

Extreme Events in The Ohra Resrvoir

*Detection of compound heatwave, bloom and inflow events
using heatwaveR*

2008 – 2024 | GOTM Model Output

What is heatwaveR?

- R package for detecting extreme events in any continuous time series
- Originally designed for marine heatwaves (Hobday et al. 2016)
- Applied here to: surface temperature, chlorophyll-a, and inflow
- Two steps: (1) build a climatology → (2) detect events above the threshold and min duration
- Output: event tables with dates, duration, intensity, and category

Variables analysed

Surface temperature (0–11 m) [°C]

Chlorophyll-a (0–11 m) [mg m⁻³]

Total inflow [m³ s⁻¹] ?? should we go to individual streams?

Key Concepts

Climatology

Smoothed daily average over the reference period (2008–2024). What is 'normal' for each day of the year.

Threshold

90th percentile for each day of the year. An event starts when the observed value exceeds this for ≥ 5 consecutive days.

Intensity

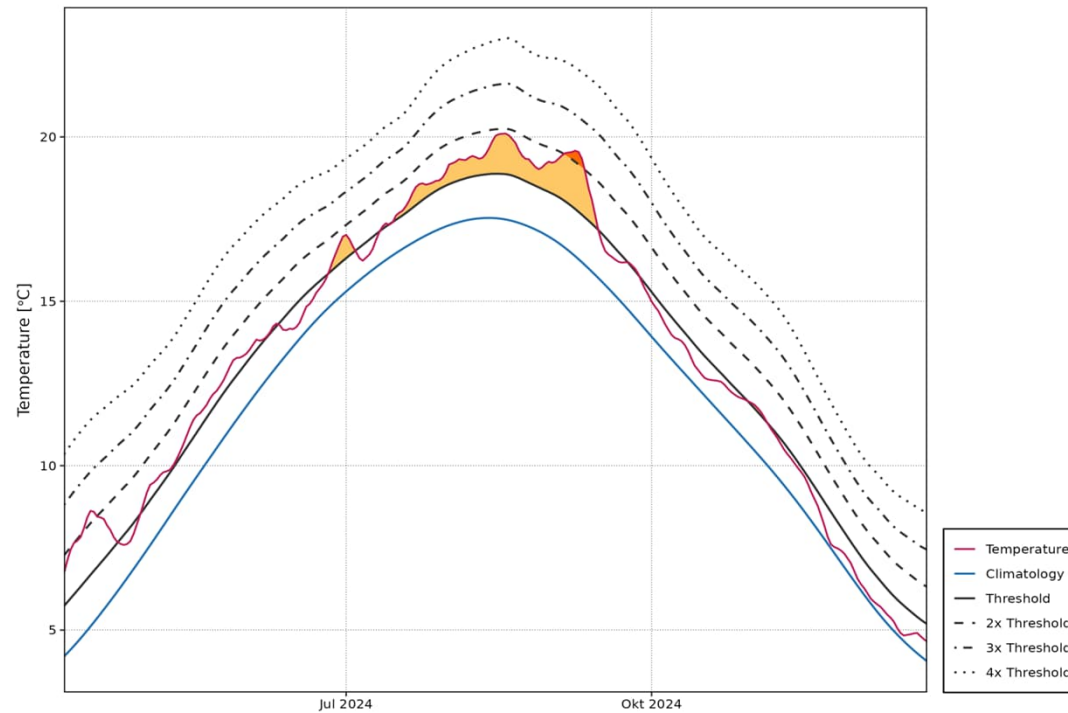
How far above the threshold the observed value is.

- Max intensity = peak exceedance
- Cumulative = total area above threshold

Categories

I Moderate (1×) II Strong (2×)
III Severe (3×) IV Extreme (4×)
Based on multiples of the threshold exceedance.

