

Spectral possibilities for phytoplankton assessment in a shallow, eutrophic lake

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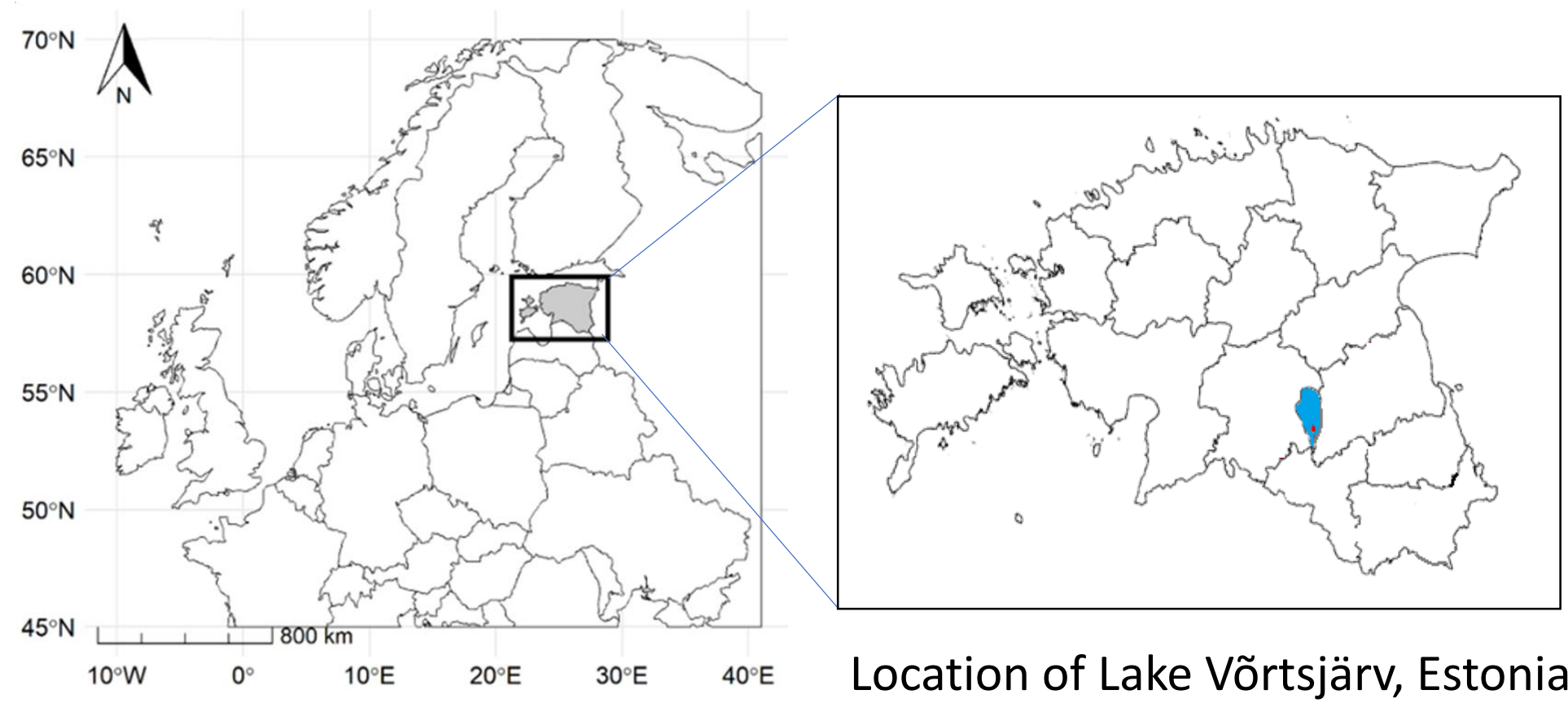
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Phytoplankton is the foundation of all food chains in inland waters, consisting of a diverse community of microscopic cells that changes seasonally. Hyperspectral water reflectance data can enable more precise retrieval of cyanobacteria information and can be applied to hyperspectral satellite data. Currently, Copernicus multispectral satellite data, especially from Sentinel-3 (S3)/OLCI, allows the retrieval of complementary information about suspended matter.

