



Supplement of

Attention enhanced 3D-U-Net++ ocean temperature and salinity reconstruction in the northwestern Pacific based on transfer learning

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WOD profile density map in 2023

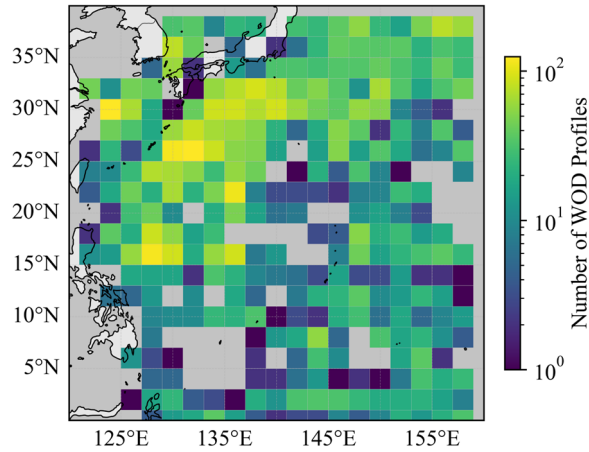


Figure S1. WOD profile density map in 2023, Each grid cell is 2°x2°.

Comparison of the Model Reconstructions with WOD T-S Profiles in 2023

To evaluate the relationship between the reconstructed temperature–salinity fields and the WOD temperature–salinity profiles, and to compare them with GLORYS2V4, correlation density scatter plots of temperature and salinity were generated at four representative depths (50 m, 200 m, 800 m, and 1000 m). The correlation density scatter plots for temperature are shown in Fig. S1, and those for salinity are presented in Fig. S2.

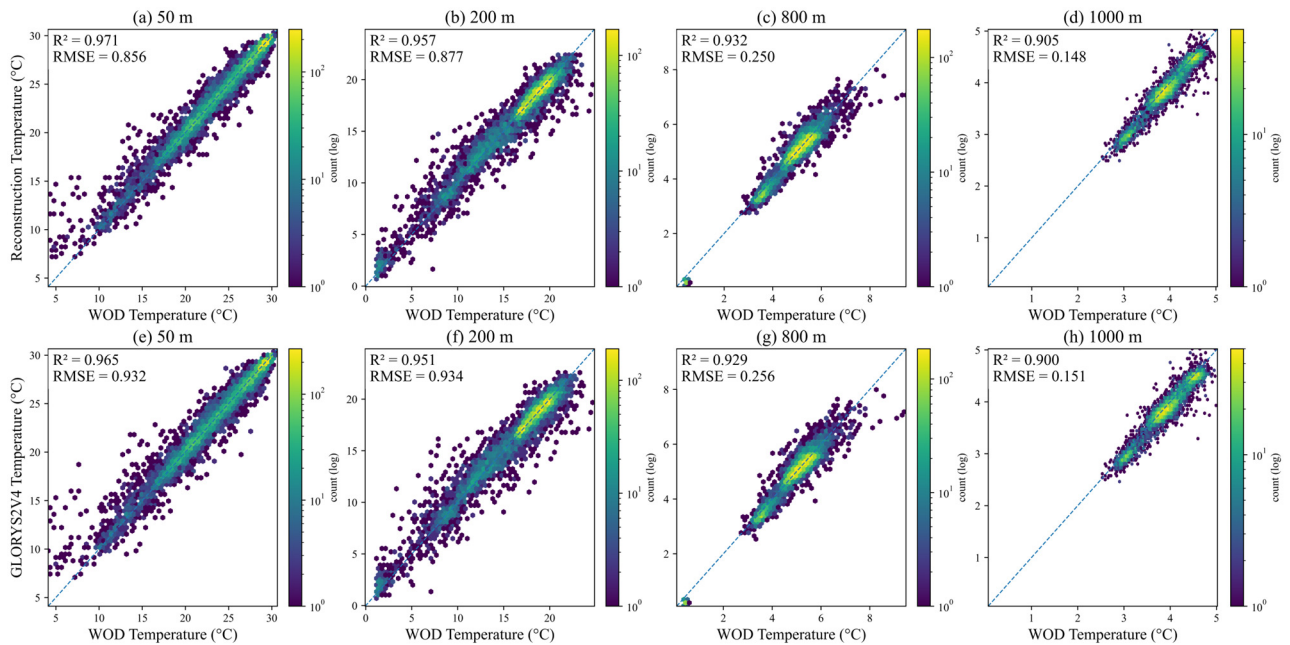


Figure S1. Density scatter plots of reconstructed temperature versus WOD observations at different depths in 2023: (a) 50 m, (b) 200 m, (c) 800 m, and (d) 1000 m; and density scatter plots of GLORYS2V4 temperature versus WOD observations at different depths in 2023: (e) 50 m, (f) 200 m, (g) 800 m, and (h) 1000 m.

