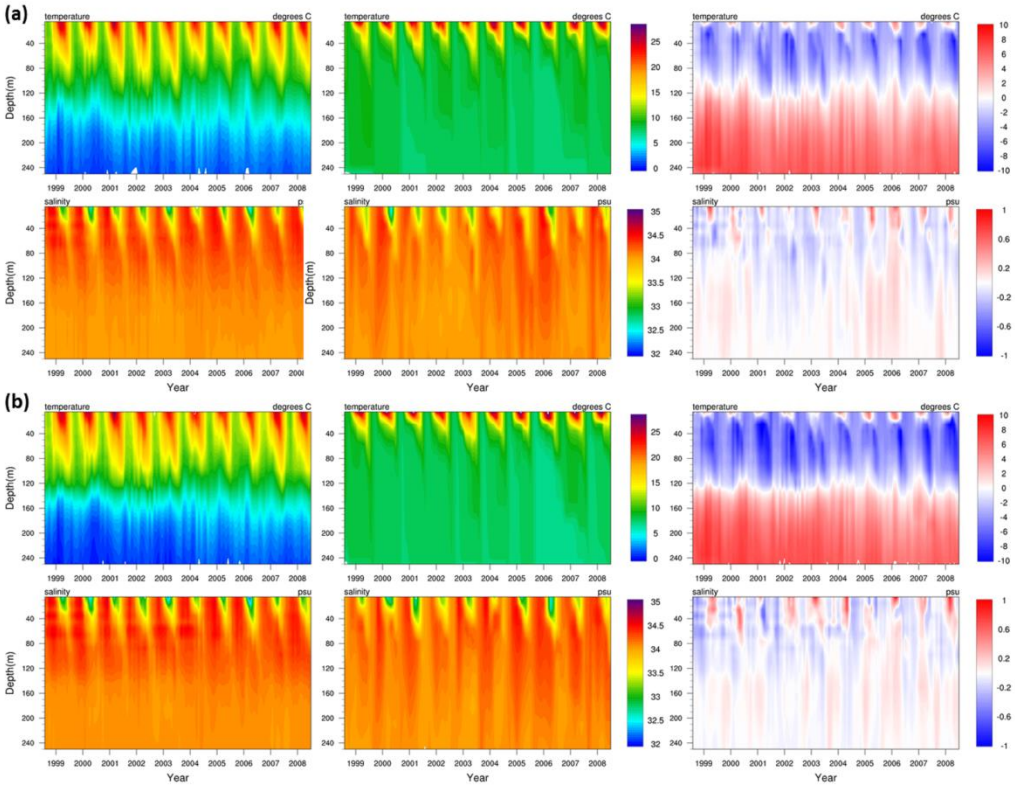
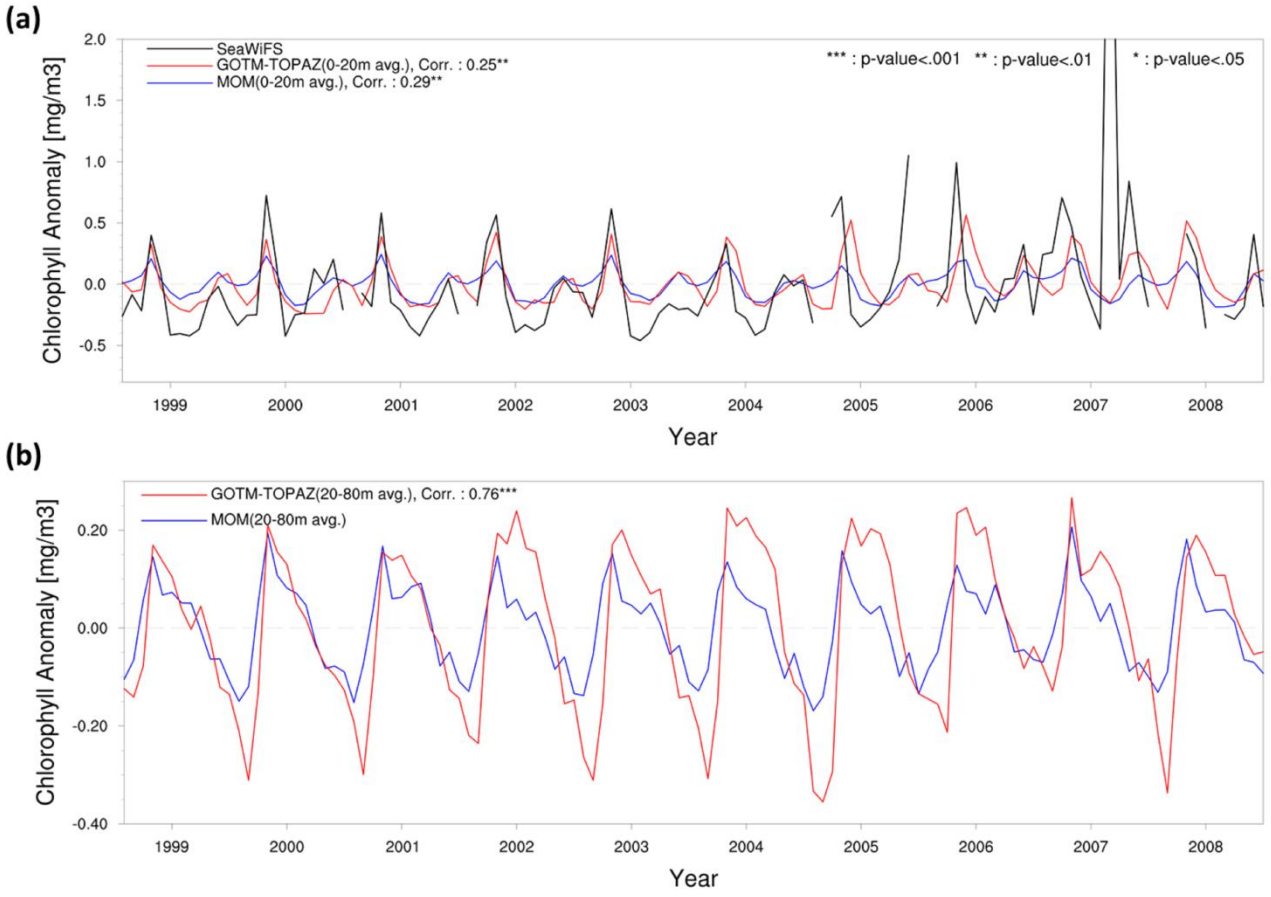
Supplementary Figures

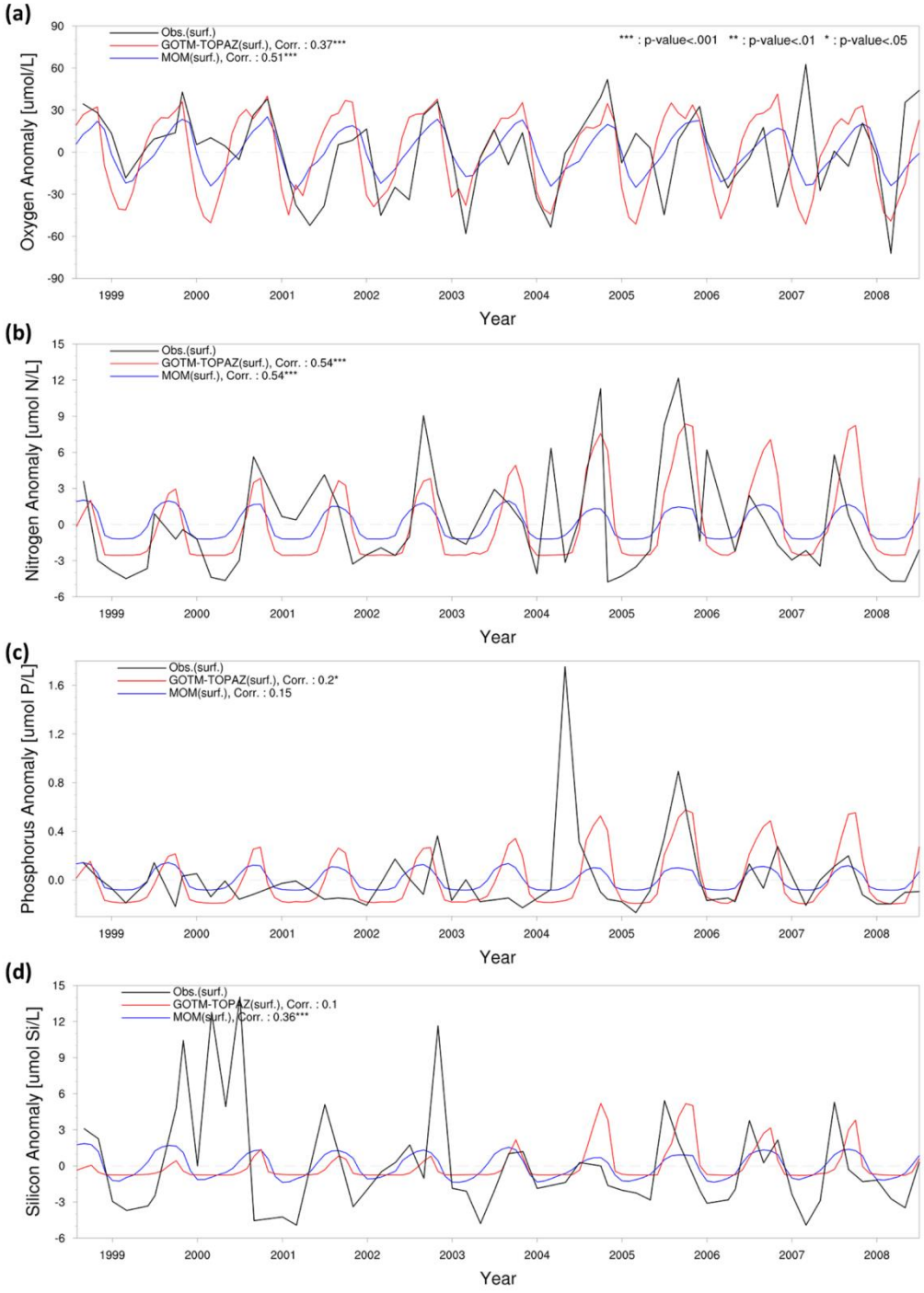
We verified the modeling performance of GOTM-TOPAZ for point 104 (131.3° E, 37.1° N) and point 102 (130.6° E, 36.1° N) in addition to point 107 (130° E, 38.0° N). The water temperatures at the former two points, like that at point 107, exhibited a cold bias in the upper layer and a warm bias in the lower layer at a depth of around 120 m (Supplementary Figure 1). This demonstrates influence from the East Korea Warm Current (EKWC) and the East Sea Intermediate Water (ESIW) that GOTM-TOPAZ could not resolve. In terms of the chlorophyll at a depth of 80 m, GOTM-TOPAZ showed an inter-annual variability similar to those from the results from observational data and MOM at both points 104 and 102 (Supplementary Figure 2, 5). Furthermore, the sea surface dissolved oxygen, nitrogen, and phosphorus concentrations simulated by GOTM-TOPAZ at those two points had correlation coefficients that were slightly lower or similar to those of results from MOM (Supplementary Figures 3, 6). The vertical distributions of dissolved oxygen and nutrients at points 104 and 102 showed patterns similar to that at point 107 when simulated by GOTM-TOPAZ (Supplementary Figures 4, 7).



