We thank the reviewer for this suggestion and agree that in situ observations from field campaigns provide valuable opportunities to assess the reliability of satellite-derived products. In response, we explored the possibility of comparing the ESA lakes_CCI chlorophyll-a product with historical in situ measurements reported in the Climlake–Climfish report (1). However, we emphasize that such comparisons remain inherently limited in this context due to methodological and scale mismatches.

The available dataset includes observations from four locations (Kigoma offshore and nearshore, Mpulungu offshore and nearshore), with chlorophyll-a measured using two analytical methods: spectrophotometry and high-performance liquid chromatography (HPLC), the latter generally considered the reference method. Between 49 and 117 observations are available depending on site and method, with sampling conducted approximately every two weeks. The comparison between the two in situ methods reveals variable agreement across sites. At Kigoma, correlations are relatively low (0.51 offshore and 0.24 nearshore), whereas stronger agreement is observed at Mpulungu (0.75 offshore and 0.93 nearshore). However, RMSE values remain substantial across all sites (0.45 to 0.83 µg/L) relative to the magnitude of chlorophyll-a concentrations. HPLC estimates are consistently lower than spectrophotometric measurements, in line with previous findings. These inconsistencies between analytical methods highlight the uncertainty affecting in situ measurements and limit their suitability as a robust reference for satellite validation.

Table 1: Comparison of chlorophyll-a estimates derived from HPLC, spectrophotometric in situ methods, and the Lakes CCI dataset across the four sampling sites.

Metric	Variables	Kigoma		Mpulungu	
		Offshore	Nearshore	Offshore	Nearshore
Correlation coefficient	HPLC vs Spectro	0.51	0.24	0.75	0.93
	CCI vs HPLC	0.06	0.15	0.17	-0.29
	CCI vs Spectro	0.50	0.44	0.12	-0.27
RMSE (µg/L)	HPLC vs Spectro	0.60	0.60	0.45	0.83
	CCI vs HPLC	0.41	0.42	0.91	1.56
	CCI vs Spectro	0.80	0.72	0.83	1.95
Mean concentration (µg/L)	HPLC	0.62	0.53	0.71	1.03
	Spectro	0.94	0.86	0.72	1.39
	CCI	0.32	0.45	0.56	0.82

For the satellite comparison, chlorophyll-a values at offshore stations were extracted from the nearest satellite pixel. For nearshore locations, lakes_CCI estimates correspond to the daily mean of the four closest pixels to the cities of Kigoma and Mpulungu that do not overlap with land. This approach implies that satellite observations do not strictly match the actual sampling locations and may be located at a significant distance from the in-situ stations. This limitation is particularly critical in nearshore areas, where strong onshore–offshore gradients in chlorophyll-a are expected, making even small spatial offsets highly impactful.

The temporal evolution of surface chlorophyll-a from remote sensing and in situ measurements is shown in Figure 1, and same-date comparisons are summarized in Table 1. Overall, correspondence between satellite-derived and in situ data is low, with correlations ranging from -0.29 to 0.50 and RMSE values from 0.41 to 1.85 µg/L. Temporal patterns often differ at nearshore locations and at the Kigoma offshore station. In contrast, a clearer correspondence is observed at the Mpulungu offshore station, where several periods of elevated chlorophyll-a are consistently captured across datasets, although absolute values remain different. Notably, this station is the furthest from the shoreline and therefore less influenced by strong nearshore gradients and land adjacency effects.

Several factors explain the limited agreement observed between satellite-derived and in situ chlorophyll-a estimates. First, in situ measurements provide point-based estimates, whereas satellite observations correspond to spatial averages over areas of approximately 1 km^2. Given the strong spatial and temporal variability of surface chlorophyll-a, substantial sub-pixel heterogeneity is expected, leading to a fundamental spatial mismatch. Second, the exact sampling locations of nearshore measurements are not precisely documented, preventing rigorous spatial matching with satellite pixels and particularly affecting nearshore sites where strong onshore–offshore gradients are expected. Third, better agreement is observed at the Mpulungu offshore station, which is the furthest from the shoreline. Here, several periods of elevated chlorophyll-a are consistently captured across datasets, even though absolute values differ. In contrast, the Kigoma offshore station is relatively close to shore and therefore more influenced by onshore gradients and land adjacency effects, which likely contributes to poorer correspondence. Finally, discrepancies between HPLC and spectrophotometric measurements, particularly at Kigoma, highlight additional uncertainty and limit the internal consistency of the in-situ dataset.

Ideally, in situ datasets specifically designed for satellite validation would be required to fully assess the performance of satellite products. Such campaigns would involve more frequent revisits and coordinated sampling across multiple locations over the lake and also several locations within pixel footprints to capture the inner pixel variability, thereby ensuring consistency between point measurements and spatially aggregated satellite observations. Such dataset does not exist for Lake Tanganyika, unfortunately.