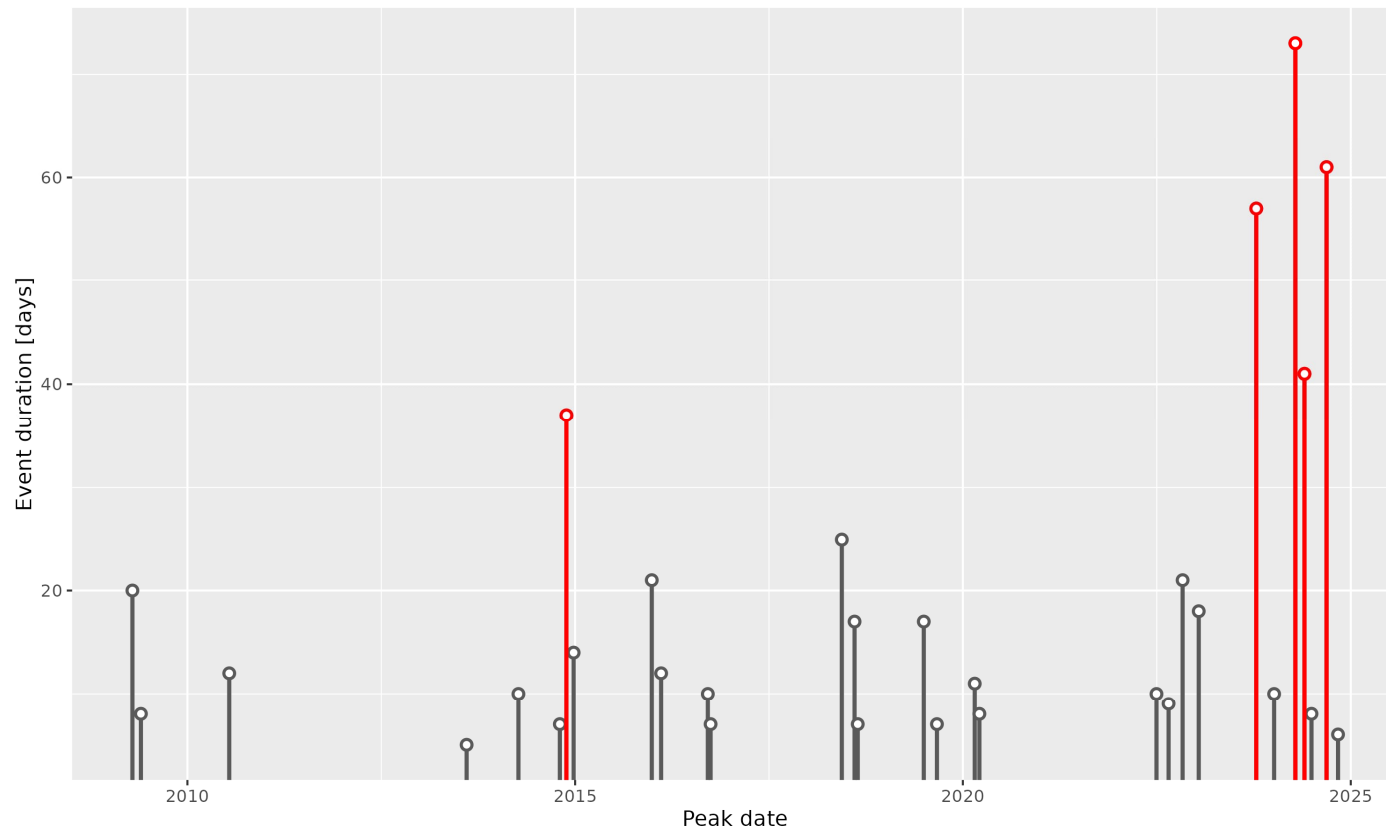
Temperature Extreme Events — Overview



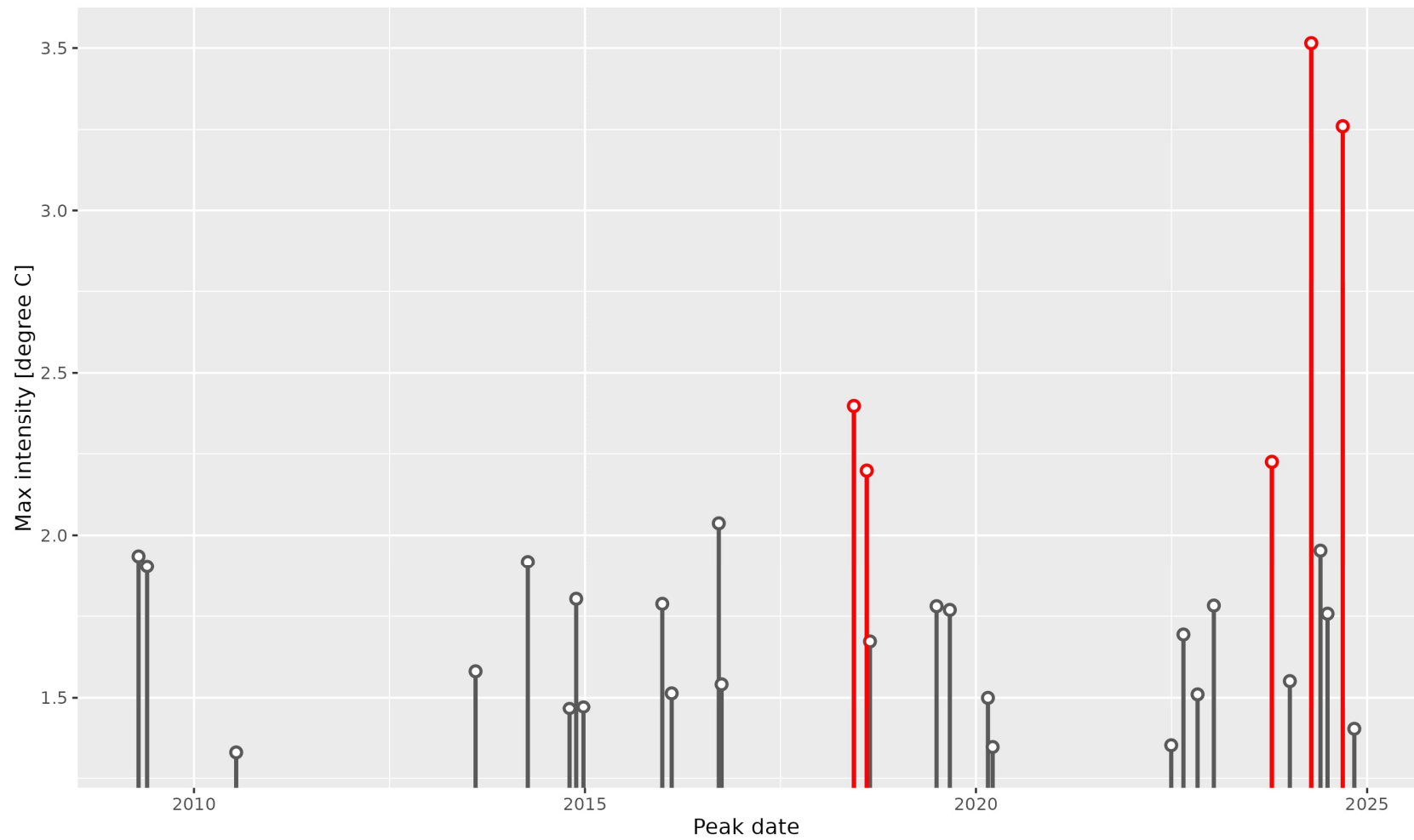
Duration × Cumulative intensity

Events cluster in summer. The 2024 spring event stands out in both duration and intensity.

