Turkish J. Mar. Sci. 1:23-35 (1995)

LONG PERIOD (SUBTIDAL) SEA LEVEL VARIATIONS AND THEIR RELATIONS TO ATMOSPHERIC FORCING IN THE GULF OF ANTALYA

ANTALYA KÖRFEZİNDE UZUN PERYOTLU (GELGİT DIŞI) SU SEVİYESİ DEĞİŞİMLERİ VE ATMOSFERİK GÜDÜMLEME İLE OLAN İLİŞKİLERİ

BEDRİ ALPAR [(1)], HÜSEYİN YÜCE [(1)], ERTUĞRUL DOĞAN [(2)]

[(1)] Department of Navigation, Hydrography and Oceanography, 81647 Çubuklu, Beykoz, Istanbul, Turkey

[(2)] Istanbul University, Institute of Marine Sciences and Management, 34470 Vefa, Istanbul, Turkey

Key words : Sea level; Subtidal variations; Atmospheric forcing; Eastern Mediterranean.

Abstract

Long period (subtidal) sea level fluctuations in the Gulf of Antalya and their relations to atmospheric forcing were examined over one-year period. Main study tools were the power spectra of time series and the cross spectral analyses of sea level on local atmospheric pressure and two orthogonal wind stress components. The results shown an inverted barometer response to atmospheric pressure and a frequency dependent response to wind

that can be tentatively interpreted in terms of wind setup or barometric setup of semi-enclosed regions.

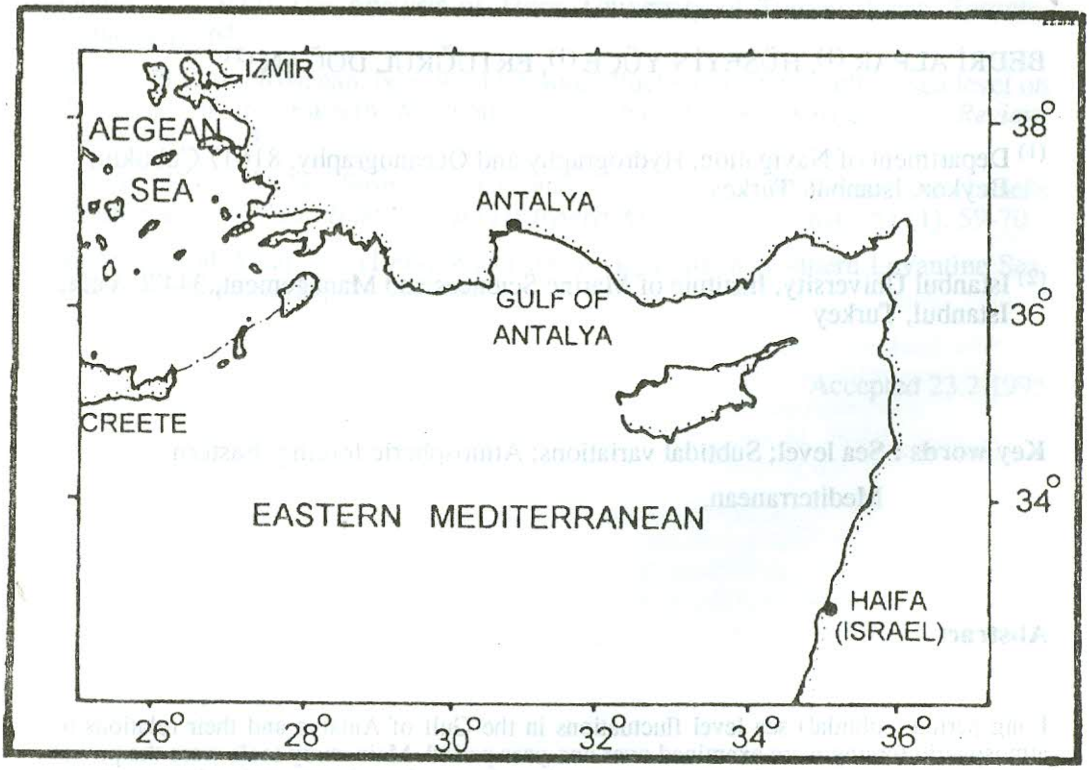
The seasonal fluctuation of the monthly mean sea level is in accord with hydrologic cycle of the Eastern Mediterranean. The dominant coastal sea level fluctuations occurred at a time scale of 2-4 weeks.

