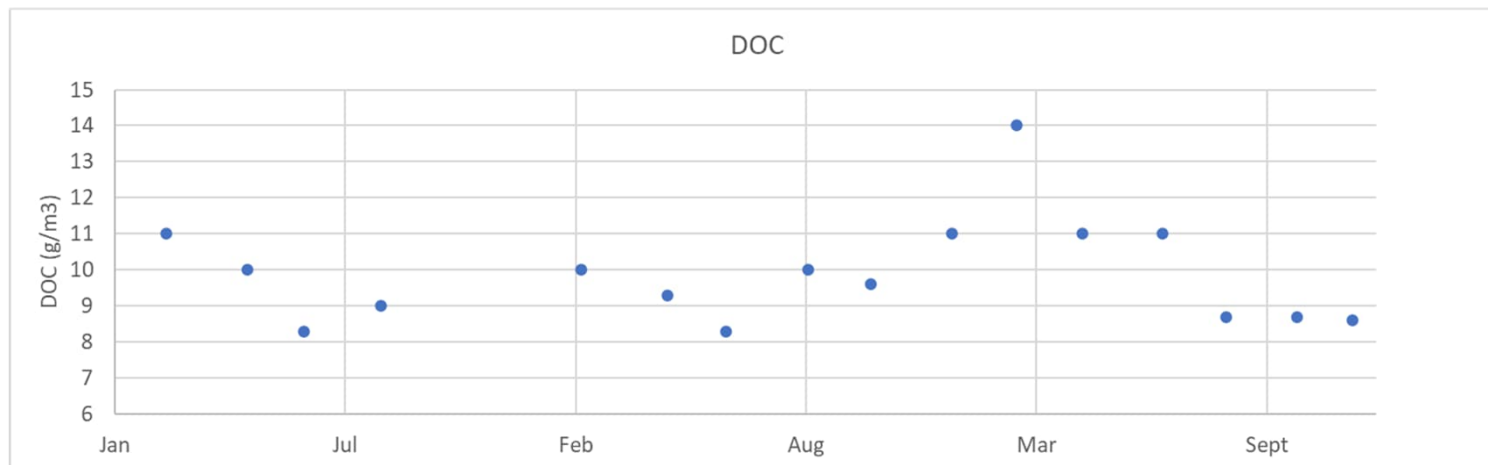
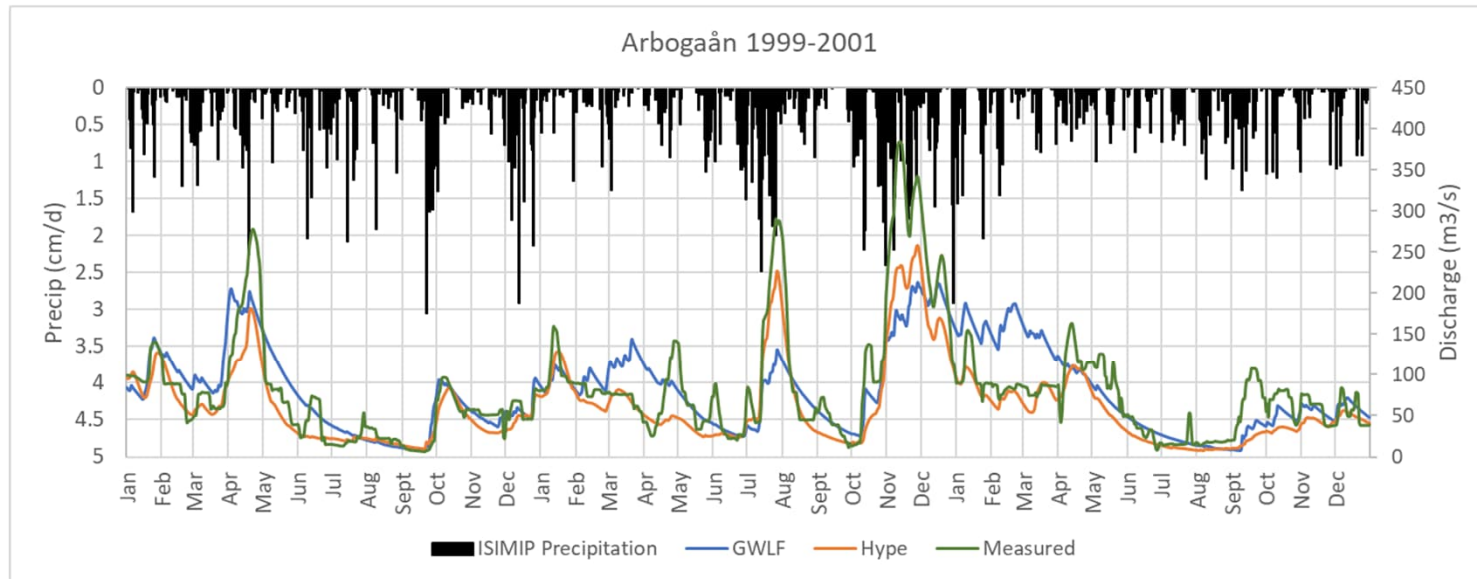
Example Calibration Data from Hedstrom



