Seasonal characteristics and formation mechanism of the thermohaline structure of mesoscale eddy in the South China Sea

Yongcan Zu

Center for Ocean and Climate Research, FIO, Qingdao 266061

Eddy-centric composites reveal that the horizontal distribution of temperature anomaly associated with eddy in winter is more of a dipole pattern in upper 50 m and tends to be centrosymmetric below 50 m, while in summer the distribution pattern is centrosymmetric in the entire water column. The horizontal distribution of eddy-induced salinity anomaly exhibits similar seasonal characteristics, except that the asymmetry of the salinity anomaly is weaker. The vertical distribution of temperature anomaly associated with eddy shows a monolayer structure, while the salinity anomaly demonstrates a triple-layer structure. Further analysis indicates that the vertical distribution of the anomalies is related to the vertical structure of background temperature and salinity fields, and the asymmetry of the anomalies in upper 50 m is mainly caused by the horizontal advection of background temperature and salinity.

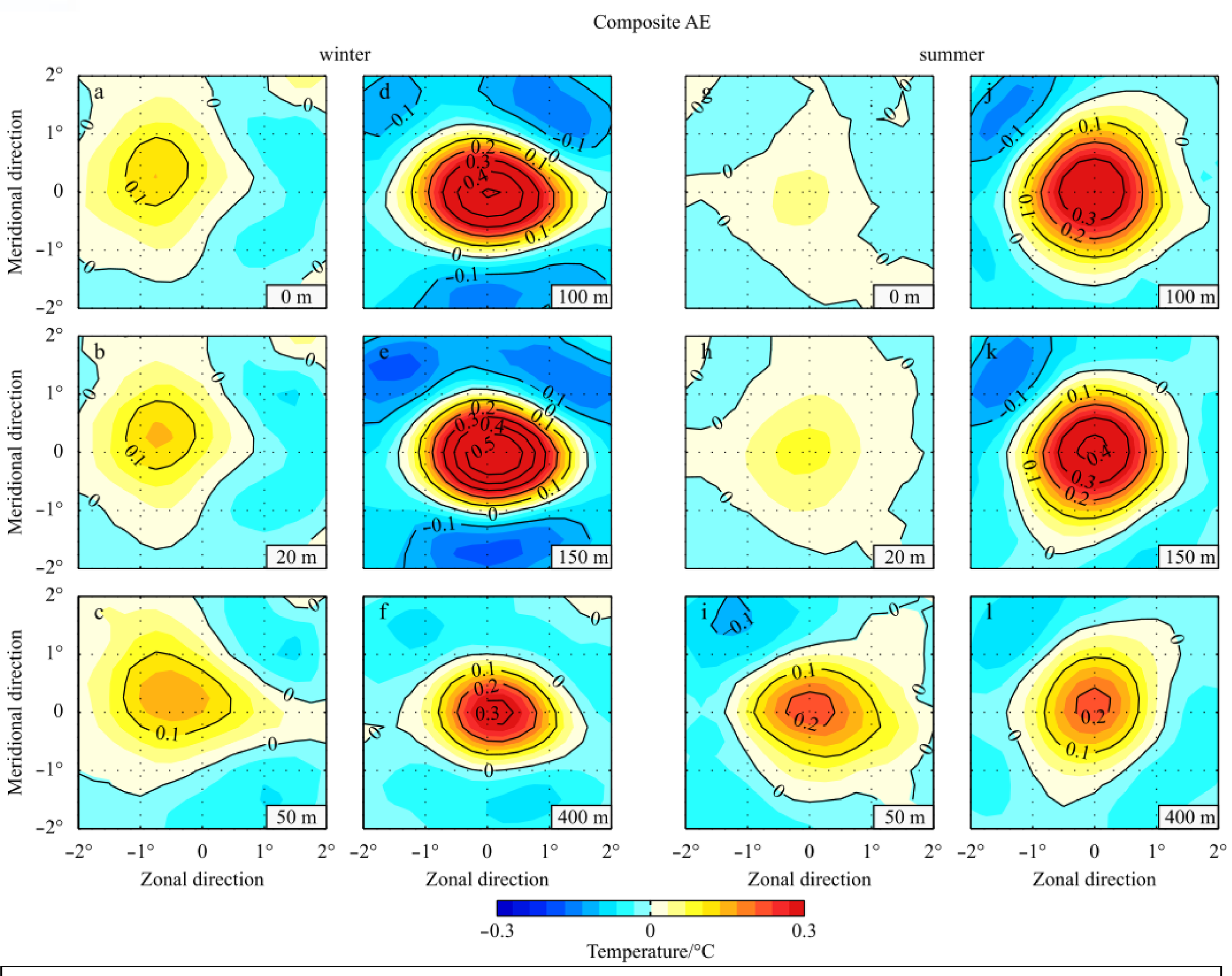

***Fig.1** Composites of horizontal distribution of the temperature anomalies (°C) associated with AEs at different depths. The left two columns are for winter and the right two are for summer. The number in the bottom right corner of each composite map is the water depth of that layer. Contour interval is 0.1°C. The X-axes and Y-axes in the composite maps indicate the latitudinal and meridional distances (°) from the center of eddy, respectively. The positive directions are eastward and northward, respectively.*

