

Comment on “Assessing temporal trends in ocean transparency using GlobColour products from the Copernicus Marine Service and accounting for associated uncertainties”

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General Comments

This manuscript investigates the dynamics of water transparency across diverse marine and coastal environments, using satellite-derived Secchi disk depth (ZSD) estimates from the Copernicus Marine Service over the 1998-2022 period. The study combines seasonal and interannual analysis in transparency in relation to environmental drivers, assesses the strength and reliability of long-term trends and the role of observational uncertainty, and finally examines the influence of spatial resolution on trend characterization.

The manuscript is well structured and well written. It fits well within the scope of *the Copernicus Ocean State Report*. The study provides a valuable contribution by highlighting how product uncertainties and spatial resolution affect trend detection in coastal and oceanic environments.

However, the manuscript requires major revisions. Several aspects need clarification or deeper justification, particularly regarding methodology, traceability, dataset limitations, uncertainty treatment, and interpretation of results. Please, find below the review to consider:

1. Novelty and scientific contribution

The integration of observational uncertainty into the trend detection process through a Monte-Carlo approach is particularly relevant, making it a valuable methodological contribution. The study also benefits from a multi-regional design which enhances the relevance of the results. Finally, the direct comparison between 1km and 4km Copernicus ocean-colour products provides useful insights regarding the influence of spatial resolution on transparency estimates and trend detection.

However, the manuscript would benefit from presenting its **scientific novelty** more clearly. In particular, the authors should explicitly state what is new compared with previous assessments of water transparency, including Morel et al. (2007), the Copernicus QUID by Garnesson et al., and previous trend studies (e.g., Kwiatkowska, Werdell, IOCCG reports). It would also be useful to clarify whether comparable trend analyses that take uncertainty into account already exist in literature, and how the proposed Monte-Carlo framework advances current practice. More generally, the introduction should more sharply frame the specific scientific contribution of this study, distinguishing it from prior work and highlighting its added value.

2. Scientific approach and methods

The methodological choices constitute clear strengths. The use of the Seasonal Mann–Kendall test combined with the Theil–Sen slope estimator is well suited for non-parametric climatological trend detection. The Monte-Carlo propagation of uncertainties is also methodologically robust, providing a more realistic assessment of trend robustness than standard single-run approaches. In addition, the incorporation of river discharge data complements the analysis, and offers valuable context for interpreting seasonal and interannual variability in transparency, particularly in estuarine systems.

A first point which requires clarification concerns the **treatment of uncertainty**. The manuscript uses the relative uncertainties reported in the Copernicus QUID and interprets them as Gaussian noise when generating synthetic time series to reflect the inherent uncertainty of the observations. The authors should clarify whether the uncertainties are intended to represent measurement errors, random noise, systematic bias, or a mixture of multiple sources of discrepancy. The authors should also justify why a Gaussian assumption is appropriate in this context. This clarification is important, as it affects how uncertainty should be propagated and interpreted in trend detection.

A second point requiring further detail concerns the **implementation of the Monte-Carlo simulations**. The manuscript should specify which uncertainty metric (quality flags, per-pixel relative uncertainty, global RMS...) is used and whether these uncertainties vary seasonally or geographically. The choice of 5000 simulations should also be justified, ideally supported by a convergence analysis showing that trend statistics stabilize beyond a certain number of iterations. In addition, it is important to clarify how gaps in the time series are handled in the Monte-Carlo simulations, as inconsistent treatment of missing data could introduce artificial variability.

The third point concerns the **spatial and temporal aggregation**. Monthly averaging of daily data is reasonable, but the use of the quadratic mean to aggregate uncertainties deserves explicit justification. The authors should explain why RMS was preferred over other averaging schemes and discuss the implications of this choice for variability and trend estimation.

The fourth point concerns the **pixel selection criterion** based on a 30% revisit threshold. This filter strongly affects the structure of the time series, particularly in regions with frequent cloud cover. The rationale for selecting 30% should be explained, and the authors may consider presenting a sensitivity analysis to demonstrate how results change with different thresholds (e.g., 20%, 40%, 50%). This would help assess the robustness of the trends to data availability.

Finally, the manuscript would benefit from a more explicit discussion of potential **confounding factors** influencing long-term trends in satellite-derived Secchi disk depth. Changes in transparency estimated from satellite data may result from changes in suspended particulate matter, CDOM, chlorophyll concentrations, or combinations of these components. In addition, atmospheric correction artifacts, shifts in sensor calibration, and the heterogeneity inherent in a multi-sensor time series spanning 25 years can introduce non-negligible biases. Addressing these factors would strengthen the interpretation of the results and place the conclusions in the context of the known limitations of ocean-colour climate data records.

3. Results, discussion, and interpretation

The results and discussion sections show several strengths: seasonal variability is clearly illustrated across regions, the relationship with river discharge is convincing in the Gironde and Loire estuaries, and the comparison between 1 km and 4 km products provides useful insight into the effect of spatial resolution. However, several aspects need clearer presentation or deeper analysis.

The **quality and clarity of several figures** should be improved. In **Figure 1**, the zoomed panel for Mayotte appears blurry and should be replaced with a higher-resolution extract. **Figure 3** would benefit from a more detailed legend: the four sub-plots should be clearly described, the different curves (ZSD, river discharge) explicitly identified, and the distinction between trends computed *with* and *without* uncertainties made visually clearer, as it is currently difficult to see. In **Figures 3 and 4**, the placement of subplot labels (a, b, c...) is confusing and should be adjusted for readability, and the y-

axis label is partially cut off and needs to be corrected. These adjustments would greatly improve the interpretability of the figures.

The **interpretation of trends** would benefit from additional support, by including spatial robustness maps, showing for each pixel the proportion of simulations in which the Seasonal Mann–Kendall test detects a significant trend. Such maps would provide a spatially explicit measure of trend reliability and would allow readers to distinguish between areas where the signal is robust and those where trends are highly sensitive to observational uncertainty. This would help clarify whether detected trends represent broad, coherent regional patterns or whether they are restricted to a few isolated pixels.

The **impact of spatial resolution** could also be more supported. The observation that the 4 km product exhibits more significant trends while potentially smoothing fine-scale variability is interesting. Including spatial maps comparing slopes derived from the 1 km and 4 km datasets would help illustrate how resolution affects trend magnitude and spatial patterns.

Finally, the **physical interpretation** of the “counter-intuitive” seasonal pattern for Mayotte, should be discussed with plausible hypotheses (e.g., lagoon sediment resuspension, cyclone-driven turbidity seasonality, tidal mixing, coral reef processes) to situate the findings within known regional processes.