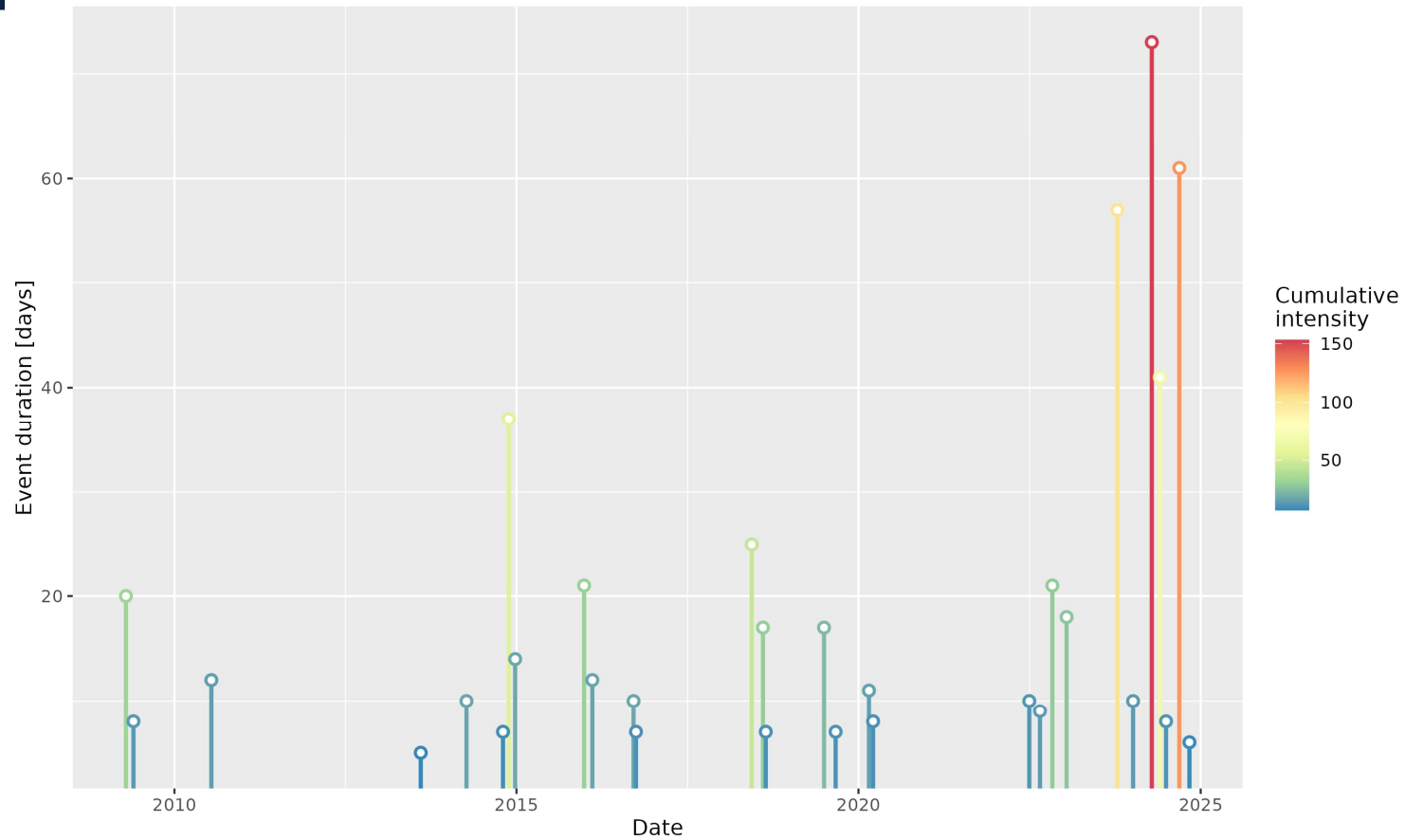
Temperature Extreme Events — Overview



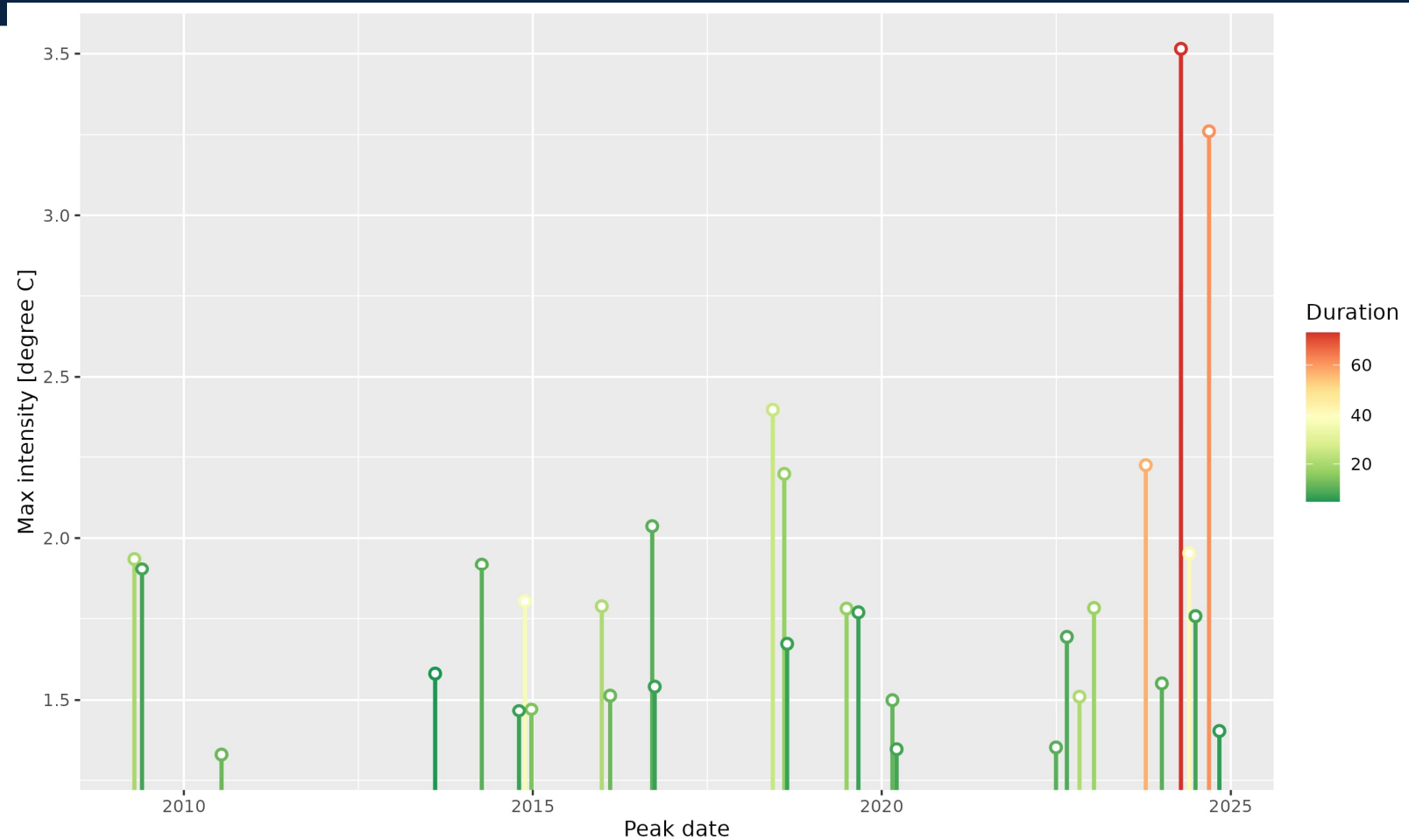
Temperature Extreme Events — Overview



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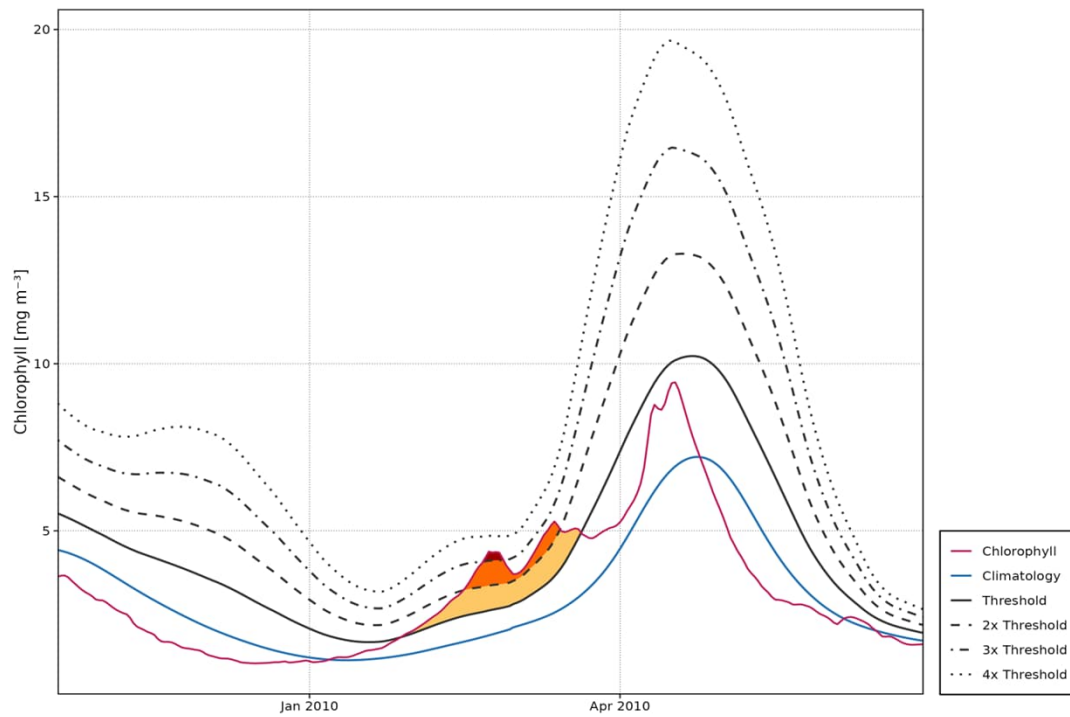


Temperature Events — Detection Output (subset)

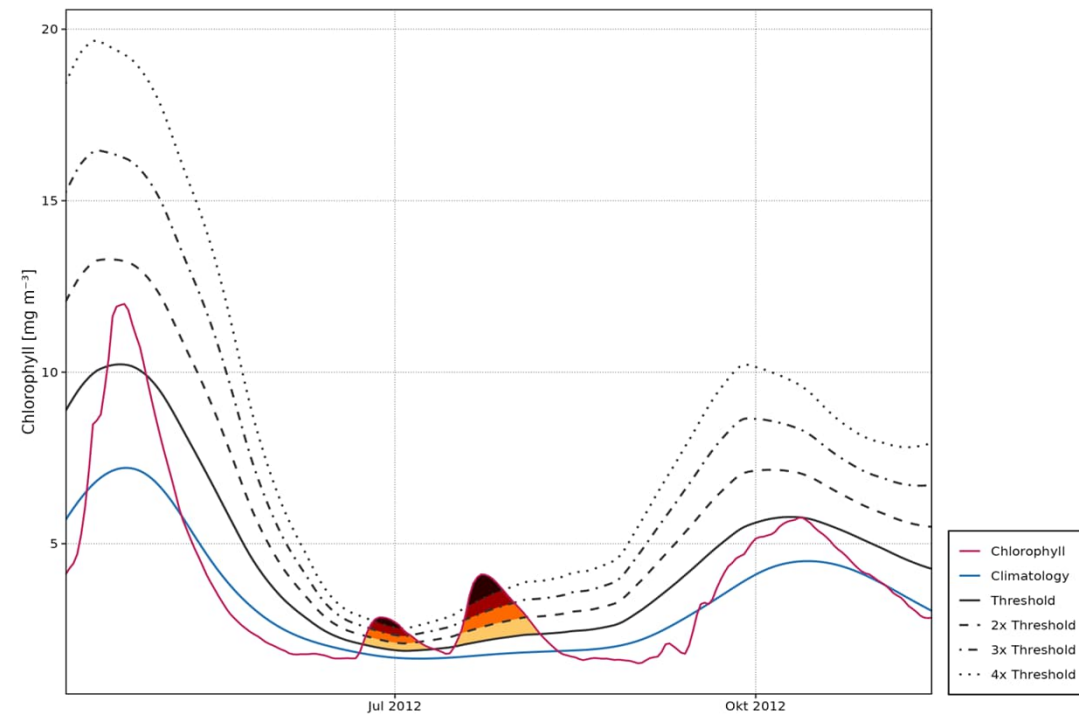
Peak date	Start	End	Duration (d)	Max intensity	Cumul. intensity	Category	Strat?
2018-08-09	2018-07-28	2018-08-13	17	2.20	30.3	I Moderate	✓
2019-07-01	2019-06-21	2019-07-07	17	1.78	23.9	I Moderate	✓
2022-07-01	2022-06-27	2022-07-06	10	1.35	12.1	I Moderate	✓
2023-10-14	2023-09-12	2023-11-07	57	2.23	101.5	I Moderate	✓
2024-04-15	2024-02-11	2024-04-23	73	3.51	153.2	II Strong	✓
2024-09-09	2024-07-16	2024-09-14	61	3.26	126.3	II Strong	✓