Data (Water reflectance from HYPSTAR, in situ cyanobacterial wet weight, SPM from S3/OLCI)

Phytoplankton community composition (Utermöhl, 1958) was measured once per month over the vegetation period of three years (2023-2025) in the framework of national monitoring. Water reflectance was measured using HYPSTAR (Hyperspectral Pointable System for Terrestrial and Aquatic Radiometry), which provides automated, *in situ*, multi-angular reflectance measurements of land and water targets across the 380-1020 nm spectral range at 3 nm spectral resolution (<https://hypstar.eu/products/>). It has been measuring at the pier of L. Võrtsjärv since 2023 during the vegetation period. Spectra were selected at 9 UTC or at the closest time, and processing was performed with a constant wind speed of 2 m/s.

The amount of suspended matter was retrieved from S3/OLCI data, downloaded from Copernicus Data Store, using ACOLITE (v20221114.0) and the Nechad equation (Vanhellemont, 2019), which was confirmed earlier to suit the best, based on validation with optically complex *in situ* data (Ansper-Toomsalu & Uusõue *et al.*, 2024).



III Case Study Area of ESA's AQUATIME project „Novel phytoplankton information for improved understanding of aquatic ecosystems and biodiversity based on synergistic time series analysis of Sentinel Expansion and Sentinel Missions“

Parameter	Võrtsjärv
Area (km ²)	270
Mean depth (m)	2.8
Max depth (m)	6
Catchment area (km ²)	3,104
Cchl (mg/m ³)	5.1 - 83.2 (36.3)
TSM (g/m ³)	4 - 58.8 (19.9)
a _{CDOM} (440) (m ⁻¹)	1.2 - 13.8 (3)
Secchi depth (m)	0.3 - 2.15 (0.7)

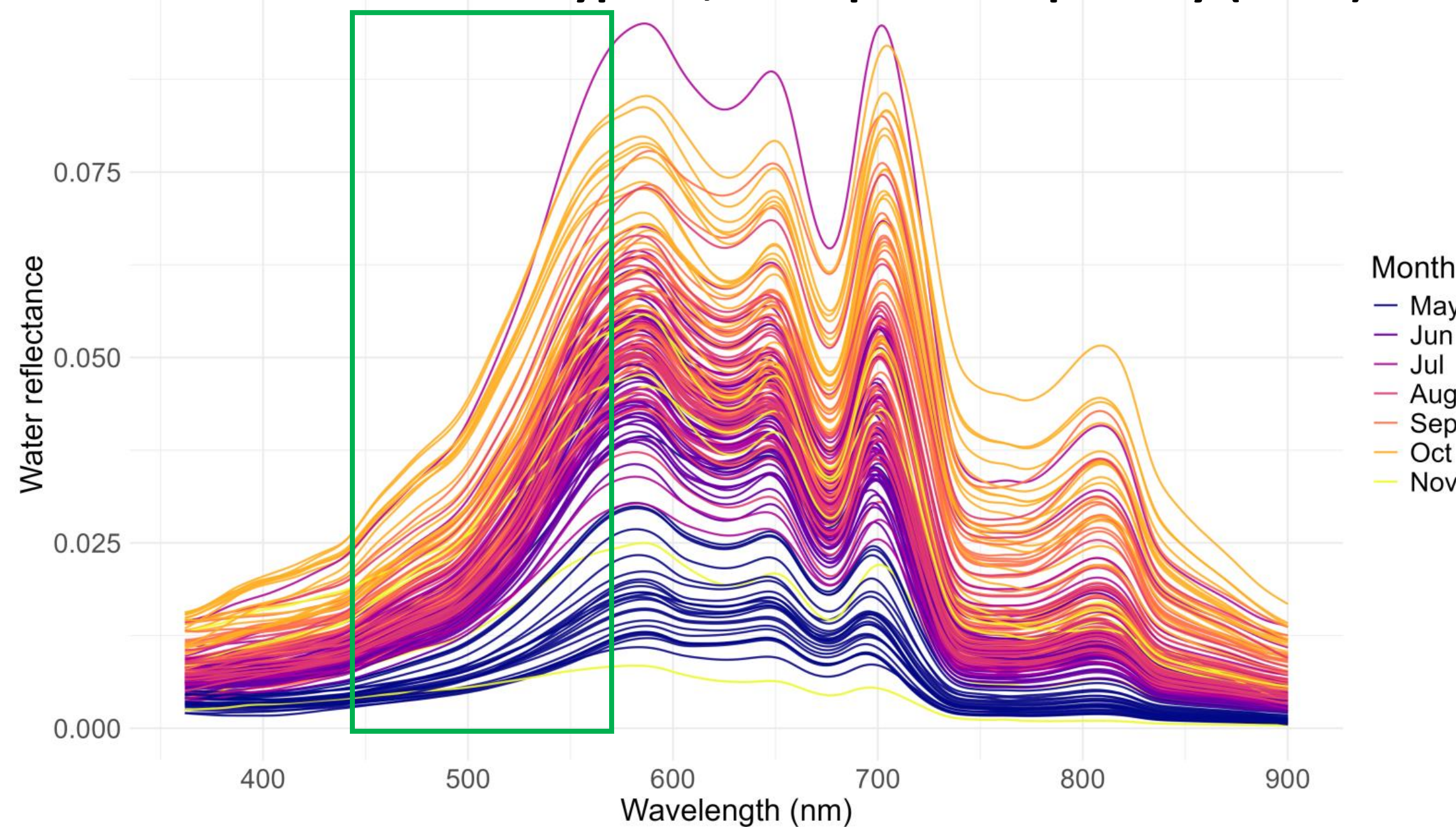
Water reflectance was calculated from HYPSTAR data:

$$R(\lambda) = \pi \frac{L_w(\lambda) - \rho(w)L_d(\lambda)}{E_d(\lambda)}$$

See more: De Vis *et al.*, (2024) *Front. Remote Sens.* <https://doi.org/10.3389/frsen.2024.1347230>

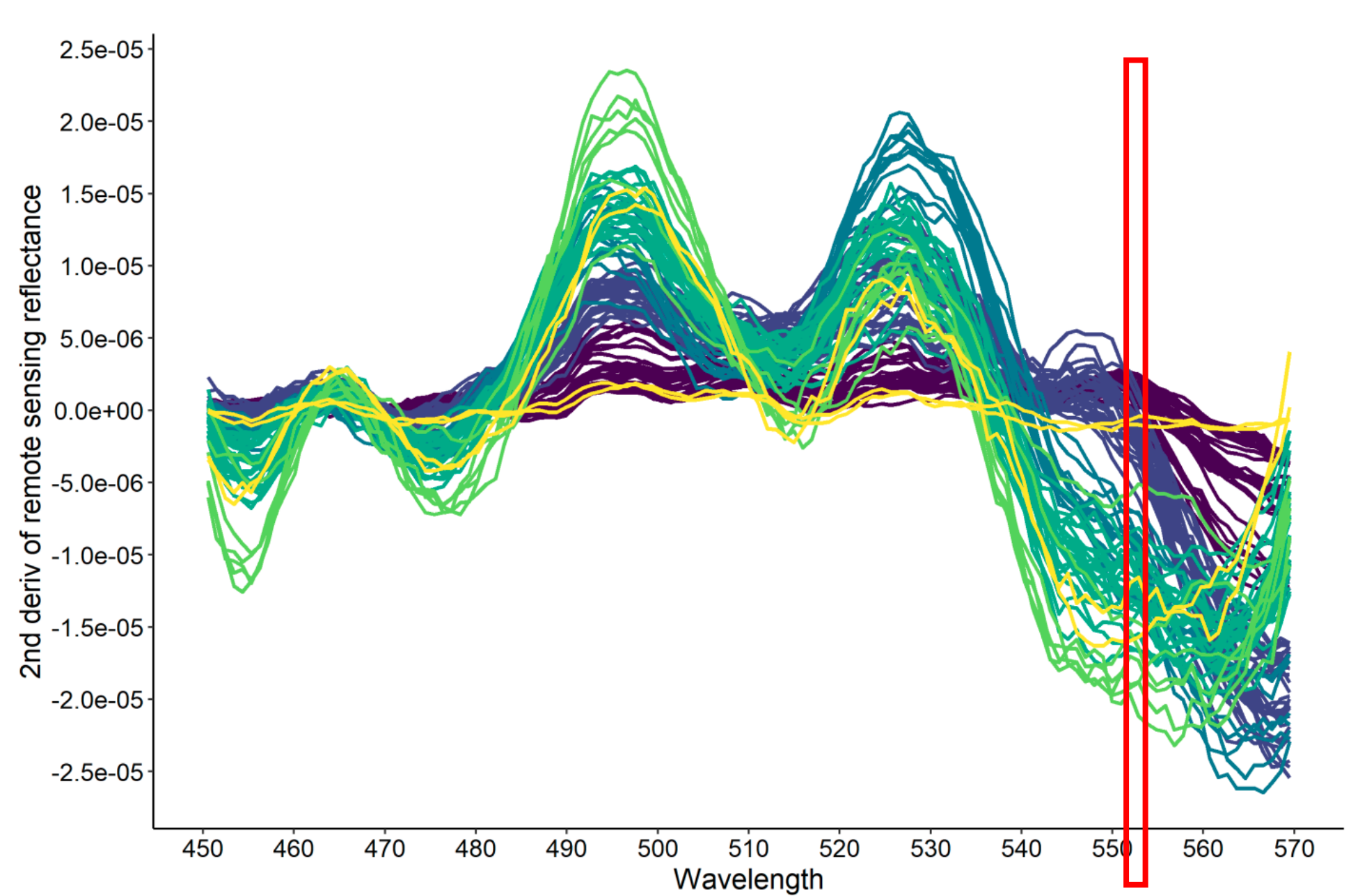


Water reflectance from Hypstar, one spectrum per day (2023)