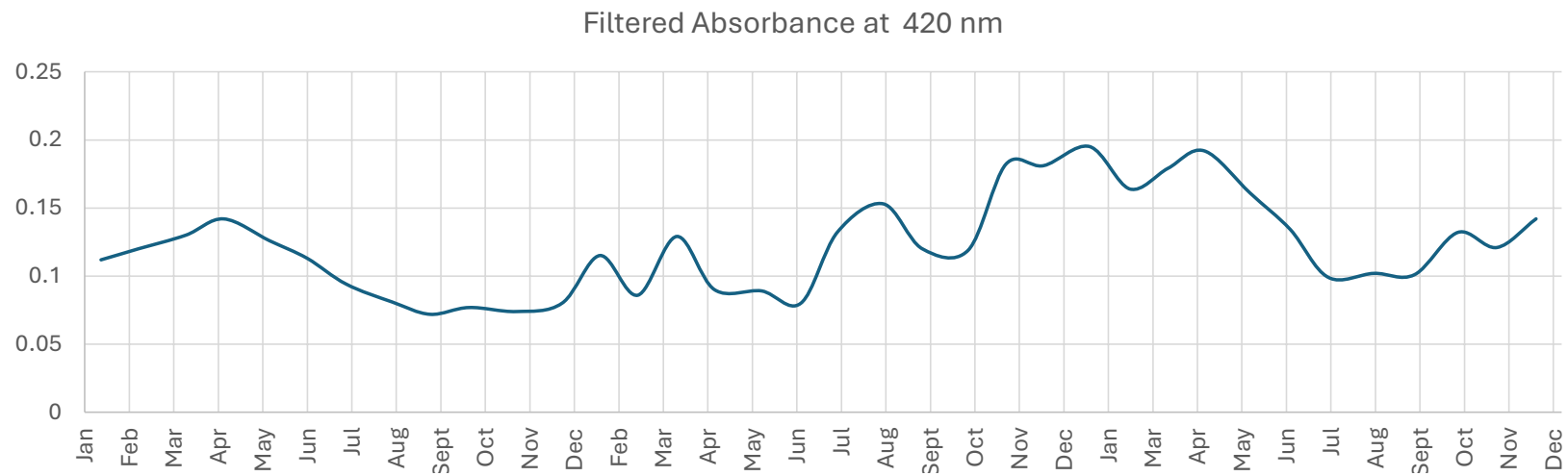
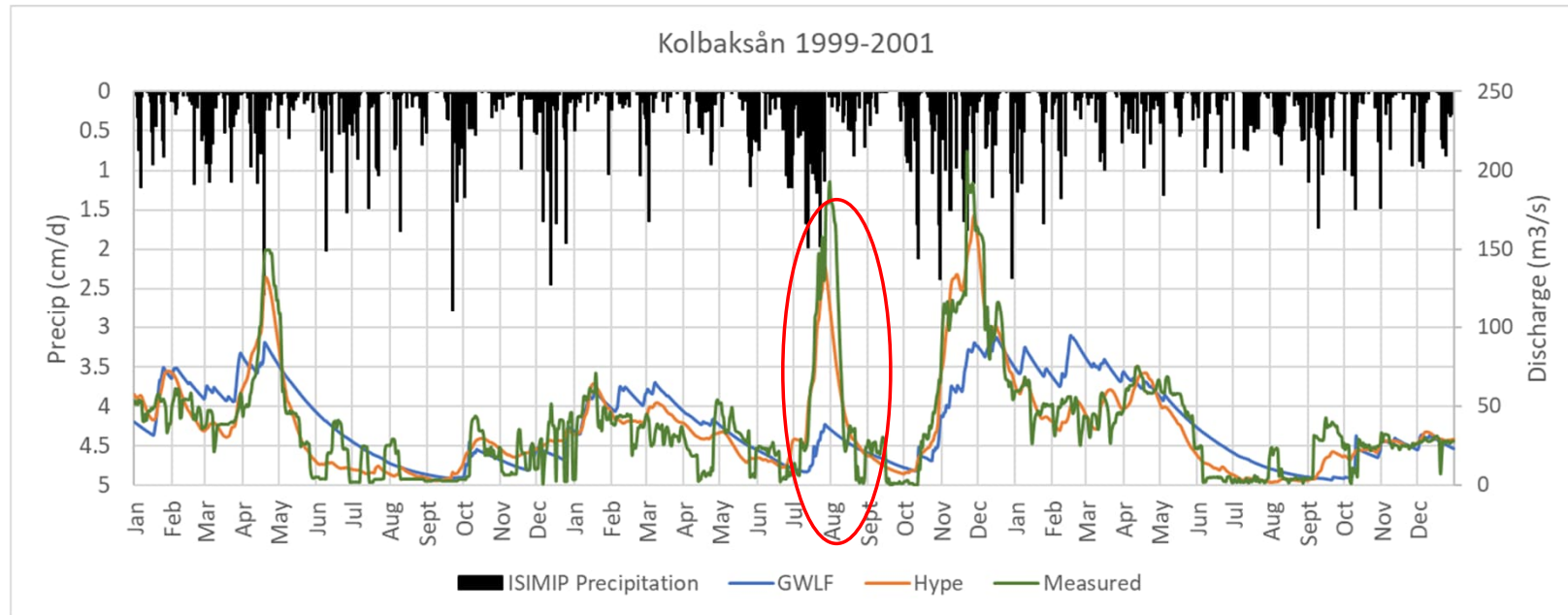
Hedström



Arbogaån



Kolbaksån



Summary of Watershed Modeling

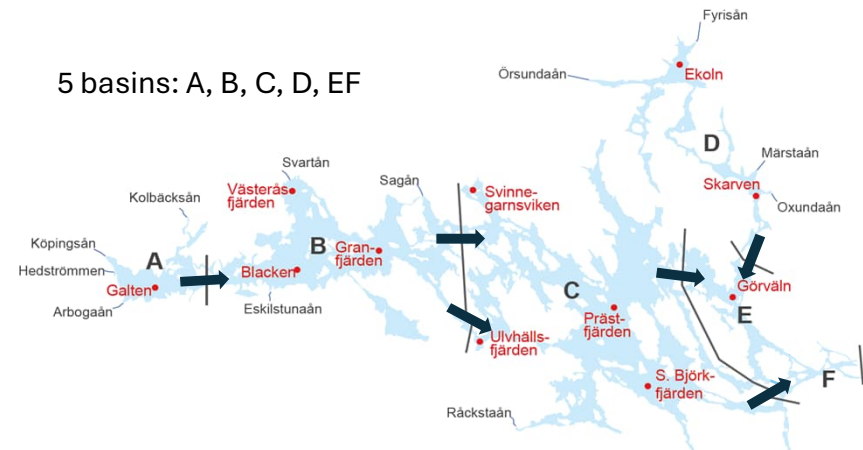
- River discharge has been calculated for all ISIMIP3a and 3b scenarios for all major watersheds contributing to Mälaren
- While we are able to identify events during stratification, they do not show the expected biogeochemical response
- Apparently, this is due to a lack of nutrient limitation which in turn is probably due to overestimation of nutrient loads
- Evaluation of extreme events shows that the GWLF model can underestimate large events.
 - This may be affecting our results on event identification
 - GWLF is good for estimating long-term changes in loading The SMHI Hype model or Measured data may be best for individual events.
- It seems better to use measured discharge or HYPE output for evaluation of specific extreme events
- GWLF may still be useful for looking at the longer-term changes in more protracted events. for simulations of climate change and for simulations of DOC loading

What needs to be done in terms of model setup?