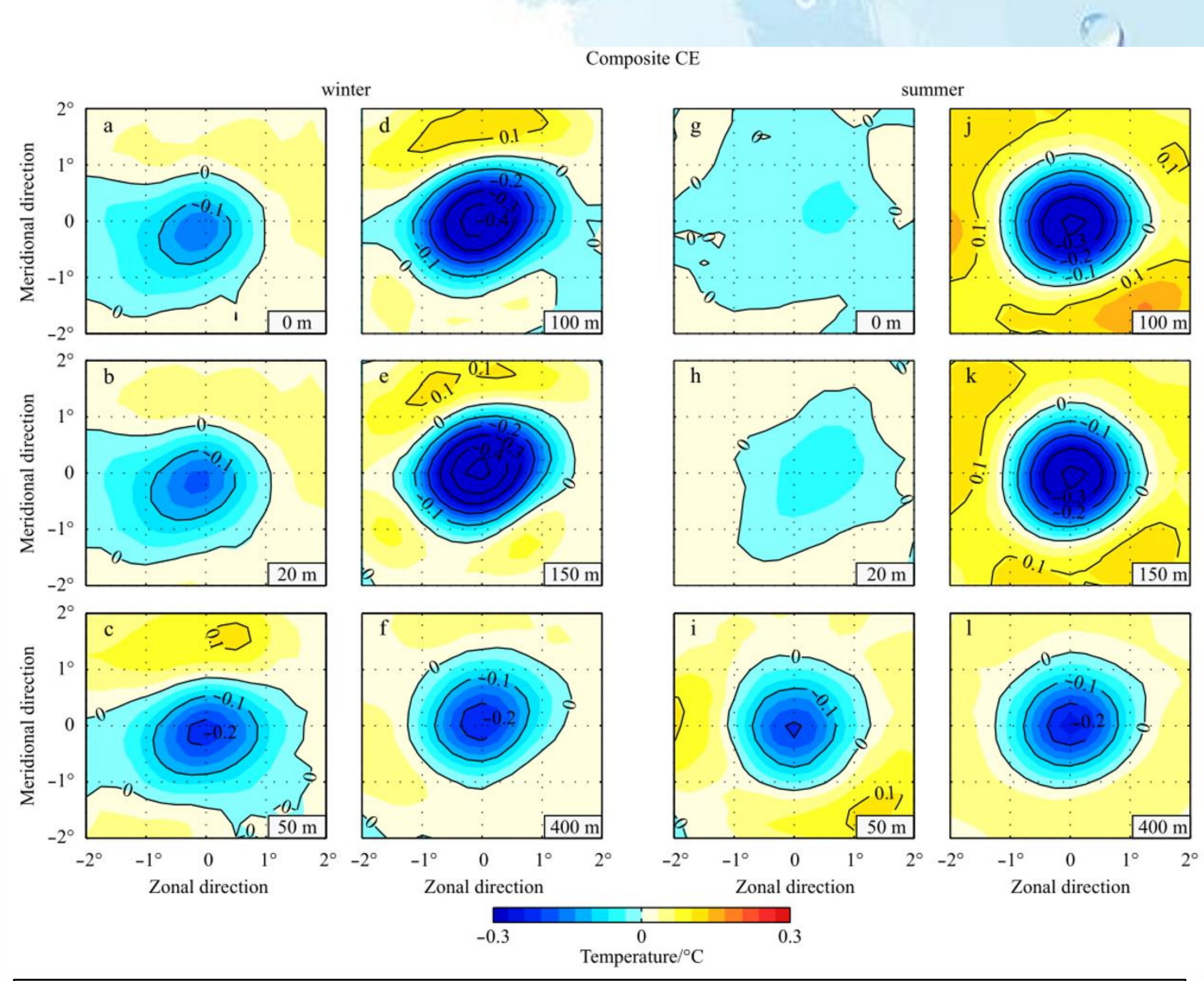

***Fig.2** Same with Fig.1 except for the CEs.*

Composite maps of eddy-induced temperature anomalies are shown in Fig. 1 and 2. One can see that, the maximal values of the anomalies in summer are located close to the center of eddy, and distribution patterns of the anomalies are largely centrosymmetric. In winter, however, the symmetry of the temperature anomalies is retained only in the layers at 100 m or deeper. For the layers shallower than 100 m (i.e., 0 m, 20 m, 50 m), the location of maximum anomaly in each layer deviates further and further away from eddy center as water depth decreases. Similar characteristics can also be found in temperature anomalies in upper layers associated with CEs in winter, except that the a symmetry of the cold anomalies (Fig. 2a–c) is not as obvious as that of AEs.

The vertical distribution of temperature anomaly induced by AEs (CEs) is a single-layer structure (Fig. 3) with positive (negative) maximum occurring at 150 m, while the salinity anomaly resulted from AEs (CEs) shows a negative-positive-negative (positive-negative-positive) triple-layer structure (Fig. 4), with maximal anomalies at 75 m, 200 m in winter/250 m in summer, and 700 m, respectively.

In an idealized two-dimensional temperature/salinity field whose gradient is uniform, the advection on the west side of an AE carries warm water from the south to the north and thus causes a warm anomaly in that region, while on the eddy's east side, cold water flows to the south and a cold anomaly thus appears (Fig. 5a). In this idealized case, the resulted anomaly exhibits a dipole pattern. For a CE, the advection will induce a similar dipole pattern, but in opposite sign (Fig. 5b). The TS background field in the surface layer (figures not shown) is just like the one illustrated by Fig. 5, so the TS anomalies induced by eddies should be similar to those demonstrated in Fig. 5.

