Swedish MEWS Progress

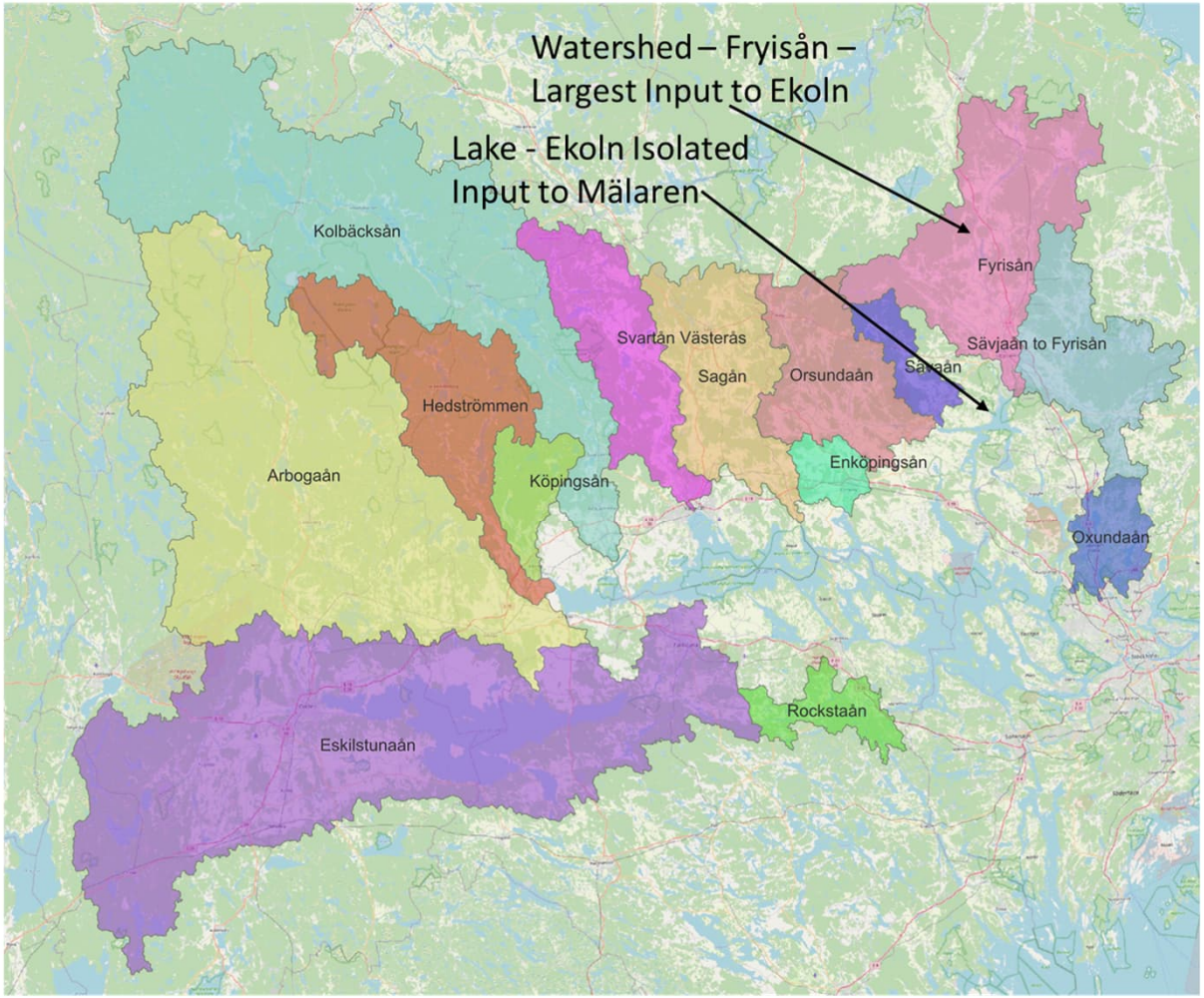
Third Annual meeting

May 26-28 2026

Progress on Watershed Modelling

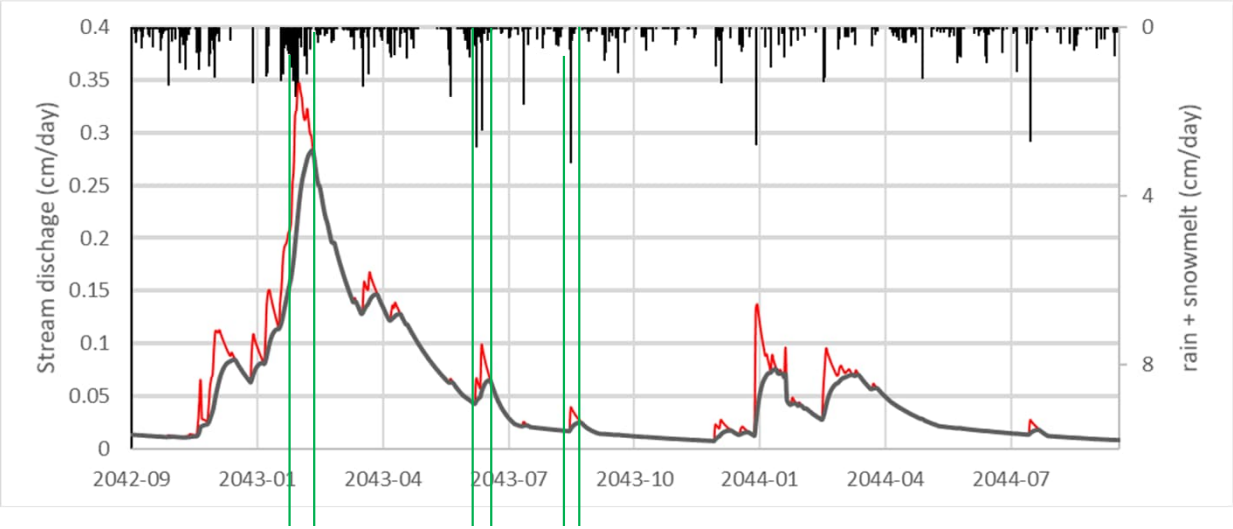
Hydrologic Events

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.

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

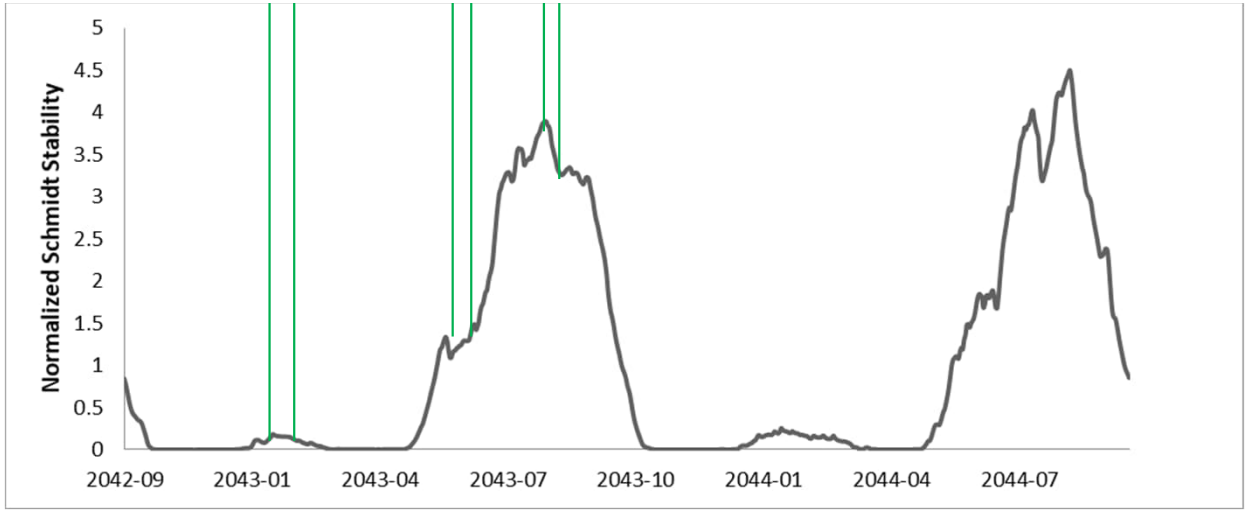
Where:

- 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



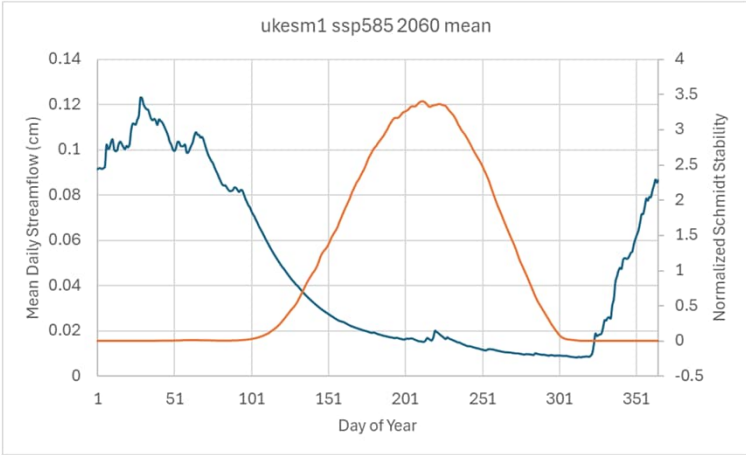
Winslow, L., J. Read, R. Woolway, J. Brentrup, T. Leach, J. Zwart, S. Albers, and D. Collinge. 2019. Package 'rLakeAnalyzer'.