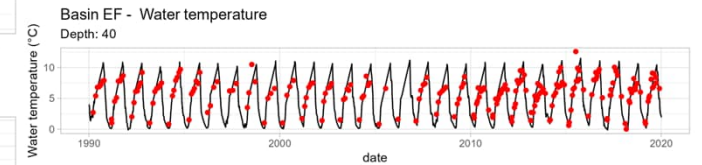
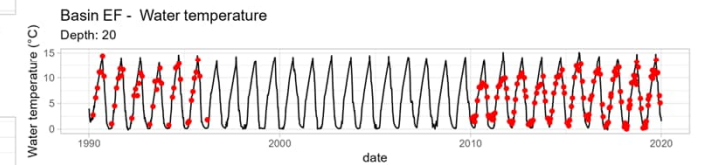
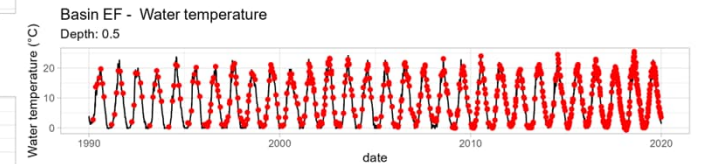
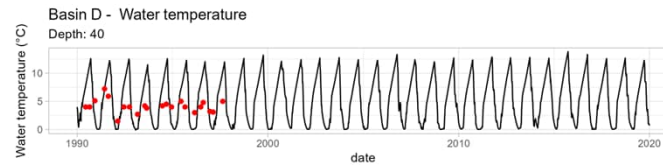
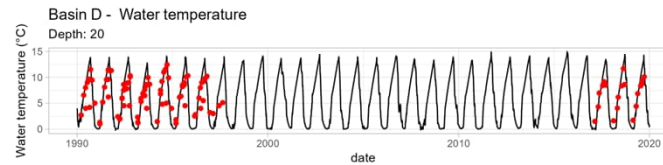
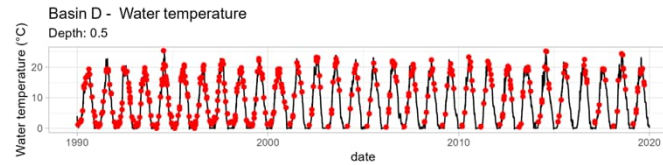
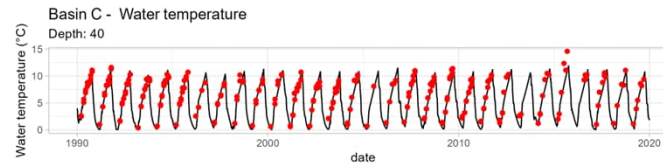
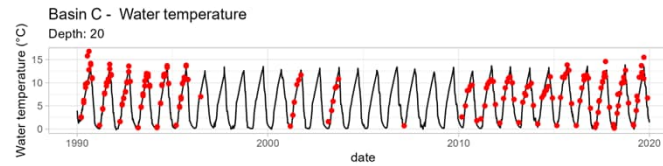
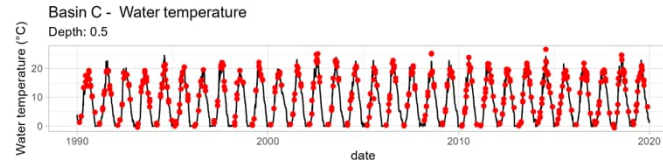
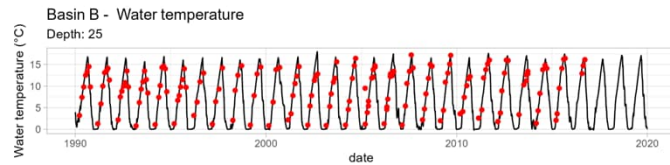
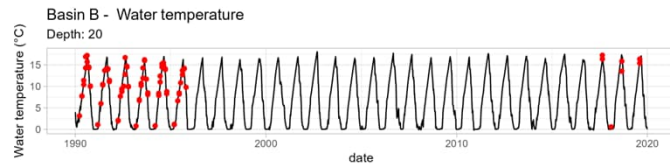
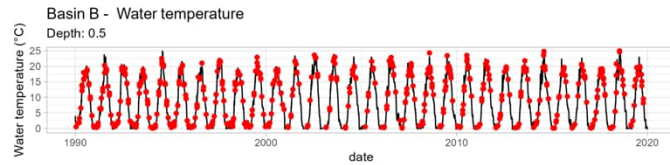
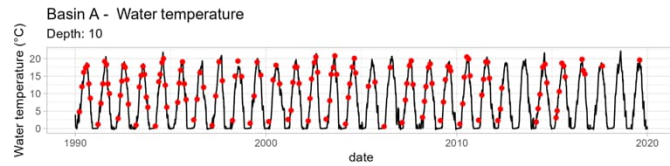
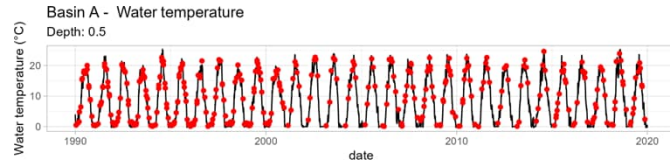
- 1D:
 - Assess terrestrial vs. aquatic DOM simulation
 - Validation (and probably recalibration) on zooplankton biomass estimates
 - Recalibrate with a proper calibration and validation period (currently it's all calibration)
- 3D:
 - Validate 3D run with observations
 - Reproduce extreme events in 3D
 - Set up potential future climate runs
 - (Optional) validation using satellite data?

