S1. Model performance time series

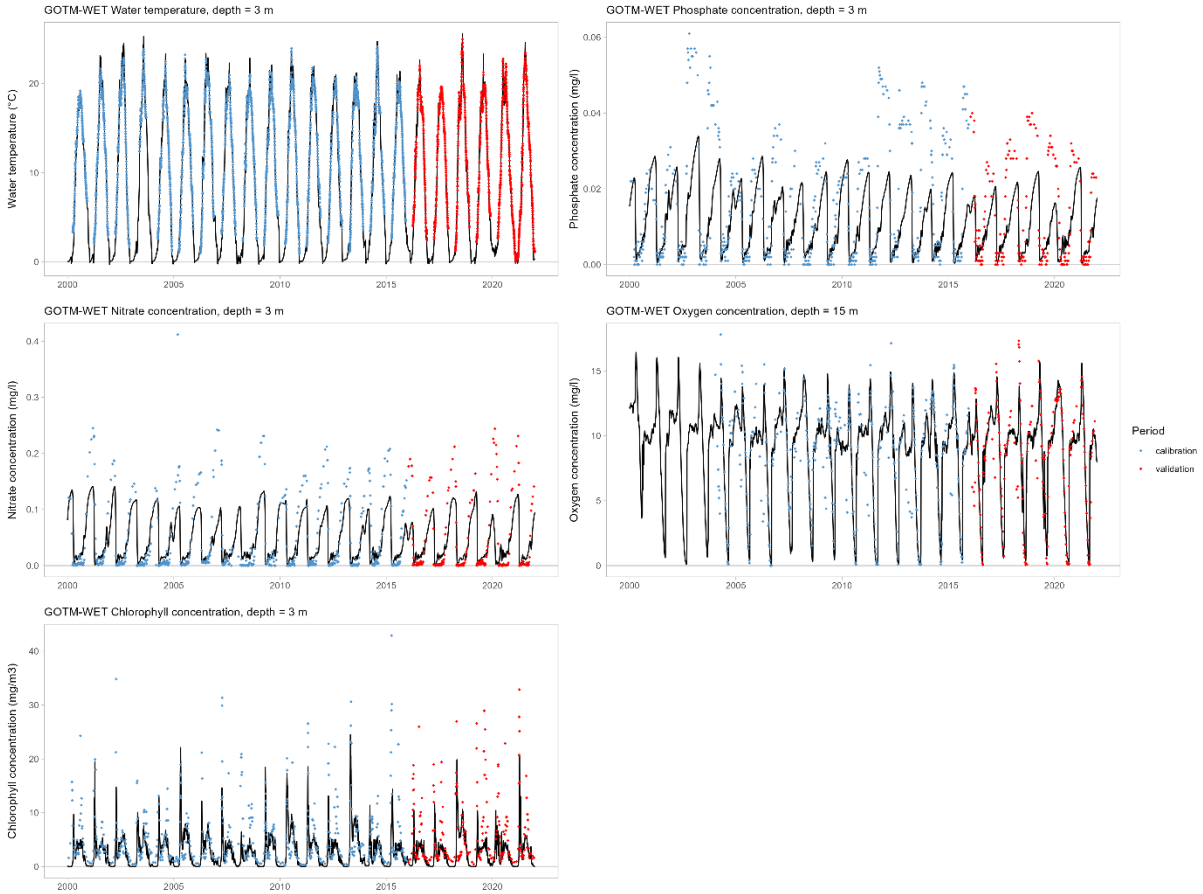


Figure S1. Time series of modelled (black line) and observed (blue dots for calibration, red dots for validation period) GOTM-WET variables.

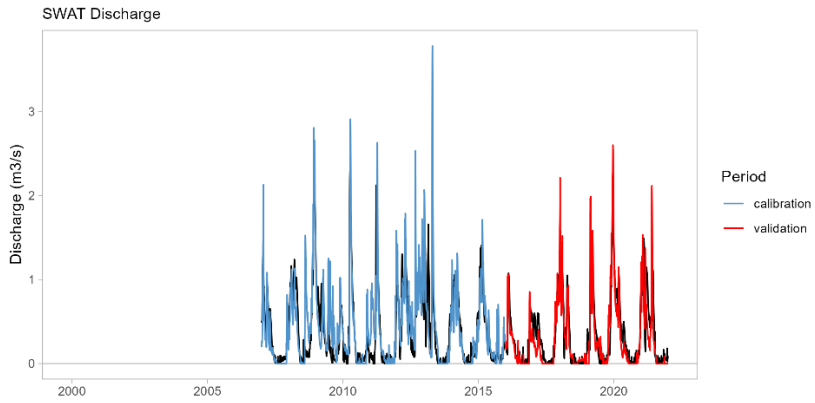


Figure S2. Time series of modelled (black line) and observed (blue line for calibration, red line for validation period) discharge.