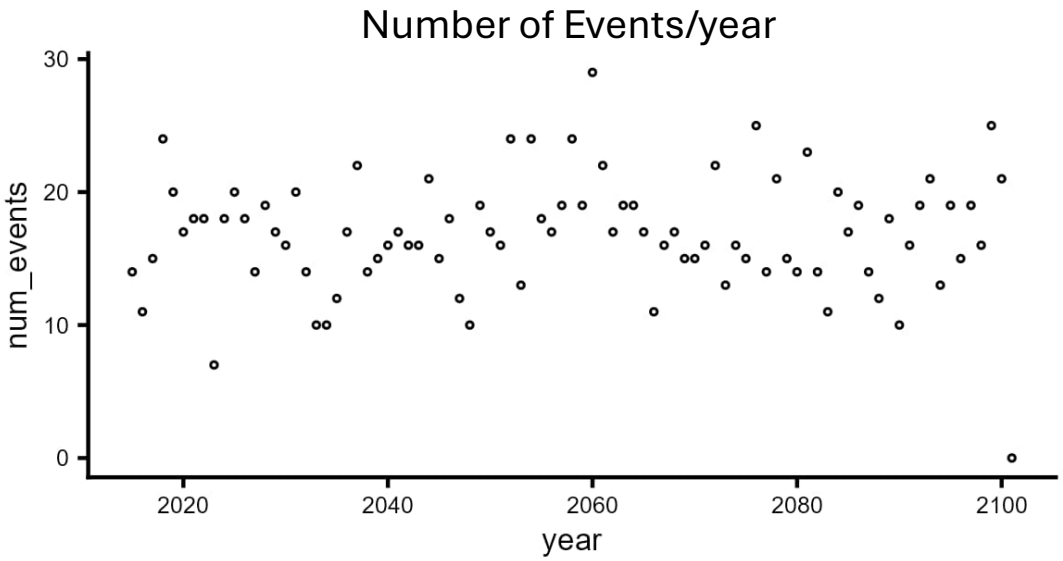
Lyne, V., and M. Hollick. 1979. Stochastic time-variable rainfall-runoff modelling. Pages 89-93 *in* Institute of engineers Australia national conference. Institute of Engineers Australia Barton, Australia.

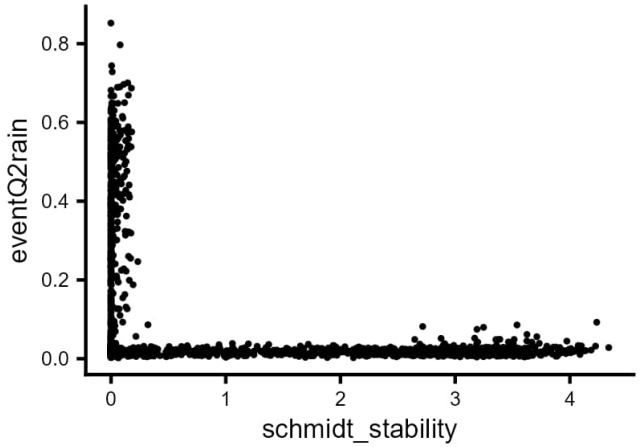
Distribution of Events relative to Thermal Stratification

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?

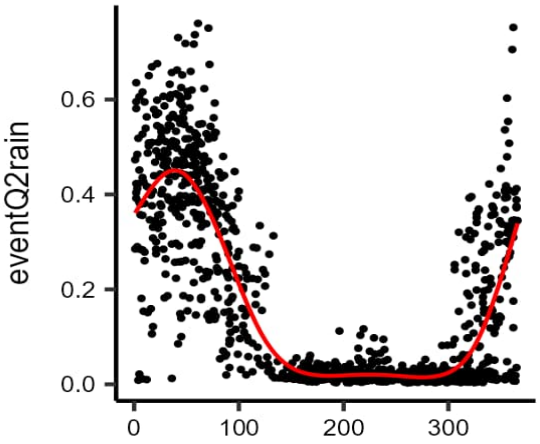


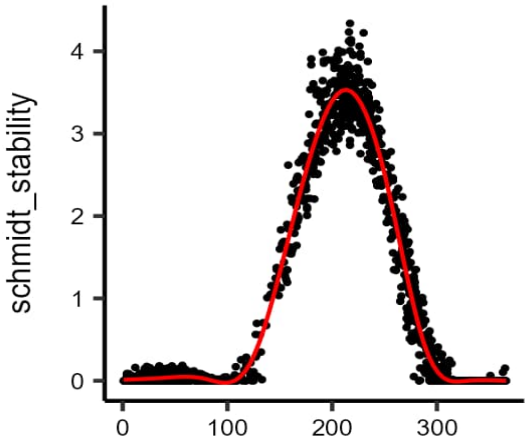


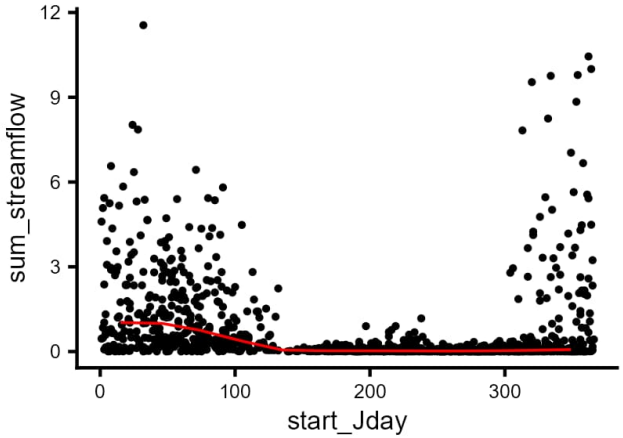


Event Screening Tool – Events During Stratification

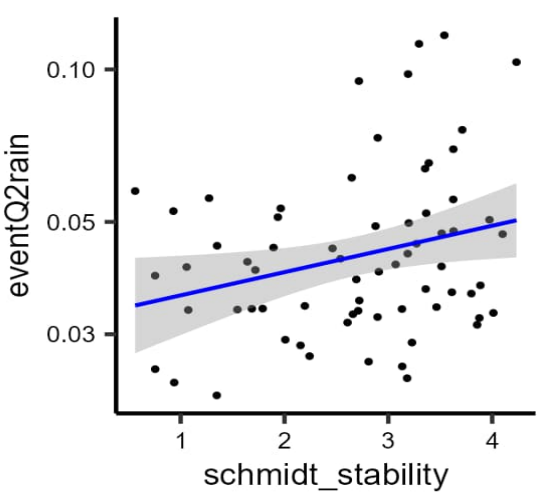
ukesm1-0-ll-ssp585

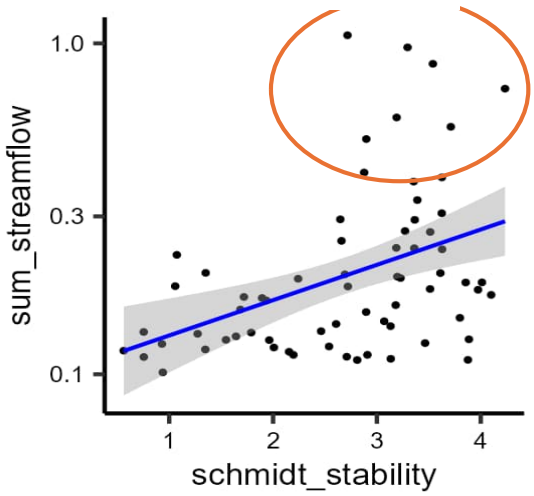






Filtered to Remove Isothermal Conditions





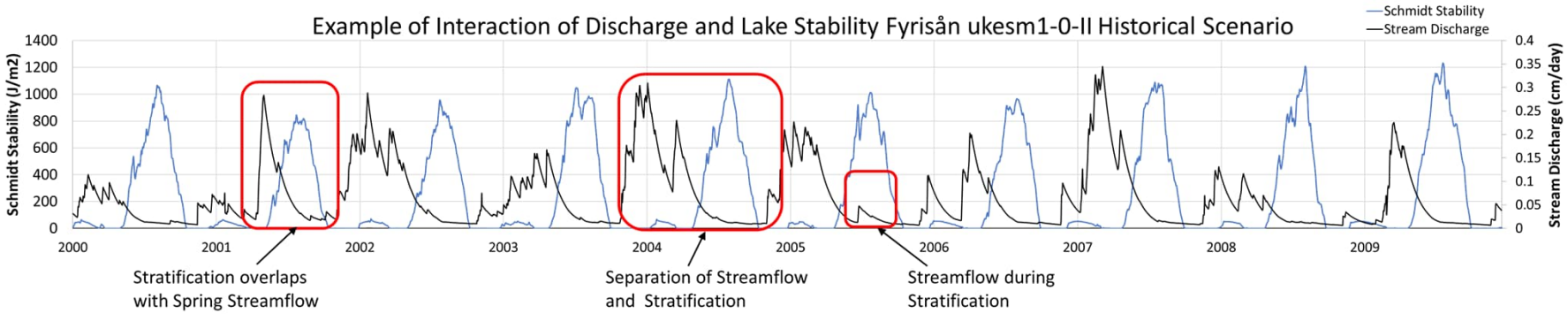
- Have recalibrated Watershed model and re-run analysis
- Evaluation of events shows hydrologic effect, but nutrient and phytoplankton?
- Although the events measured are relatively large during stratification they are a small component of the seasonal flow.

