



Wintertime shoaling of mixed layer in the low-mid latitude in the North Pacific

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Wintertime oceanic surface mixed layer has been believed to deepen due to cooling and wind stirring. However, by analyzing the climatological data (World Ocean Atlas 1998), wintertime shoaling of the mixed layer is found in the latitude band of 18 degree - 30 degree in the world ocean even in the region of sea surface cooling (Takeuchi and Yasuda 2003; GRL). In Takeuchi and Yasuda (2003), this wintertime mixed layer shoaling is also confirmed by analyzing time series data of mixed layer depth which is obtained by temperature time series data of White (1995). The mixed layer shoaling is mostly accompanied by sea surface temperature (SST) cooling from January to February, and SST warming from February to March.

These wintertime mixed layer shoaling phenomena cannot be explained by existing theories of oceanic mixed layer based on monthly surface flux data. In the regions of mixed layer shoaling, the density increase in the lower part of mixed layer is larger than that near the sea surface, leading to the stratification within the mixed layer and causing the shoaling. In this study, the repeat of heating and cooling in daily time scale is considered for one possible explanation of the above wintertime mixed layer shoaling. The 1-D bulk model, using the daily net heat flux and sea surface momentum flux for input and temperature profile for initial condition, suggest that more than half of mixed layer shoaling phenomena can be explained by the heating effect.