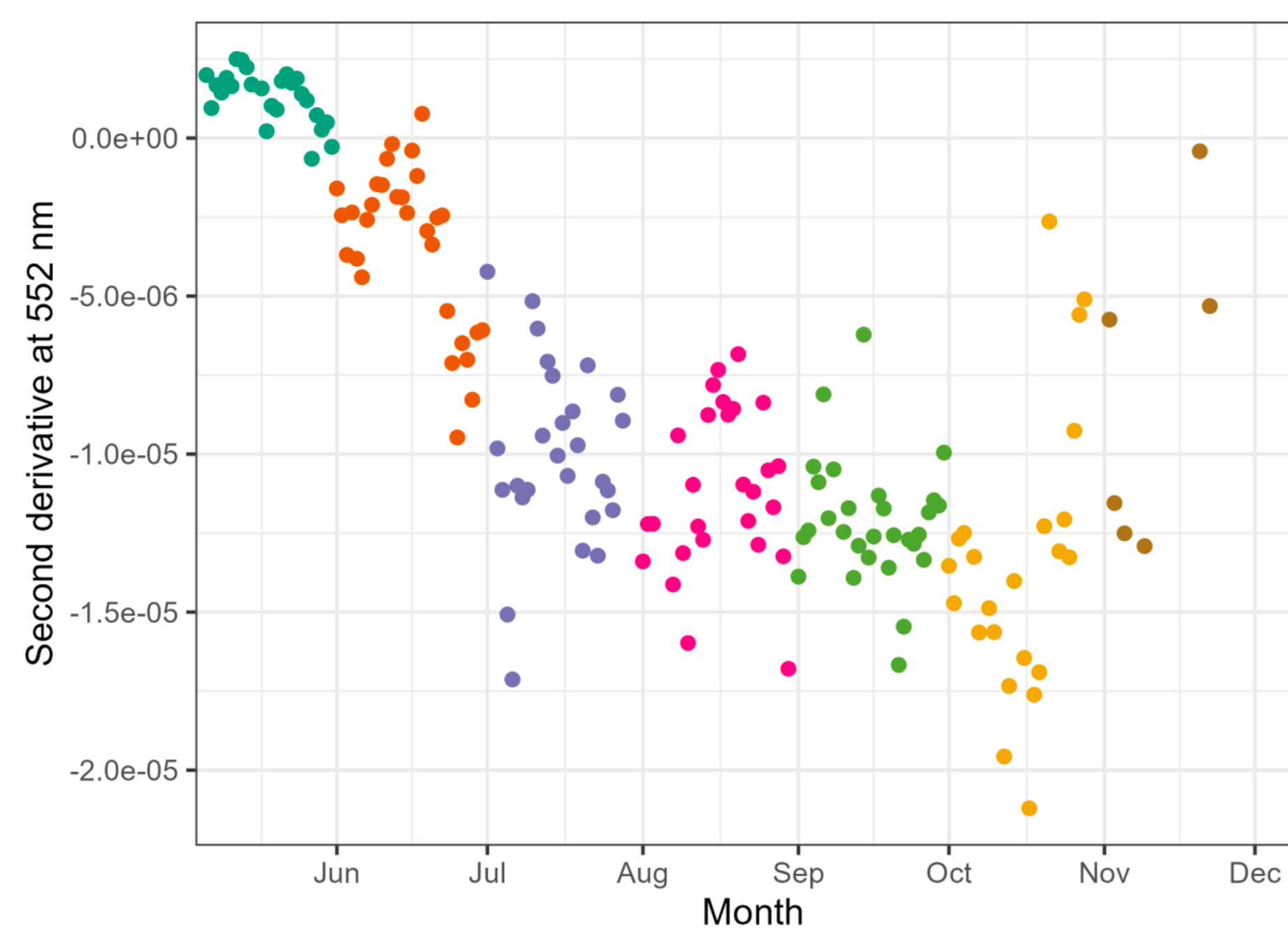


Method by Lavigne *et al.* (2022), binning to 1 nm and smoothing 3 times with 