The 1000 km-scale variability of the dynamic height revealed by Argo CTD data at 40°N in the North Pacific

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Introduction

The variability of the Sea Surface Height (SSH) has been investigated using satellite altimetry in the oceans. Many studies were associated with the **baroclinic Rossby wave** having scales of 100 to 1000 km and a year to decade (e.g. Chelton and Schlax, 1996; Zang and Wunsch, 1999; Polito and Liu, 2003; Fu and Chelton, 2001; Fu, 2004). However, since these studies were based on Gill (1982) that the SSH varies being correlated empirically with the thermocline depth. This means that the isobaric surface below the pycnocline is parallel to the Geoidal surface.

In the subarctic North Pacific, **the thermocline is too weak** to assume the isobaric surfaces in the lower layer is horizontal.

We analyzed spatial and temporal variability of dynamic height referred to 1000 dbar estimated using Argo CTD data and compared with SSH from satellite altimetry.

Data and Method

1. Used Argo CTD data were archived by (<http://www.usgodae.org/argo/argo.html>).

2. We calculated 20 dbar dynamic height referred to 1000 dbar for each profile. The reference level was below the pycnocline.

3. Optimal interpolation (OI) was applied to make 1°x1°grid dynamic height. Since **the spatial resolution of the Argo data used** was variable, OI was carried out for the three separated areas.

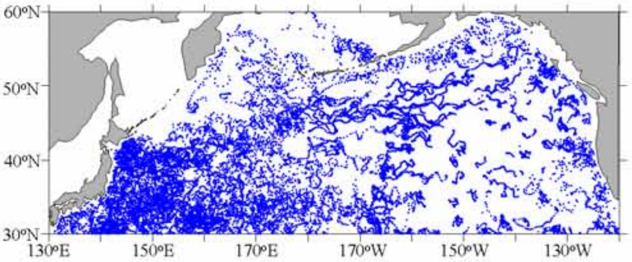


Fig.1. Positions of the floats that have delivered data between September 2005 and October 2007

Mean Structure

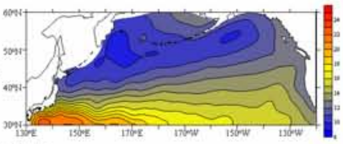


Fig.2. Mean dynamic height (m²/s²) referred to 1000 dbar at 20 dbar during the observation period.

Spatial and Temporal Variability

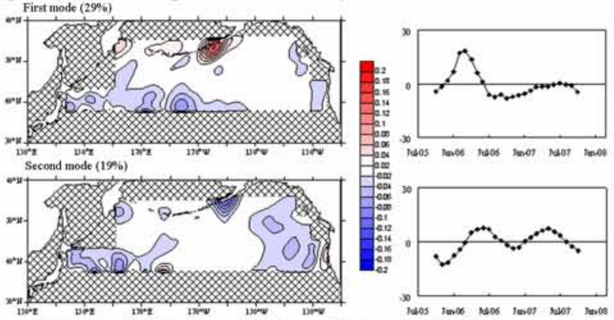


Fig.3. First two EOFs (both the spatial patterns and their associated time functions) representing the dynamic height.

- Based on EOF analysis, local variation of the dynamic height was strong along 40°N and coast.
- High and low anomalies are seen in rows along the latitudes with wavelengths of about 1000 km.

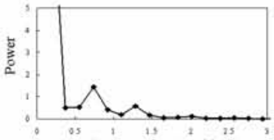


Fig.4. The temporal average power spectrum of zonal dynamic height along 40°N from 145°E to 170°W

- Spectrum analysis showed that the zonal variation peaked at wavelength of 1300 km along 40°N.