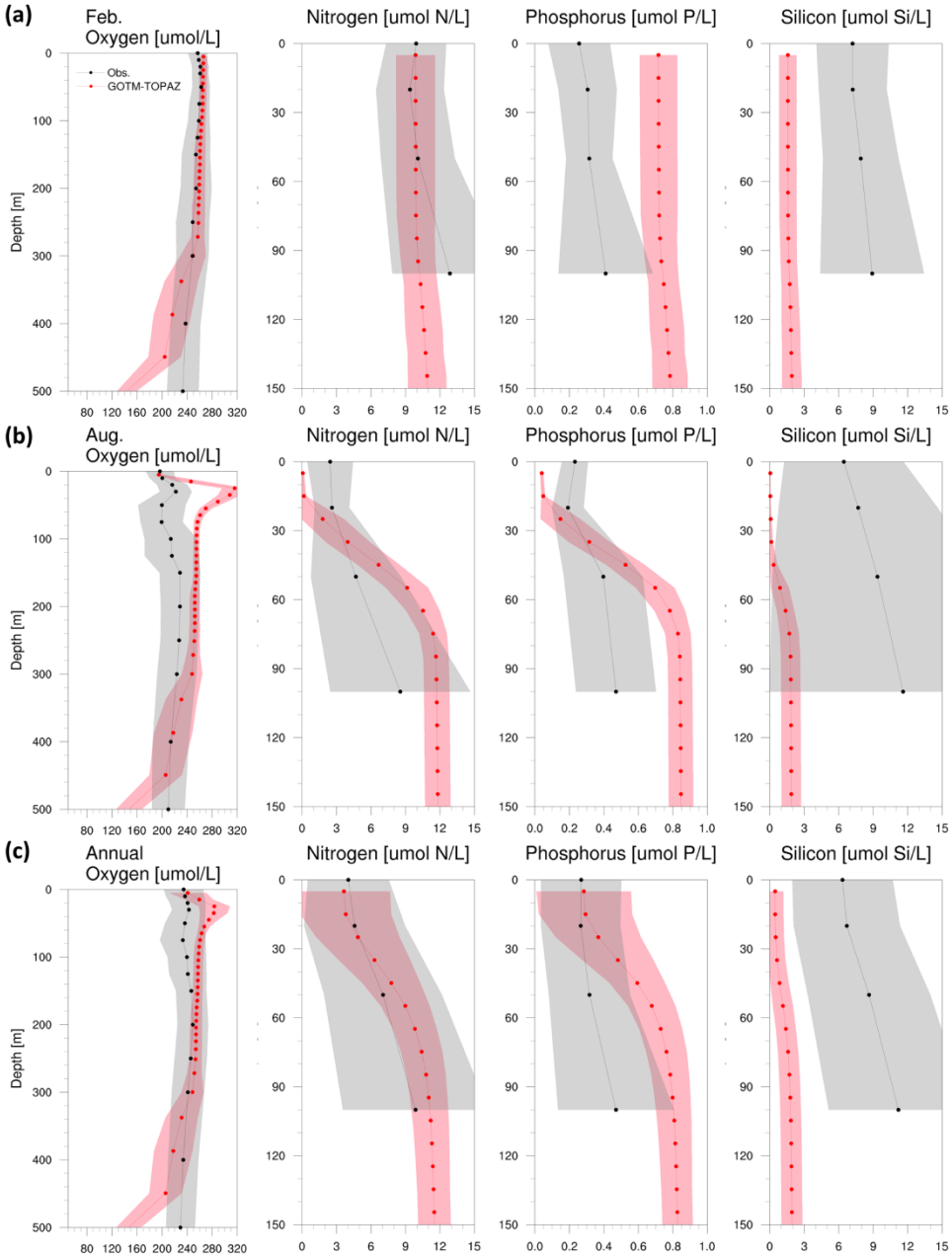
Supplementary Figure 1: Comparison of the vertical distribution over time for water temperature [℃], salinity [psu] and the difference between the two (GOTM-TOPAZ minus observational data) at points (a) 104 and (b) 102 for the 10-year period 1999–2008.



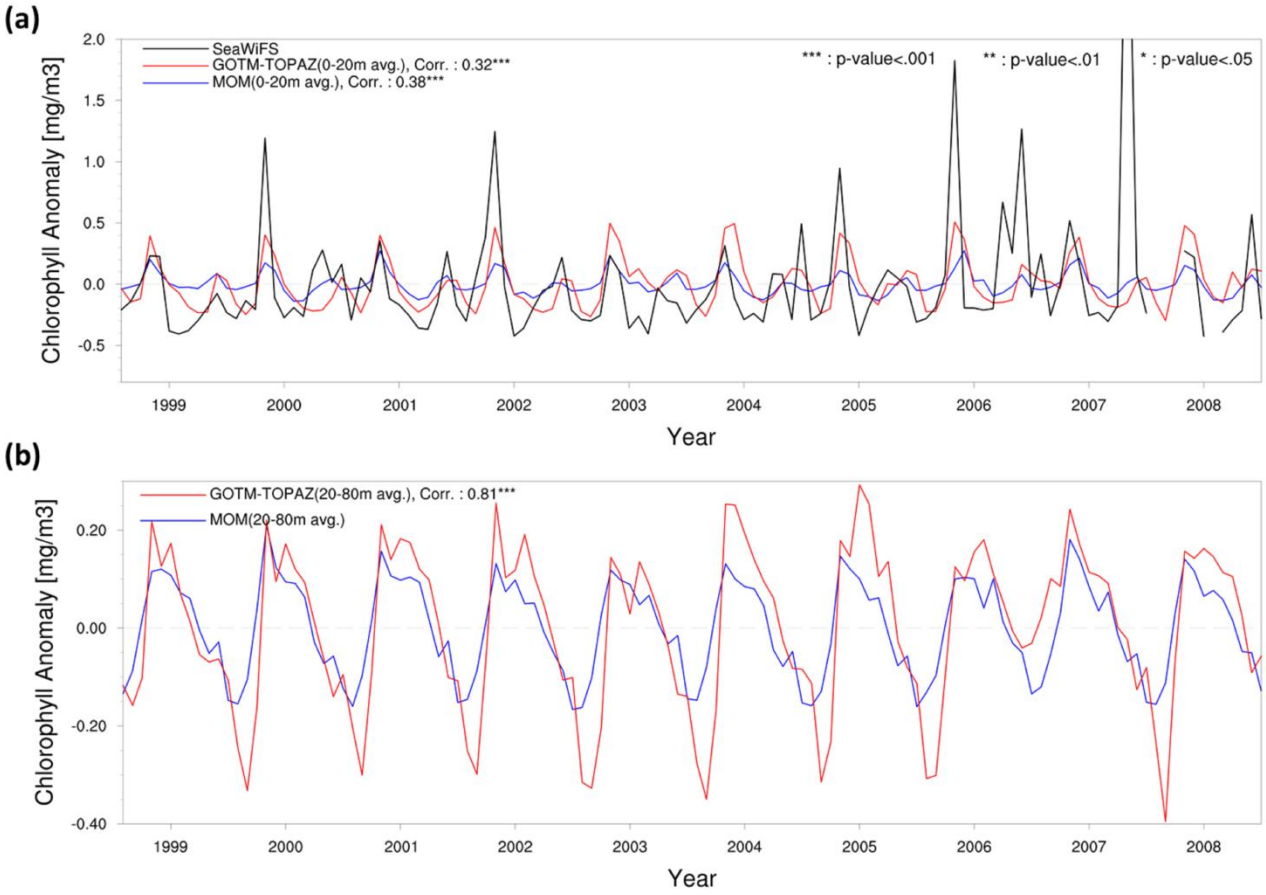
Supplementary Figure 2: Chlorophyll anomaly time series and correlation values for observational data (black lines), MOM5_SIS_TOPAZ results (blue lines), and GOTM-TOPAZ results (red lines) at point 104 for the 10-year period 1999–2008; (a) the mean value at depths ≥ 20 m and the correlations between the observations and each model; (b) mean values at depths of 20–80 m and the correlation between the two models.



