Referee Report

"Daily Global Sea Surface Ageostrophic Current Dataset from 1993–2023 via Physics-Informed Deep Learning"

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Summary of the submission

The manuscript (Cui et al., 2026) presents a daily, global, 0.25° surface current dataset for 1993–2023. A physics-informed neural network (AC-PIDNN) adds Ekman and nonlinear advective corrections to altimetric geostrophic currents by minimizing the residual of a steady momentum balance among advection, Coriolis, pressure gradient, and wind terms (their Eqs. 1–2). The product is assessed through its momentum-balance residual, through comparison with tropical moored current observations and the OSCAR product, and through comparison with a regional ROMS simulation.

The comments below concern the description of the simulation used for evaluation, a claim made about its resolution, a missing methodological detail, the representativeness of the in situ validation, the comparison product, and prior work that should be cited. Line numbers refer to version 2 of the manuscript.

Comments

1. **Section 2.2 (Simulation Data) is inadequate (ll. 107–118).** The ROMS simulation is used as the "ground truth" for the method, yet it is described in a few lines that give only the domain, the grid spacing, and the averaging period. The following need to be answered in the text:

   - How was this ROMS simulation forced? Section 4.1.3 states that the simulation "neglects the Ekman component" (l. 303), which makes the nature of the surface forcing unclear.
   - Did it assimilate any observations? If so, which ones?
   - How was the model spun up?
   - How many years were simulated?
   - Why are 30-day means used (l. 114)? Averaging over 30 days erases any trace of the submesoscale.
   - Is ROMS part of the training, or is it used only for evaluation?

2. **The statement that the simulation resolves the submesoscale is incorrect (l. 115).** The manuscript states: "This high-resolution setup effectively resolves mesoscale and submesoscale oceanic dynamical processes." A 3 km grid does not resolve the submesoscale. Dong et al. (2020) estimate that resolving wintertime surface mixed layer eddies requires grid spacings of 1.9 km (50% of regions resolved) and 0.92 km (90%) globally, and finer still in summer (1.3 km and 0.55 km). Dong et al. (2021) estimate that beginning to resolve symmetric instability requires grid spacings of 24 m (50%) and 7.9 m (90%) in winter. A 3 km simulation is therefore mesoscale-resolving and, at best, submesoscale-permitting; and, as noted in Comment 1, the

30-day averaging removes whatever submesoscale variability the model does permit. The sentence should be corrected.

3. **How are the derivatives in the advection terms calculated (Eqs. 1 and 2, ll. 123–125)?** The terms $\mathrm{ADV}_x = u\,\partial u/\partial x + v\,\partial u/\partial y$ and $\mathrm{ADV}_y = u\,\partial v/\partial x + v\,\partial v/\partial y$ require horizontal derivatives of the predicted velocity, but the manuscript does not say how these are evaluated; for example, by automatic differentiation of the network outputs with respect to the input coordinates (x, y), or by finite differences on the 0.25° grid. Because the advective component is the principal new quantity in the dataset, and it is defined entirely through these derivatives, the method of calculation must be stated.

4. **The in situ validation is biased toward the regime where the advective and Ekman effects are large (Section 4.1.2, ll. 254–298).** The in situ comparison uses only the TAO, PIRATA, and RAMA tropical moored arrays, all within roughly ±25° of the equator, and the manuscript itself reports that the largest errors are concentrated within about ±5°. Testing against near-equatorial observations biases the assessment toward conditions in which advection and Ekman effects are large relative to the geostrophic flow, particularly in the meridional currents. The improvement reported over geostrophic and Ekman-corrected currents is therefore not representative of the global dataset, most of which lies outside the region sampled. This limitation should be stated wherever the error statistics are quoted, including the abstract, and the validation should be extended to observations outside the tropics if possible (e.g., surface drifters, which the manuscript already mentions in its introduction).

5. **Product for comparison: OSCAR.** The manuscript describes the comparison product only as "the existing OSCAR surface current product (1993–2022)" with a link to the ESR web site (l. 257); no version is given and the product is not in the reference list. The comparison should be made with, and the manuscript should cite, the *Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents – Final 0.25 Degree (Version 2.0)* product (ESR and Dohan, 2021):

   > ESR; Dohan, Kathleen. 2021. Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents – Final 0.25 Degree (Version 2.0). Ver. 2.0. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at doi:10.5067/OSCAR-25F20.

6. **References that should be cited.**

   - Wunsch and Gaposchkin (1980), on the use of satellite altimetry to determine the general circulation of the oceans, where the manuscript introduces geostrophic currents derived from sea surface height (ll. 35–38).
   - Gold (1908), for the gradient wind relation. The manuscript states that the iterative solution of the gradient wind equation "was first developed in atmospheric science" (ll. 62–64) but supports this only with recent oceanographic papers.
   - The experimental multimission gridded Level-4 sea surface heights and velocities that include SWOT (MIOST) (CNES and CLS, 2025), as a current altimetric height and velocity product relevant to the data described in Section 2.1.

Web sources

Source	Link
OSCAR Final 0.25 Degree, Version 2.0 (PO.DAAC)	https://doi.org/10.5067/OSCAR-25F20
Wunsch and Gaposchkin (1980)	https://doi.org/10.1029/RG018i004p00725
CNES/CLS MIOST with SWOT Level-4 (AVISO+)	https://doi.org/10.24400/527896/a01-2025.001
Gold (1908)	https://doi.org/10.1098/rspa.1908.0038
Dong et al. (2020), submesoscale baroclinic instability	https://doi.org/10.1175/JPO-D-20-0043.1
Dong et al. (2021), symmetric instability	https://doi.org/10.1175/JPO-D-20-0159.1

References

CNES and CLS. Experimental Multimission Gridded (MIOST with SWOT) Level-4 Sea Surface Heights and Velocities. Processed by SSALTO/DUACS and distributed by AVISO+, supported by CNES, 2025. doi:10.24400/527896/a01-2025.001.

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Jihai Dong, Baylor Fox-Kemper, Hong Zhang, and Changming Dong. The Scale of Submesoscale Baroclinic Instability Globally. *Journal of Physical Oceanography*, 50(9):2649–2667, 2020. doi:10.1175/JPO-D-20-0043.1.

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ESR and Kathleen Dohan. Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents – Final 0.25 Degree (Version 2.0). NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC), CA, USA, 2021. doi:10.5067/OSCAR-25F20.

E. Gold. The Relation between Wind Velocity at 1000 Metres Altitude and the Surface Pressure Distribution. *Proceedings of the Royal Society of London. Series A*, 80(540):436–443, 1908. doi:10.1098/rspa.1908.0038.

Carl Wunsch and E. M. Gaposchkin. On Using Satellite Altimetry to Determine the General Circulation of the Oceans with Application to Geoid Improvement. *Reviews of Geophysics*, 18(4): 725–745, 1980. doi:10.1029/RG018i004p00725.