Determination of the Mean Sea Level at Algiers Harbour From the Tidal Data Analysis

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Abstract : The present study aims at defining a national sea level reference in Algeria and can be integrated in other oceanographic projects for determination of the mean sea level. Whatever the principle of measure is. a tide gauge is able to provide a local information on the height of the sea referred to the chosen reference.
The main points of this study are: the calibration of the data of the electronic tidal gauge with an automatic data acquisition system installed in Algiers harbour; the comparison of these data with the data acquired from the analogical tidal gauge installed on the same site; and the determination of the mean sea level using the harmonic analysis.
The exploitation of the data recorded with the electronic tide gauge of Algiers during a period of two years provide an estimate of the mean sea level and the harmonic components which can be also used for the prediction. The estimated mean sea level differs by a few centimeters of the actual value currently used which was determined in a "arbitrary" way.

Keywords. Electronic tide gauge, analogical tide gauge. calibration. mean sea level. harmonic analysis.

1. Introduction

During the last two decades. the measurements of the height of seas using tide gauges have given acceptable results along the coastal lines. These data are used to predict a tide from harmonic components. and on the other hand. to validate the global models of tide and the observations provided by altimertic satellites.
Being aware of the interest to establish tide gauge sites. in framework of its activities, the National Institute of Cartography and Remote Sensing is currently planning a project to install new tide gauges with automatic acquisition along the Algerian coast line. A newly national altimetric referential will replace the existing reference defined from the tidal meter of La Goulette (Tunisia).

In this paper. we present the analysis of the data from the electronic tide gauges of Algiers to determine the mean sea level witch will serve as the reference point for the levelling network of Algeria

2. Description of the electronic tide gauge of Algiers

The tide gauge for automatic data acquisition installed near the analogical tide gauge is a prototype conceived by Dr. Michel van Ruymbeke of the Royal Observatory of Belgium (ORB). This prototype records every minute the height of the sea as frequencies generated by a capacitive sensor.

Fig. 1 Tidal gauge site of Algiers sheltering the two tide gauges electronic (in the left) and analogical (in the right).

3. Tidal gauge data

The electronic tide gauge with automatic data acquisition was installed in may 2003 in Algiers harbour. Due to technical problems. the store times series started in may 2004.
This electronic tide gauge is installed close to an analogical one in order to compare the observations produced form both sources.
The data of the electronic tide gauge used in this study. are those collected during the period from March 29. 2004 to February 27. 2006 with a sampling rate of one minute.

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A low pass filter was applied to the electronic tidal data with a cadence of 60 readings (equivalent to one hour observation) using the software µDAS Grapher (ORB).

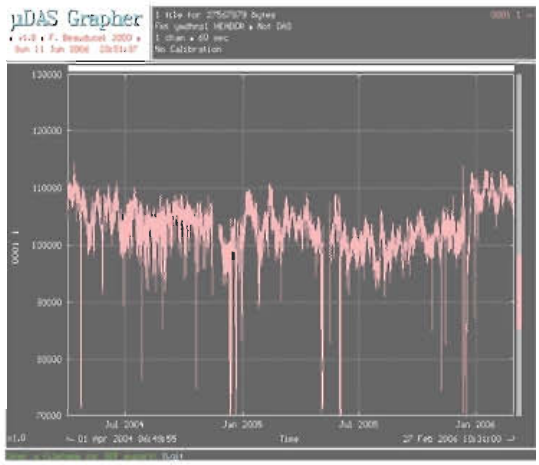

Fig. 2 Raw Recordings of the electronic tide gauge of Algiers, Period: March 29, 2004 to February 27, 2006.

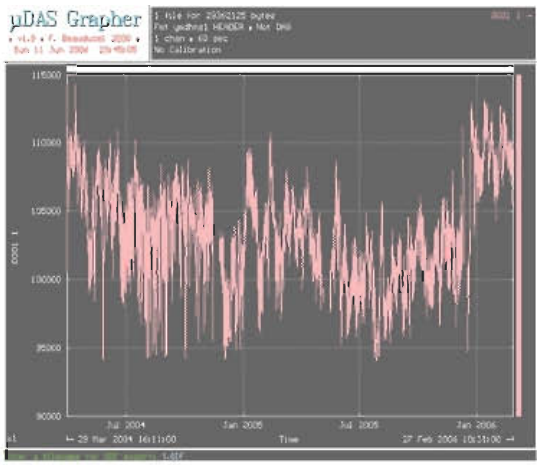

Fig. 3 Filtering of the data of the electronic tide gauge.

4. Calibration of the data automatic tide gauge

The direct measurements of the sea level using a luminous probe provided the calibration factors of the tide gauge. A linear model has been used:

$$h = a_0 + a_1 \ f \qquad (1)$$

where a_0 and a_1 are calibration parameters, f the recorded frequency and h the height of sea observed referring to the reference of the hydrographic zero, deduced from the readings obtained by luminous probe.

The sea level referenced to the hydrographic zero is obtained by one of the following equations:

$$N_1 + N_3 - height_{top\ of\ the\ tube\ -\ sea\ surface} \qquad (2)$$

$$N_2 + N_3 - height_{plateforme\ -\ sea\ surface} \qquad (3)$$

where N_1 is the height of the top of the water stabilizer tube referring to the Algerian General Level. N_2 is the height of the plate-form referring to the Algerian General Level. N_3 is the altitude of the zero point of the AGL referring to the altitude of the hydrographic zero which is fixed to 34 cm, and the, $height_{top\ of\ the\ tube\ -\ sea\ surface}$, $height_{plateforme\ -\ sea\ surface}$ are the readings obtained by luminous probe.