9-step window (Ruddick *et al.*, 2024)

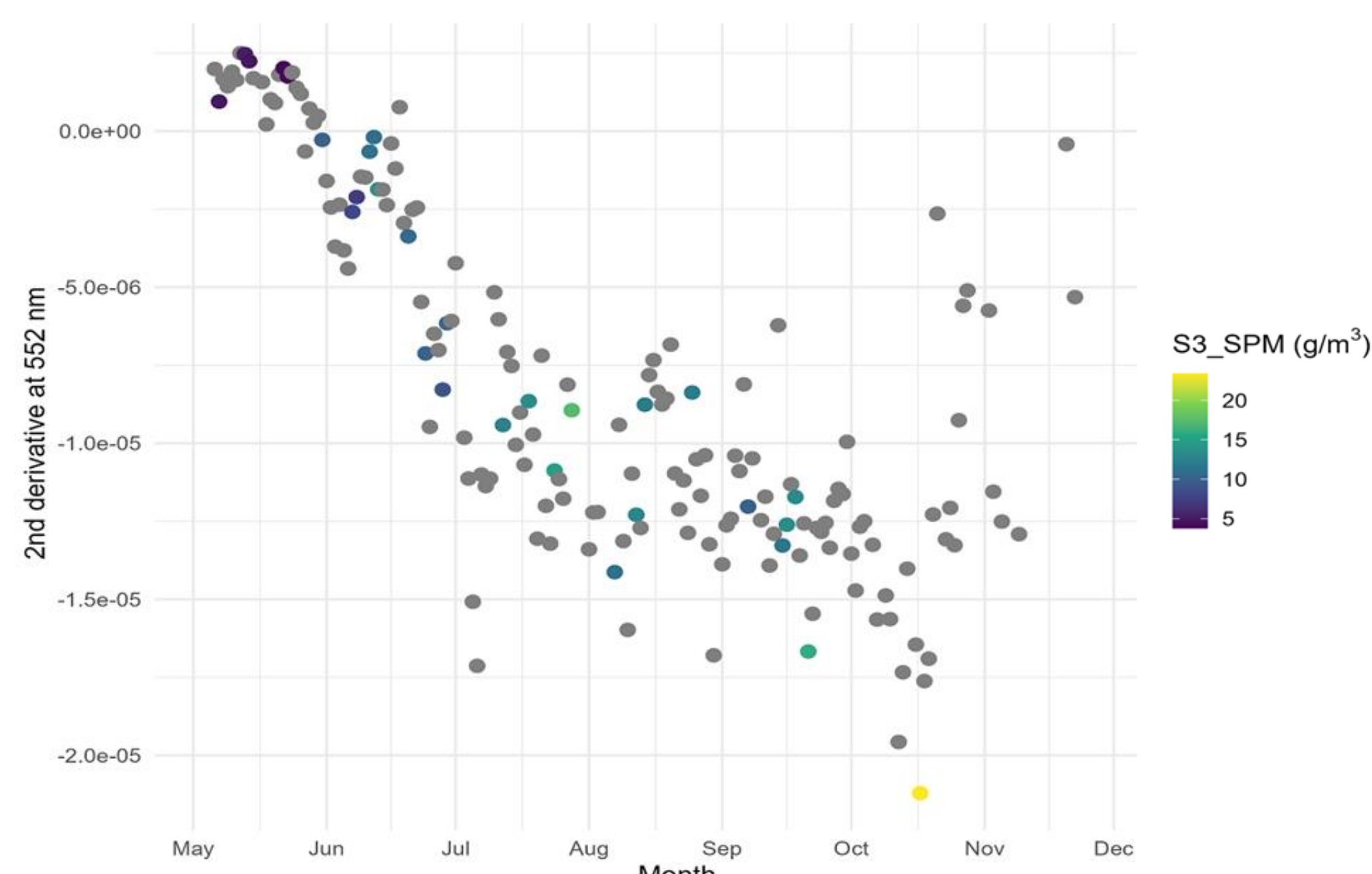
2nd derivative from reflectance data (2023)



