WAVENUMBER AND DEPTH PROPERTIES OF TEMPERATURE FINESTRUCTURE IN THE REGION AROUND THE RYUKYU ISLANDS

BAO Xian-wen, WU Ke-jian, LUO Yi-yong

(Dept of Physical and Environmental Oceanography, Ocean University of Qingdao, Qingdao 266003, China)

Received June 6, 1998; revision accepted Nov. 10, 1998

Abstract Forty-two CTD profiles gathered in summertime of 1997 were used for finestructure studies around the Ryukyu Islands indicating that finestructure properties varied with depth; and that the wavenumber spectra density is a negative (-3 to -4) power function of the wavenumber in the high wavenumber range. The identical finestructure spectral features in different stations indicate considerable water exchange through the Kerama Trench. The wavelet spectrum's spatial structure and intermittency is related to the vertical mixing of water.

Key words: finestructure, spectrum, wavelet, Ryukyu Islands

INTRODUCTION

The oceanic finestructure in the East China Sea (ECS) Kuroshio region had been studied by various researchers. Fang et al. (1988) studied the features of the finestructure in the southern shelf area and the Kuroshio area in the ECS by using CTD data. Bao et al. (1996) analyzed some features of thermohaline finestructure and revealed its relation with the water masses and currents system in the northern ECS. But oceanic finestructure in the eastern region of the Kuroshio has seldom been studied. In this paper, based on 42 CTD profiles gathered in summer of 1997, the properties of the temperature finestructure are analyzed by maximum entropy spectral estimation in Section 3 and local wavelet spectra in Section 4. The properties include wavenumber spectra variations with region and depth, local wavelet spectra distributions with depth and local intermittence. This study on the properties of the temperature finestructure yielded evidence of water exchange through the Kerama Trench. The locations of sections and stations are shown in Luo et al. (1998).

The CTD data were pretreated by the method of Fang et al. (1992) to ensure their quality.

TEMPERATURE FINESTRUCTURE IN THE REGION AROUND THE RYUKYU ISLANDS

The temperature finestructure in the region around the Ryukyu Islands was obvious at each CTD profile and consisted of "slices", in which temperature varied rapidly, and "layers", in which temperature varied slowly. This slices and layers structure is presented in Fig.1a. Fig.1 shows the distribution of temperature (Fig.1c) and density stratification (Fig.1b) with depth. It was quite clear that the temperature finestructure, an irregular fluctuation of temperature, weakened or strengthened at some depths. Analysis shows that in general, the finestructure variation weakens (strengthens) at depths where density stratification usually weakens (strengthens). Fig.1a indicates that the temperature finestructure variation becomes weak with increase of depth.

* Project supported by the China-Japan Joint Investigation of Subtropical Circulation, and Shandong Province's NSF (No. Q971101444).
RESULTS OF SPECTRAL ESTIMATION BY THE MAXIMUM ENTROPY METHOD

Spectral estimation of temperature fluctuation and its gradient is an important aspect of study on oceanic finestructure properties. Extensive research on finestructure spectral analysis (Hayes, 1975; Fang et al., 1988; Bao et al., 1996) revealed some properties of finestructure spectra in ocean fronts and shallow seas and indicated that the spectral slope (-2 to -3) in oceans is less steep (-3 to -4) than that in fronts and shallow seas.

The CTD profiles of the vertical distribution of water temperature of the region around the Ryukyu Islands are divided into 70 - 120 m (upper), 470 - 520 m (middle), 970 - 1020 m deeper and 2970 - 3020 m (bottom) layers. Finestructure spectra were calculated by the maximum entropy method which can provide excellent resolution in wavenumber space. Fig. 2 shows finestructure spectra at the upper layer in section B (covering station F1, G3, G2, H1) and section K located respectively in the eastern and western region of the Kerama Trench. Temperature finestructure properties of the middle layer and deeper layer in section B and section K were very similar. Generally, the temperature finestructure spectral properties are different in different water masses. So their similarity in different stations in the eastern and western regions of the Kerama Trench indicated the same water mass occupying the eastern region and western region of the Kerama Trench. Li (1998)1) and Luo et al. (1998)’s analysis of the thermohaline distribution in the region showed water-exchange through the Kerama Trench. Bao et al. (1996)’s analysis of differences of finestructure properties in different water masses in the northern ECS showed that the spectral properties in the region around the Ryukyu Islands were the same as those in the eastern region of the Kuroshio, so we infer that the Pacific water comes into the ECS through the Kerama Trench and spreads to the northern region.

Ensemble average spectra at the upper layer, middle layer, deeper layer and the bottom layer had some regularities. The following fitting curve equations were obtained based on the spectral level and slope at different layer:

Upper: \[ S(\lambda) = 9.4 \times 10^{-7} \lambda^{-3.68} \quad 0.4 \leq \lambda \leq 4 \]
Middle: \[ S(\lambda) = 5.17 \times 10^{-7} \lambda^{-3.25} \quad 0.4 \leq \lambda \leq 4 \]
Deeper: \[ S(\lambda) = 3.3 \times 10^{-8} \lambda^{-3.17} \quad 0.4 \leq \lambda \leq 4 \]
Bottom: \[ S(\lambda) = 6.6 \times 10^{-10} \lambda^{-3.07} \quad 0.4 \leq \lambda \leq 4 \]

1) Li Fengqi, Li Lei, Qi Jianhua et al., Distinction and analysis of water masses in the region at both sides of the Ryukyu Islands. (To appear).