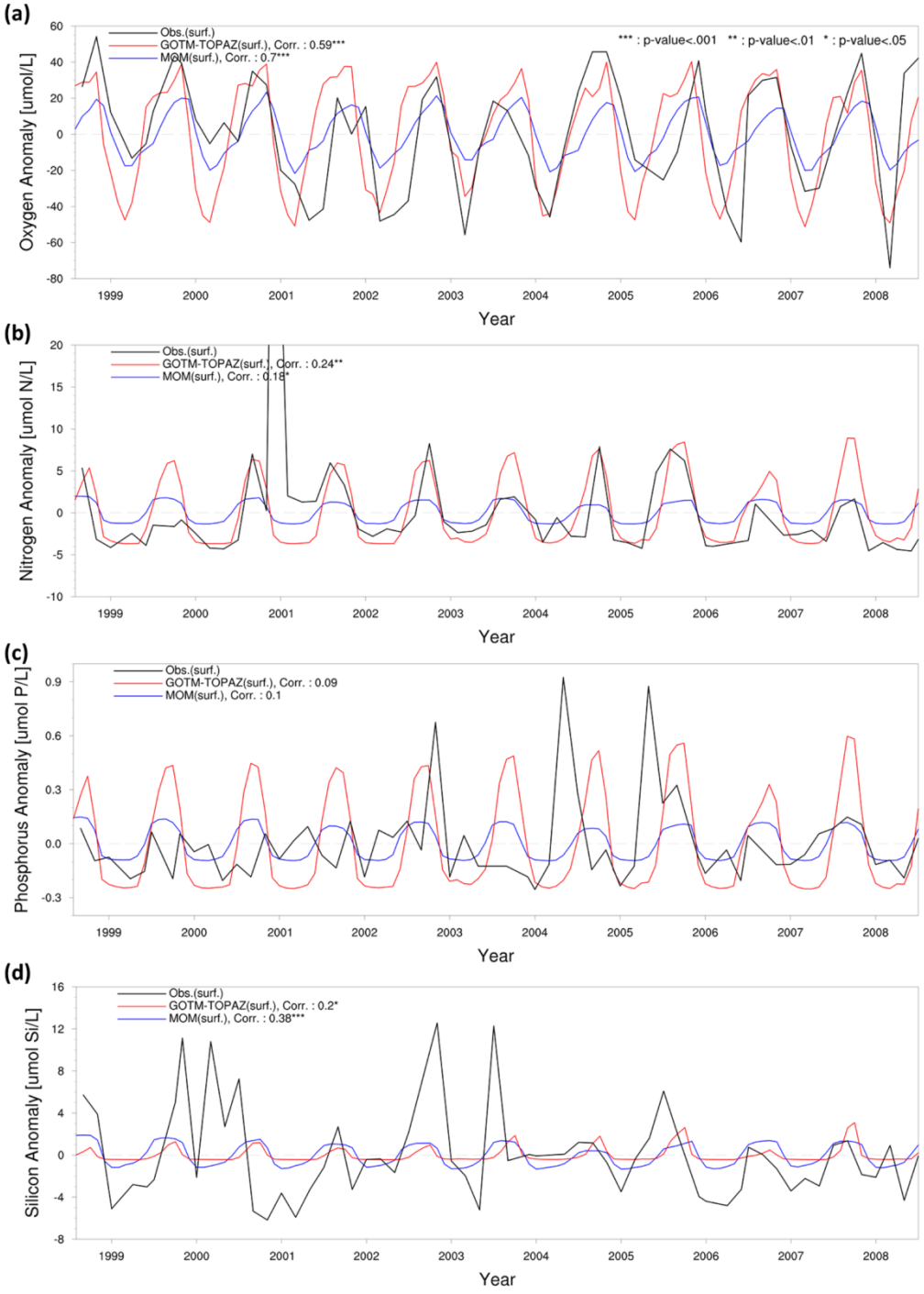
Supplementary Figure 3: Anomaly time series and correlation values from observational data (black lines), MOM results (blue lines), and GOTM-TOPAZ results (red lines) for concentrations of (a) dissolved oxygen, (b) nitrogen, (c) phosphorus, and (d) silicon at point 104for the 10-year period 1999–2008; in this figure, nitrogen, phosphorus, and silicon include NO_3, PO_4, and SIO_4, respectively.



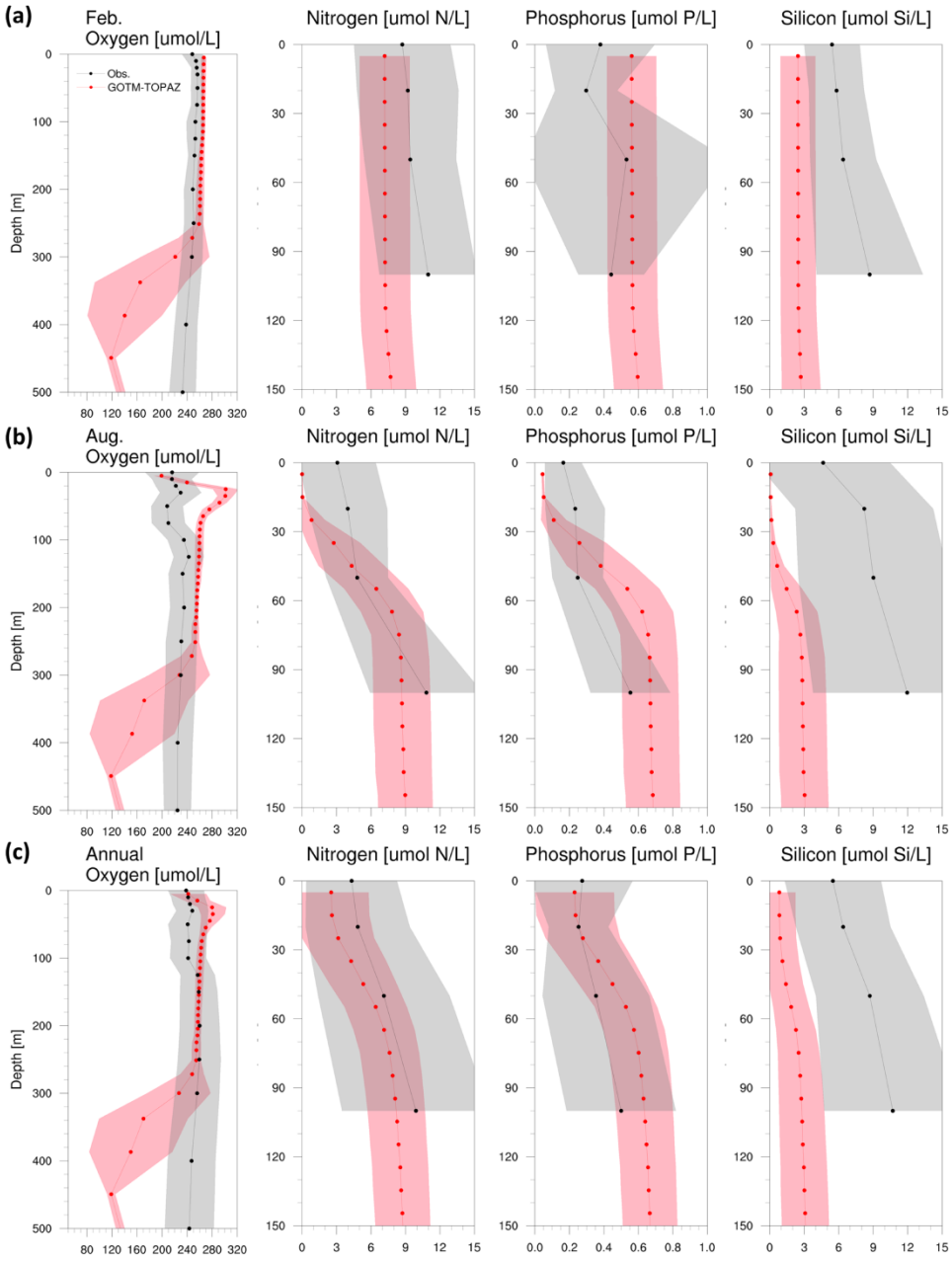
Supplementary Figure 4: Vertical profile from observational data (black dots) and GOTM-TOPAZ results (red dots) at point 104 for concentrations of dissolved oxygen, nitrogen, phosphorus, and