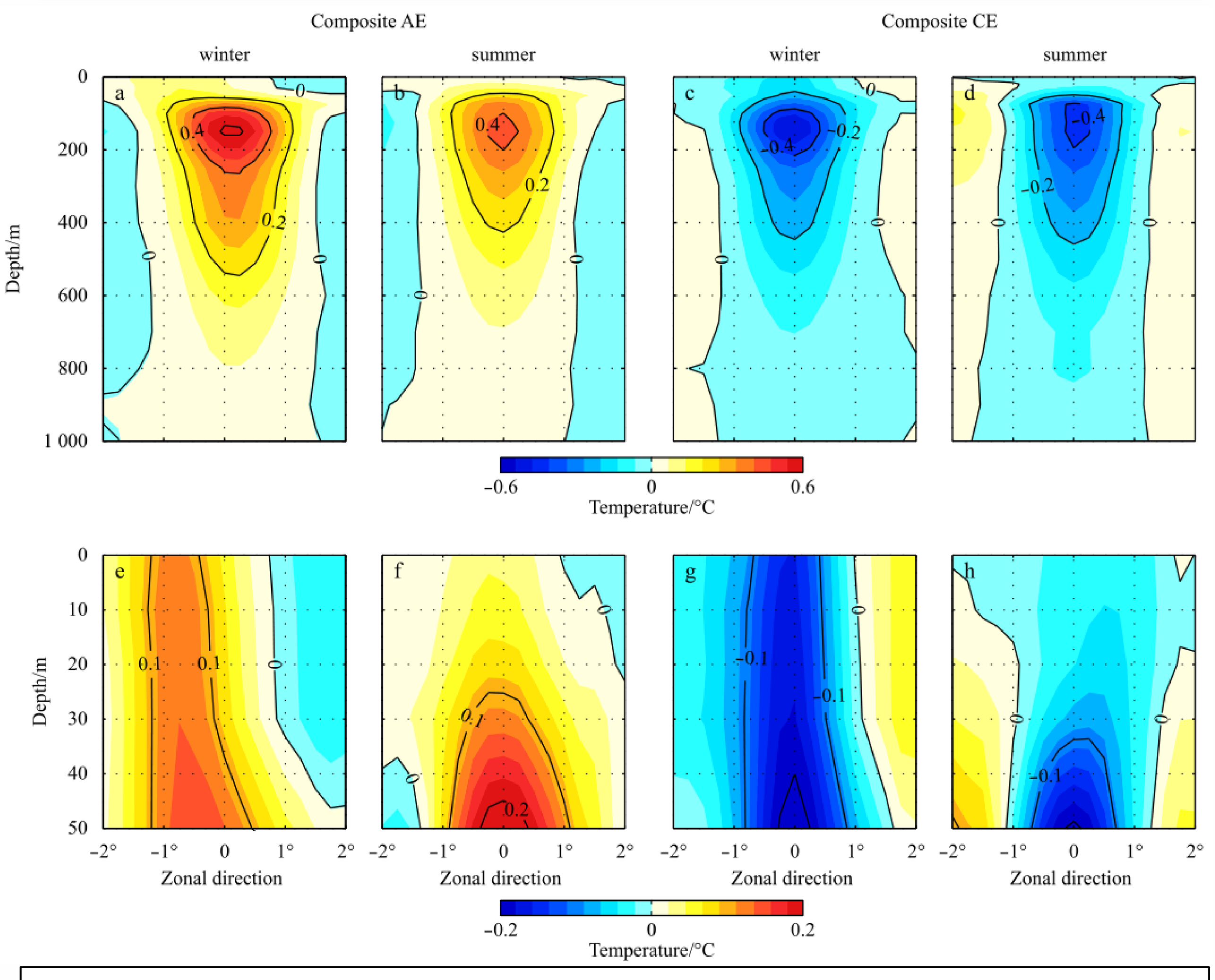

***Fig.3** West-east sections of temperature anomaly (°C) across the eddy center in winter and summer. The upper four panels cover the water column from 0 to 1 000 m, and the lower four panels show the details of 0–50 m of the upper panels. Contour intervals of upper and lower panels are 0.2°C and 0.1°C, respectively. The X-axes in the composite maps indicate the latitudinal distances (°) from the center of eddy. The positive direction is eastward.*

