Supplementary information:

　　Fig. S1. Trends of sea surface temperature in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S2. Trends of wind speed in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S3. Trends of mixed layer depth in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S4. Trends of gridded absolute dynamic height in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S5. Trends of steric height in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S6. Trends of sea surface temperature front in the whole year for linear trend of classic least squares model (a), 75th quantile (b), 50th quantile (c), and 25th quantile (d). e-h are for winter and i-l are for summer.

　　Fig. S7. The mean of chlorophyll *a* concentration, sea surface temperature, wind speed, mixed layer depth, steric height, sea surface temperature front in the last five years (2015-2019) minus the mean of the first five years (2005-2009).

　　The supplementary information is available online at https://doi.org/10.1007/s13131-022-2097-y and http://www.aosocean.com/. The supplementary information is published as submitted, without typesetting or editing. The responsibility for scientific accuracy and content remains entirely with the authors.