silicon averaged from 1999–2008 (a) for February; (b) for August; and (c) annually. The shaded areas represent 1 sigma. In this figure, nitrogen, phosphorus, and silicon include NO_3, PO_4, and SIO_4, respectively.



Supplementary Figure 5: Chlorophyll anomaly time series and correlation values for observational data (black lines), MOM5_SIS_TOPAZ results (blue lines), and GOTM-TOPAZ results (red lines) at point 102 for the 10-year period 1999–2008; (a) the mean value at depths ≥ 20 m and the correlations between the observations and each model; (b) mean values at depths of 20–80 m and the correlation between the two models.



Supplementary Figure 6: Anomaly time series and correlation values from observational data (black lines), MOM results (blue lines), and GOTM-TOPAZ results (red lines) for concentrations of (a) dissolved oxygen, (b) nitrogen, (c) phosphorus, and (d) silicon at point 102 for the 10-year period 1999–2008; in this figure, nitrogen, phosphorus, and silicon include NO3, PO4, and SIO4, respectively.



Supplementary Figure 7: Vertical profile from observational data (black dots) and GOTM-TOPAZ results (red dots) at point 102 for concentrations of dissolved oxygen, nitrogen, phosphorus, and silicon averaged from 1999–2008 (a) for February; (b) for August; and (c) annually. The shaded areas represent 1 sigma. In this figure, nitrogen, phosphorus, and silicon include NO_3, PO_4, and SIO_4, respectively.