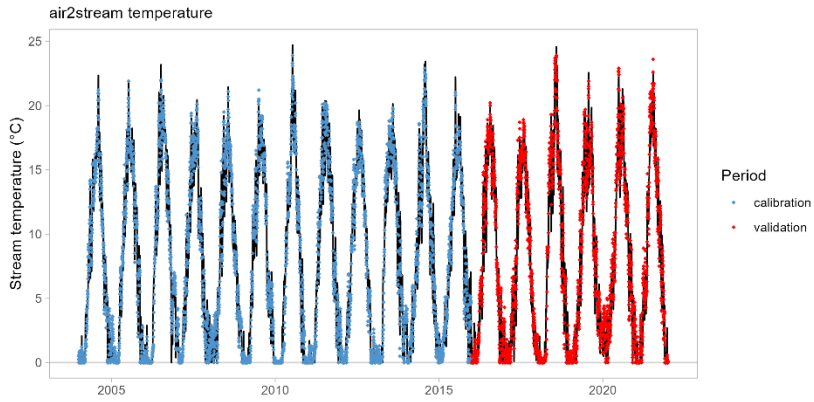


Figure S3. Time series of modelled (black line) and observed (blue dots for calibration, red dots for validation period) stream temperature.

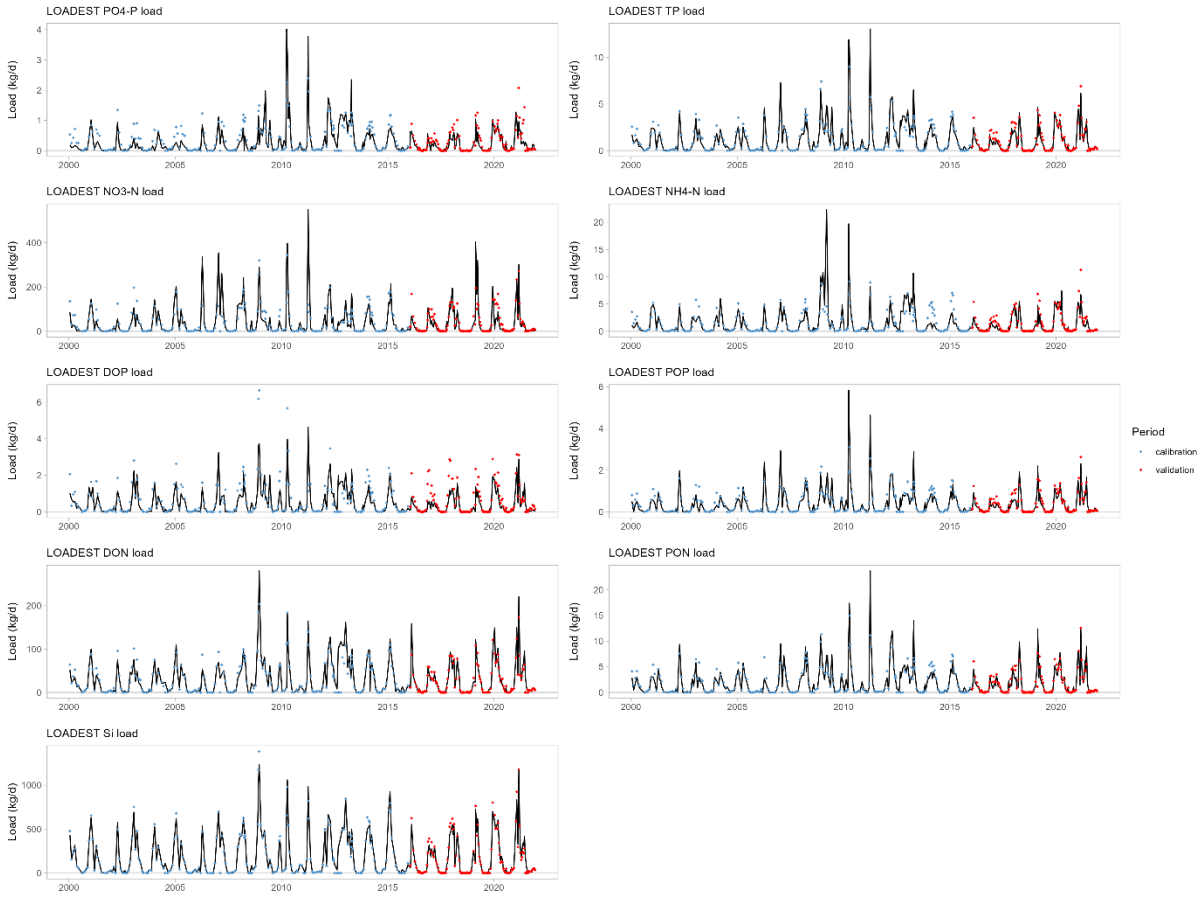
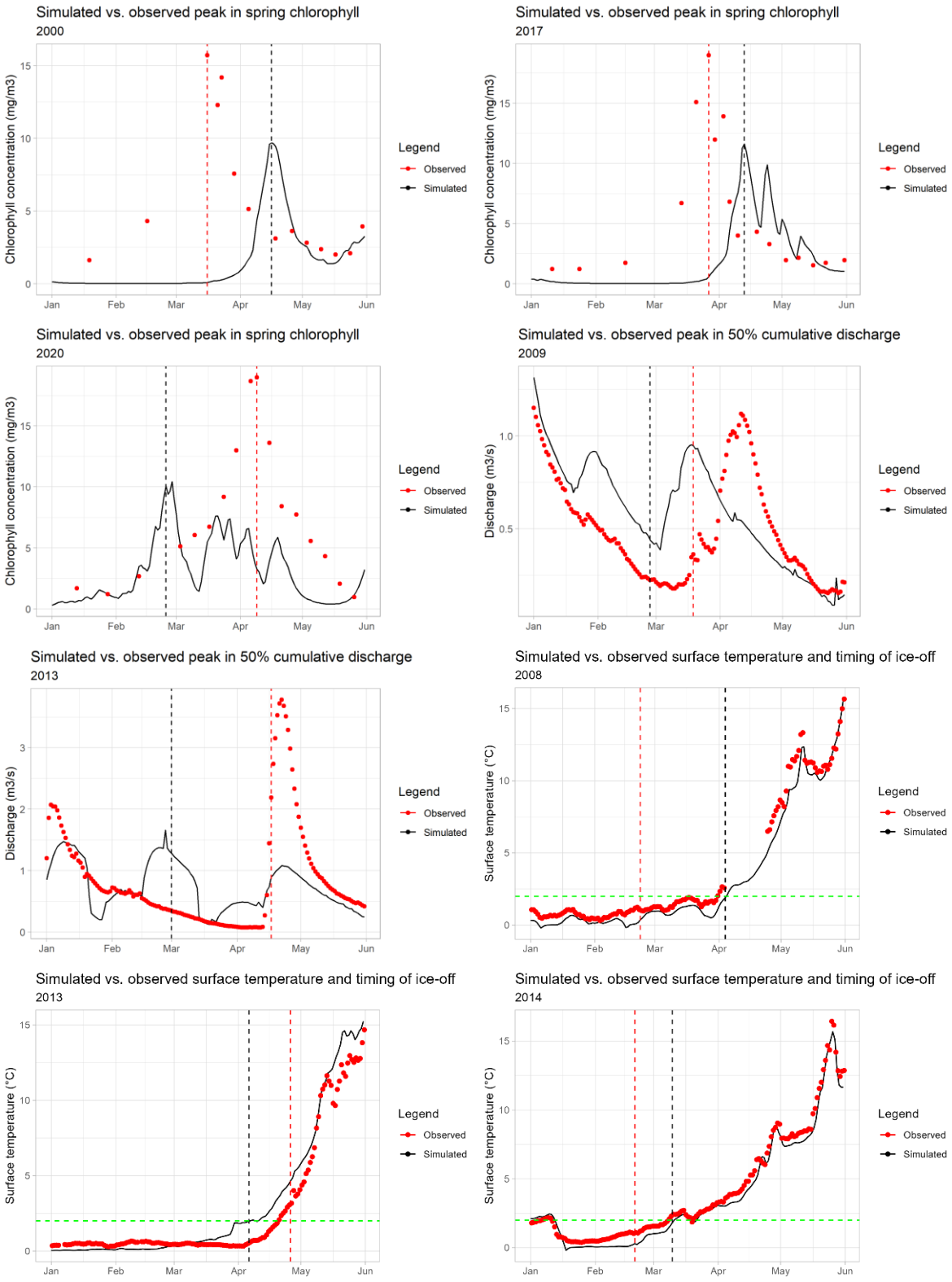


