Dear Editor,

Thank you for the opportunity to review the manuscript “A Black Hole Eddy Dataset of North Pacific Ocean Based on Satellite Altimetry” by Tian et al. This dataset paper presents an ambitious attempt to detect materially coherent Lagrangian eddies (so-called Black Hole Eddies, BHEs) in the North Pacific using a GPU-accelerated implementation of a geodesic eddy detection algorithm. The work contributes to the growing demand for Lagrangian eddy datasets derived from altimetry, with relevance to ocean transport, climate dynamics, and eddy-resolving model evaluation.

The authors present a new dataset (BHE v1.0) of 18,387 long-lived, materially coherent eddies in the North Pacific (1993–2023), derived via a GPU-enhanced version of the null-geodesic detection method for coherent Lagrangian vortices. They compare BHEs against Eulerian and RCLV-based eddy atlases, highlight eddy coherence via Lagrangian particle advection, and quantify zonal and meridional transports. They also report a subset of “Naked BHEs” not detected by conventional methods.

While the technical ambitions of this study are commendable, the manuscript falls short in multiple key areas. The detection framework, while important, lacks transparency, and several scientific claims are overstated without support from independent benchmarks or statistical uncertainty. The language and structure are often difficult to follow, further obscuring key methodological and conceptual points. With improvements in algorithmic clarity, quantitative rigor, and language polish, particularly the very concerning use of AI writing tools, this paper could contribute to ESSD and the broader eddy-resolving community.

1. Inadequate Algorithm Description and Lack of Code Transparency

The paper presents a GPU-accelerated version of the null-geodesic BHE detection method but does not provide sufficient technical detail to reproduce the dataset. For example:

- There is no publication or sharing of the source code, despite the centrality of the algorithm to the study.
- The CUDA kernel logic, grid configuration, and interpolation choices (e.g., cubic B-splines) are only briefly mentioned and not documented in usable form.
- The description of the numerical solver for null geodesics is too high-level and lacks algorithmic pseudocode, flowcharts, or performance benchmarks beyond one test case (January 1, 2021).

Given that ESSD emphasizes reproducibility, this is a critical omission. The dataset’s utility is severely limited without a transparent and replicable workflow.

2. No Quantitative Validation of Detected Eddies

The manuscript claims that BHEs are materially coherent and more robust than Eulerian or RCLV eddies, but provides no external validation:

- There is no comparison with drifter trajectories, synthetic benchmark fields, or any ground-truth datasets.
- The evaluation is purely qualitative, relying on particle advection visualizations (Figures 8–9) without metrics like retention rate, edge dispersion, or FTLE gradients.
- The label “Naked BHEs” is introduced based on non-overlap with other eddy datasets, but without a demonstration that these features correspond to real or meaningful oceanic structures.

This absence of validation raises concerns about false positives and algorithm selectivity. A rigorous analysis—quantifying detection accuracy or boundary fidelity—is necessary to justify confidence in the dataset.

3. Unsubstantiated Claims about Transport Accuracy

The authors state that BHEs provide a more accurate estimate of oceanic transport (e.g., 1.5 Sv westward flow), but this assertion is flawed:

- "More accurate" implies a benchmark or truth reference, which is not provided. It is inappropriate to draw such conclusions by comparison to RCLV fluxes alone.
- The transport calculation uses idealized assumptions: a fixed eddy depth (500 m), spherical geometry, and a simplified volume formulation V=sπR^2h. The sensitivity of transport estimates to these assumptions is never tested.
- Only zonal and meridional surface-integrated transports are estimated; vertical fluxes, submesoscale exchange, and isopycnal pathways are ignored despite their relevance to the stated motivation (e.g., biogeochemical cycles).

The transport interpretation should be reframed more cautiously, or supplemented with uncertainty ranges and alternate metrics (e.g., Lagrangian coherence indicators).

4. Sensitivity to Detection Parameters Not Assessed

The results are strongly conditioned on two key detection parameters:

- Minimum eddy radius: 20 km
- Minimum lifespan: 4 weeks

However, there is no sensitivity analysis to show how the number, distribution, or transport of BHEs would change with different thresholds.

- For instance, a minimum radius of 20 km excludes coastal or tropical eddies that may be materially coherent.
- A stricter lifespan cutoff (>6 or 8 weeks) may reveal whether BHEs are truly more persistent than RCLVs.
- Parameter tuning can significantly impact regional eddy statistics, yet this issue is not acknowledged or tested.

Without such analysis, the robustness and generalizability of the dataset remain in question.

5. Geographic Scope Is Narrow but Conclusions Overreach

While the dataset is limited to the North Pacific (0–50°N, 130–270°E), the authors occasionally use language implying broader relevance (e.g., "first BHE dataset", "offers better transport estimates").

However:

- The dynamical regimes of the Southern Ocean, Atlantic, or Indian Ocean differ considerably (e.g., stronger stratification, different baroclinic instability characteristics).
- It is unclear whether the same GPU algorithm, with its current assumptions and thresholds, would perform well in those settings.