The calibration parameters were calculated using this process for equivalent periods of one month.

5. Validation with the data of the analogical tide gauge

An external validation of the data of the electronic tide gauge measurements was carried out by comparing with the data from the analogical tide gauge measurements over the period of March 29 2004 to February 21 2005:

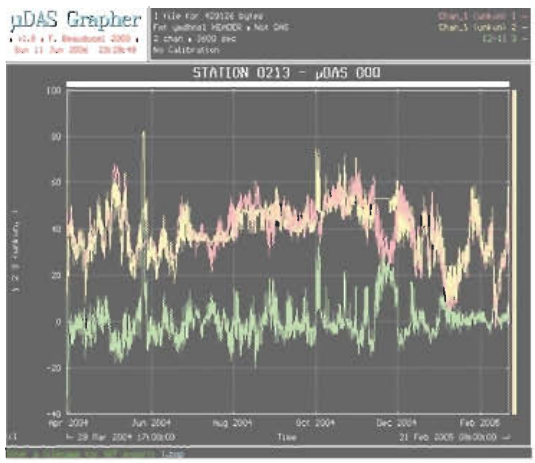

Fig. 4 Difference (in green) between the filtered and calibrated data of the electronic tide gauge (in yellow) and those stemming from the analogical tide gauge (in red). Period from March 29, 2004 till February 21, 2005.

The statistical results of this comparison are given in the following table:

Table I. Comparison between data stemming from the electronic tide gauge and from the analogical tide gauge.

Tide gauge	Min. value (cm)	Max. value (cm)	Average (cm)	Standard deviation (cm)
Electronic	4	82	38.76	11.17
Analogical	-3	68	39.40	11.36
Difference	-37	49	0.0011	8.27

Both systems present a good agreement only where the luminous probe calibration data are available.

6. Tidal harmonic analysis

The tide can be considered as the sunmation of a series of periodic functions and an error (ε).

$$h(t) = Z_0 + \sum_i A_i \cos(V_i - G_i) + \varepsilon \qquad (4)$$

In this expression, Z_0 is the mean level, A_i the amplitude, V_i the argument of the cosine in the harmonious development of the generative potential of the tide, and G_i the phase of the constituent *i*.
Z_0, A_i and G_i are the harmonious constants in a given place.
The situation of a harmonic component of the tide represents its delay expressed in angle, regarding to the corresponding constituent of the potential (to obtain its delay expressed at time, it is enough to divide it by the angular speed *dVi/dt*).
Only *Vi* depends on time. Its expression is generally done by astronomical elements.

7. Determination of the mean level

The preliminary determination of the mean level of the sea at Algiers harbour by the harmonic analysis is done using the T_TIDE version 1.2b package under Matlab [R. Pawlowicz, R. Beardsley, S Lentz].

Table 2. Obtained mean level and differenee regarding to the current reference of Algerian General Level.

Tide gauge	Period	Mean level (cm)	Diff. / current reference (cm)
Analogical	29/03/2004 ---- 21/02/2005	39.8	5.8
Electronic	29/03/2004 ---- 21/02/2005	39.1	5.1
	29/03/2004 ---- 27/02/2006	38.1	4.1

This table shows that the results of the mean level obtained from the data of the electronic and analogical tide gauges during the same period of March 29 2004 to February 21 2005 are close near (39.1 cm and 39.8 cm). This confirms the good preprocessing of electronic tide gauge measurements. The mean level obtained from the data of the electronic tide gauge data of the period from March 29, 2004 to February 27, 2006, present an offset of 4.1 cm to the current reference. The harmonic constants obtained from the series of the electronic tide gauge over of the period from March 29, 2004 to February 27, 2006, were also used for the prediction of the tide for the same period. The difference between the observed and predicted tides vary in an interval of ± 20 cm:

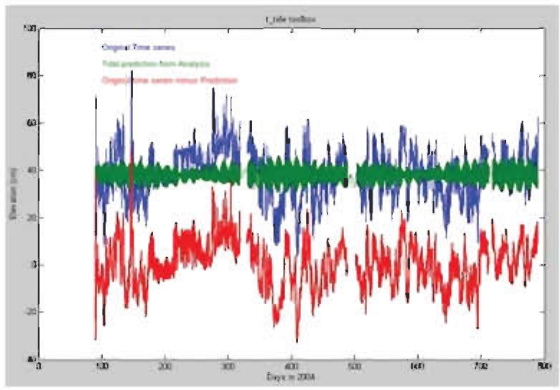

Fig. 5 Difference (in red) between the observed tide data (in blue) and the predicted tide data (in green).

8. Conclusion

The objective of this study was to determine the mean sea level at Algiers harbour using an electronic tide gauge. The calibration of data revealed the need of more frequent obtained calibration data using of the luminous probe or the ladder of tides.
The preliminary mean sea level obtained with the electronic tide gauge shows an offset of 4.1 cm compared to the mean sea level reference currently used.

Acknowledgments

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