Mälaren 1D model Model Calibration

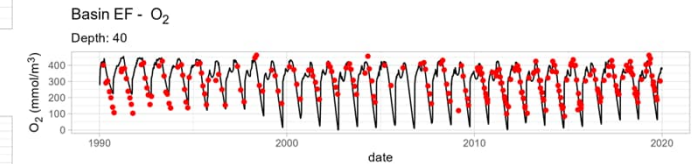
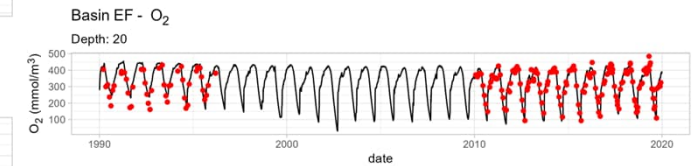
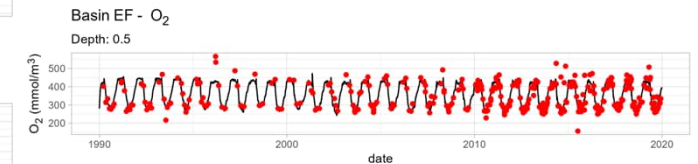
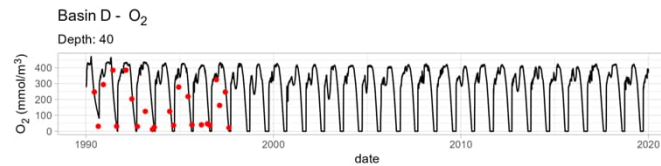
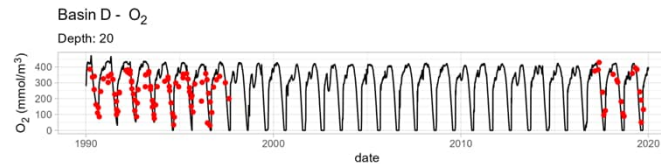
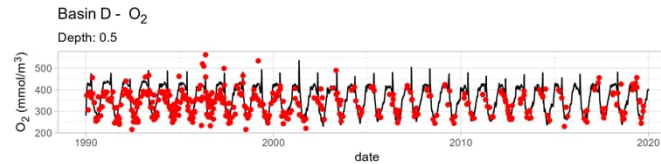
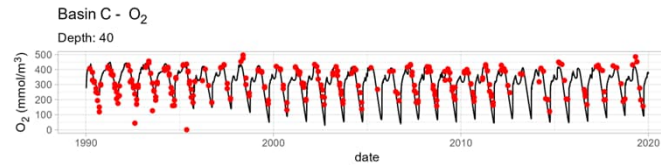
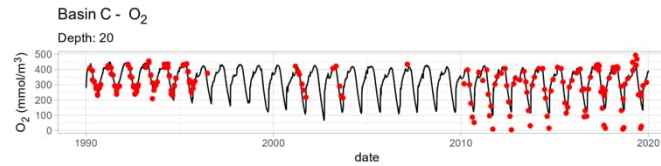
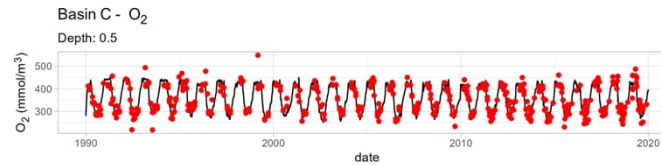
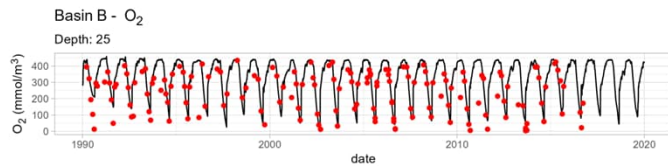
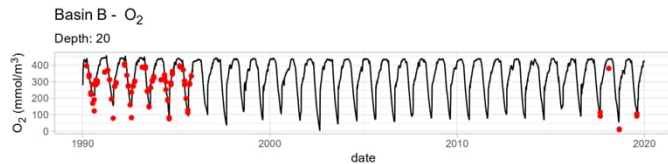
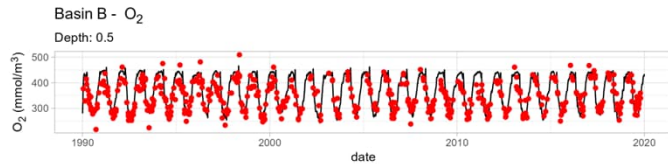
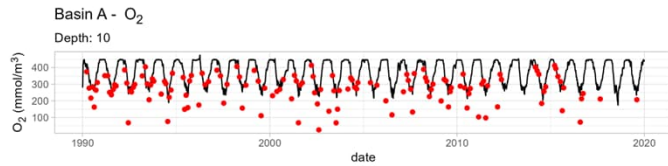
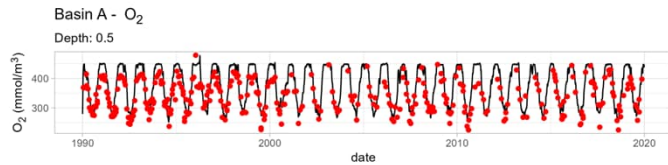
- Switched to only 1 phytoplankton and zooplankton group
 - Without compiling data on individual groups, the model is likely to present a skewed image (unless not calibrating the group parameters)
- Added a DOM simulation



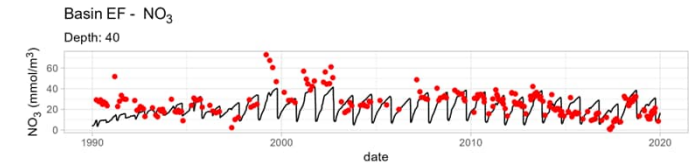
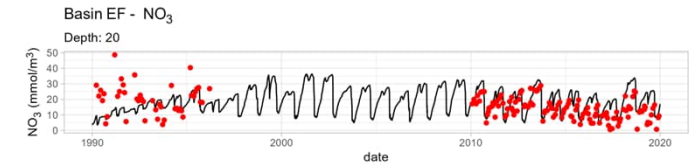
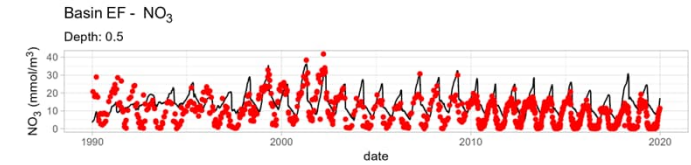
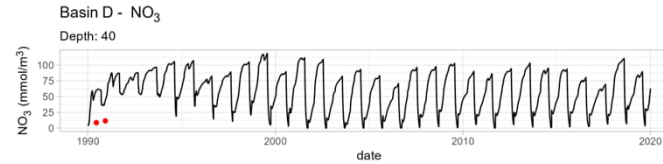
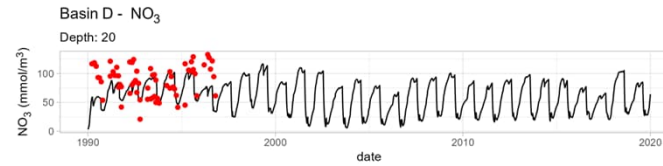
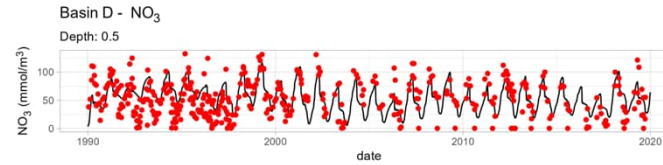
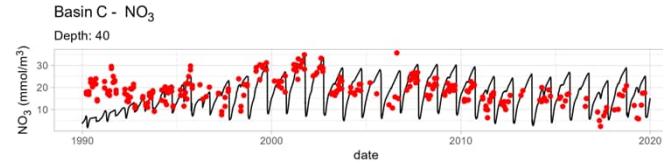
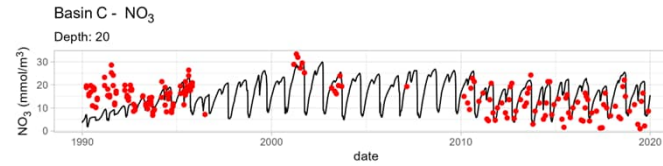
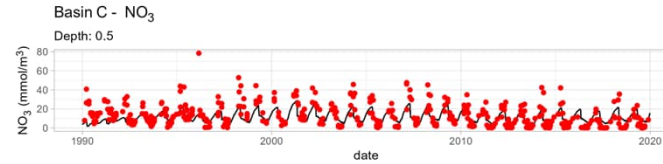
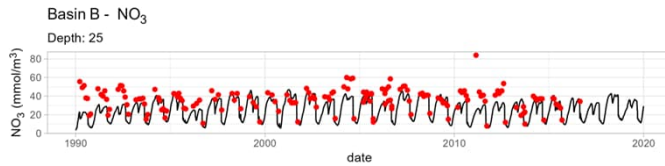
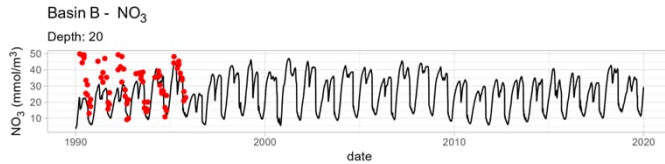
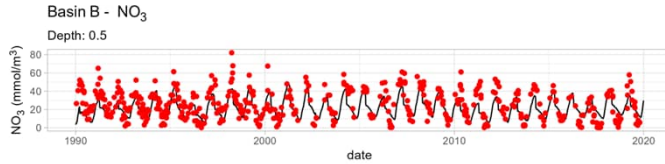
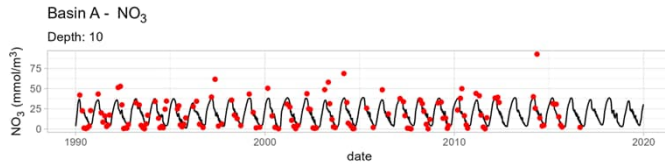
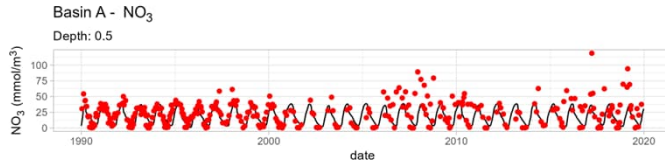
1D model calibration - Temperature