Despite the observed discrepancies, the lakes_CCI product can be considered a reliable dataset for studying relative space-time dynamics of Chl-a. It is developed within the ESA Climate Change Initiative framework using a consistent processing chain, including harmonized atmospheric correction and quality control procedures applied uniformly over time. This methodological consistency ensures that the dataset is internally coherent, making it particularly well suited for the analysis of temporal trends. The product has also been extensively evaluated across a wide range of lakes worldwide and is widely used in the scientific literature, further supporting its credibility and relevance; a list of related publications is available on the ESA Climate Change Initiative Lakes project website (https://climate.esa.int/en/projects/lakes/).

To further strengthen satellite chlorophyll-a concentration estimations in the African Great Lakes, dedicated in situ campaigns with precise geolocation and frequent sampling should be implemented.

The manuscript’s discussion has been slightly revised with the addition of a sentence indicating that validation with in situ data is complicated, primarily due to substantial spatial mismatches between point-based field measurements and satellite observations, compounded by sparse coverage, temporal gaps, and methodological variability, as shown in this note.

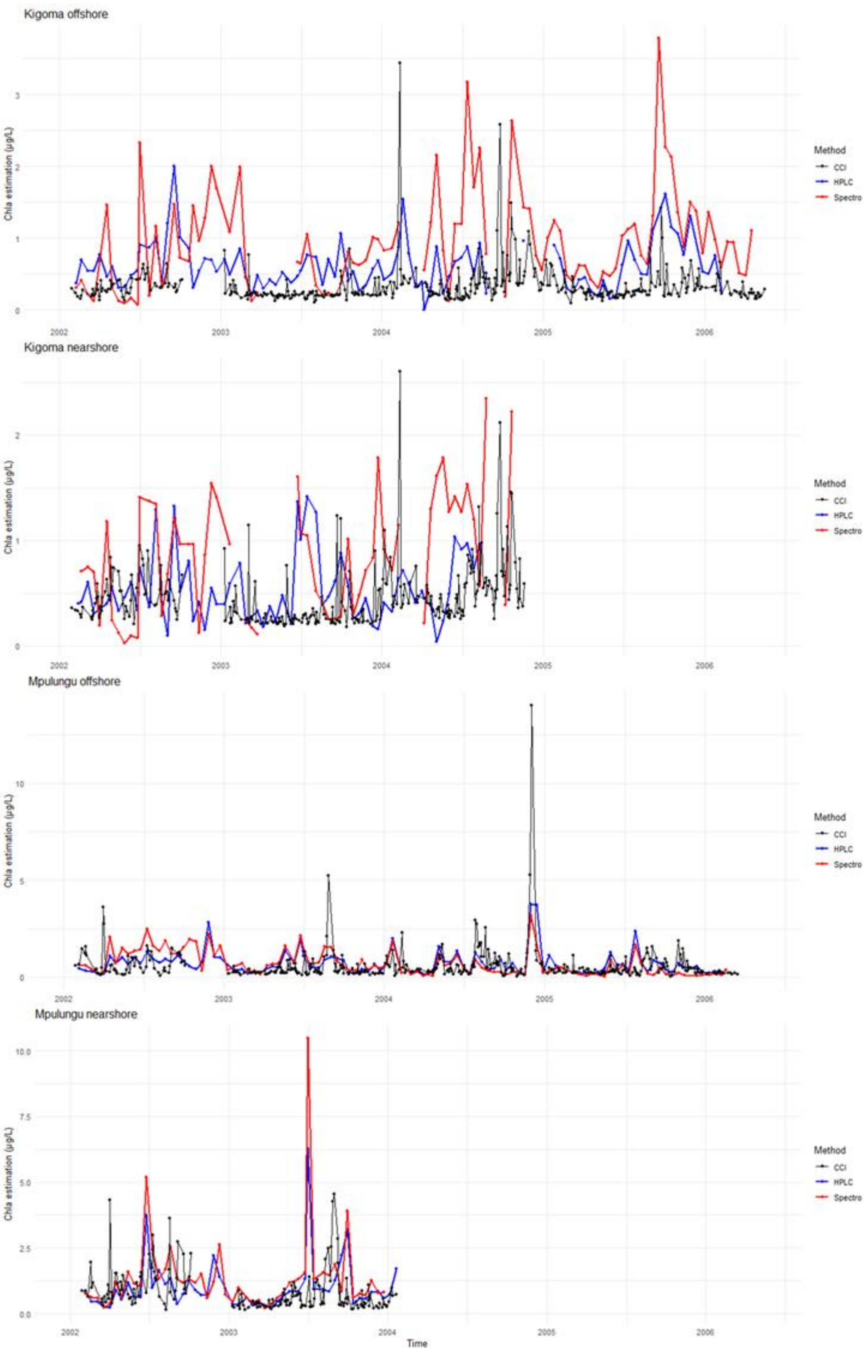

Figure 1: Temporal evolution of chlorophyll-a concentrations estimated from HPLC, spectrophotometric measurements, and the lakes_CCI satellite dataset at the four sampling locations.

References

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