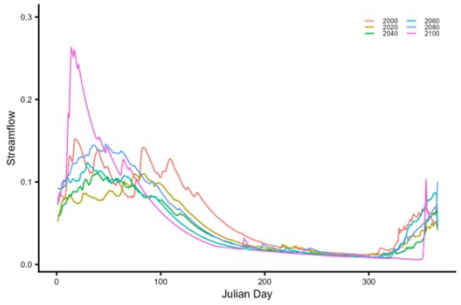
Summary Short-Term Events

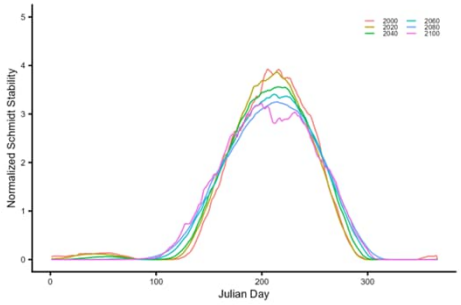
- Have good information on events
- Most events occur during isothermal conditions.
- Largest events are during isothermal conditions
- Not clear of the relative importance of events during isothermal vs stratified conditions
- There is fairly large annual and seasonal variations in the
  - Number of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

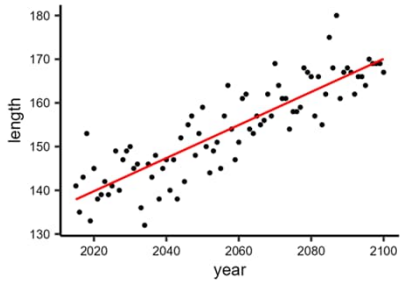
- Present Problem – Apparent lack of nutrient limitation

Distribution of Streamflow Between Stratified and Isothermal Lake Conditions









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

Example of variability of events during Isothermal and stratified conditions over long-term climate scenario ukesm1-0-ll-ssp585

All Events

Event length
- Mean = 8 d
- Max = 82 d

Event Discharge
- Mean = 0.56 cm/d
- Max = 11.6 cm/d

Event Discharge/Rain
- Mean = 0.124
- Max = 0.852

Isothermal Conditions

Event length
- Mean = 11.3 d
- Max = 82 d

Event Discharge
- Mean = 1.0 cm/d
- Max = 11.6 cm/d

Event Discharge/Rain
- Mean = 0.215
- Max = 0.852

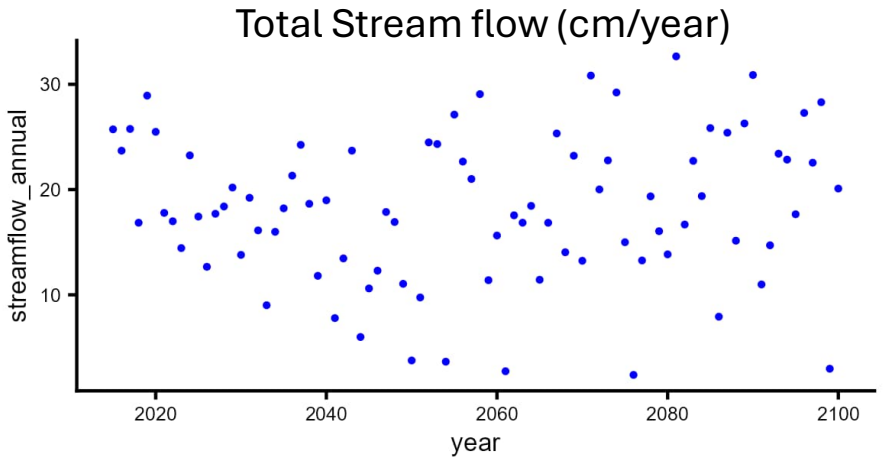
Stratified Conditions

Event length
- Mean = 4.1 d
- Max = 41 d

Event Discharge
- Mean = 0.057 cm/d
- Max = 1.17 cm/d

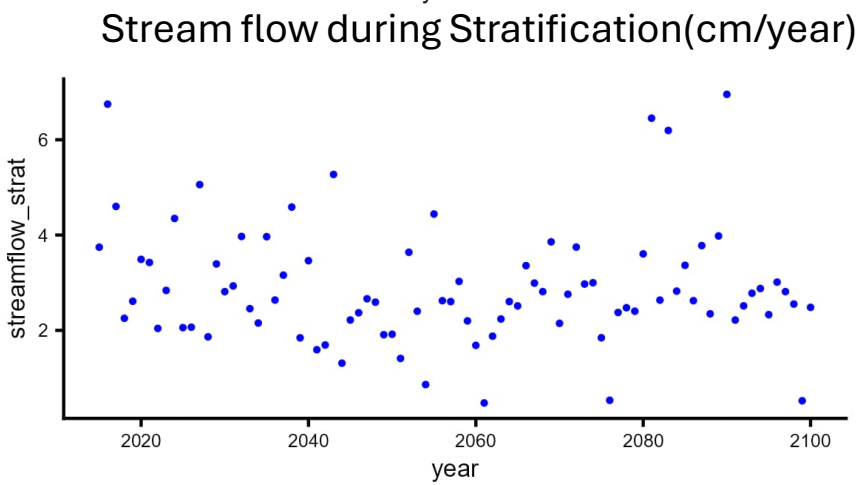
Event Discharge/Rain
- Mean = 0.019
- Max = 0.093

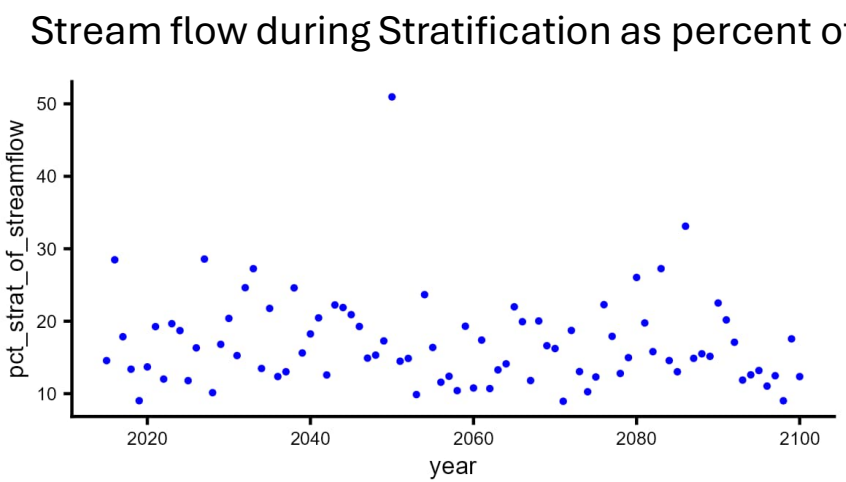
Analysis of the amount of streamflow during stratified and isothermal conditions



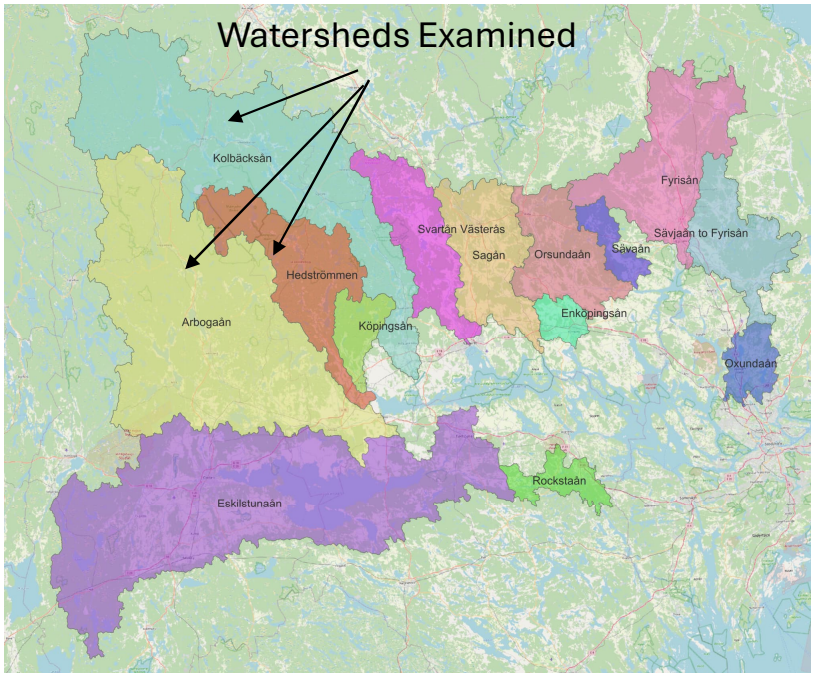
No clear trend
Large inter-annual variability

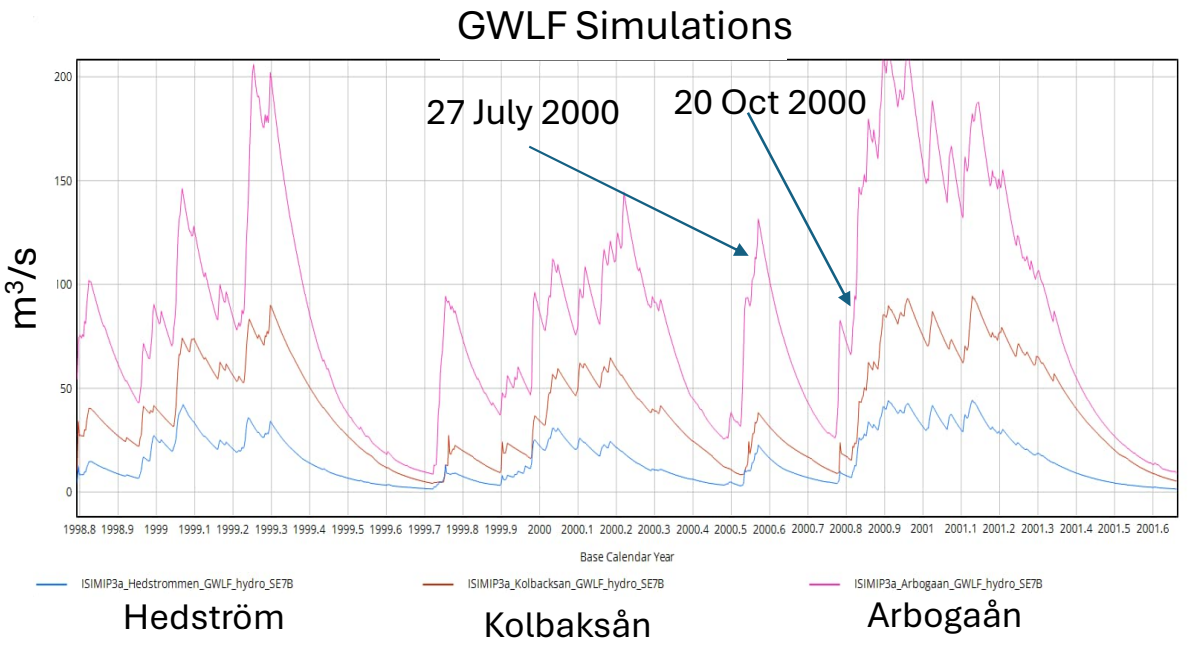
Potential problem with model not correctly simulating the largest events.
Trying with measured data
Test identifying events with frequency distribution method