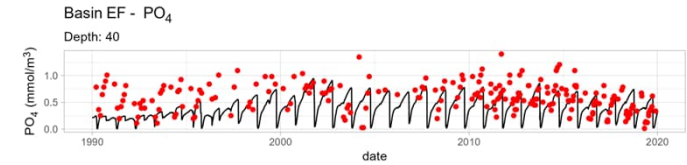
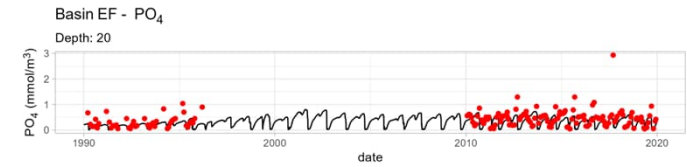
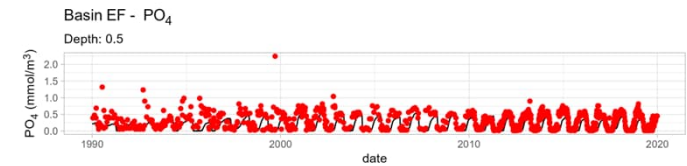
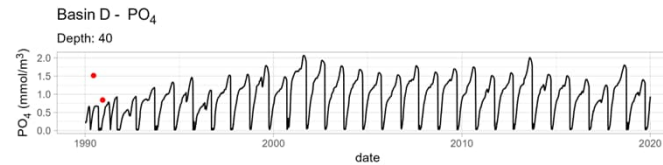
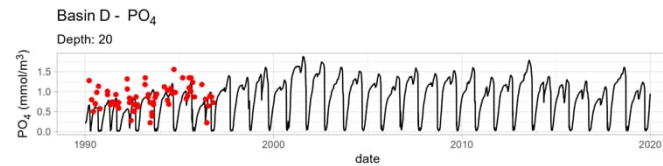
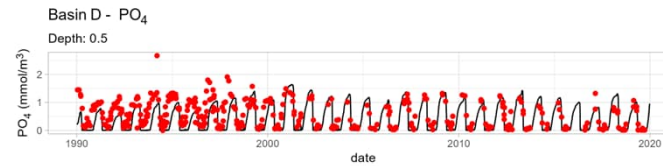
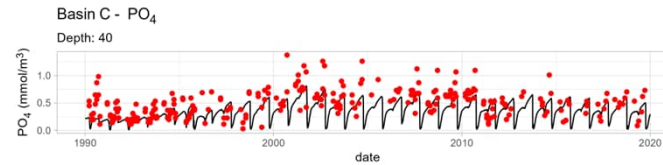
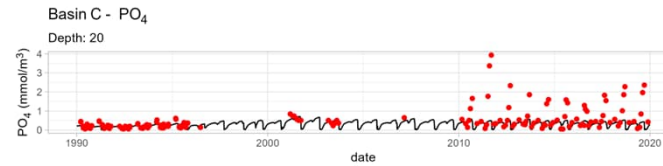
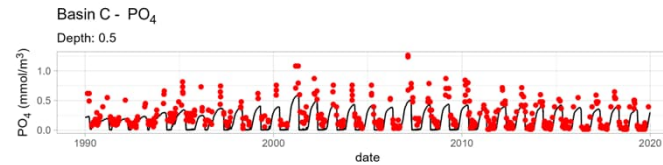
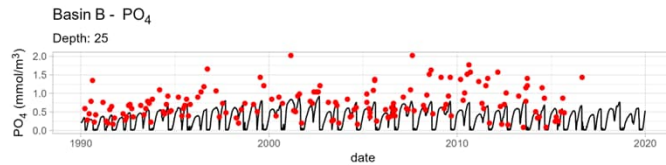
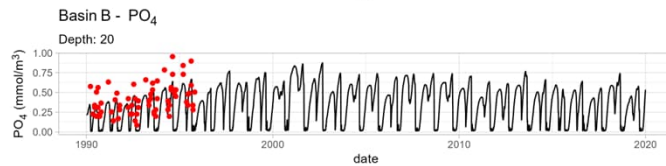
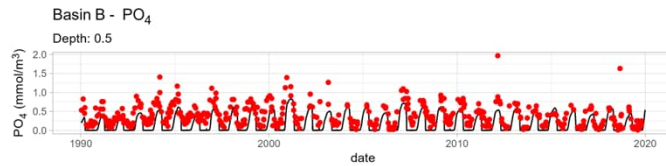
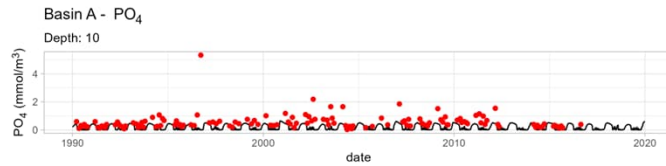
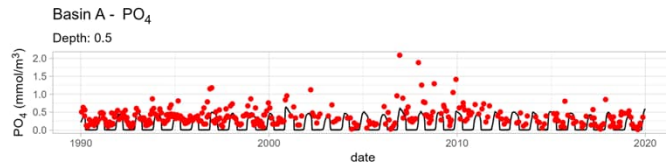
1D model calibration - Oxygen