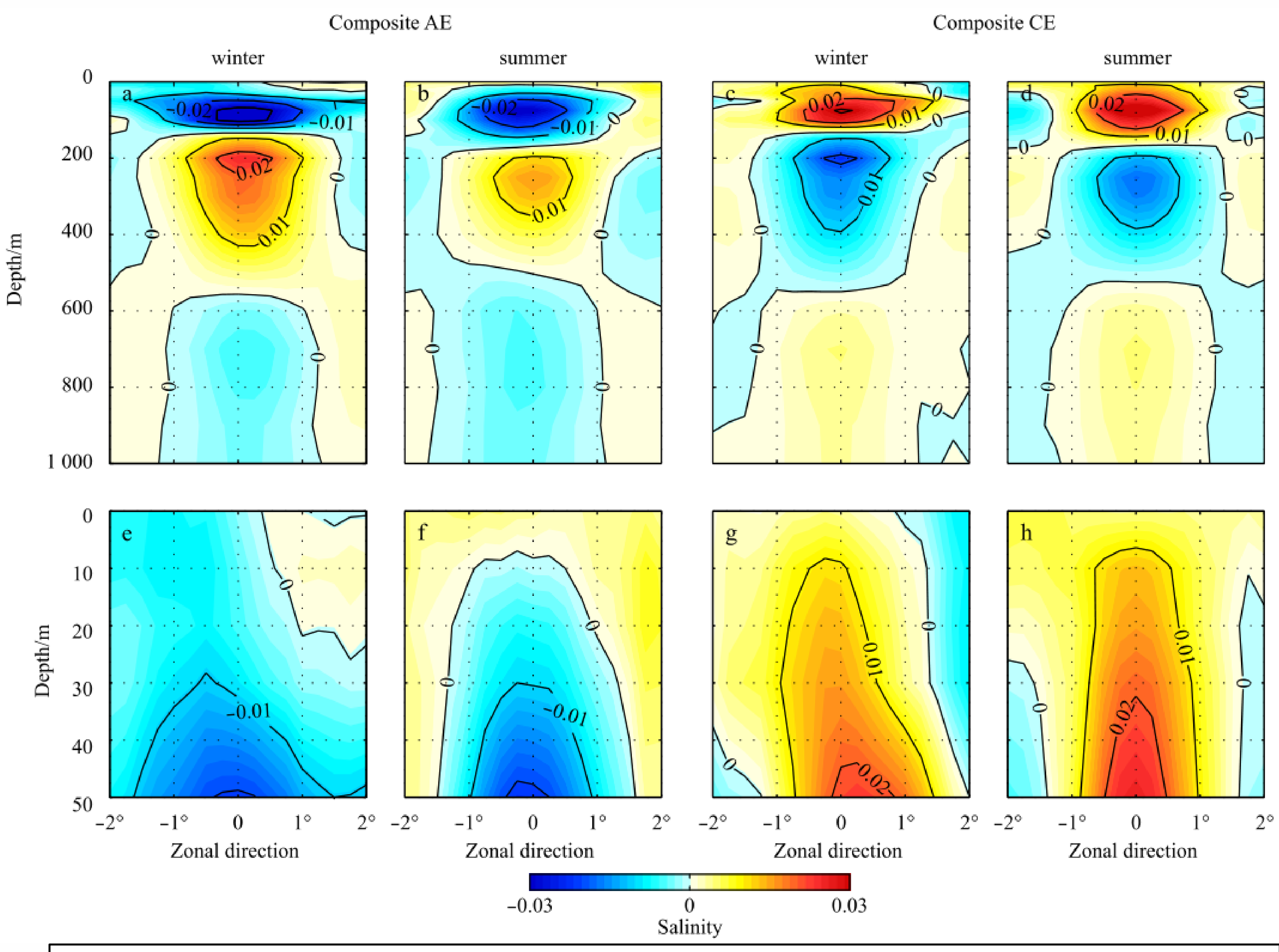

***Fig.4** Same with Fig.3 except for the salinity.*

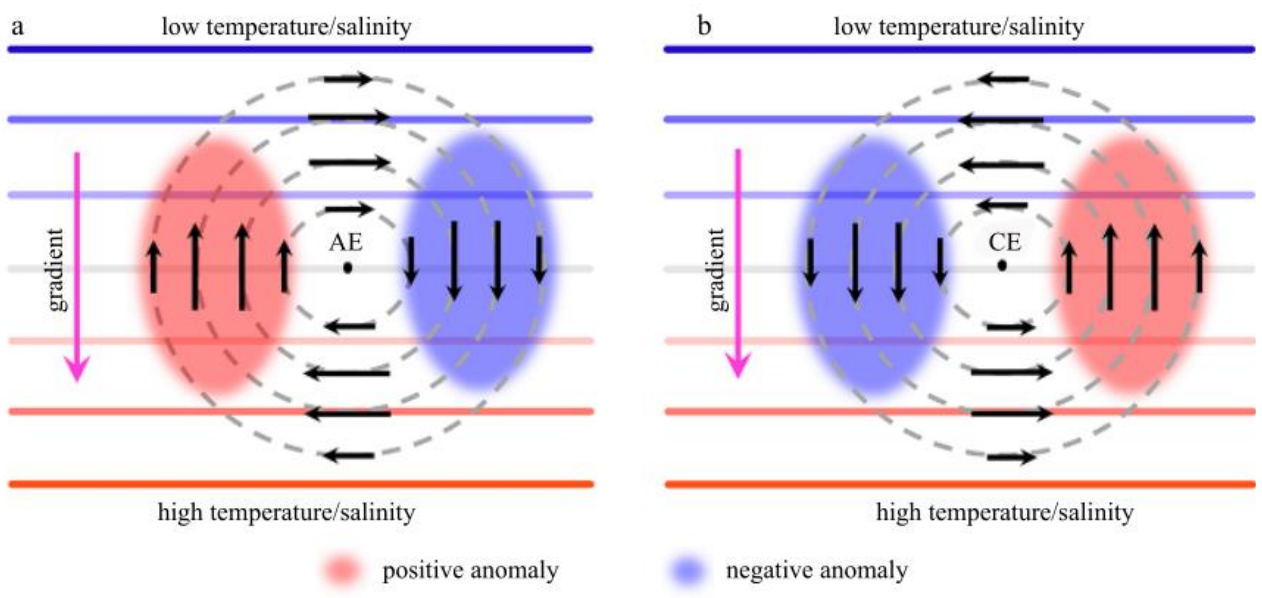

***Fig.5** Schematic diagram of the effects of horizontal advection in a non-homogenous background temperature/salinity field.*

