

IVc - IEO MEDITERRANEAN TIDE GAUGE STATION

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INTRODUCTION

Sea level has been monitored in the IEO from 1943 when a tide gauge network of 23 stations covering the Spanish coast. Presently the network consists of 13 tide gauges, six on the Mediterranean Coast; three in the Iberian Peninsula, two in the Balearic Island and one on the African coast. Some of these stations (Ceuta and Palma de Mallorca) were selected for the MedGLOSS Pilot Network.

The sea level measurements are relative to the Tide Gauge Zero (TGZ), normally the chart datum. In collaboration with the IGN, which is the national responsible of the National Levelling Network, the TGBM had been connected to the National Geodetic Network.

The IEO network has been renewed by connecting the float tide gauge with an encoder and a data logger in order to have a digital output with data transmission through a telephone line.

During 1996-1998, in the frame of the project: Integration of Spanish Tide Gauge Network, financed by CYCIT, through the National Programme of Marine Science and Technology, a big effort was made by the partners (IEO, PE/CM), IGN, IHM) in order to harmonize the different Spanish tide gauge networks.

The monthly mean sea levels are regularly sent to the PSMSL. Recently an annual bulletin has been published which includes: mean sea levels, extreme sea levels, tidal ranges and harmonic constants.

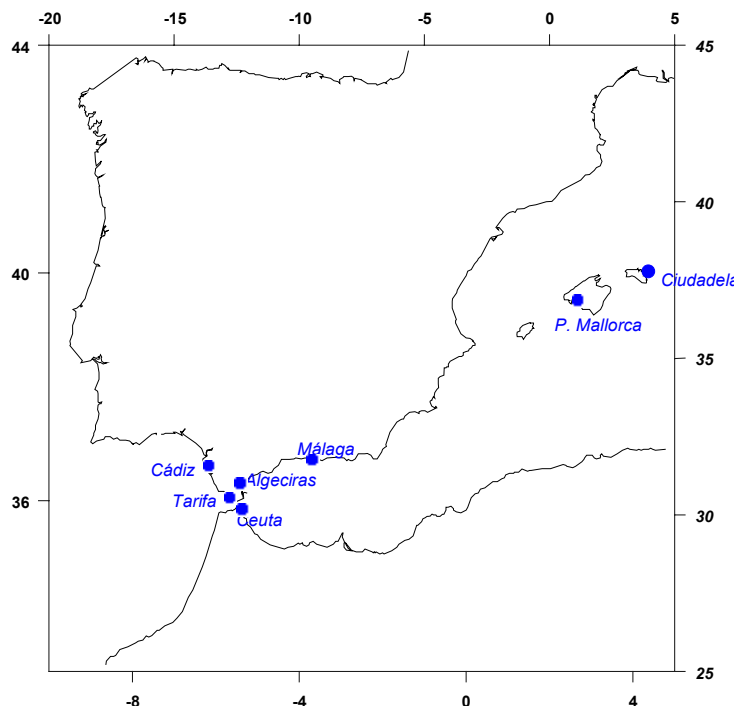
Up to now, there is not any clear data policy at the IEO but, in any case, many scientists are using these data in their researches.

In this paper we present the state-of the-art of the IEO Mediterranean Tide Gauge Stations: Installations and equipment, reference system, time series data and some activities related to the sea level in the Mediterranean.

STATIONS

The IEO stations do not cover the Mediterranean coast very well. Three are located in the Strait of Gibraltar, two in the Balearic Island, one in the south coast of Spain and there is one in the Gulf of Cadiz. (Figure 1).

The station in Cádiz may be of interest for monitoring the flow through the Strait of Gibraltar.



IEO Mediterranean Tide Gauge Stations			
Code	Name Station	Latitude	Longitude
008	Cádiz	36° 32' N	06° 17' W
009	Tarifa	36° 00' N	05° 36' W
019	Ceuta	35° 54' N	05° 19' W
010	Algeciras	36° 07' N	05° 26' W
011	Málaga	36° 43' N	04° 25' W
014	Palma de Mallorca	39° 33' N	02° 38' E
027	Ciudadela	40° 00' N	03° 51' E

Figure 1: Geographical Distribution of the IEO stations.

Installations and Equipment

All the stations are ready to fulfill the MedGLOSS requirements. Only at the station of Málaga there are no telephone lines and no atmospheric barometer is installed. However, a phone line can be installed. Currently the station of Ciudadela is not working because of the building station problem.