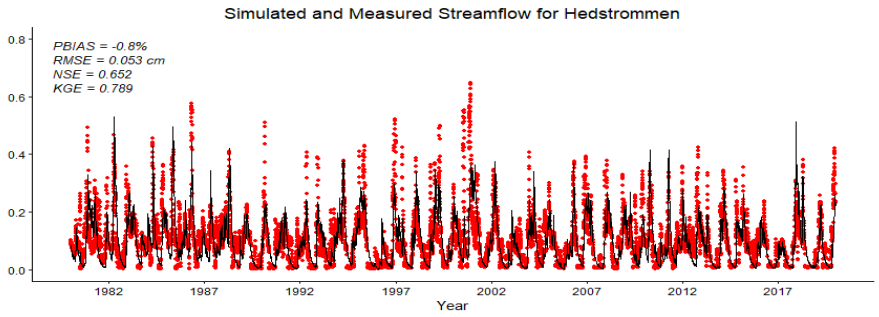
Stakeholder Identified Event Large DOC inputs During the Late summer and Fall of 2000

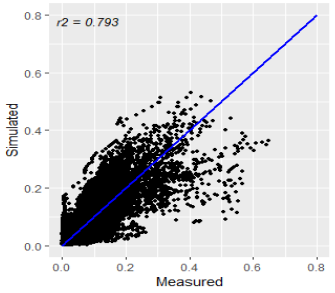


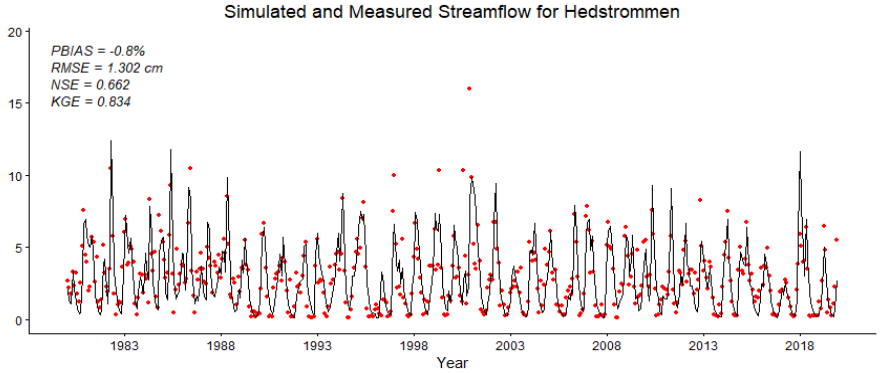


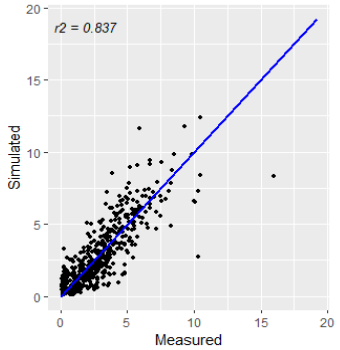
- This event led to highly elevated DOC concentrations at the Stockholm drinking water intakes – with a large delay time
- The first peak would be during stratified conditions downstream of Galten
- The second peak is during Isothermal conditions