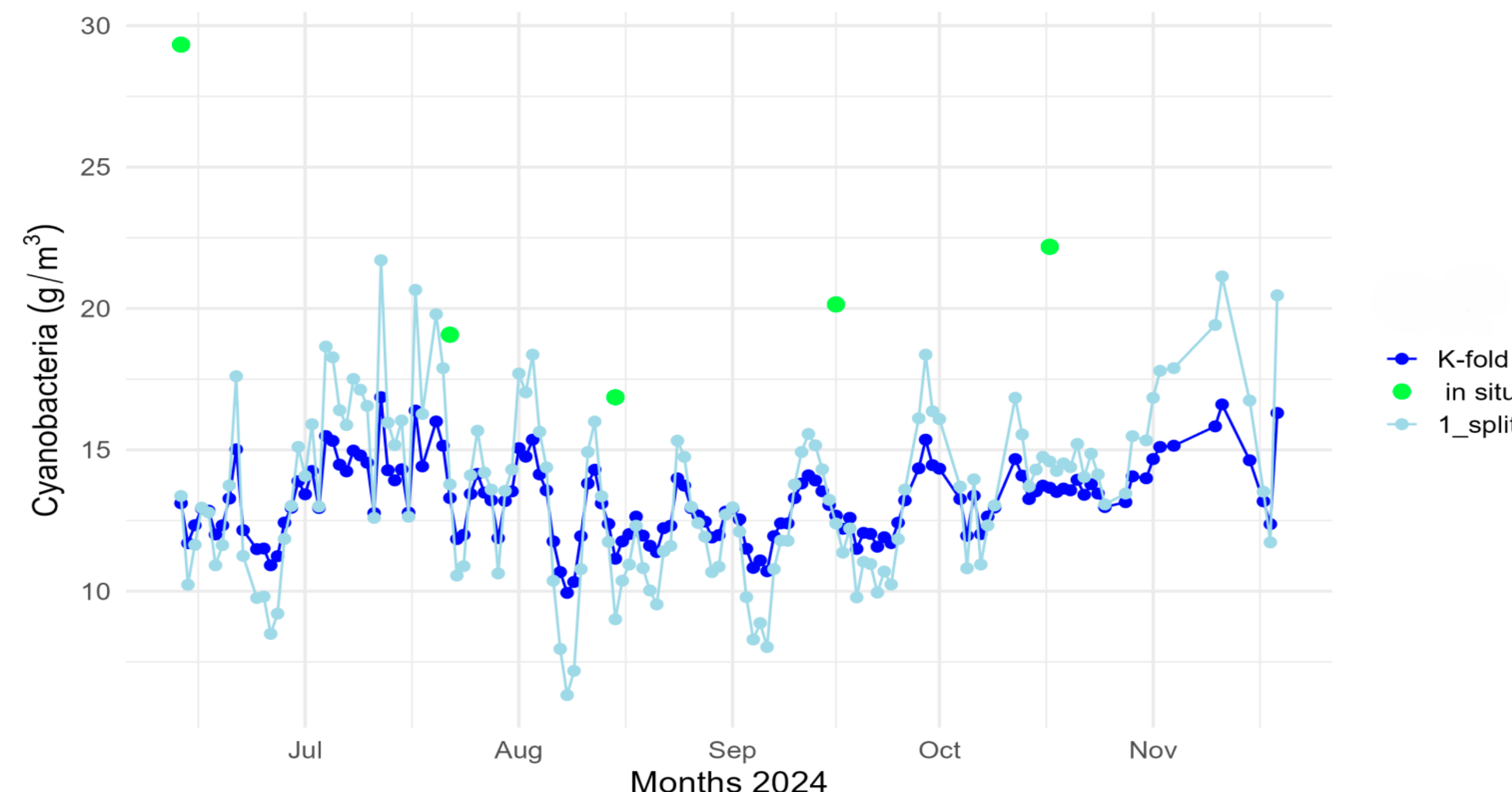
2nd derivative at 552 nm (2023)