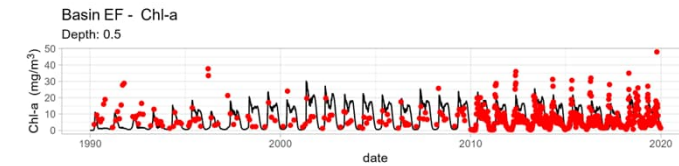
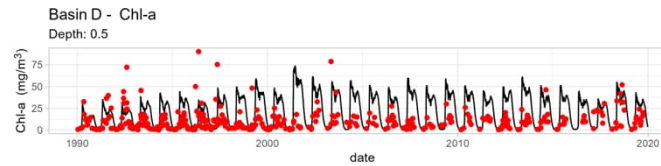
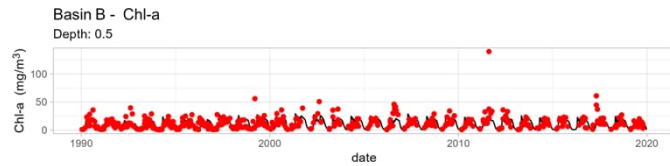
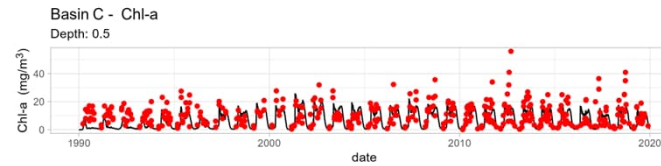
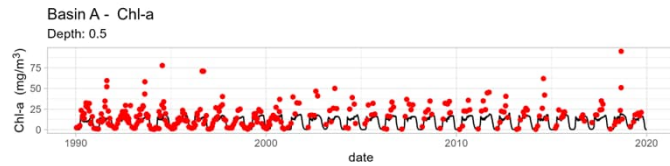
1D model calibration - Nitrate



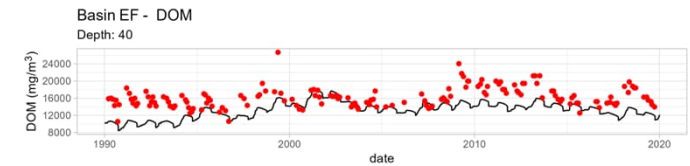
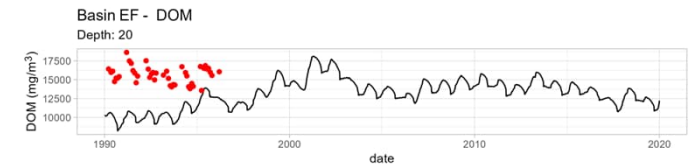
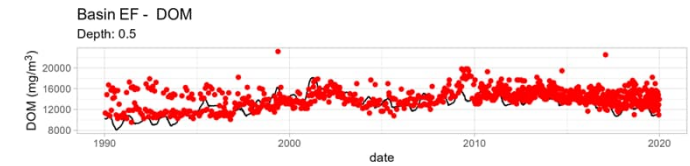
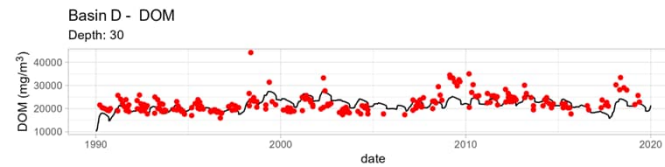
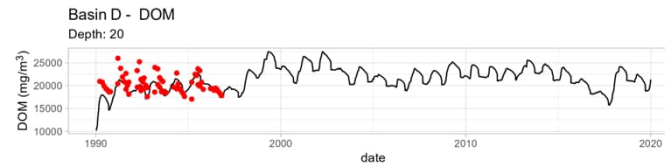
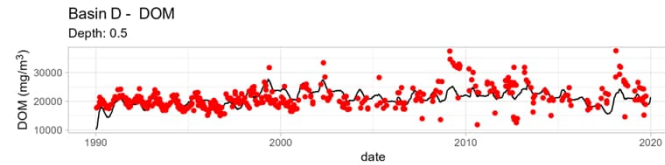
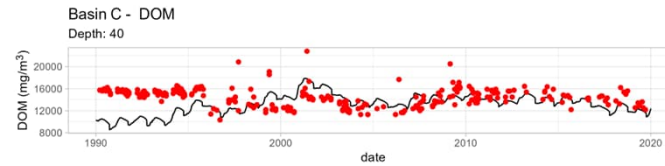
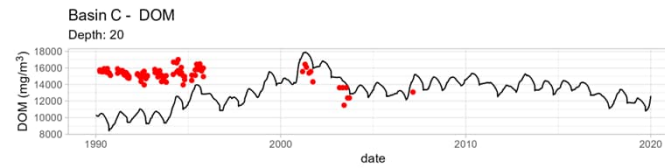
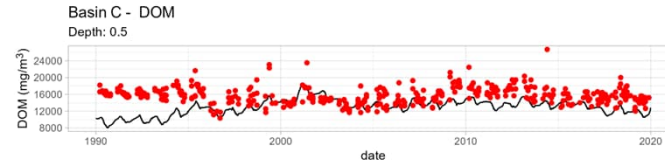
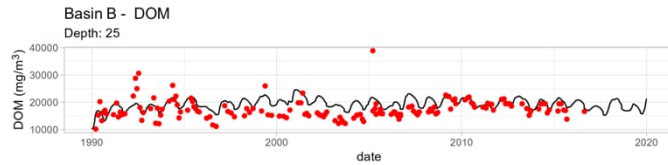
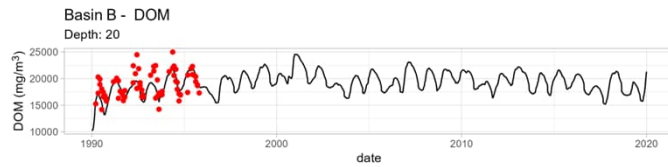
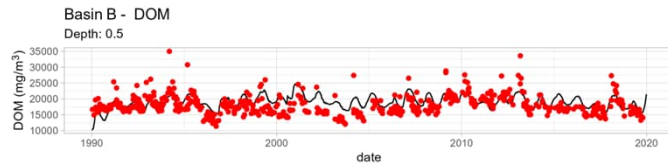
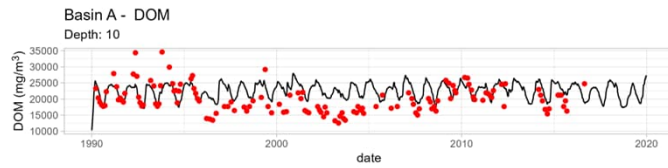
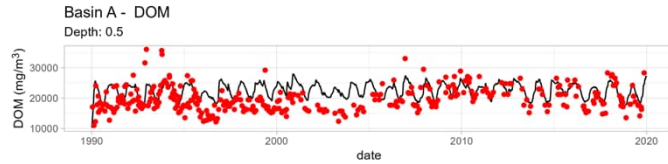
1D model calibration - Phosphate



