The mixed layer variations in the North Pacific as detected by the Argo floats

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1. Introduction: Oceanic mixed layer (ML) plays an important role in air-sea heat exchange and formation of water masses such as STMW in the North Pacific. However, the detailed distribution of ML and its temporal variation has not been understood well. Based on the Argo float data, we investigate the spatial and temporal features of ML variation in detail.

2. Data and Data Processing Procedure

2.1. Argo float data: April 2000 to December 2005 (41,303 profiles) T, S and derived potential density were interpolated to 1m interval using Akima (1970) method.

2.2. Net sea surface heat flux: NCEP/Ncar Reanalysis data (net sensible heat flux, net latent heat flux, net long wave radiation flux, net shortwave radiation flux)

MLD = depth(\(\rho_{10} = \rho (10 \text{ m})\))

3. The MLD Distribution

MLD distribution is generally similar to that obtained from WOA01, except in the northwestern Pacific, where the MLD detected by the floats is systematically shallower (deeper) in the region to the north (south) of the Kuroshio Extension than the WOA01 MLD as shown in Ohno et al. (2004).

4. Temporal variation of ML (30N-35N zone)

4.1. Seasonal variation

<table>
<thead>
<tr>
<th>Sector</th>
<th>140E-160E</th>
<th>160E-160W</th>
<th>160W-120W</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLD range (m)</td>
<td>10 ~ 300</td>
<td>10 ~ 200</td>
<td>10 ~ 150</td>
</tr>
</tbody>
</table>

© Deeper MLD with denser and colder water appeared behind the stronger surface cooling by 2 ~ 3 months.

4.2. Year-to-year variation

<table>
<thead>
<tr>
<th>Sector</th>
<th>140E-160E</th>
<th>160E-160W</th>
<th>160W-120W</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLD in Feb. 2003 (m)</td>
<td>250 ~ 300</td>
<td>150 ~ 180</td>
<td>160W-120W</td>
</tr>
<tr>
<td>MLD in Feb. 2004 (m)</td>
<td>250 ~ 300</td>
<td>100 ~ 150</td>
<td></td>
</tr>
<tr>
<td>MLD in Feb. 2005 (m)</td>
<td>200 ~ 270</td>
<td>150 ~ 200</td>
<td>100 ~ 130</td>
</tr>
</tbody>
</table>

MLD_{2004-2005} < MLD_{2003-2004}
Surface cooling < Surface cooling
2004-2005 < 2003-2004

In Feb. 2003, deep ML with fresher and colder water is seen in 160E-160W without strong surface cooling

5. Relation to changes in surface heat flux

Investigating the ML variation in selected small areas using Argo float data.

5.1. Seasonal variation

Area A: large amplitude (10m ~ 350m)
- This region has large surface flux variation
Area B: amplitude is 10m ~ 110m
- Double pycnocline in spring and summer

5.2. High frequency variation

Surface flux: cooling → warming
Area A: Small vertical gradient of density
Area B: Strong warming events make shallow ML


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NCEP Reanalysis data provided by the NOAA-CIRES ESRU/PSD Climate Diagnostics branch, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/