Example Calibration Data from Hedstrom

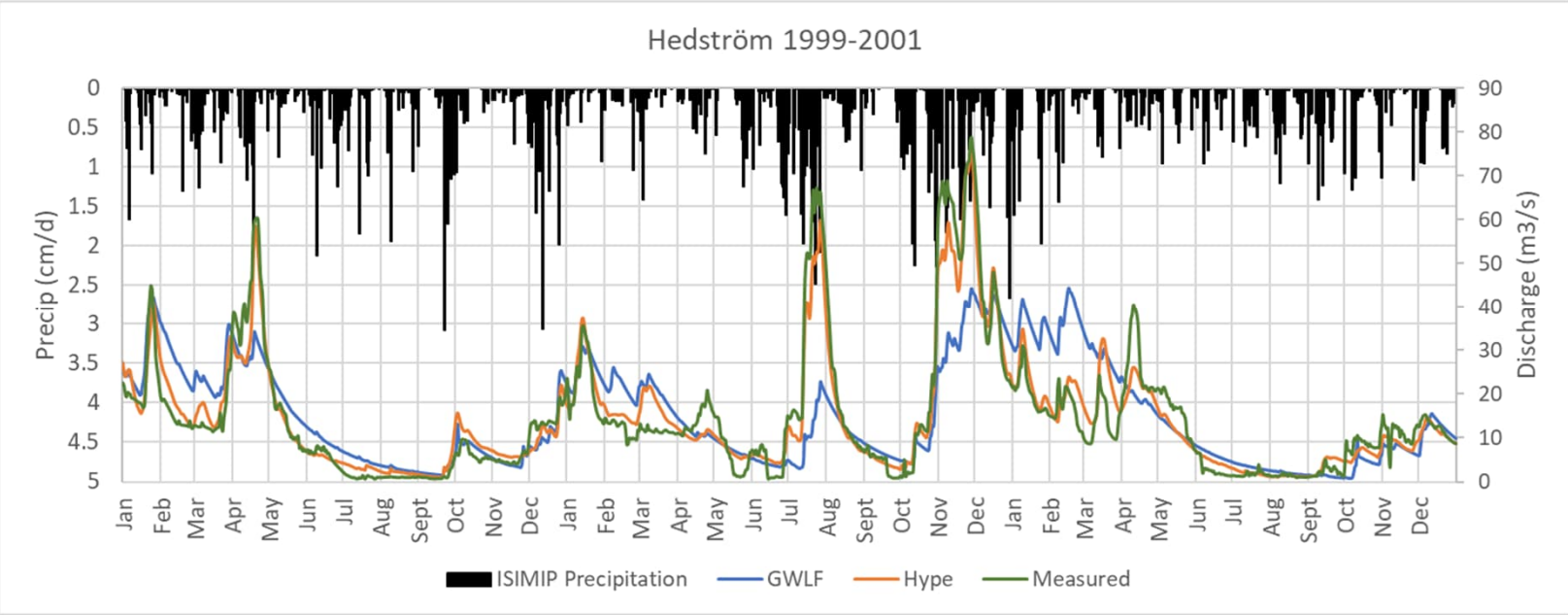




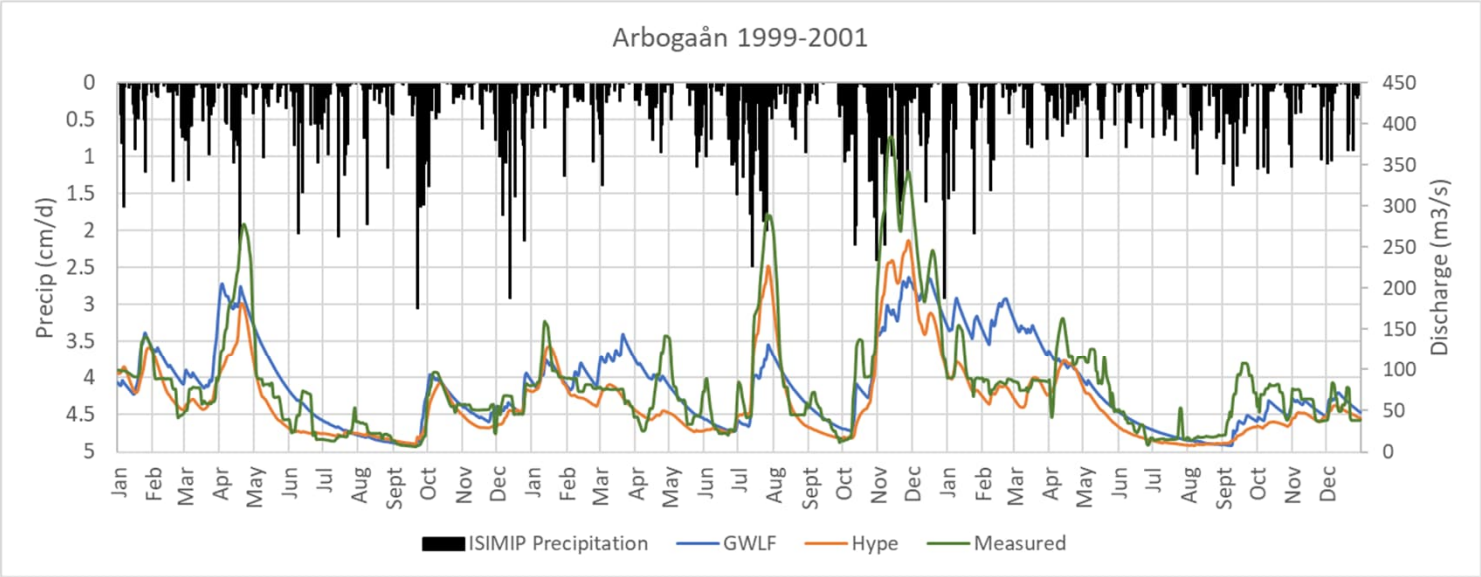


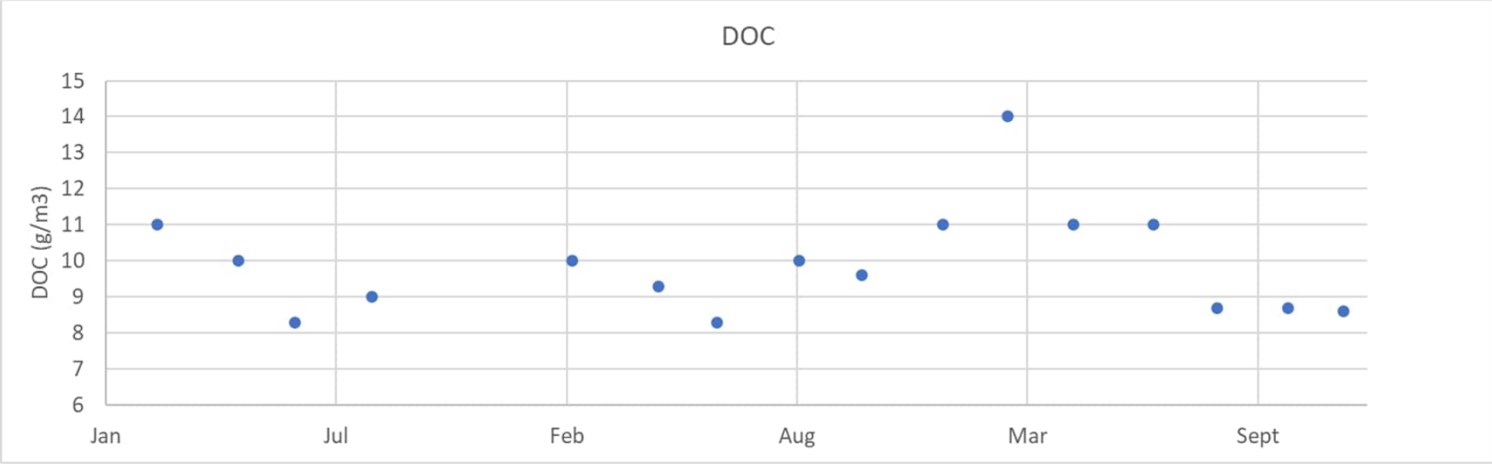


Hedström

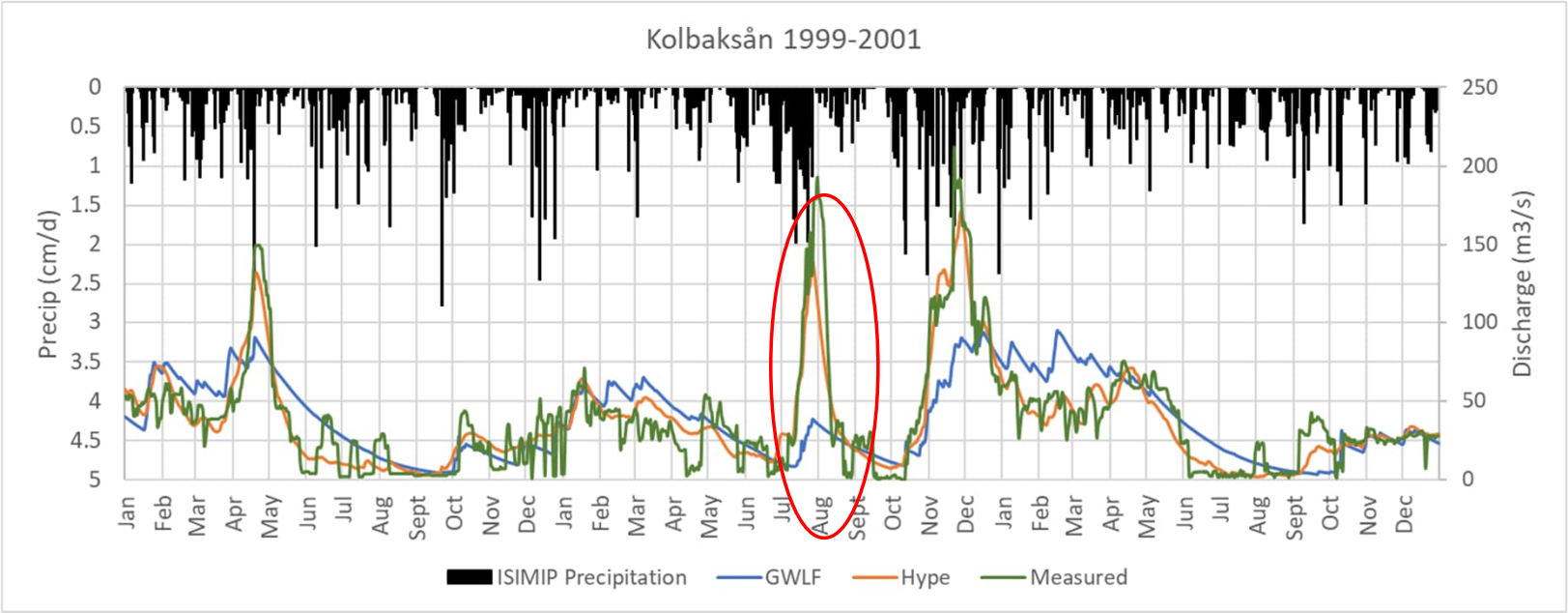

Hedström 1999-2001
Precip (cm/d)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Discharge (m3/s)
90
80
70
60
50
40
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
ISIMIP Precipitation
GWLF
Hype
Measured

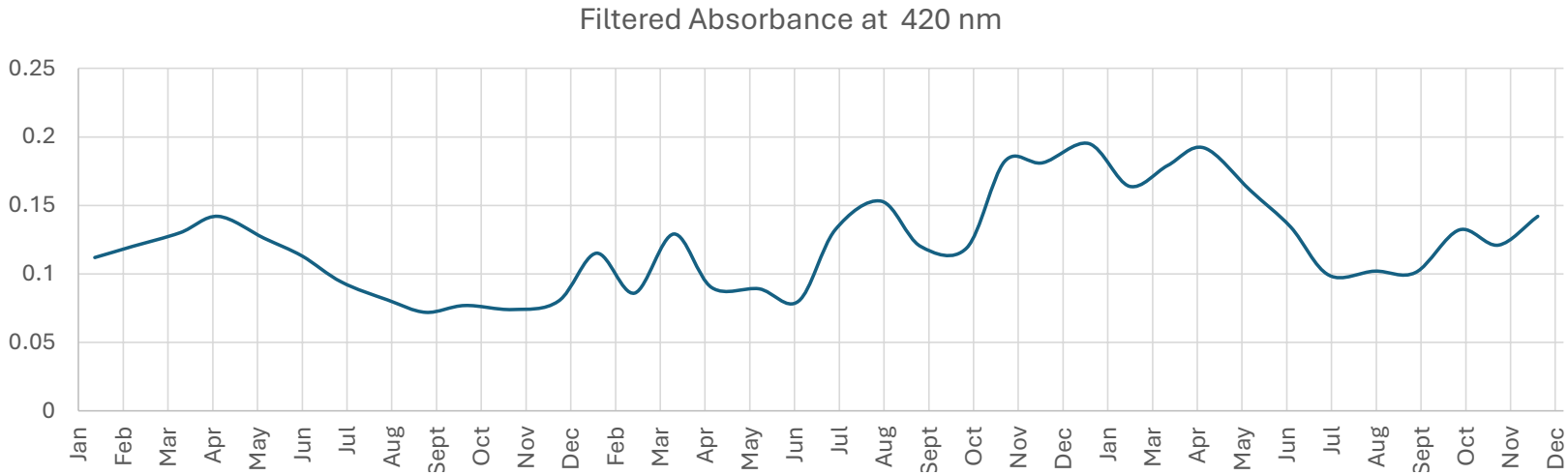
Arbogaån


Arbogaån 1999-2001
Precip (cm/d)
Discharge (m3/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
450
400
350
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
ISIMIP Precipitation
GWLF
Hype
Measured


DOC
DOC (g/m3)
15
14
13
12
11
10
9
8
7
6
Jan
Jul
Feb
Aug
Mar
Sept

Kolbaksån


Kolbaksån 1999-2001
Precip (cm/d)
Discharge (m3/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
ISIMIP Precipitation
GWLF
Hype
Measured

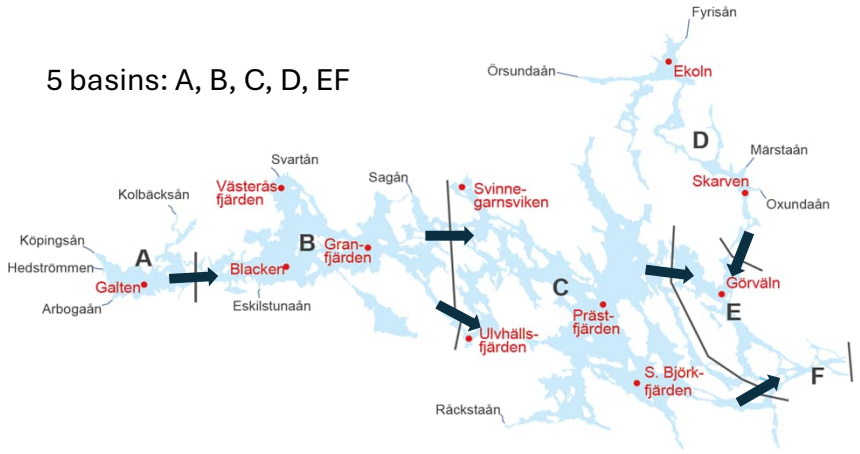

Filtered Absorbance at 420 nm
0.25
0.2
0.15
0.1
0.05
0
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Mar Apr May Jun Jul Aug Sept Oct Nov Dec