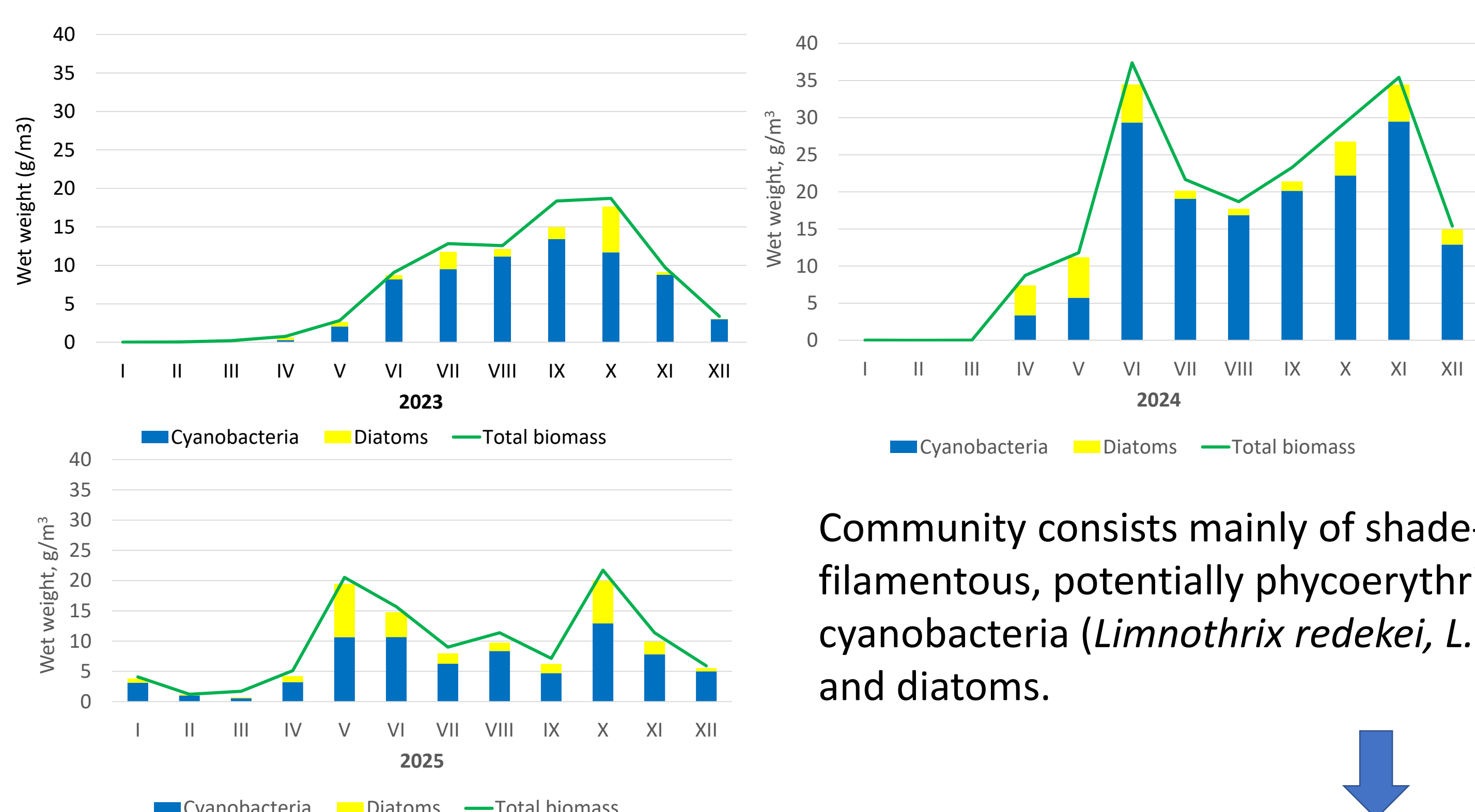
2nd derivative at 552 nm, with SPM derived from ACOLITE (2023)