Station	Type	Res.	Acc.	Parameter	GPS	BM	Inst.
Cádiz	Float / digital output	1mm	± 3mm	atm. pres	SELF SELF II (1)	yes	elect. tele-line
Tarifa	Float / digital output	1mm	± 3mm	atm. pres	MAGIES 93 SELF SELF II	yes	elect. tele-line
Algeciras	Float / digital output	1mm	± 3mm	atm. pres	MAGIES 93 SELF SELF II	yes	elect. tele-line
Ceuta	Float / digital output	1mm	± 3mm	atm. pres air temp	MAGIES 93 SELF SELF II (2)	yes	elect. tele-line
Málaga	Float / digital output	1mm	± 3mm		(2)	yes	elect.
P. Mallorca	Float / digital output	1cm	± 3mm	atm. pres sea-temp	(2)	yes	tele-line
Ciudadela	Float / digital output	1mm	± 3mm			yes	

Note: (1) The ROA has installed an Antenna in the City of Cádiz
(2) The IGN is going to install Antenna on those places.

The GPS received are not being connected directly to the benchmark and some campaign has to be done every one or two years.

Reference Systems

The sea level measurements are relative to the TGZ but from the beginning the TGZ were related to TGBM. Normally more than one BM is close to the gauges and all are connected to the national levelling network. The origin of this network is the Mean Sea Level in Alicante (NMMA) obtained for the period 1870-1880.

Station	TGBM	Altitude over NMMA	Auxiliary Benchmarks
Cádiz	NAPG-479	3.595 meters	
Tarifa	Cruz	2.345 meters	NGM353, SS/NGK-92
Algeciras	NGR-15	1.691 meters	NGR-16, NAPG486
Ceuta	NGR-101		SSC-1, SSC-7
Málaga	SS2NGK-236	0.829 meters	NAPA-548, NGS-406
P. Mallorca	MFO	2.537 meters (over local NM)	CIavo AYT0
Ciudadela			

Note: these altitudes are obtained in 1998 and they are very different to those in the earlier reports.

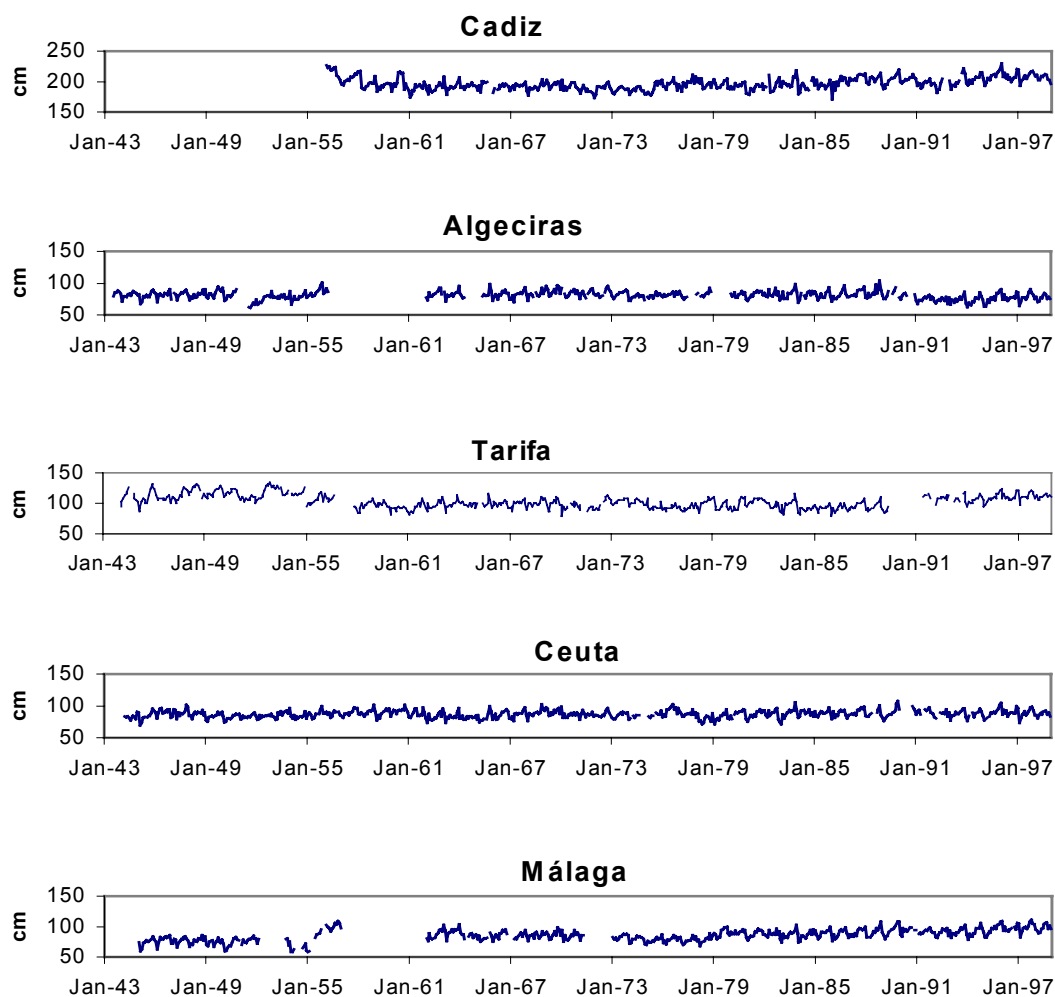
During these last years, some GPS campaign has been performed in Palma de Mallorca and in the Strait of Gibraltar but up to now there is no information about the crustal movements.