Summary of Watershed Modeling

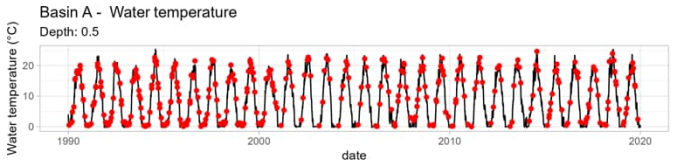
- River discharge has been calculated for all ISIMIP3a and 3b scenarios for all major watersheds contributing to Mälaren
- While we are able to identify events during stratification, they do not show the expected biogeochemical response
- Apparently, this is due to a lack of nutrient limitation which 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

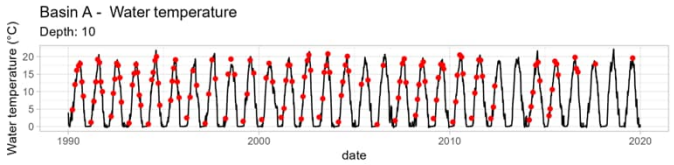
Mälaren 1D model Model Calibration

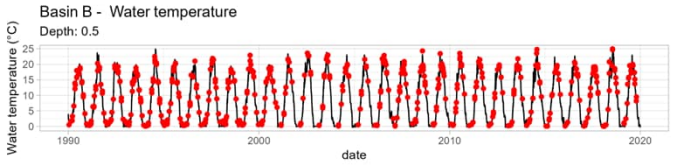
- Switched to only 1 phytoplankton and zooplankton group
  - Without compiling data on individual groups, the model is likely to present a skewed image (unless not calibrating the group parameters)
- Added a DOM simulation