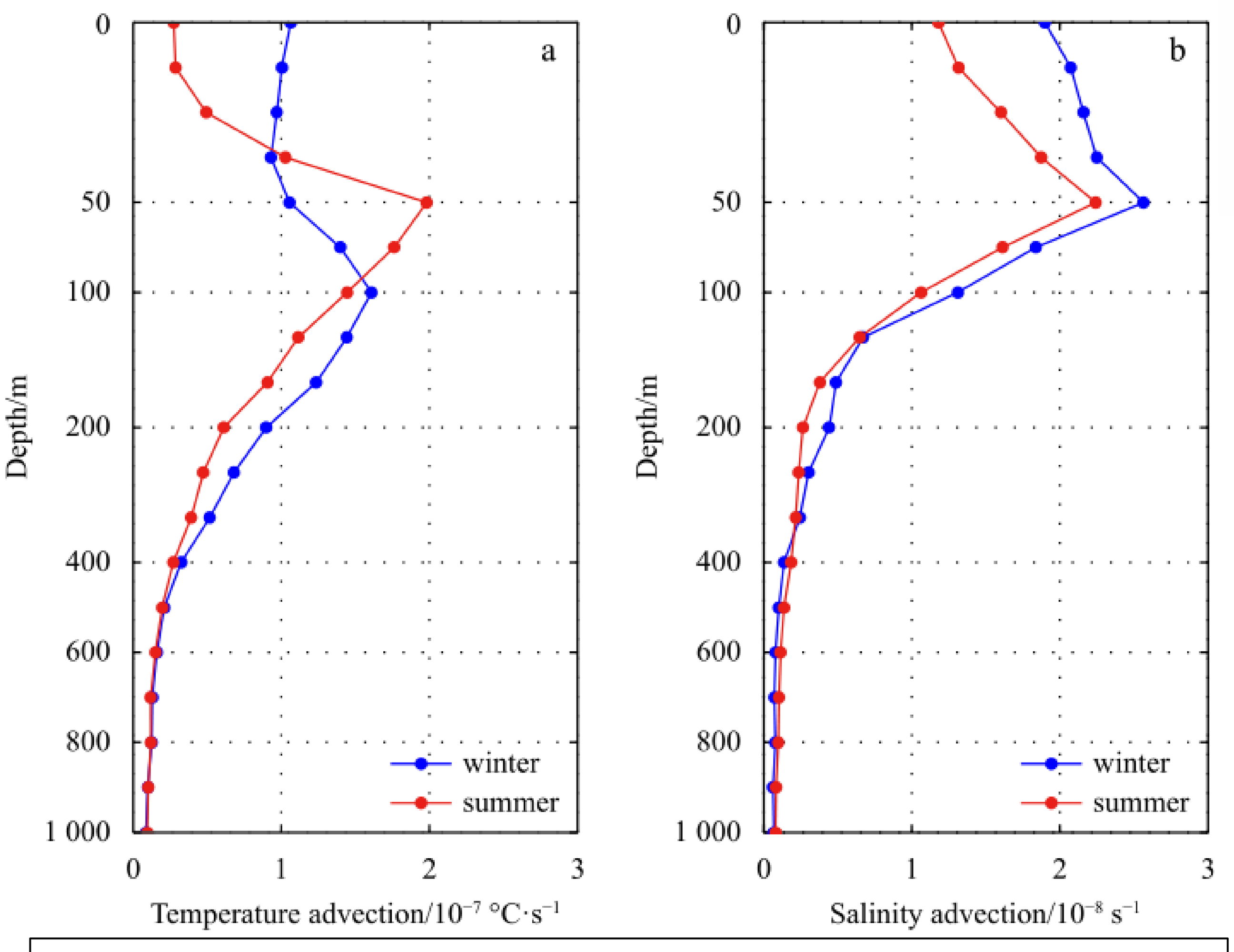

***Fig.6** Vertical variation of mean horizontal advection of temperature (a) and salinity (b) in winter and summer.*

The magnitude of advection decreases dramatically in the layers deeper than 200 m. For the layers shallower than 200 m, the variation of advection is more complicated and shows remarkable seasonality (Fig. 6). A common feature of it is that the advection in each of the upper layers in summer is significantly weaker than that in winter. This is because the horizontal gradient of background TS in summer in the SCS is much smaller.

Characteristics of the thermohaline structure associated with eddies in the SCS are mainly determined by the balance of the horizontal and vertical advection of background TS fields. The vertical distribution patterns of TS anomalies associated with eddies are mainly determined by the vertical structure of background TS fields.

References:

Zu Yongcan, Sun Shuangwen, Zhao Wei, Li Peiliang, Liu Baochao, Fang Yue, Samah Azizan Abu. 2019. Seasonal characteristics and formation mechanism of the thermohaline structure of mesoscale eddy in the South China Sea. Acta Oceanologica Sinica, 38(4):29–38, doi: 10.1007/s13131-018-1222-4