The manuscript should clearly delimit the spatial scope of its claims and avoid generalizations unless supported by multi-basin tests or transferability arguments.

Minor comments:

While the authors appear to have used AI tools to address language issues—a practice I generally view with caution—I appreciate their transparency in doing so. That said, this manuscript still contains some grammar issues, vague phrasing, a lot of missing space inbetween, redundancy, missing or imprecise terminology, and unclear logic in comparisons, and many are obviously related to the use of AI tools. Many technical points are introduced without context or explained in overly dense mathematical language without intuitive guidance.

Frankly, if AI-generated text plays a significant role in scientific writing, it raises serious questions about why human reviewers should invest their time and expertise in carefully reading and critiquing such work. While I understand the appeal of these tools, I find their use in this context concerning and, in principle, disagreeable. I believe this issue merits ongoing discussion within the scientific community.

Following I list some, but not all issues with the writing. The authors should seriously consider taking a more thorough proofreading process or seeking assistance from a native English speaker, rather than relying heavily on AI tools for language editing. I expect to see substantial improvement than revising the listed issues.

Line 10:
“The methodologies employed for the identification of ocean coherent eddies…”
"ocean coherent eddies" should be "coherent ocean eddies".

Line 21:
“maintain strong material coherence and are able to maintain concentration…”
Repetitive “maintain”; also “concentration” is ambiguous here. Better: “retain material coherence throughout their lifecycle without significant mixing.”

Line 24:
“Transport analysis shows that BHEs induce westward transport about 1.5 Sv…”
Missing “of”: should be “transport of about 1.5 Sv”.

Line 26:
“These finding addresses…”
Should be “These findings address…”
Line 30:
“Mesoscale eddies…can persist for periods of a few weeks to several years.”
“Periods of a few weeks” is vague; could benefit from citing eddy lifetimes more precisely by region.

Line 34:
“influencing on the marine material cycle…”

Remove “on”. Correct: “influencing the marine material cycle…”

Line 36:
“Eulerian approachs…”
Should be “approaches”.

Lines 41–45:
There is repetition about Eulerian methods being “frame-dependent” and generating filamentation. This point is important but can be made more concisely.

Line 49:
“provide a more accurate structures…”
Should be: “provide more accurate representations of structures…”

Line 52:
“Before Lagrangian coherent structures (LCSs) entered into strict mathematical definitions…”
Wordy. Consider simplifying to “Before LCSs were rigorously defined…”

Lines 62–63:
“These eddies boundary are commonly referred to as the ‘photon sphere, analogous to Black Holes…”
“Eddies boundary” should be “eddy boundaries”; quotation wrong; analogy should be better justified.

Line 164:
“…includes daily-averaged, 5-day-averaged, 8-day-averaged…”
Repetitive and wordy. Consider: “Includes datasets with daily to monthly averages…”

Line 214:
“…indicative of the BHE.”
The sentence assumes readers understand how minimal deformation implies BHE status—should elaborate or clarify.

Line 224:
“…relies on direction field integration…”
"direction field" could be more accurately termed "vector field" or “eigenvector field (?)

Line 230:
“This paper utilizes CUDA as a multithreaded toolkit…”
Passive voice preferred in scientific writing: “CUDA was used…”

Line 272:
“effectively mitigates the noise in the eigenvector field…”
Needs clarification of how densification and interpolation specifically mitigate numerical

noise.

Line 290:
“the program consolidates the output data and transmits it to the host…”
Wordy. Consider: “Results are compiled and transferred to the host CPU after each step.”

Line 409-416:
“Non-scientific formatting. Use consistent table structure.

Line 427:
“…anticyclonic\cyclonic eddy…”
Use proper slash spacing and formatting: “anticyclonic/cyclonic eddy”.

Lines 430–450:
The description of coherence comparisons via particle trajectories is visual but lacks a quantitative metric (e.g., relative dispersion, FTLE, boundary leakage).

Line 455:
“The simultaneous presence of the three eddy types…”
Clarity: Consider rephrasing like “Instances where BHEs overlap both Eulerian eddies and RCLVs are dominated by cyclonic events…”

Line 460:
“the eddy in Figure 11a and Figure 12a is not initially located around a closed SLA contour or LAVD contour…”
The sentence is long and ambiguous. Break into two parts: one observation, one interpretation.

Line 485:
“eddies generated at low latitudes (below 10°N) are very few…”
Better phrased as “are relatively rare” or “are infrequent”.

Line 496:
“strongly anticyclonic (red) in the region north of 30°N…”
Correlation to Kuroshio shear is speculative without supporting reference or cross-analysis.

Line 549:
“we calculate the averaged zonal and meridional transport across the section for each 1° × 1° grid by…”
Define all symbols clearly; use consistent formatting. Currently hard to parse.

Line 560:
“The peak value…is only about 1.5 Sv, which is three times smaller…”
Prefer “one-third of the RCLV estimate” instead of “three times smaller” (ambiguous and

mathematically sloppy).

Line 580:
"…Chen et al. (2021), oceanic eddies have a significant mean egg-like shape…"
Tone: "Egg-like" may appear informal.