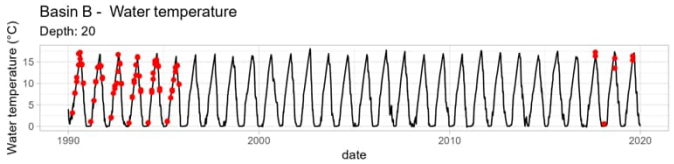


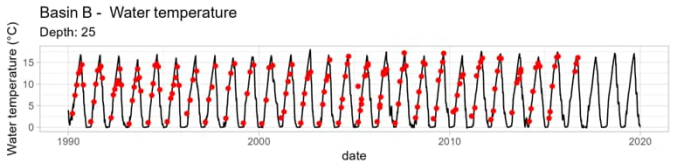
1D model calibration - Temperature

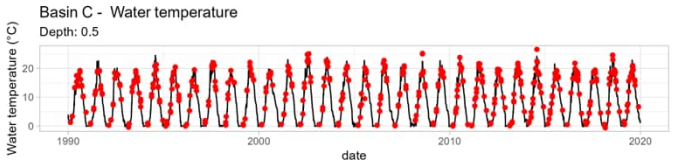


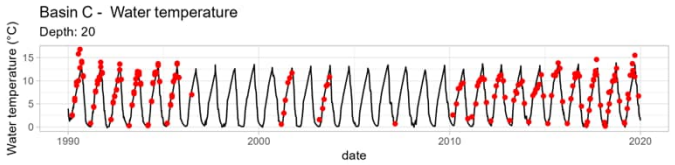


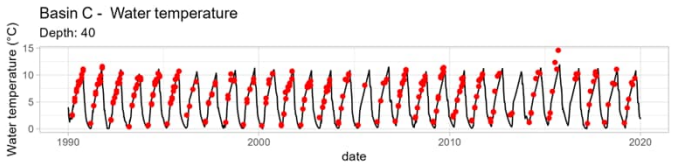


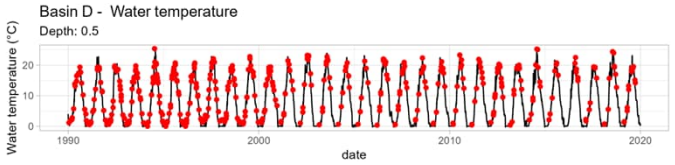


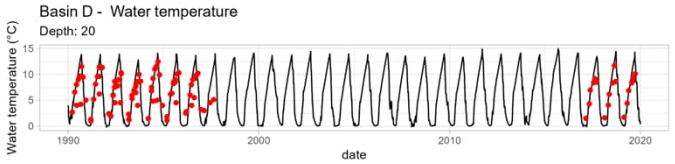


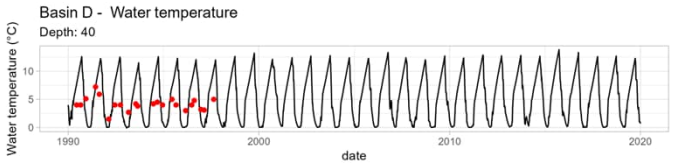


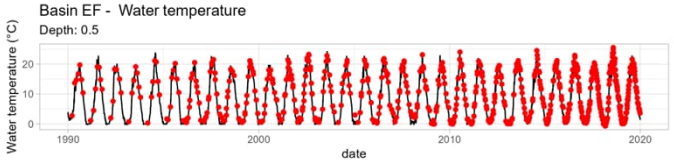


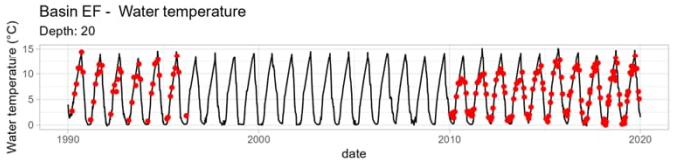


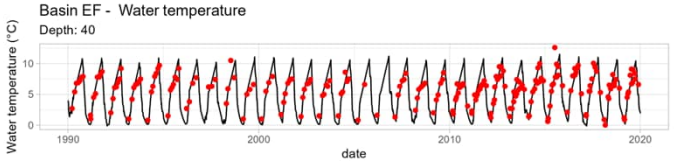




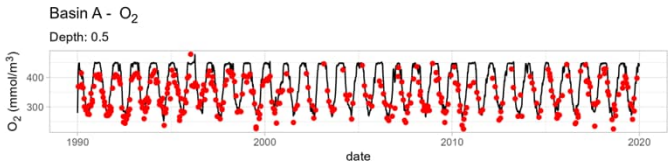


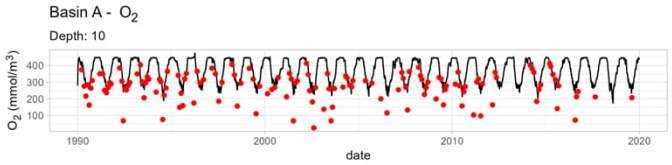


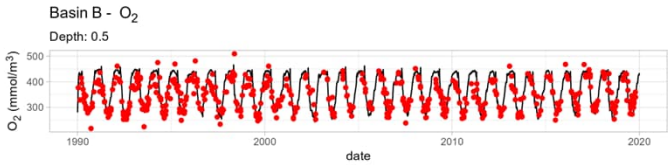


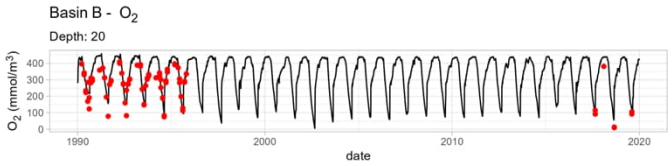


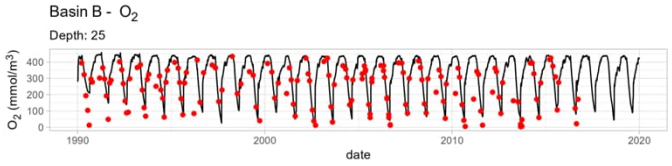
1D model calibration - Oxygen

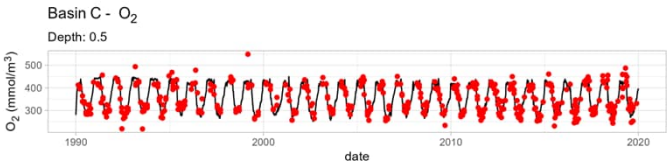


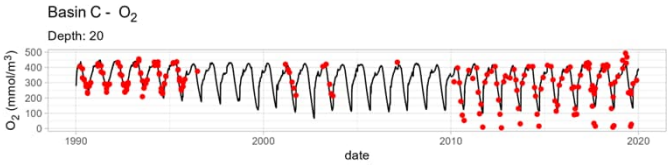


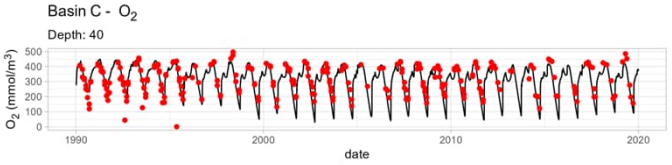


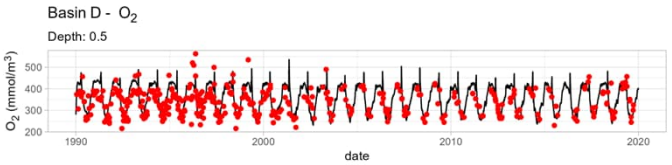


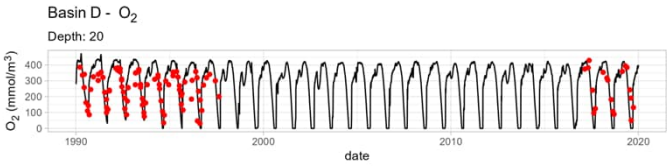


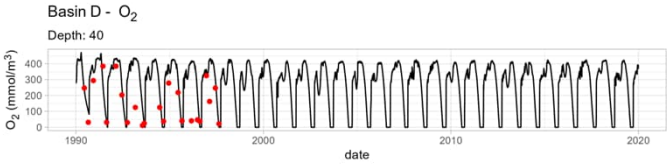


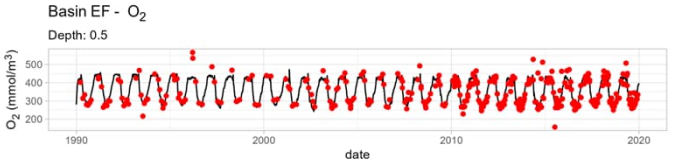


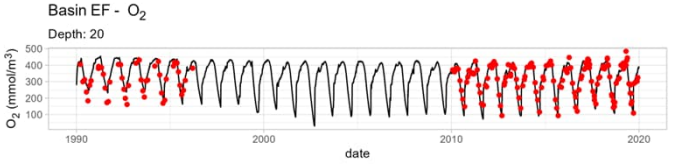


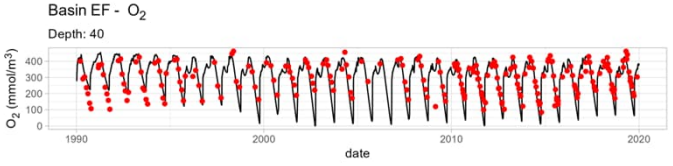




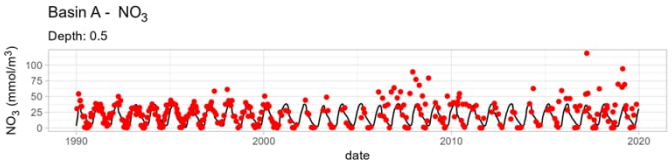


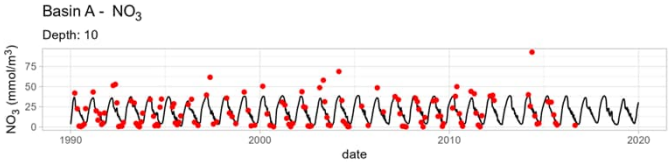


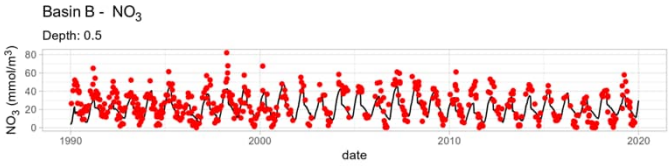


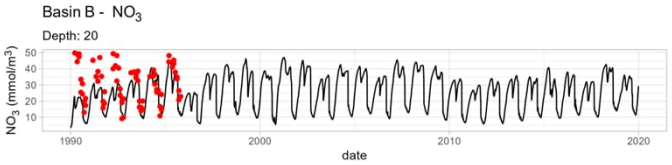


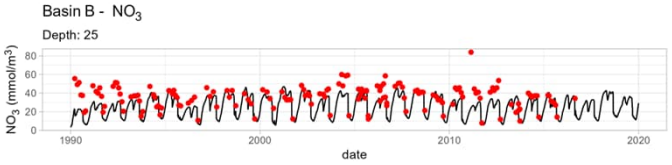
1D model calibration - Nitrate

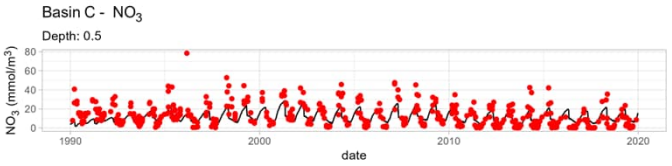


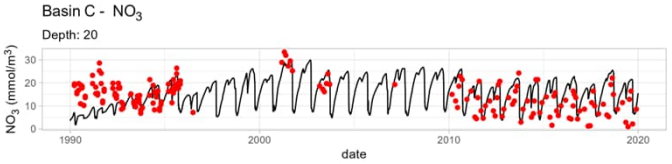


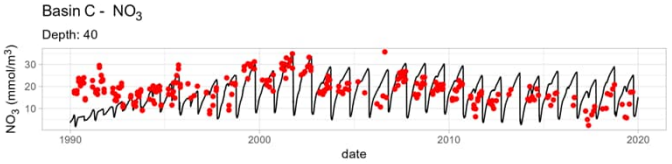


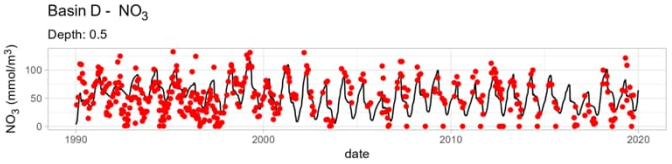


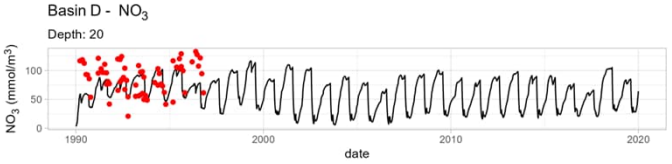


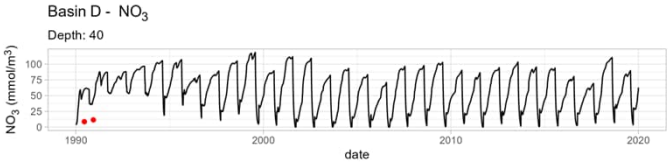


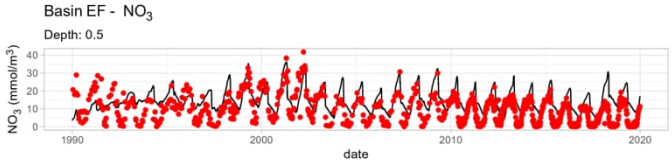


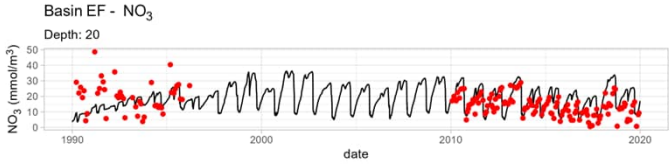


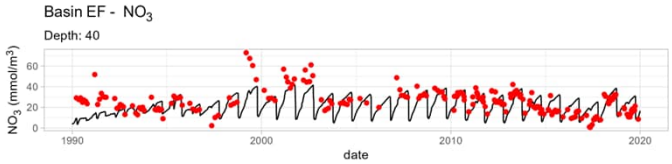