Bold rows = II Strong events — both occurred in 2024 during stratification

Chlorophyll-a Extreme Events — Overview



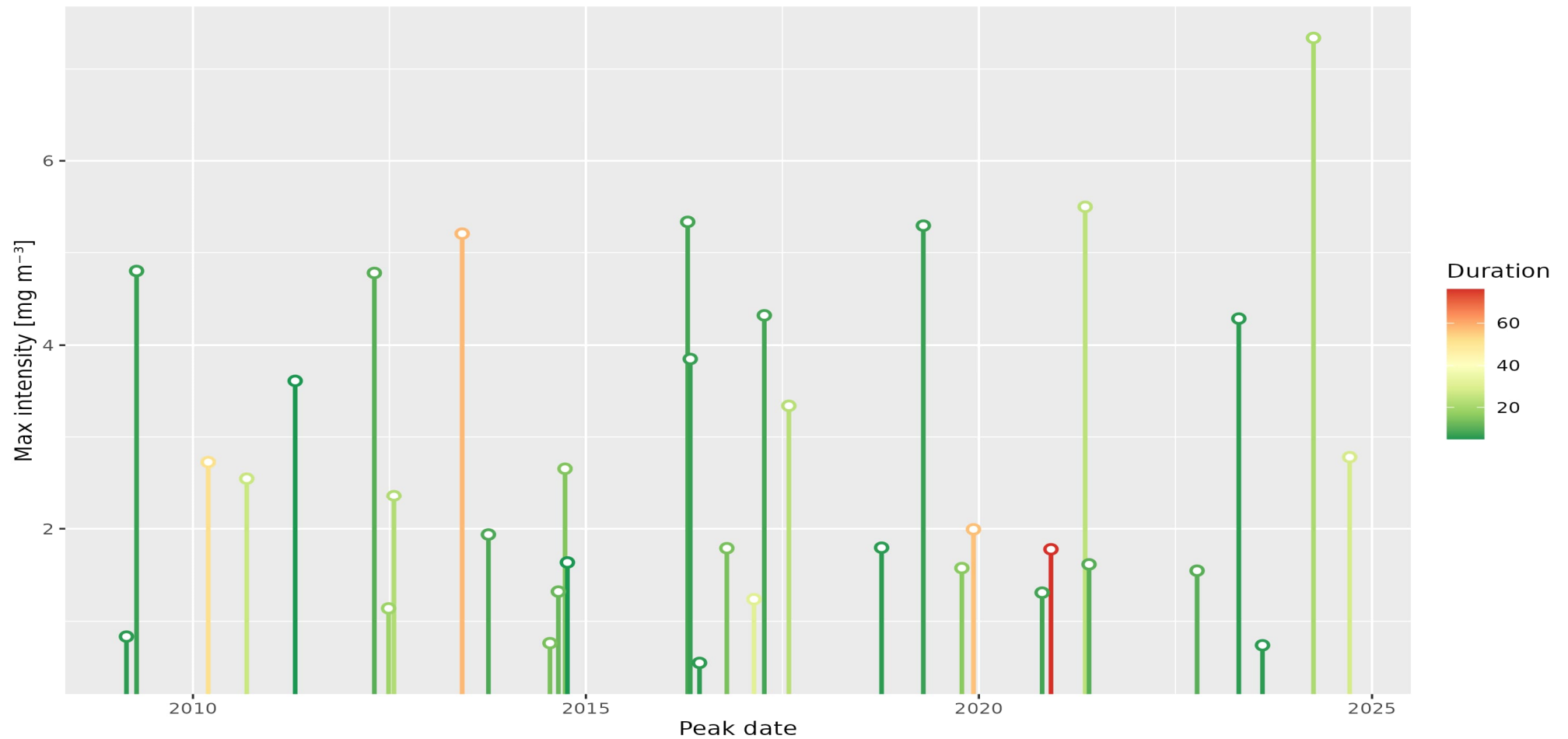
Duration × Cumulative intensity



Max intensity × Duration

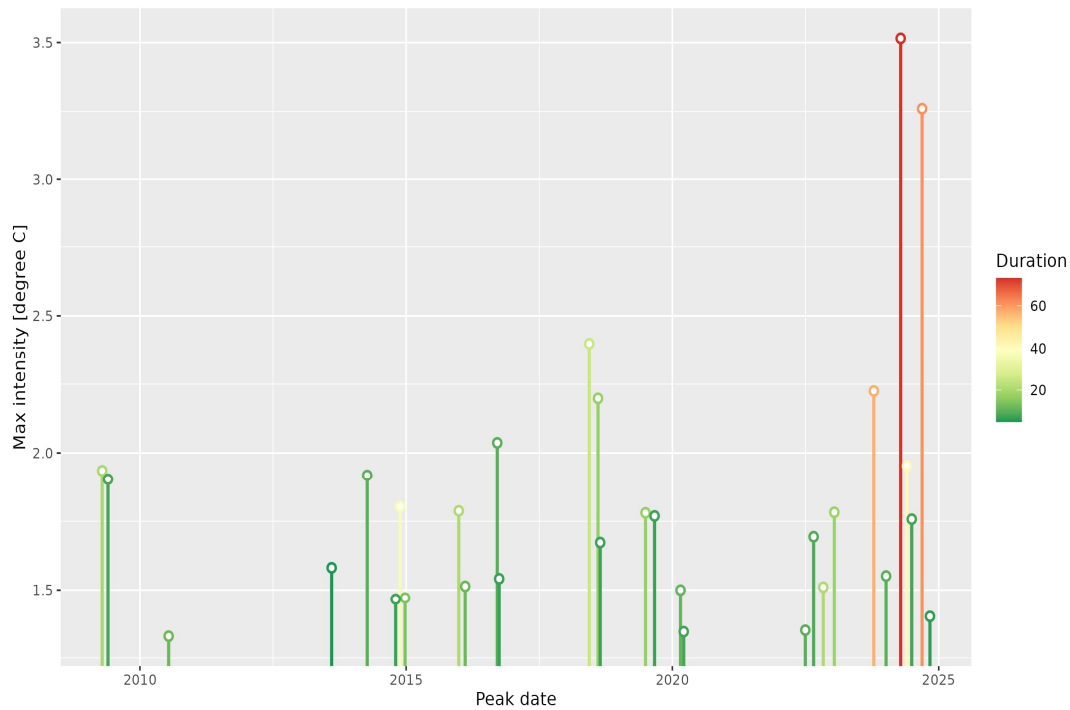
2013 event: longest bloom (58 days). 2021 event: highest cumulative intensity.

