

Supplementary Materials

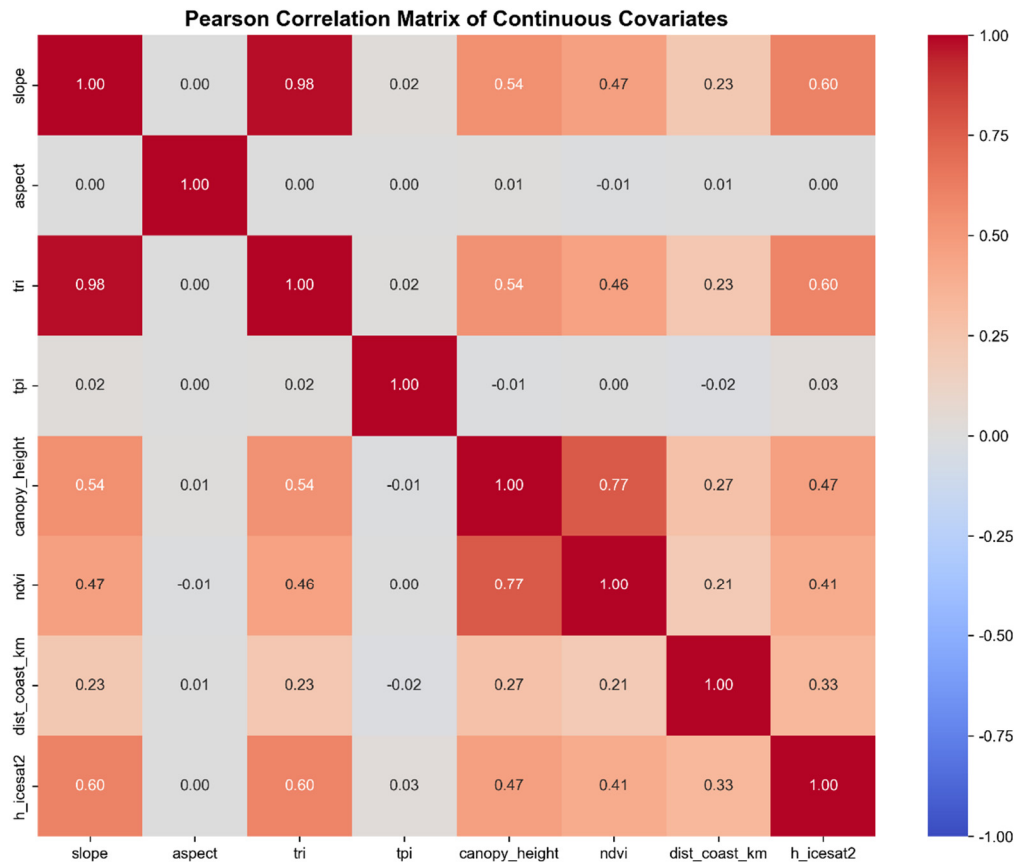


Figure S1. Pearson correlation matrix heatmap of the continuous covariates used for vertical error modeling. The color gradient indicates the strength and direction of the linear correlation (r). A remarkably high positive correlation ($r = 0.98$) was identified between the Topographic Ruggedness Index (TRI) and Slope. To prevent the destabilization of SHAP value allocations caused by this severe multicollinearity, Slope was excluded from the final XGBoost models.

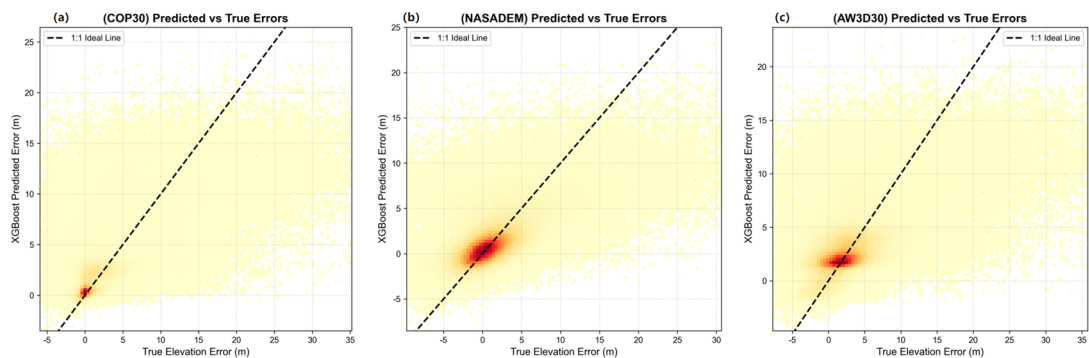


Figure S2. Scatter plots comparing the XGBoost-predicted vertical errors against the true vertical errors for (a) COP30, (b) NASADEM, and (c) AW3D30. The direct

comparison demonstrates the model's robust fitting capability across the entire error spectrum, including its performance on heavy-tailed extreme outliers.