The variance of barotropic fluctuaton is higher in the winter (November - April) than in the summer (May - October), due to the increased cyclone activities. Local wind forcing as important and most of the coastal sea level change as driven by the cross-shore wind in the Gulf of Antalya.

Introduction

The Levantine Sea is one of the four major basins of the Eastern Mediterranean. It is connected to the Ionian and Aegean Seas by means of the Creete-Africa passage and two straits to the east of Creete (Figure 1).

Figure 1. Location of the study area.



Striem and Rosenan (1972) and Striem (1974) studied seasonal fluctuations, storm surges and unusual sea level changes on Israel's coasts and reported semi-diurnal tidal patterns with a mean spring range (Defant, 1961) of 52 cm. They also reported, based upon 10 - year averages of monthly mean sea levels, a major minimum in April and a major maximum in July/August with a range of 21 cm between extremes.

The tidal characteristics of water level variations in the Gulf of Antalya have been studied by Yüce and Alpar (1994). Their numerical analysis for coastal sea level energy distribution indicates that the water level variations are mainly governed by the energy inputs (56 %) in low frequency band and semi-diurnal variations (39 %). That means low frequency subtidal energy input is dominant in the Gulf of Antalya. Tides, on the other hand, are characterised by the semi-diurnal components. The amplitude and phase values of the 4 main constituents (semidiurnal lunar M_2, semi-diurnal solar S_2, soli-lunar diurnal K_1 and the main lunar diurnal 0_1) were calculated by using the software package developed by Caldwell (1991) and presented in Table 1. The amplitudes and phases were calculated as applying the nodal corrections to the outputs from the linear least squares tidal analysis. The results indicate that the tidal regime at Antalya are mixed, predominantly semi-diurnal. The tidal components are not pure astronomical but also linked with the solar radiation (daily temperature evolution). The gravitational efect, although in a small quantity, may also contribute.

Table 1. Tidal harmonic constituents. Amplitude values (H) in cm; phase lags (g) in degrees, relative to the Eastern European time (30 E).

M_2		S_2		K_1		O_1		MEAN RANGES	
H	g	H	g	H	g	H	g	SPRING	NEAP
6.2	304	4.2	308	2.4	281	1.5	296	20.8	4.0

Despite the previous studies, subtidal sea level changes and their relations to atmospheric forcing has not yet received much attention for the region. To have a better understanding of the nature of barotropic response in the Gulf of Antalya, we took into account coastal sea level and meteorological data for one-year period. The subtidal sea level variability, its relation to atmospheric forcing and its seasonal variation are investigated, and the driving mechanism is discussed.

Sea Level and Meteorological Data

Sea levels are routinely monitored at Antalya with a mechanical R. Fuess stilling well type permanent tide guage that is operated by the General Command of Mapping (1991). Since the records have been found to be dependable in quality and without any gaps, the tidal projections are based on data collected between

0100 EET January 1st 1971 and 2400 EET December 31st, 1971 (Figure 2). The datum levels for these tidal projections are directly related to the tide staff zeroes.

In order to obtain subtidal variations, tidal and high frequency oscillations should be eliminated. So hourly sea level records were lowpass filtered using the tide-killing numerical filter, $A^2 25 A 24$ / $(25^2 x24)$ (Godin 1970). These tidal free data were adjusted for inverse barometric effect and then decimated to a 4-h interval (Figure 3).

Surface barometric pressure and wind (speed and direction) data were obtained over the same period (1971) from Antalya Meteorological Station. All barometric pressure data are expressed in millibars and corrected to the sea level and zero degrees temperature (Figure 2, 3). Wind stress components were computed from usual quadratic stress formulation using a constant drag coefficient of $2.5x10^{-3}$ and then lowpass filtered and decimated to a 4-h interval (Figure 4). This computation provides a relative measure for wind stress which quantify the effect of the wind forcing.

Figure 2. The hourly sea level and barometric pressure at Antalya for the year of 1971.