Chlorophyll Event Example — Spring 2010

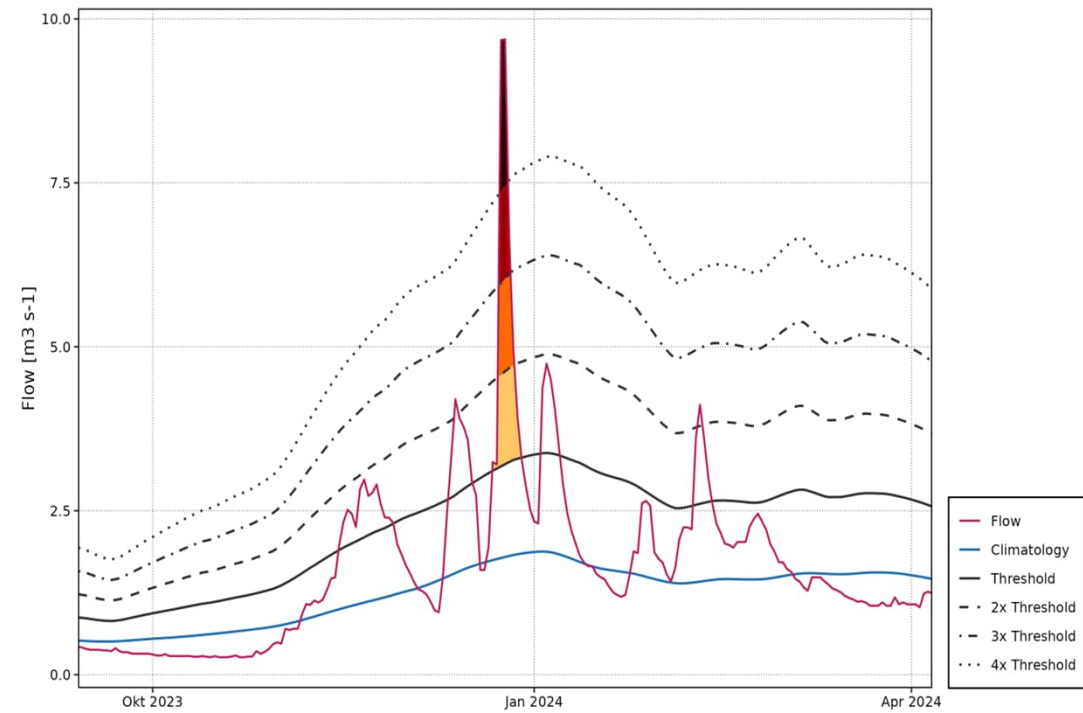


Early spring bloom — peak Mar 2010, 52 days duration. Occurs before summer stratification.

