ASTRONOMICAL AND METEOROLOGICAL TIDE DESCRIPTION IN THE CATALAN COAST.

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Abstract

Due to small tidal induced sea level variations [1], the Mediterranean Sea is an attractive site to calibrate and validate altimeter data from the TOPEX/POSEIDON and JASON satellites. Hence, the need to determine accurate sea level variations and to better estimate different components that contribute to sea level variability. The objectives of this study are therefore, to associate sea level variations with astronomical tide, to determine and to quantify the atmospheric forcing that cause these sea level variations.

Keywords: sea-level, Mediterranean, tides.

Introduction

Time series of sea level in the Catalan Sea, provided by the l'Estartit harbour tide-gauge, operational since 1990, and the XIOM net tide-gauges set in la Ampolla and San Carles de la Ràpita harbours both operational since 1997, was used. From these time series the study of sea level variation was divided in several phases.

The first phase consists in following the evolution of the mean daily, monthly and annual sea level values. Second phase includes the harmonic analysis of the tide-gauges data to determine the harmonic components of the astronomical tide. After obtaining a tide prediction and a meteorological residual, an analysis to compare residual with the atmospheric pressure effect, known as inverted barometer effect, was made. In the dates that, the previous effect, did not adjust to the residual, a wind analysis will take place, in order to determine the cause of this non-pressure residual.

Mean daily, monthly and annual value analysis

From these analyses, there are two interesting conclusions to comment. An annual cycle of sea level with maximum mean sea level values in autumn (October and November) and the minimum mean values in winter (February and March). This annual cycle can be explained by the steric component, ocean dynamics and upper layer heat variability as commented in [2].

Moreover, we can also observe a small ascent of the annual mean sea level in the Catalan Coast through the years, although we can find two abnormally high mean sea levels for the years 1996 and 1997.

Tidal harmonic components analysis

From a least-squares fit between the time series and the frequencies associated to the astronomical movements, done with the Foreman method [3] and with the T_TIDE program [4], the amplitudes and phases of the harmonic tidal constants have been found and quantified. The same has been done with 95% confidence interval for both amplitude and phases of the harmonic tidal components. The most important harmonic components found for the Catalan Coast are, in decreasing importance order: M2, K1, O1, P1, S2 and N2 (Table 1). The amplitudes associated to each one of the previous components are smaller than 5 cm. We can also find large period components with similar amplitude order than M2 component.

Component		Estartit	Ampolla	San Carles
M2	Amplitude (cm)	5.37	3.68	3.12
	Phase	307.33	237.78	237.67
K1	Amplitude (cm)	2.96	3.07	3.10
	Phase	190.56	172.65	166.85
O1	Amplitude (cm)	1.72	1.92	1.89
	Phase	172.08	123.62	123.90
P1	Amplitude (cm)	1.08	1.24	1.21
	Phase	180.86	166.90	155.41
S2	Amplitude (cm)	1.78	1.00	0.80
	Phase	270.44	242.04	244.10
N2	Amplitude (cm)	1.11	0.88	0.73
	Phase	272.65	222.88	215.89

The components with semidiurnal frequencies have an interesting behaviour. The amplitudes associated to these components increase their values from South to North along the Catalan Coast. However the diurnal components do not present a clear behaviour and remain near constant values along the Catalan Coast. This behaviour is also observed in other tide-gauges [5]. This change in the amplitudes of the semidiurnal harmonic components produces a change in the Form Factor (F) value,

$$F = \frac{A(K1) + A(O1)}{A(M2) + A(S2)}$$

which increases its value southward.

Once we have the amplitudes and phases of the harmonic components, we can predict the tide. This prediction fits quite well to the real measured sea level time series. But there is a difference between them, this difference is known as meteorological tide, and can be caused by atmospheric forcing like atmospheric pressure or wind stress.

Inverted Barometer Effect and wind stress analysis

With the atmospheric pressure data obtained from the meteorological stations placed very close to the tide-gauges, the inverted barometer effect [6] has been calculated to obtain the relation with the meteorological residual. There is a clear relation and a good fit between both, meteorological residual and inverted barometer effect, nevertheless there are still some periods in which the difference between the two parameters are still important.

To determine the cause of these differences, it is necessary to analyse the wind systems of those periods to obtain the main direction, mean velocity and hence, the wind stress in each period. The goal of this study is to calculate the relation between the wind stress and the remaining meteorological residual. All this work will allow us to know the effect of the distinct storms in the Catalan Coast and to be able to forecast with great accuracy sea level changes in this part of the Mediterranean Sea.

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