Figure S4. Time series of modelled (black line) and observed (blue dots for calibration, red dots for validation period) nutrient loads. Nutrient concentrations were simulated with LOADEST statistical models and both the observed and simulated concentrations were fitted to simulated discharges.

S2. Investigation of events with an error larger than 14 days



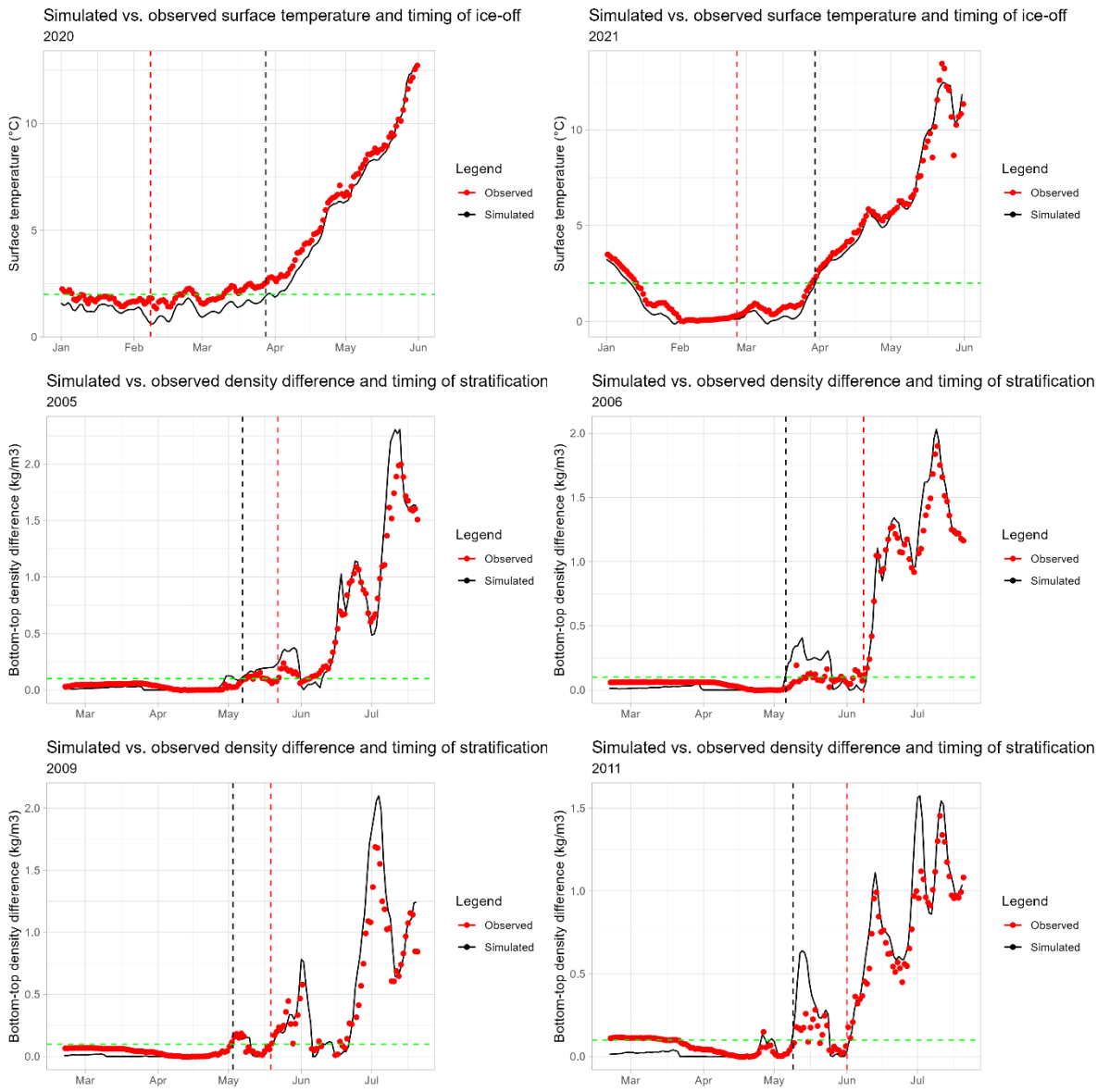


Figure S5. Plots of simulated (black line) and observed (red dots) values related to the peak in chlorophyll, date of ice-off, date of 50% cumulative spring discharge, and onset of stratification, where error values exceeded 14 days. Vertical dashed lines indicated the timing calculated for the simulations (black) and observations (red). A horizontal green line is plotted to denote the threshold values for simulated timing of ice-off (2 °C) and density-difference for onset of stratification (0.1 kg/m^3).

Table S1. Reason for bad fit for each of the events plotted in Figure S5. "Model failure" indicates that the model did not capture the dynamics of the lake. "Method failure" indicated that the method to identify the peak was the main cause of the discrepancy between model and observations, rather than the inability of the model to capture in-lake dynamics.

Year	Event	Reason for bad fit
2000	Chlorophyll peak	Model failure. Perhaps related to a short spin-up period
2017	Chlorophyll peak	Model failure
2020	Chlorophyll peak	Either model failure or a gap in observations missed the real first spring peak. Observations before and after the simulated peak are in line with the simulation, but there is an observation gap of 20 days, in which the model simulated a peak in chlorophyll, which cannot be confirmed by measurements.
2009	Discharge peak	Model failure