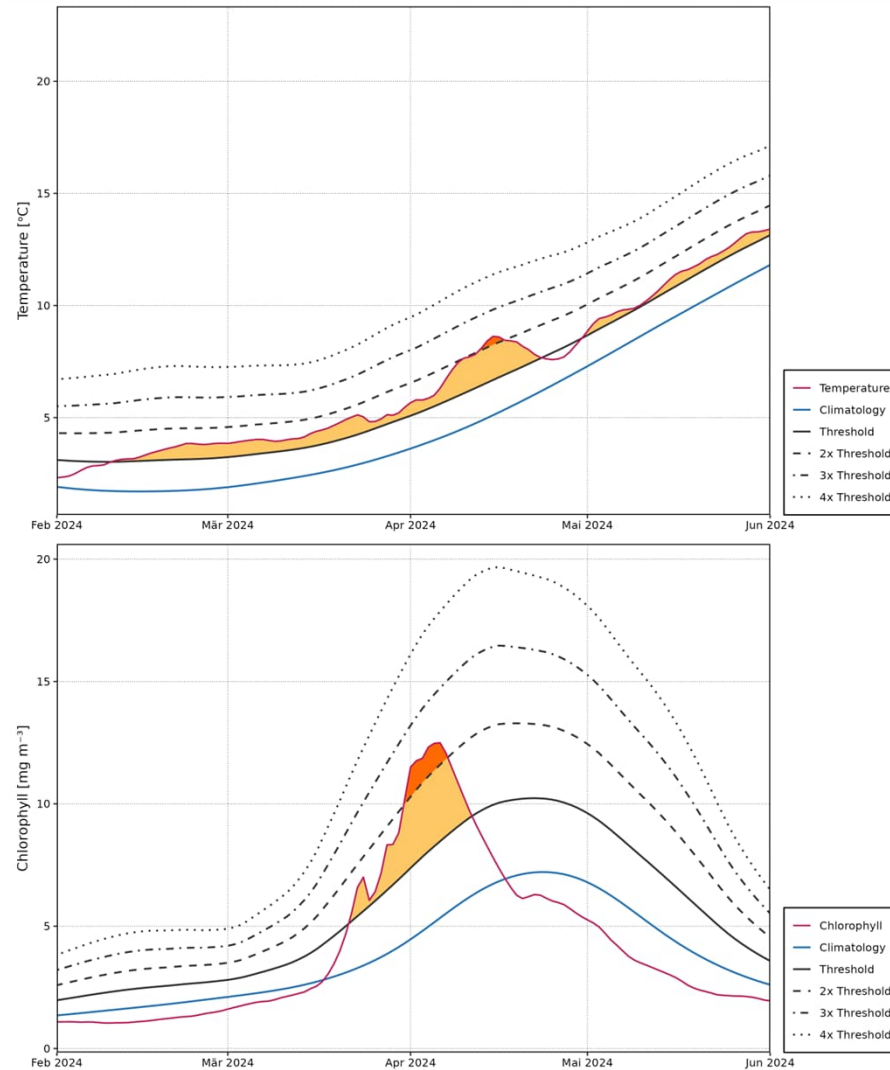
Inflow Extreme Events — Overview



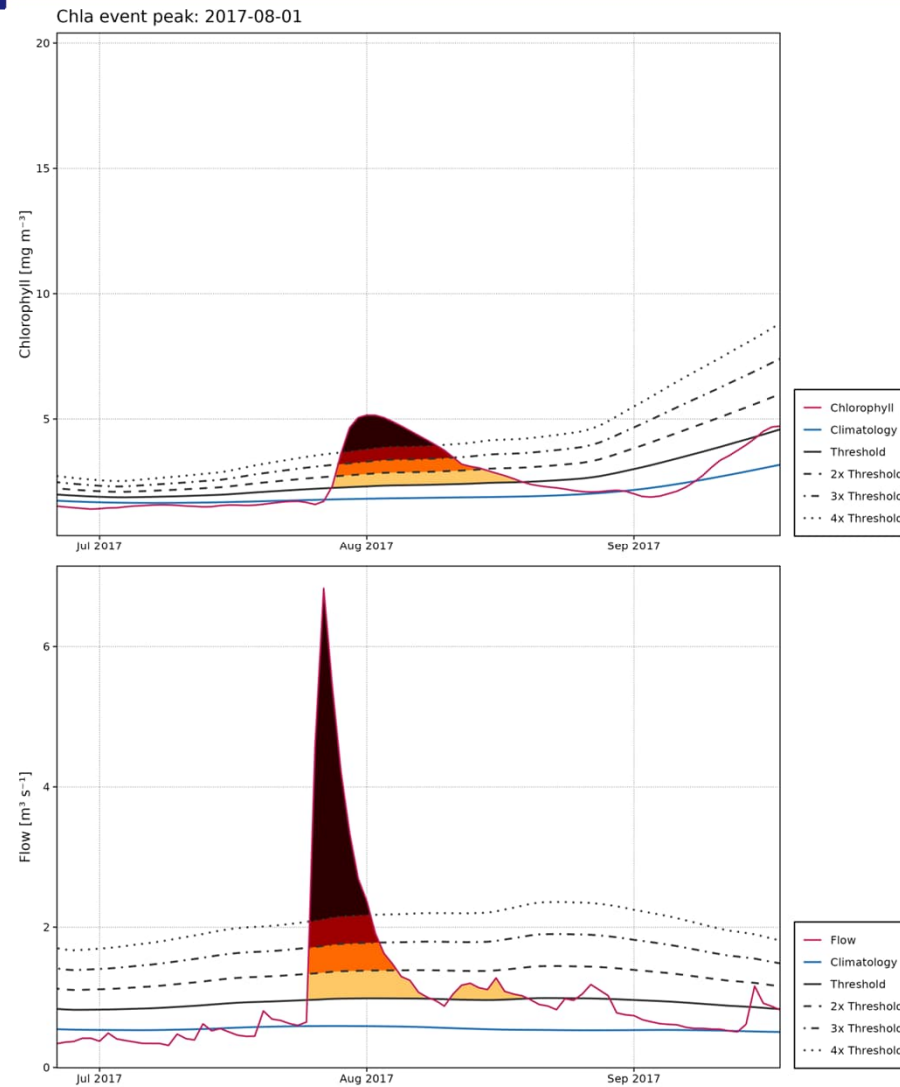
Duration × Cumulative intensity



Temp_cholorphyll Compound event

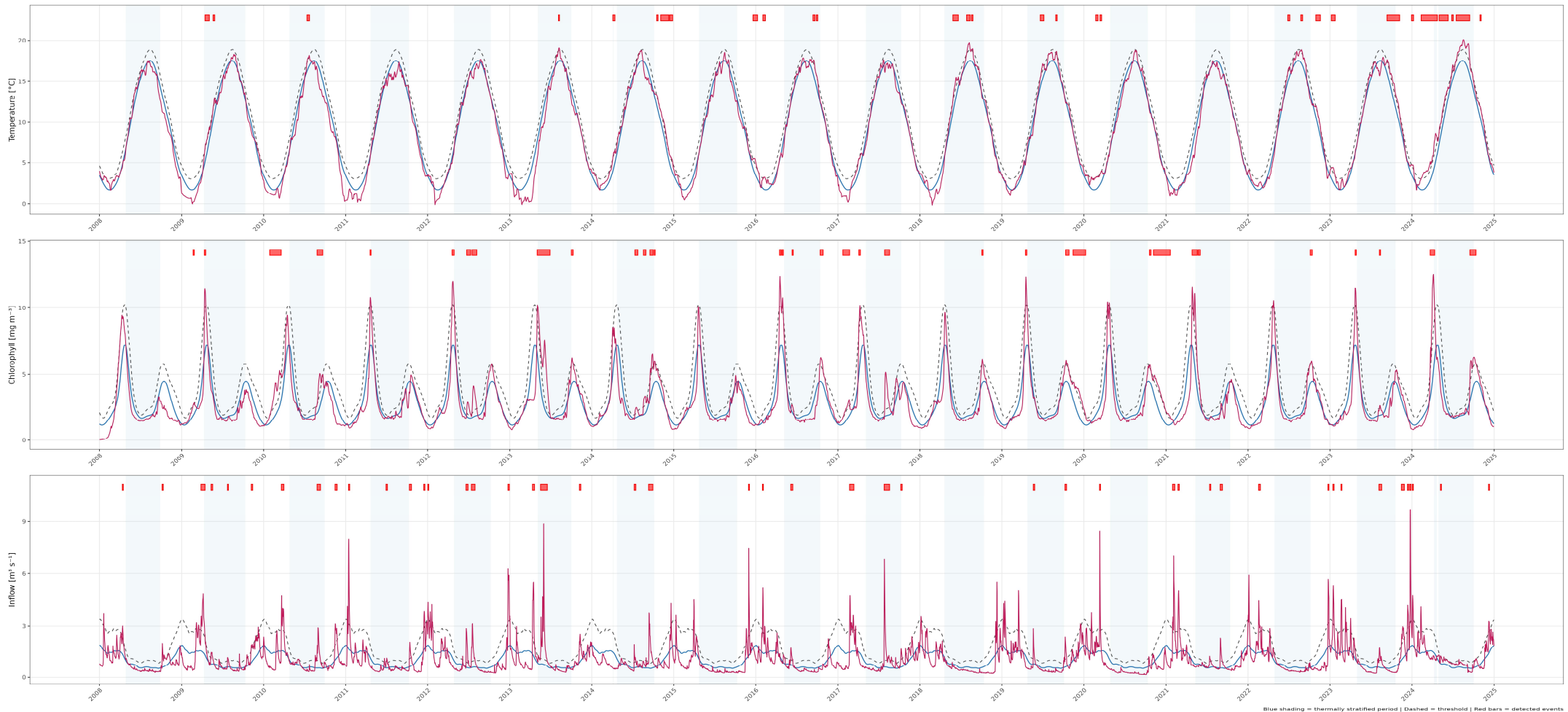


Flow_chlorophyll Compound event



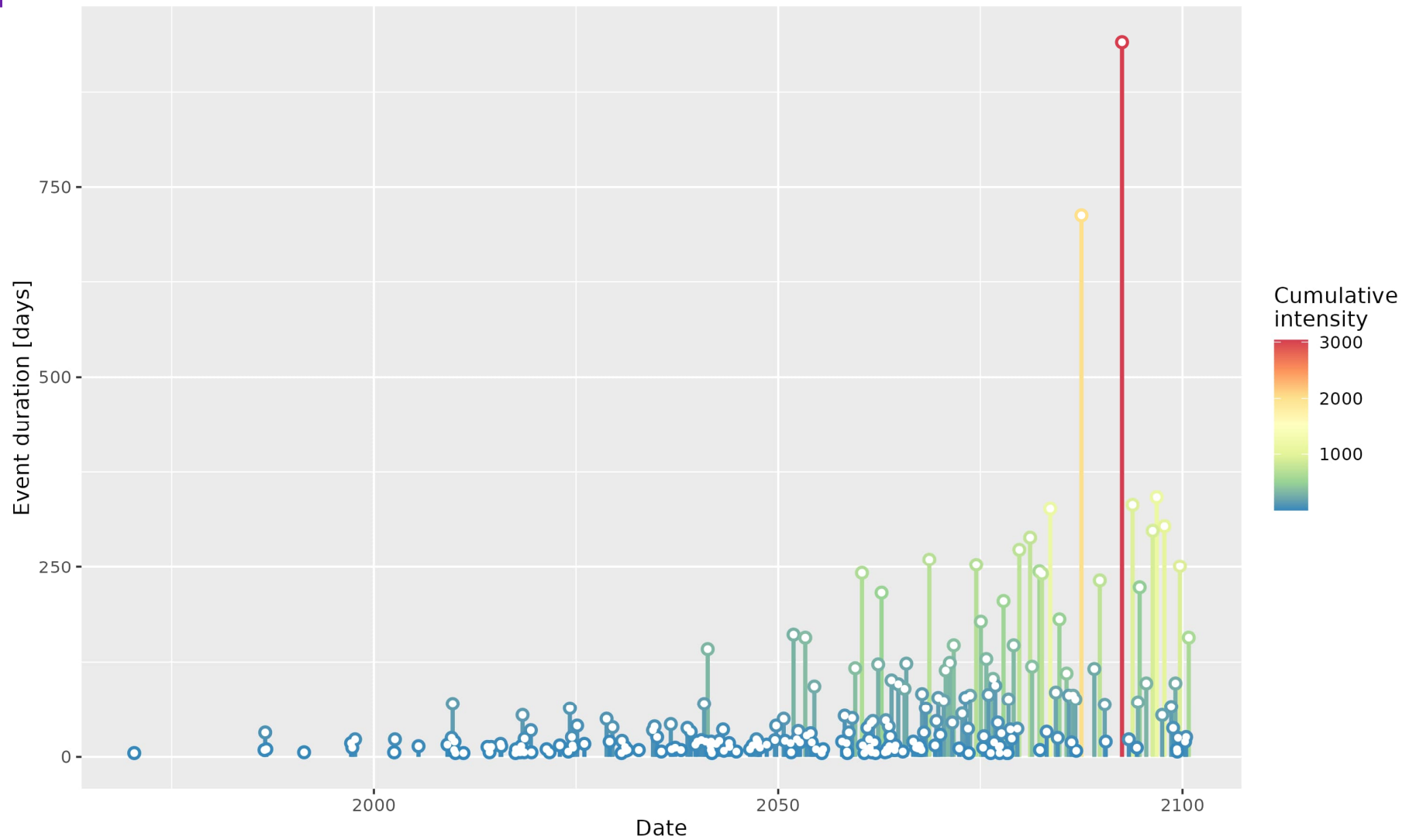
Compound Event — Temperature + Chlorophyll+ Flow