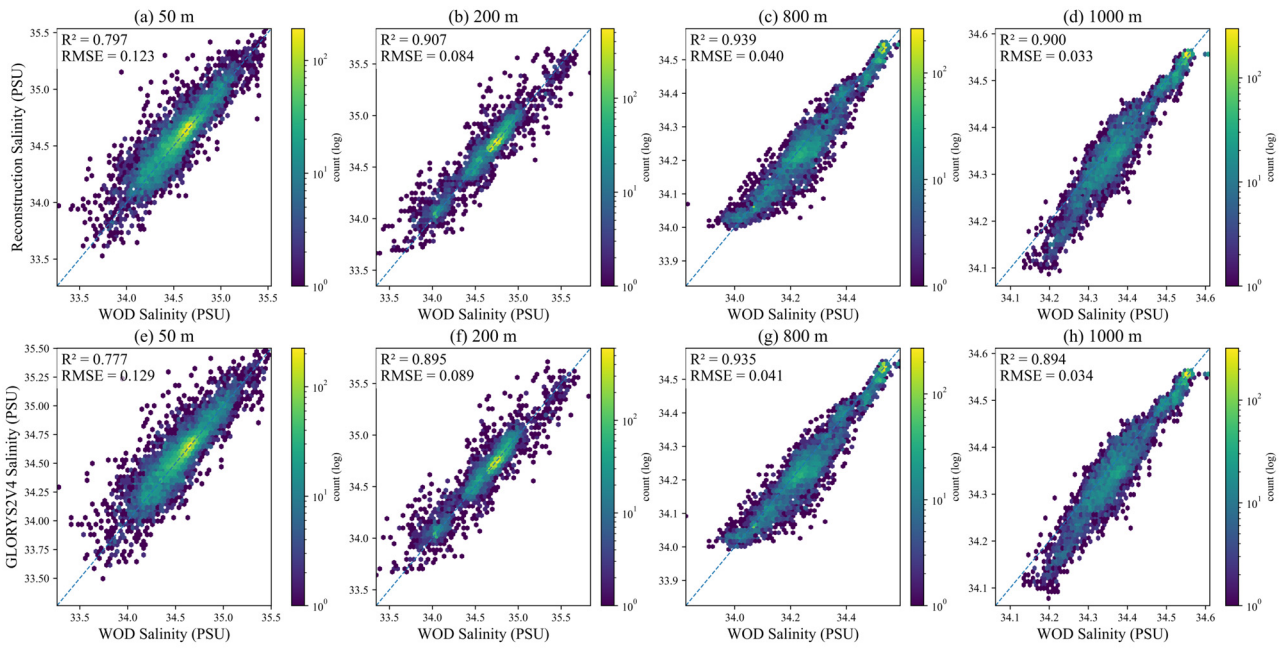


Figure S2. Density scatter plots of reconstructed salinity versus WOD observations at different depths in 2023: (a) 50 m, (b) 200 m, (c) 800 m, and (d) 1000 m; and density scatter plots of GLORYS2V4 salinity versus WOD observations at different depths in 2023: (e) 50 m, (f) 200 m, (g) 800 m, and (h) 1000 m.

As shown in Fig. S1 and Fig. S2, both temperature and salinity reconstructions exhibit strong linear correlations with the WOD observations, with most scatter points densely distributed along the 1:1 diagonal line. This indicates that the model successfully reproduces the thermohaline characteristics of oceanic water masses at all depth levels.

In contrast, GLORYS2V4 shows larger deviations in the upper layer, particularly at 50 m, with RMSE values significantly higher than those of the reconstructed results. The reconstruction model maintains higher R^2 and lower RMSE values in both the surface and intermediate layers, suggesting a better fit to the observed data. As depth increases, the correlation of the reconstructed temperature and salinity further improves and the errors decrease, reflecting greater reconstruction stability in the deeper ocean. Overall, the proposed reconstruction method achieves higher accuracy than GLORYS2V4 at all depths and captures the observed thermohaline variations more effectively.

Quality Control Methods of WOD Data

The WOD dataset contains many raw profiles with sensor errors, missing values, or single-variable records (e.g., XBTs measuring only temperature). Validating against erroneous data would lead to incorrect assessment of our model. The reduction in the number of profiles is strictly due to a rigorous, automated quality control pipeline designed to ensure that we are validating against reliable “ground truth.” Specifically, our automated QC procedure, which led to the final selection, includes the following five steps:

Step 1. Variable Completeness Check: The NetCDF file must contain both Temperature and Salinity variables. Profiles lacking one of these (indicating potential sensor damage or single-variable probes) are excluded.

Step 2. Profile-level Flag Check: Both Temperature_WODprofileflag and Salinity_WODprofileflag must be 0 (accepted WOD standard for good data).

Step 3. Depth-wise Filtering: We remove specific depth points where Temperature_WODflag or Salinity_WODflag are non-zero.

Step 4. Gross Error Check: If a profile contains excessive anomalies (values equal to 0, temperature $< -0^{\circ}\text{C}$, or salinity > 35 psu [specific to low-salinity contexts if applicable, or general outliers]), the entire profile is discarded.

Step 5. Regional Statistical consistency (3-Sigma Rule): For each profile, we search for neighboring profiles within a specific spatiotemporal window. Current data is checked against the mean and standard deviation of its neighbors. Data falling outside three standard deviations (3σ) are identified as outliers and removed.