2013	Discharge peak	Model failure
2008	Ice-off	Method failure
2013	Ice-off	Model failure and method failure
2014	Ice-off	Method failure
2020	Ice-off	Method failure
2021	Ice-off	Method failure
2005	Stratification onset	Method failure. A temporary stratification event lasted slightly longer than 7 days in the simulation and slightly shorter in the observations, causing a mismatch. The start of the permanent stratification period was simulated well.
2006	Stratification onset	Same as above
2009	Stratification onset	Same as above
2011	Stratification onset	Same as above

S3. Mann-Kendall test results for the relative comparisons

Table S2. Results of Mann-Kendall trend tests for relative trends of the timing of spring events during the future climate scenarios.

Variable	Relative to	SSP	p-value	Sen's slope (days/decade)	Intercept (days)
50% spring discharge	Chlorophyll peak	2-45	0.994	0	-27.40
Ice-off	Chlorophyll peak	2-45	0.555	0.3	-4.58
50% spring discharge	Ice-off	2-45	0.766	-0.12	-24.90
Chlorophyll peak	Stratification onset	2-45	0.001	-1.23	-31.26
50% spring discharge	Stratification onset	2-45	$4.8 \cdot 10^{-4}$	-1.07	-62.99
Ice-off	Stratification onset	2-45	$5.6 \cdot 10^{-6}$	-0.94	-34.57
50% spring discharge	Chlorophyll peak	5-85	$3.7 \cdot 10^{-4}$	1.12	-33.51
Ice-off	Chlorophyll peak	5-85	0.388	-0.21	-5.18
50% spring discharge	Ice-off	5-85	$3.6 \cdot 10^{-4}$	1.44	-31.35
Chlorophyll peak	Stratification onset	5-85	$2.0 \cdot 10^{-10}$	-1.87	-31.36
50% spring discharge	Stratification onset	5-85	0.103	-0.58	-66.66
Ice-off	Stratification onset	5-85	$3.4 \cdot 10^{-15}$	-2.00	-33.20

S4. Surface water temperature, nitrate, and phosphate concentrations, underwater shortwave radiation during the spring chlorophyll peak