Extreme events 2008-2024

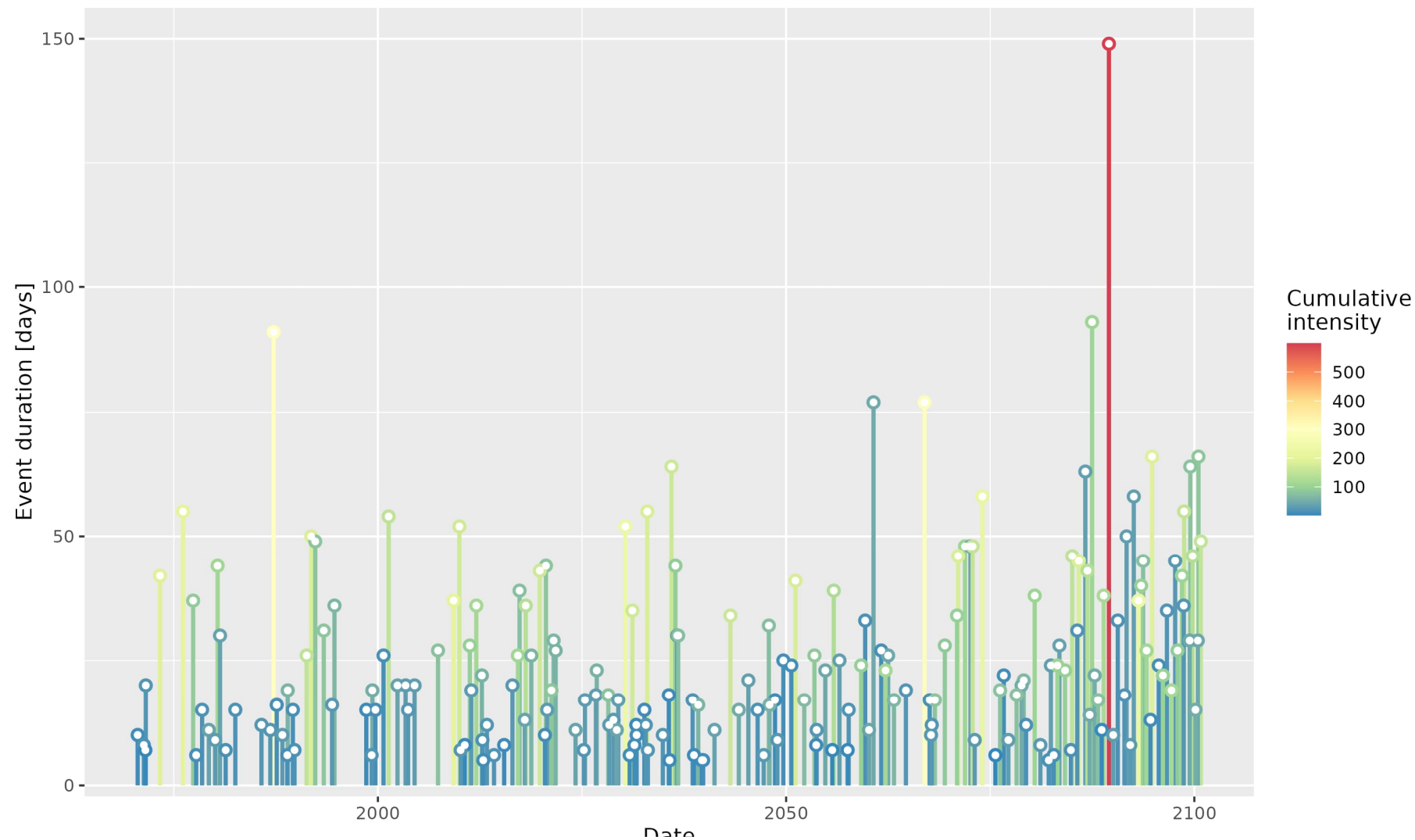


Spring 2024: simultaneous temperature heatwave (II Strong) and extreme bloom. Lake becoming stratified.

A single member of RCP 8.5 run analysis, Temperature



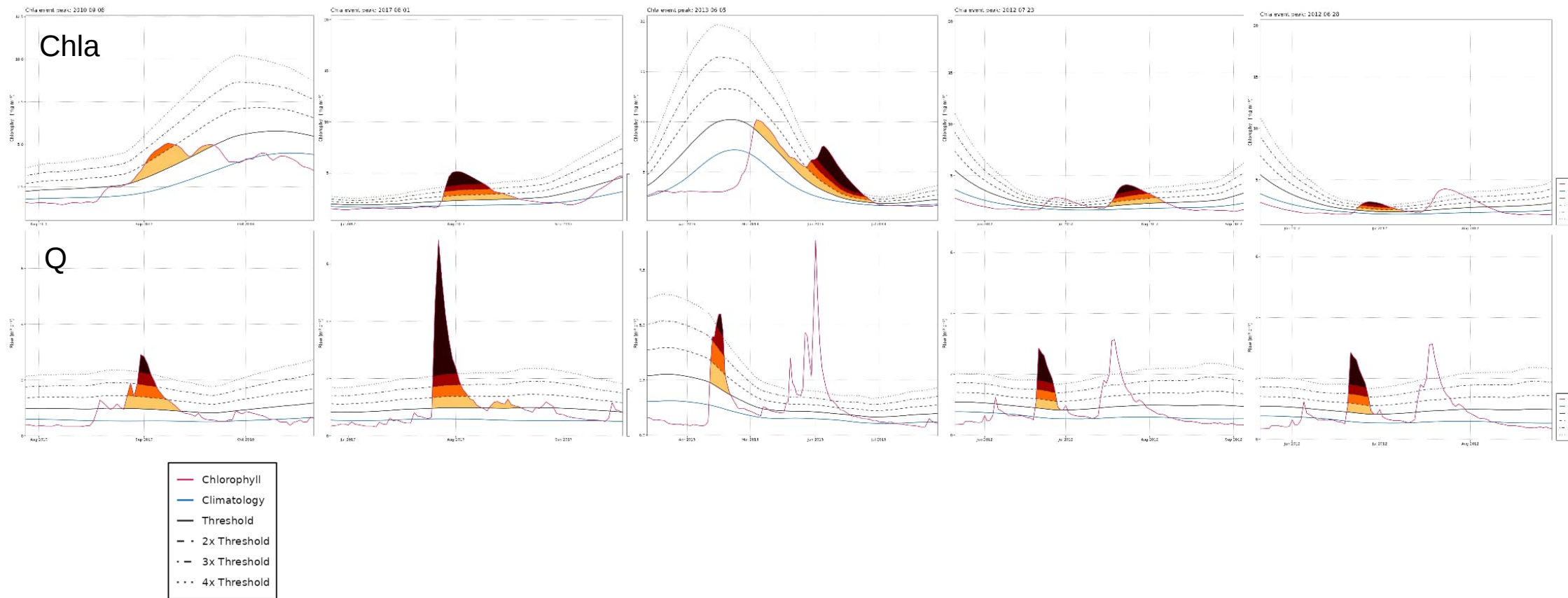
A single member of RCP 8.5 run analysis, Chlorophyll



Questions

- Which events should we focus on
- Should we look at the surface instead of 0-11
- Should we look at other layers ?
- Should we do something more for the 2100 scenarios?
- Should we simulate something with 3D
- What are the antecedent conditions for us

