SPECTRA OF CURRENTS AND TEMPERATURE OFF GODAVARI
(EAST COAST OF INDIA)

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ABSTRACT

Time series data of currents and temperature obtained from a mooring of current meters off Godavari (East Coast of India) during September 1980 are analysed to study the space scales of semidiurnal and internal oscillations in the range of buoyancy and internal frequencies. Rotary spectra of currents and spectra of temperature are computed and presented. Influence of semidiurnal tide is well discernible up to the bottom layers. Turbulence is observed near 15 m depth. Existence of internal waves is clearly seen from temperature spectra at all the depths.

Key-words : Spectra, currents, internal waves, Bay of Bengal.

Analysis of rotational spectra of currents and spectra of temperature is an important tool for interpretation of internal wave field and tidal oscillations. In respect of the sea off the east coast of India, a few earlier works (La Fond, 1954, 1962, La Fond and La Fond, 1967) reported the presence of internal waves and concluded in general that the tidal forces influenced the internal wave pattern in the ocean. La Fond (1959) inferred that rotary currents and sea surface slicks might be the manifestation of shallow progressive internal waves. But none of these studies discuss the spectra of currents and temperature in this region. To study the structure of currents and temperature off Godavari, in the western Bay of Bengal, time series data were collected from 24 to 28 September 1980 by mooring Aandera Recording Current Meters at three depths. The mooring location (G-11) is shown in Fig.1. The preliminary results were published elsewhere (Sarma and Rao, 1986). In this paper the features of internal wave field between the internal and buoyancy frequencies are discussed from rotary and spectral estimates.

Processed time-series data of currents and temperature i.e., 1026 observations at 5 minute interval for each of the three depths 15, 115 and 240 metres are used to compute spectral energies. Two sets of data with 81 observations each (30 minutes average) are used to compute low frequency rotary and spectral estimates of currents and temperature. For high frequency spectral estimates (0.0031 to 0.1000), 16 data sets, each of 5 minutes interval on 64 observations are used. Rotary spectrum method (Gonella, 1972) decomposes the vector time series into circularly polarised components rotating clockwise and anticlockwise at each frequency. For high frequency spectral estimates 99% confidence intervals and for low frequency spectral estimates 80% confidence intervals (Bendat and Peirsol, 1972) are computed from $\psi^2 / \nu$ distribution tables. 99% confidence intervals are found to range from 0.43 to 2.01 and 80% confidence intervals from 0.26 to 1.94 times of spectral estimates.
Rotary spectra of currents: Figure 2.1 presents the rotary spectral estimates of currents at 15 m depth. Clockwise (S⁻) and anticlockwise (S⁺)
Figure 2.2 shows the rotary spectral estimates of currents at 115 m depth. Clockwise rotation (S-) is predominant at 0.0004 cpm (40.5 hours). From 0.0012 cpm (13.5 hours) the anticlockwise rotation is predominant. Increase in spectral energy is observed towards high frequencies. Notable peaks are observed at periods, 40.5, 10.12 and 5.05 hours. Minimum energy is observed at 1.56 hours for anticlockwise rotation and at 1.31 hours for clockwise direction.

Rotary spectral energies of currents at 240 m depth are presented in Fig. 2.3. Anticlockwise rotation (S+) is observed at all periods except at 40.5
and 20.25 hours. Decrease in spectral energies are observed in anticlockwise rotation.

It is clear from the results that the tidal influence is the predominant force to produce clockwise rotation at 15 m and anticlockwise rotation at 115 and 240 m depths.

Rotary spectra of current (High Frequency): Figure 2.4 present the high frequency spectra of currents at 15 m depth. The spectral estimates are computed with 32 degrees of freedom. Dominance in clockwise rotation is observed. There is a sharp decrease in spectral energy from 0.0062 cpm (5.3 hours) frequency. Maximum spectral energy is observed at 0.0031 cpm frequency. Peaks are observed at 53, 40, 32 minutes in clockwise and anticlockwise directions alternately. Figure 2.5 shows the spectral estimates of currents at 115 m depth. Spectral energies in clockwise rotation are almost equal to those of anticlockwise rotation. Predominant peaks are observed at various frequencies. Spectral energies at high frequencies are given in Fig.2.6 for currents at 240 m depth. Clockwise rotation (S-) is predominant at this depth. At 0.0031 cpm maximum energy and peaks are observed at various frequencies. Fig.2.7 represents the total [(S-) + (S-)] spectral estimates of currents at 15, 115 and 240 m depths. Maximum spectral energies are observed at 0.0031 cpm frequency at all the depths. From 0.0125 cpm onwards spectral energies at 115 m depth show increasing trend than at 15 and 240 m depths. At frequencies 0.0313 and 0.0906 cpm increase in spectral energy is observed at all the depths.

Rotary Coefficient: Rotary coefficient values of spectral estimates for 15, 115 and 240 m depths are plotted against frequencies (Fig.2.8). Magnitude of rotary coefficient varies between 0 and 1. Sign indicates the polarisation of the ellipse. Magnitude is equal to one for pure rotary motion and zero for unidirectional (linear) motion. At 0.004 cpm rotational motion is observed and is more at 15 m depth. At 0.0012 cpm rotational motion is opposite in directions. Pure rotational motion is observed in clockwise direction at 0.0016 cpm near 15 m depth. At very few frequencies linear motion is observed. From the figure it is observed that rotational motion is predominant at more frequencies and direction of the flow at one depth is always opposite to that at other two depths. Fig.2.9 represents the rotary coefficients plotted against high frequencies. The flow at 15 and 240 m depths show more rotational nature. But at 115 m depth linear motion is predominant.

Temperature spectra: Spectral estimates of temperature at 15, 115 and 240 m depths are presented in Fig.3.1. The spectral energies at 115 m depth are greater than that at 15 and 240 m. Predominant peaks are observed at frequencies 0.0004, 0.0012, 0.0086 and 0.0119 cpm at all the depths. At 15 and 115 m depths, the maximum spectral energy is observed at 0.0004 cpm while at 240 m depth this maximum is at 0.0012 cpm. The steepness of the spectra (Townsend, 1956, Monin, 1976) at 15 m depth indicates the presence of turbulence. But at 115 and 240 m this nature is absent. The spectral energy shows increase near inertial frequency (0.0004 cpm) at 15 and 115 m depth. The peaks at 0.0012 (13.5 hours) at all the depths indicate the influence of semidiurnal tide. The spectral estimates of temperature for high frequencies are presented in Fig.3.2. High spectral energy values at low frequencies and
Figs. 2.4-2.7. Rotary spectra (HF) at 15, 115, 240 m depths and (s+) plus (s-) respectively
Fig. 2.8. Frequency distribution of Rotary Coefficient

Fig. 2.9. Frequency distribution of Rotary Coefficient (H.F.)
Fig. 3.1. Temperature spectra

Fig. 3.2. Temperature spectra (H.F.)
sharp cutoff trend near the Vaisala frequency are generally in agreement (Garrett and Munk, 1972) with the model. However, the rate at which the spectral energies decrease in the present study is slightly less than \(\omega^2\) suggested in the model. At 115 m the energy is greater than that at 15 and 240 m depths. Turbulence at 15 m depth is inferred. Near to buoyancy frequency (\(\approx 10\) cph) sharp increase in spectral energy is observed. As the thermocline is situated near 115 m the spectral energy is more variant at this depth than other two depths.

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REFERENCES