Time-Longitude Matrix along 40°N

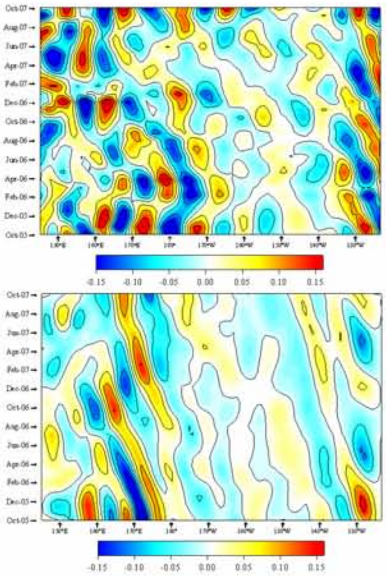
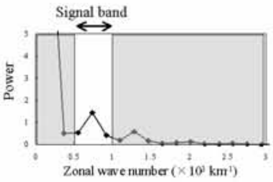


Fig.5. Time-longitude matrix of the filtered dynamic height (upper) and filtered SSH from satellite altimetry (lower). The SSH was multiplied by the gravity acceleration to compare the dynamic height.

- We applied band pass filter to extract the signals having wavenumbers 0.5-1.0 x 10^3 km^{-1}.



- Amplitudes of the filtered dynamic height were large in the west of 170°W and in the east of 140°W, being small between 170°W and 140°W.
- Amplitudes of the filtered SSH were large around 170°E.
- High-amplitude signals of the filtered dynamic height and SSH propagated westward

Table 1. Phase speeds were estimated by the filtered dynamic height

Wavenumber	TimeScale	PhaseSpeed
0.73	211	-1.74
0.73	203	-1.99
0.91	177	-1.97
mean	197.2	-1.90
×10^{-3}km^{-1}	day	cm/s

Comparison of Geostrophic Velocity Variation between Dynamic Height and SSH

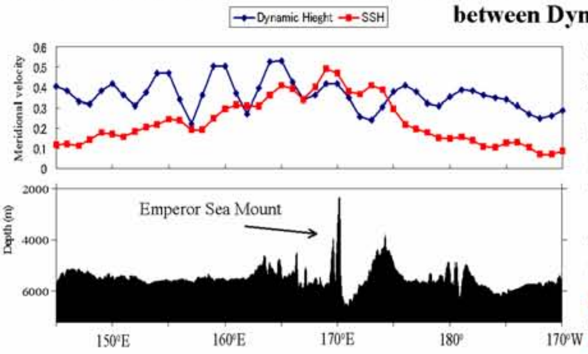
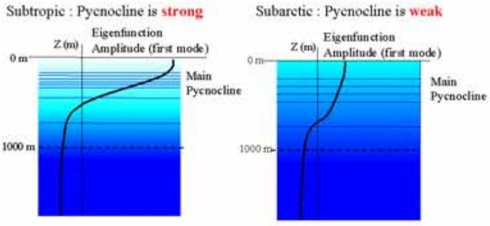
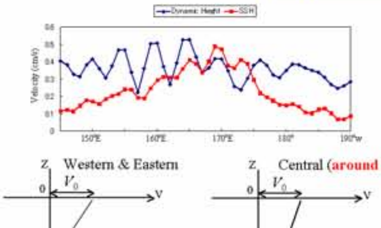


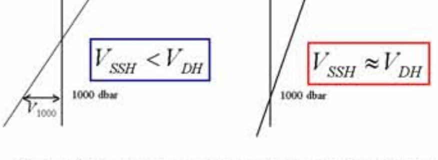
Fig.7. Temporal root-mean-square of meridional velocity (cm/s) from dynamic height and SSH (upper) and bottom topography (lower) along the 40°N.

- We calculated RMS of geostrophic velocity using dynamic height referred to 1000db and SSH from the satellite, which were filtered.
- Velocity RMS of the SSH **is equal to or greater than** the dynamic height around 170°E, **being smaller** at the other longitudes.

Discussion: Difference of the velocity structure between the Central and the Western & Eastern







- In the subtropic, no motion at the 1000db surface is good approximation for the geostrophic velocity calculation on the sea surface.
- In the subarctic, the geostrophic velocity cannot be ignored because of the small vertical shear in the upper layer.

Fig.7 shows:
$\mathrm{RMS}(V_{SSH}) < \mathrm{RMS}(V_{DH})$ in the Western and Eastern regions, meaning the velocity is in antiphase between upper and lower layer (Left Panel)

$\mathrm{RMS}(V_{SSH}) \approx \mathrm{RMS}(V_{DH})$ in the Central region, meaning the velocity is small in the lower layer (Right Panel).

Velocity component may be redistributed forced by the topographic effect around the Emperor Sea Mount.