1D model calibration – Chlorophyll-a



1D model calibration - DOM



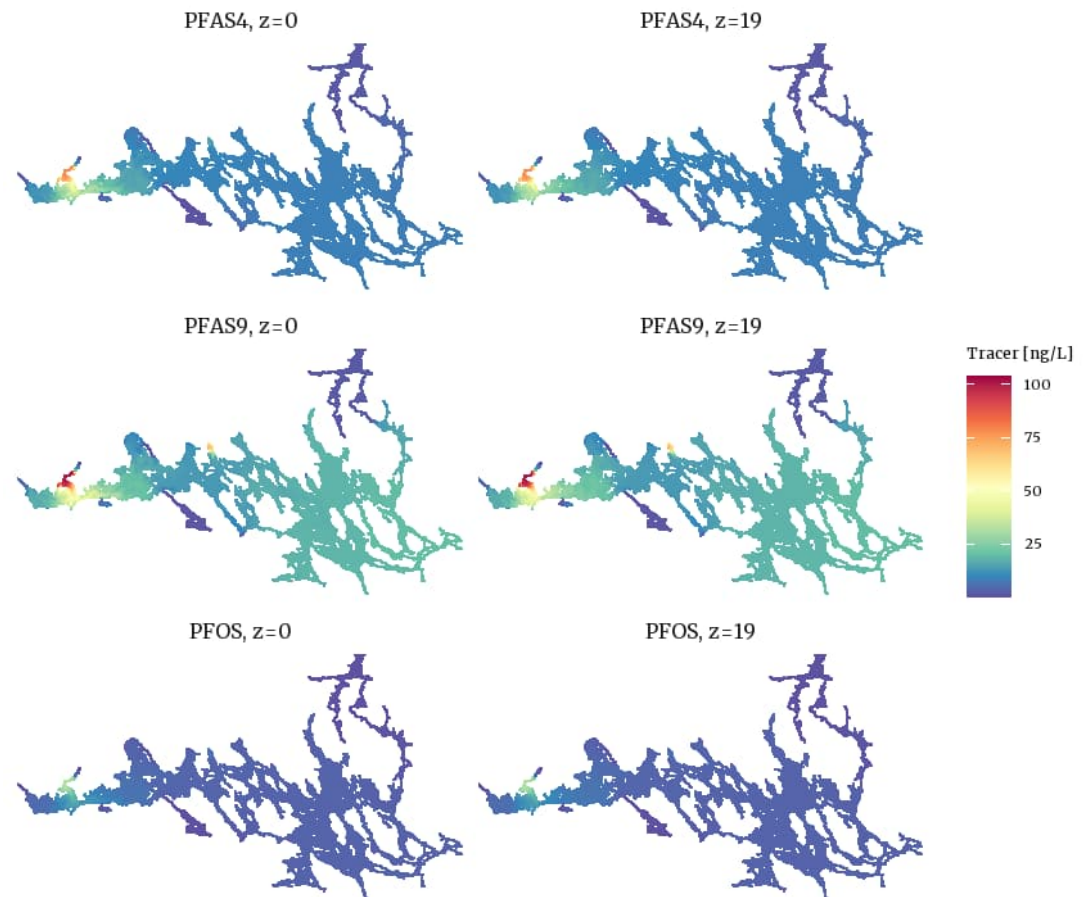
2026 MEWS Student projects

- Alexandra Goede - *Spatial and Temporal Dynamics of PFAS in Lake Mälaren*
- Elin Tjell - *Simulating Tracer Transport Times in Mälaren*
- Saroj Khanal - *Modelling Fate and Transport of Pharmaceuticals in Lake Mälaren*
- (Kasper Göjeryd - *Spring wind events as drivers of lake stratification anomalies: a 1D modelling case study of Lake Erken*)