Dynamics of cyanobacteria for 2024

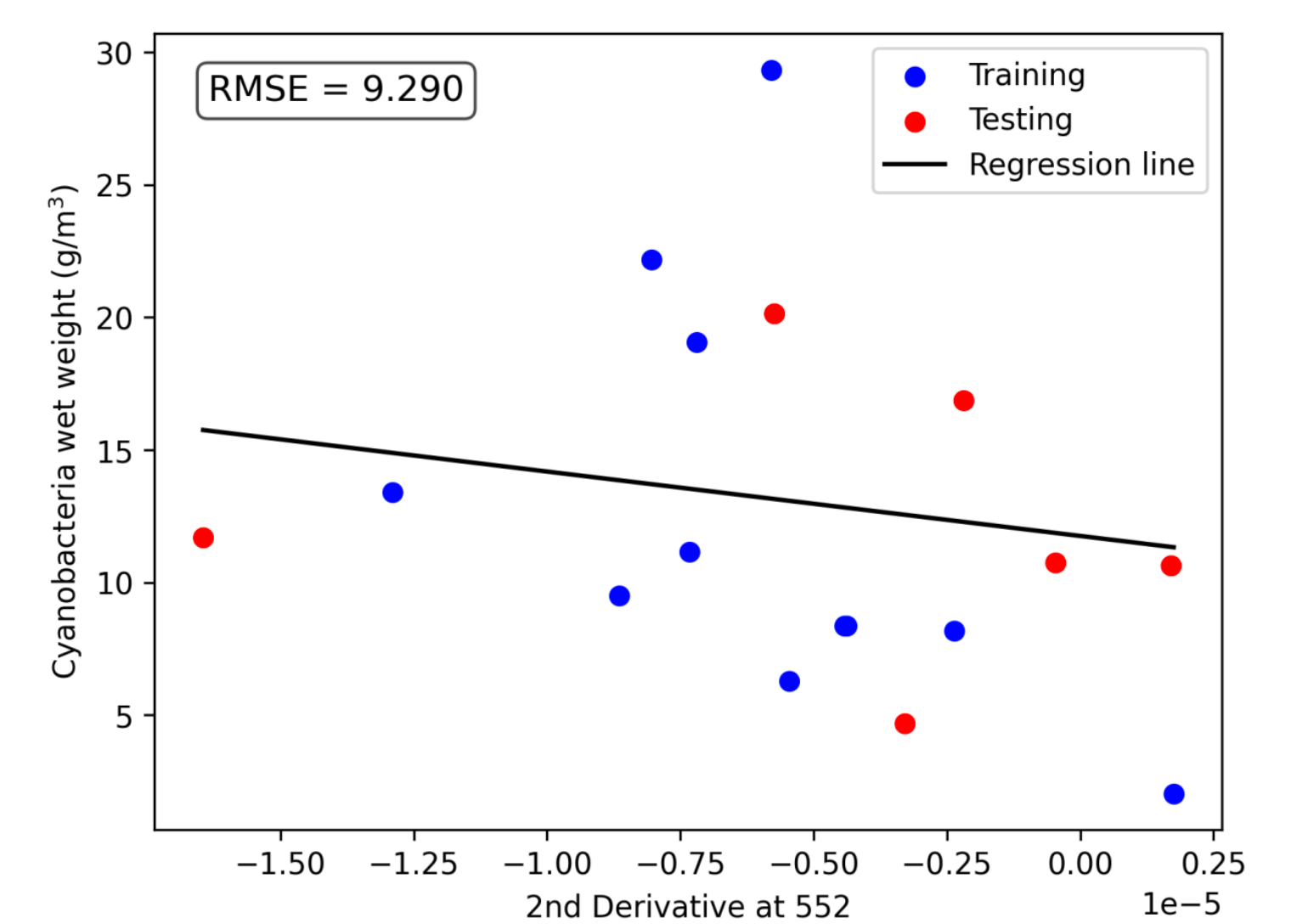


Phytoplankton community



Community consists mainly of shade-tolerant filamentous, potentially phycoerythrin-containing cyanobacteria (*Limnothrix redekei*, *L. planctonica*) and diatoms.

2nd derivative at 552 nm and *in situ* wet weight of Cyanobacteria (2023-2025)



2 equations for Cy wet weight calculations:

- 1) Splitting dataset to 70% for training and 30% for testing
- 2) K-fold cross-validation: 5 times splitting (80% and 20%) resulted mean RMSE + 95% CI = 6.8 ± 2.8 g/m³

- More concurrent data is needed to characterize variability
- Testing with multilake data – approach suitability
- Does normalization (e.g. with 665 nm) allows better characterization?

Acknowledgements

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References

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