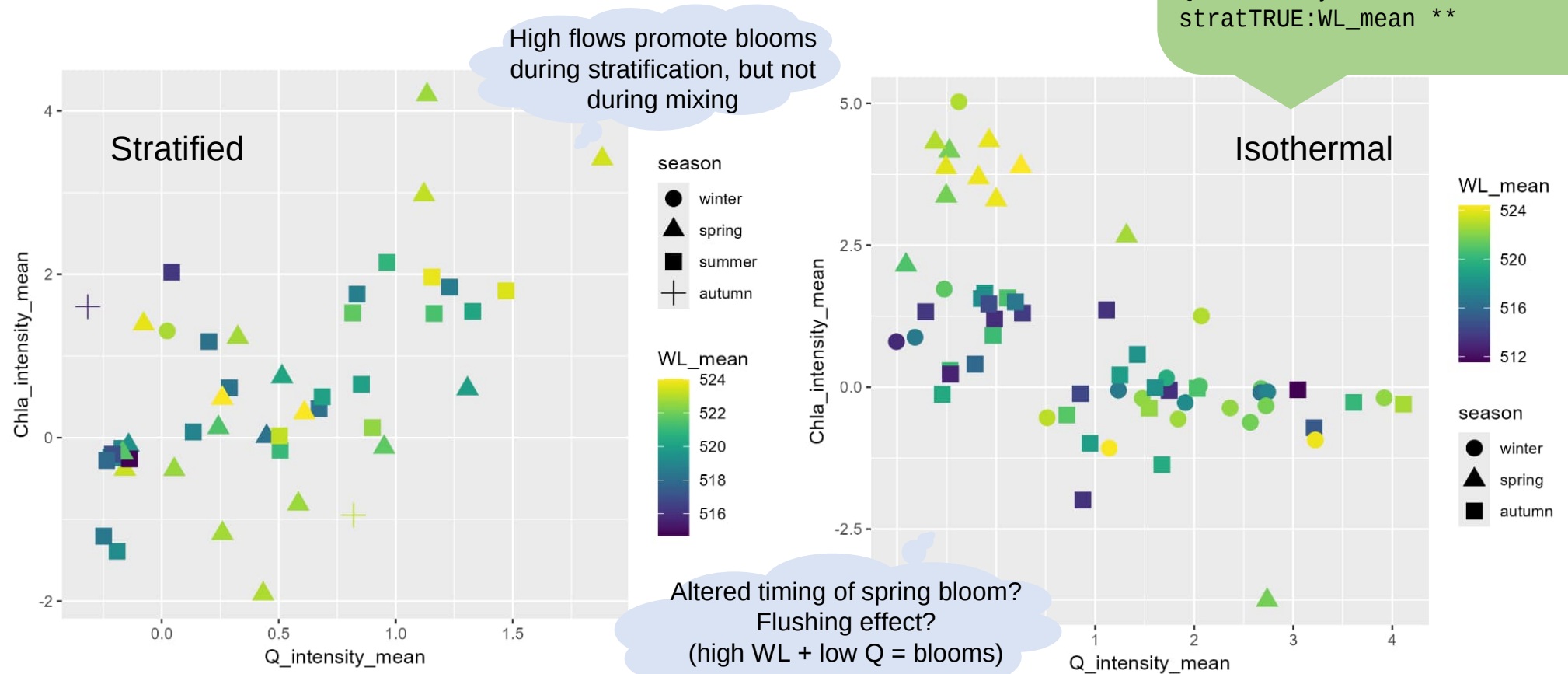
Compound events of Discharge and Chlorophylla



What affects Chla anomaly?

- Tested variables:
Q anomaly, stratification (strat), Water level (WL), temperature anomaly + interactions

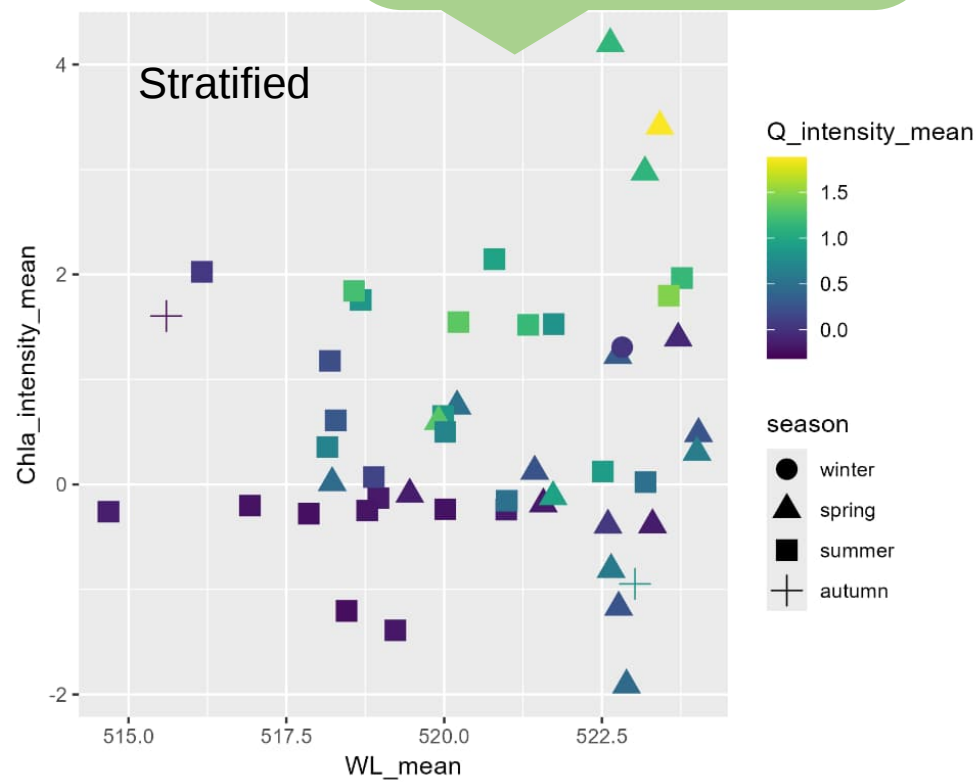
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Q_intensity_mean **
stratTRUE **
WL_mean ***
Q_intensity_mean:stratTRUE ***
Q_intensity_mean:WL_mean **
stratTRUE:WL_mean **



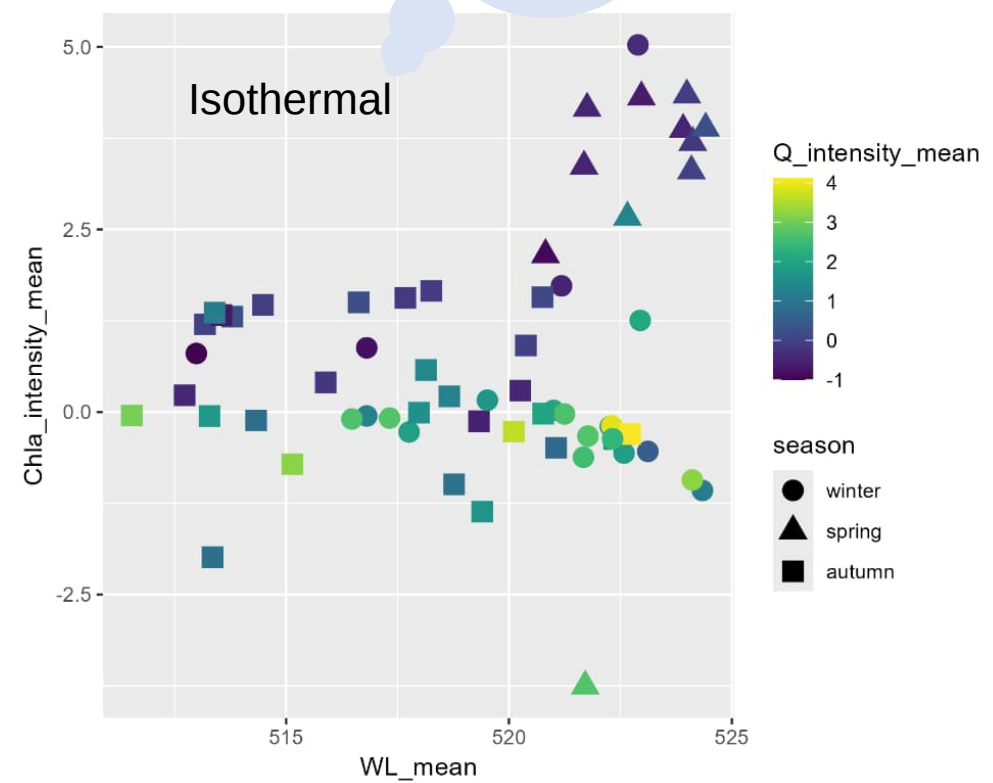
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(Intercept) ***
Q_intensity_mean **
stratTRUE **
WL_mean ***
Q_intensity_mean:stratTRUE ***
Q_intensity_mean:WL_mean **
stratTRUE:WL_mean **

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Does flushing decrease blooms during mixing?



Summary

- Significant effect of discharge, stratification (maybe water level) & interactions
- Temperature anomaly has no significant effect
- High flows affect chlorophylla but not low flows
- Flushing may have an effect

- Many to dos: properly define variables with time lag/offset
- Look at runoff/rainfall
- Assess compound events