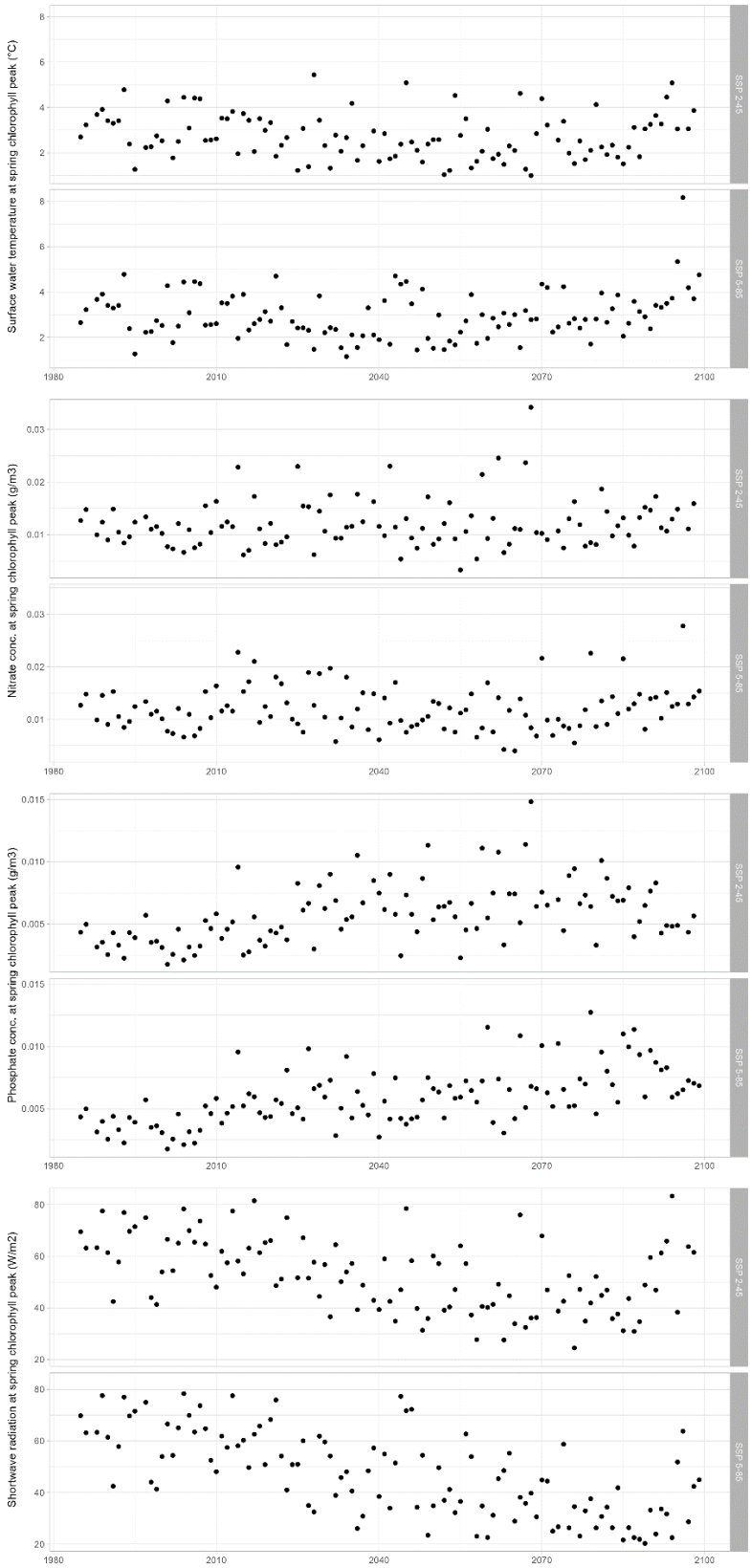


Figure S6. Surface water temperature, nitrate concentration, phosphate concentration, and underwater shortwave radiation (top to bottom) at 0.5 m depth during the spring chlorophyll peak, averaged over all GCMs, for both SSP 2-45 and SSP 5-85.

S5. Zooplankton dynamics

The zooplankton simulations could not be compared to detailed field data and the concentrations simulated by the model are unlikely to be in line with observations, as also predators of zooplankton (e.g. fish) were absent in the simulations. Although zooplankton grazing on phytoplankton is indeed likely to occur throughout the year, especially the summer zooplankton concentrations would be strongly suppressed by fish predation in Lake Erken. These results are shown primarily as supporting information for how they may have influenced the simulated phytoplankton dynamics.