Spatial and Temporal Dynamics of PFAS in Lake Mälaren

Alexandra Goede

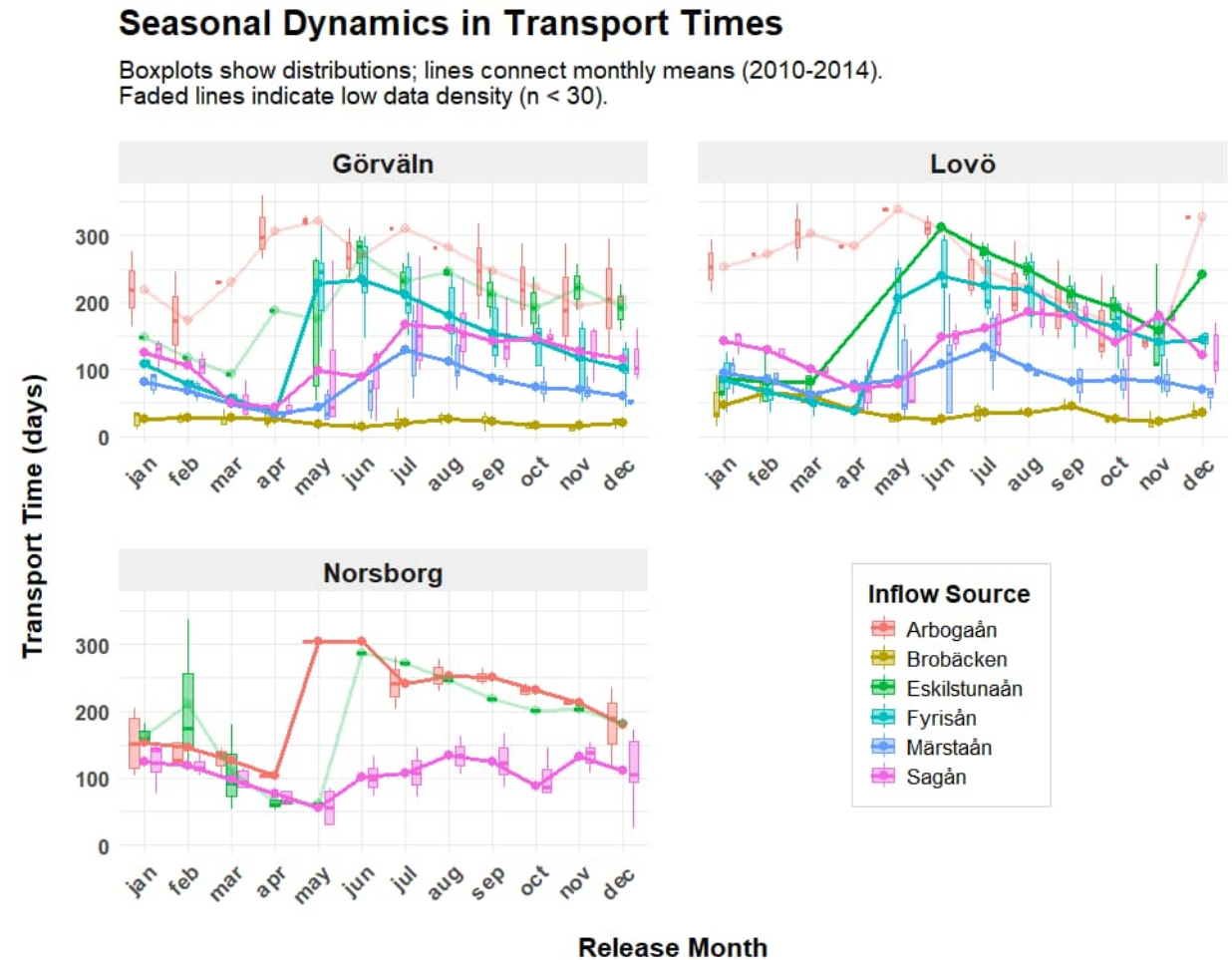
- No final report yet – preliminary results so far
- PFAS₄ simulated and scaled PFAS₉ and PFOS
- Defence on June 18



Simulating Tracer Transport Times in Mälaren

Elin Tjell

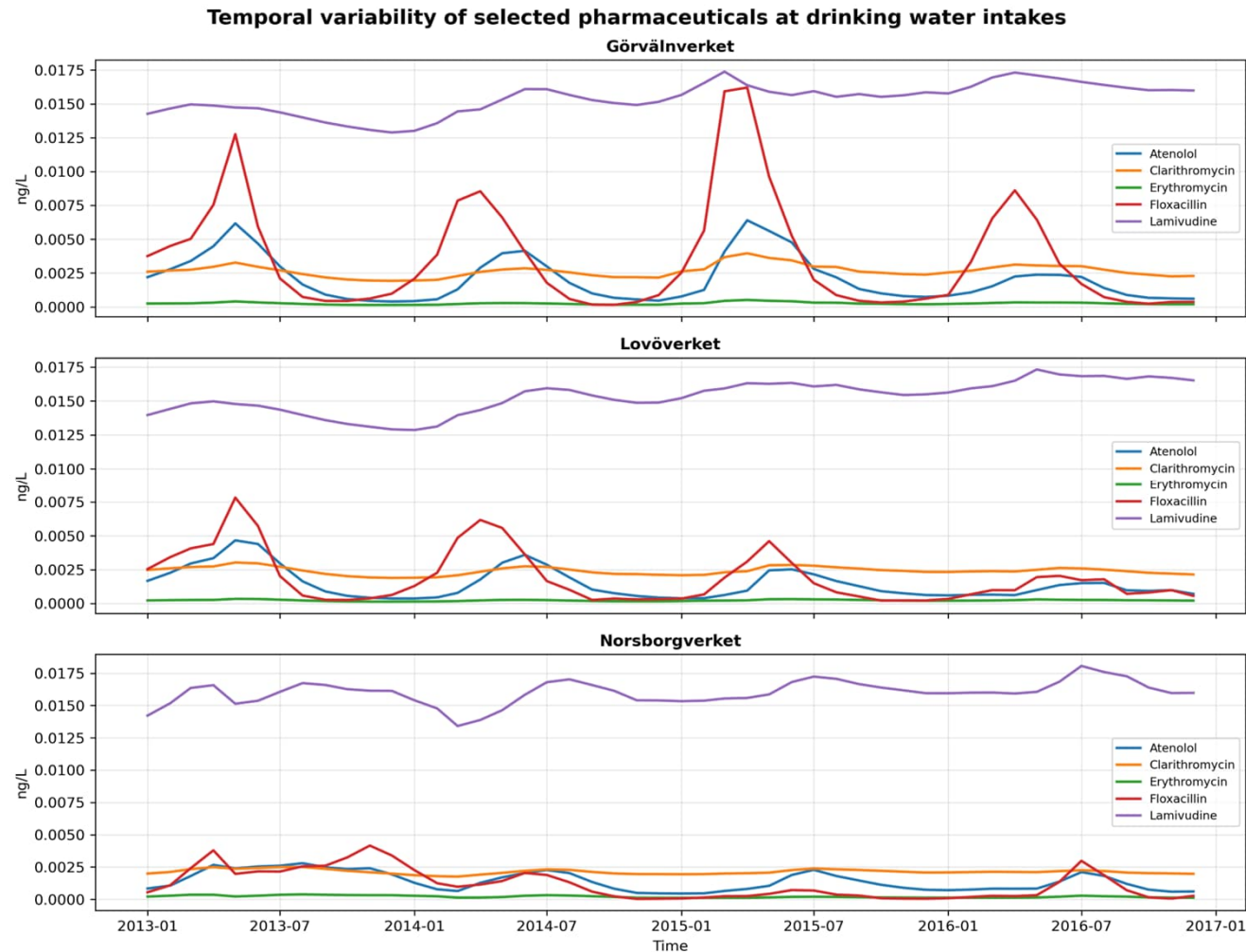
- Overview of transport times from 6 inflows to drinking water intakes
- Some analyses into seasonal variation
- Defended this morning



Modelling Fate and Transport of Pharmaceuticals in Lake Mälaren

Saroj Khanal

- Five degradation classes of pharmaceuticals
- Degradation class affected spread
- Scalable approach for multiple pharmaceuticals
- Defended yesterday



Spring wind events as drivers of lake stratification anomalies: a 1D modelling case study of Lake Erken

Kasper Göjeryd

- Spring wind was identified as primary cause of years with weak mixing
- Future trend will likely make these events more rare
- Defends on Thursday