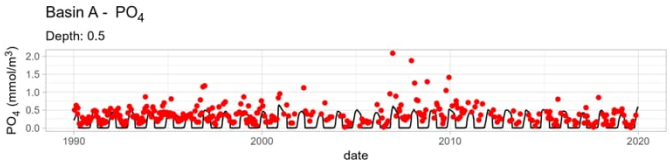


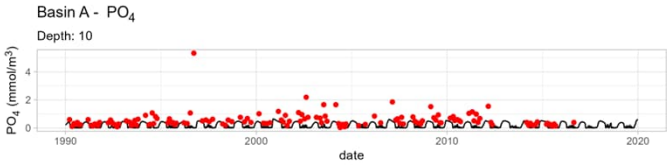


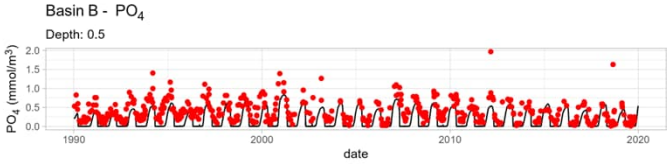


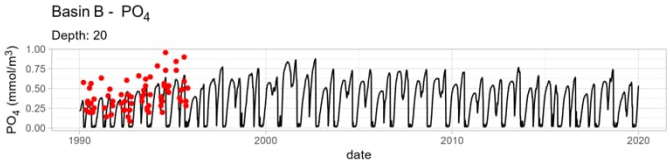


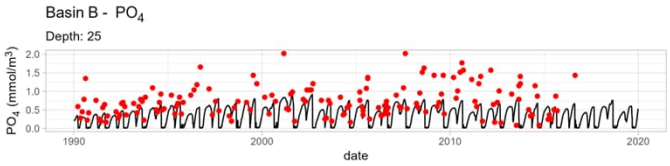
1D model calibration - Phosphate

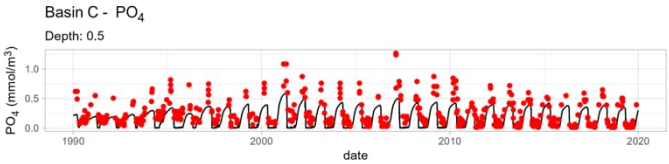


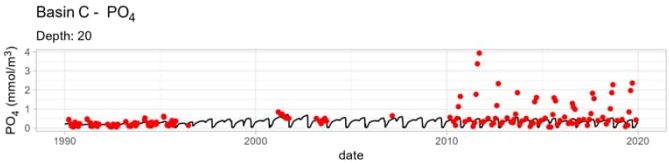


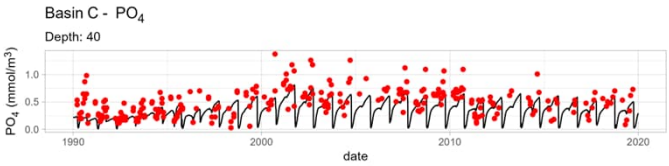


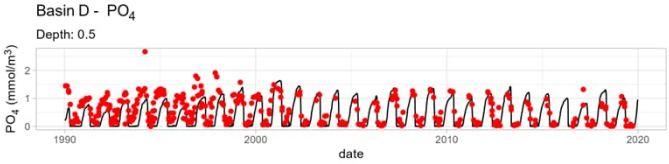


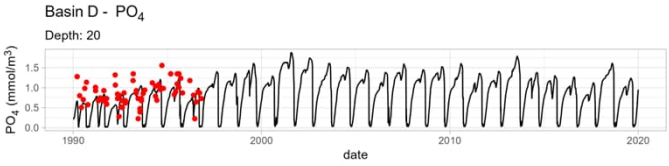


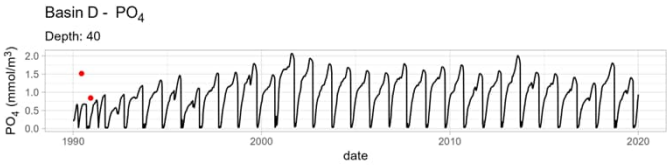


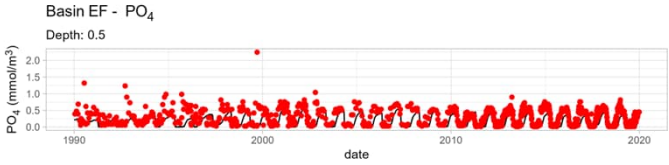


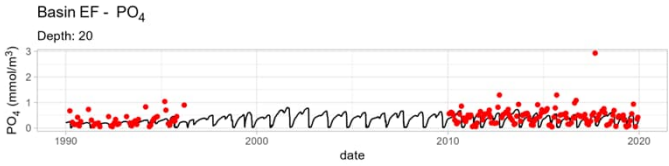


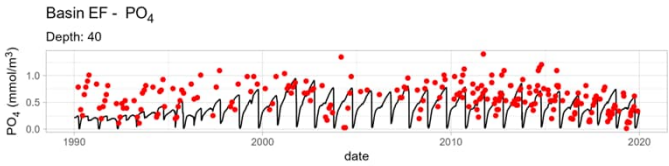




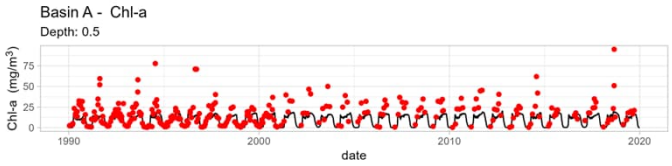


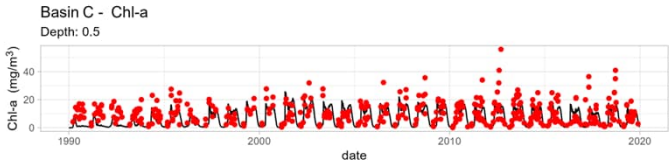


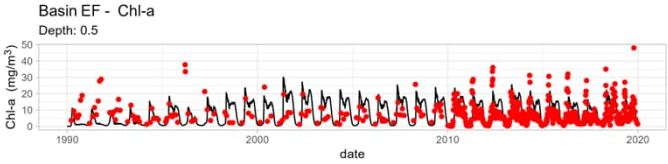


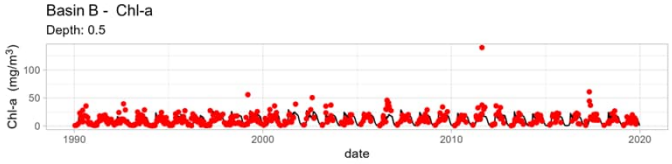


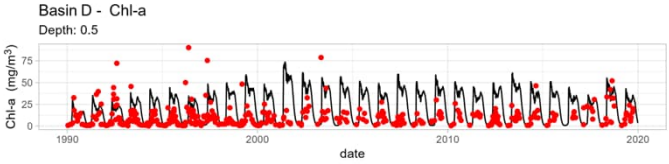
1D model calibration – Chlorophyll-a



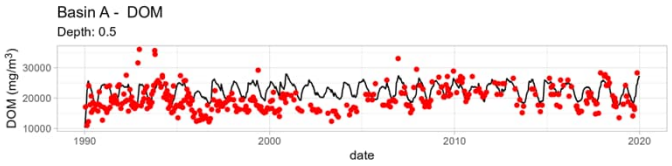


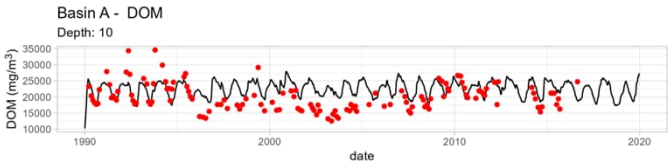


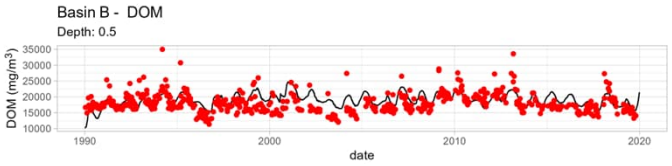


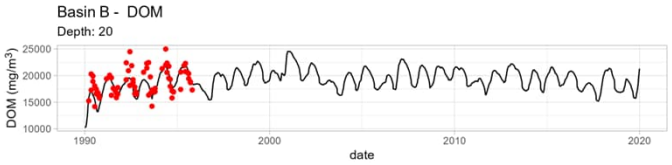


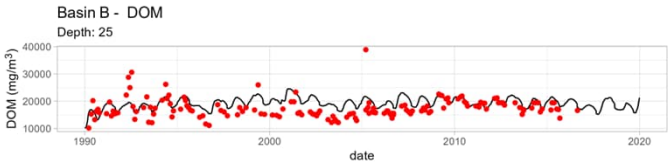
1D model calibration - DOM

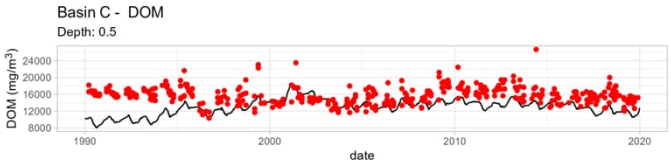


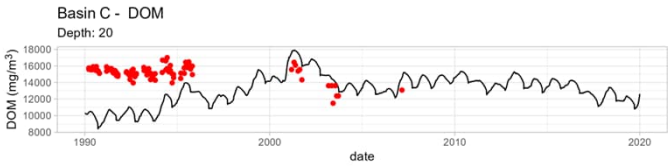


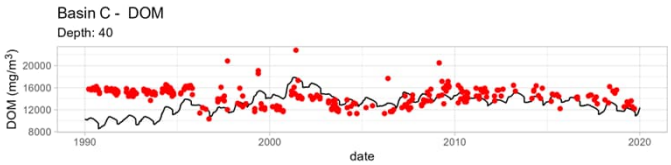


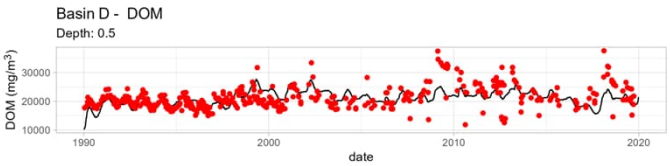


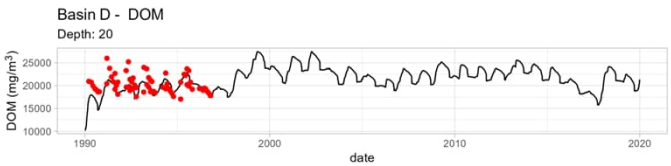


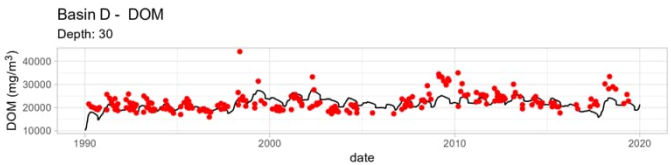


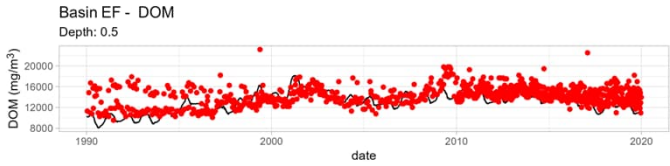


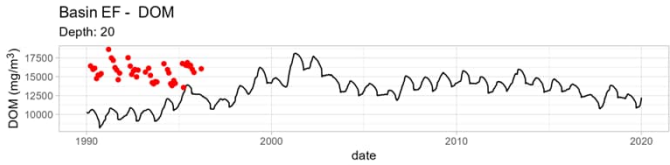


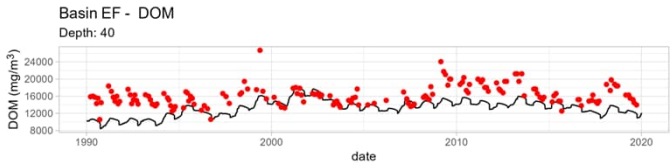












Application of Calibration to 3D

- Sadly didn’t manage to retry this with the latest calibration…
- This is the most critical part of the workflow and I’m looking for suggestions in case this does not work well…

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?