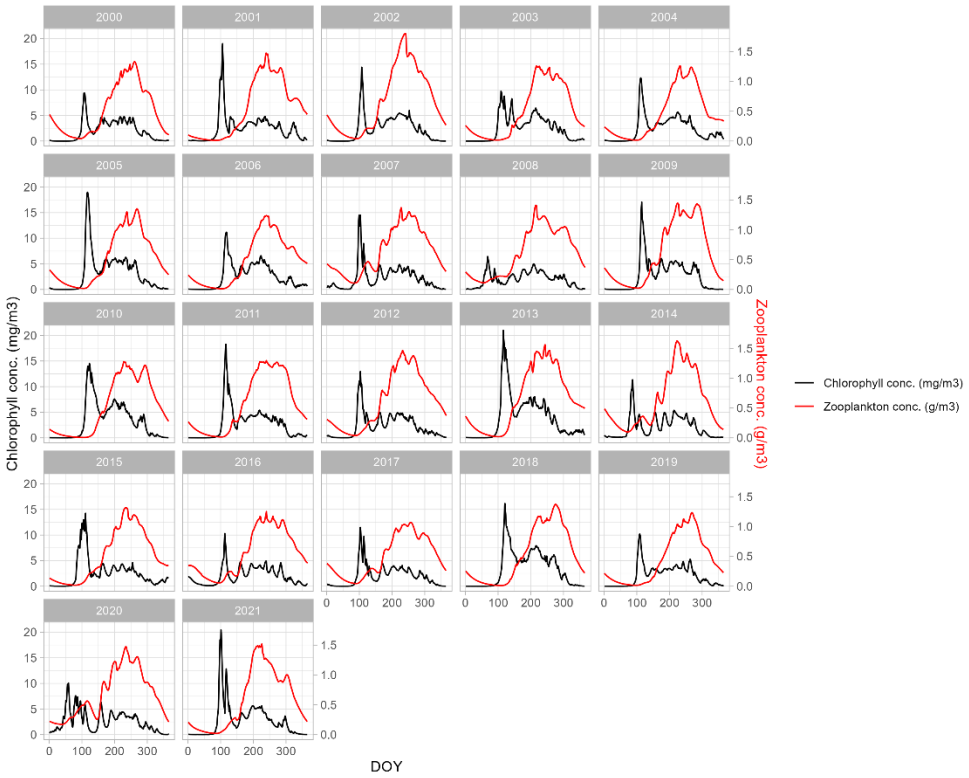


Figure S7. Chlorophyll (black line, left y-axis) and zooplankton concentration (red line, right y-axis) per day-of-the-year (DOY), for every year in the calibration run. Simulated concentrations at 0.5 m depth are shown.

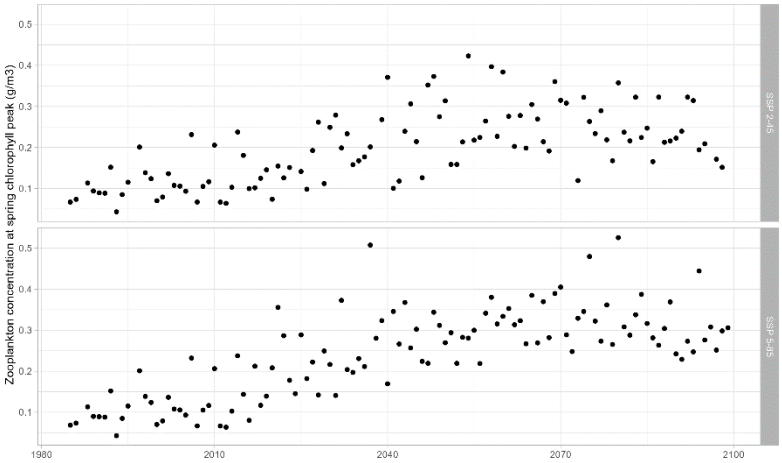


Figure S8. Zooplankton concentration at 0.5 m depth during the spring chlorophyll peak, averaged over all GCMs, for both SSP 2-45 and SSP 5-85 (top and bottom panel, respectively).