The information of TGZ related to the reference system WGS-84 has been performed by the ROA (Jorge Garata & J. Martín Davila) during the SELF II campaigns:

Station	Altitude: TGZ over WGS-84	Distance: TGZ under TGBM	TGBM
Cádiz	43.197 meters	5.423 meters	NAPG-479
Tarifa	40.492 meters	3.300 meters	Cruz
Algeciras	41.713 meters	2.300 metros	NGR-15
Ceuta	41.314 meters	4.195 meters	NGR-101

Time series

Sea level has been monitored since 1943, but there are some gaps in the time series. The data is already digitized but in some stations the quality control is not finished. The monthly mean sea levels are presented in the graph where the different TGZ references can be seen.



A general inventory is presented in this table.

Stations	Years
<i>Cadiz</i>	1945-1999
<i>Tarifa</i>	1943-1961 1963-1989 1991-1999
<i>Algeciras</i>	1943-1955 1961-1999
<i>Malaga</i>	1943-1959 1961-1999
<i>Ceuta</i>	1943-1999
<i>P. Mallorca</i>	1963-1982 1989-1993 1996-1999
<i>Ciudadela</i>	1990-1991

Routine Processing:

- ❖ data is registered at 10 minutes interval.
- ❖ data is transmitted to the Data Center by Modem. (except Málaga).
- ❖ quality control of the raw data (date, picks, obvious errors).
- ❖ filtering to obtain hourly data.
- ❖ conversion to USLC format.
- ❖ quality control, mean sea level and harmonic constants. USLC software.
- ❖ extremes and tide ranges.
- ❖ Annual bulletin with the above information

Quality Control Review

In addition to the time series the information about the TGZ is needed to determine the sea level trends. Detailed information as sent to PSMSL is presented:

Country: Spain

Station: Málaga

Latitude: 34° 43' N

Longitude: 04° 25' W

Period: (1944-1951):

Unit Used: centimeters

Datum of observation: TGZ

TGBM: Clavo N° 3

Description of the TGBM: Clavo located in the mouth of the well of the tide gauge, with a geometrical altitude over the Mean Sea Level of Alicante of 1.216 meters.

Levelling: from NAPA 546 located in the lighthouse

Vertical distance between Datum of observations and the TGBM: 2.134 meters.

Period (1962:1997): NEW INSTALATION

Unit used: centimeters.

Datum of observations: TGZ

Reference Bench Mark: SSK 236

Description of the TGBM: SSK-236 located in front of the door of the tide gauge building, with a geometrical altitude over Alicante mean sea level of 0.644 meters. Levelling Motril-Málaga line.

Vertical distance between Datum of observations and the TGBM: 1.64 meters

OBSERVATIONS:

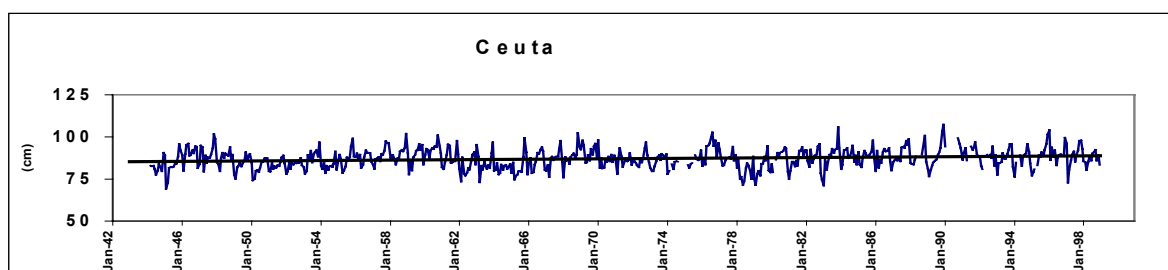
During the period from January 1973 to May 1979 probably the datum has been changed about 5 cm but there is no information in the documentation.

Mean Sea Level

An example of Ceuta sea level trend and the monthly variability is presented:

- Country Spain
- Station Ceuta (GLOSS Number 249)
- Datum of observations: TGZ TGBM: NGR-101
- Description of TGBM: NGR-101. Located in the stilling well mouth.
- Geometrical altitude 3.401 meters. Levelling: Ceuta-Tetuan line (1929)
- Vertical distance between Datum of observations and the TGBM: 4.195 meters
- Type of gauge: Mechanical Float with digital output.

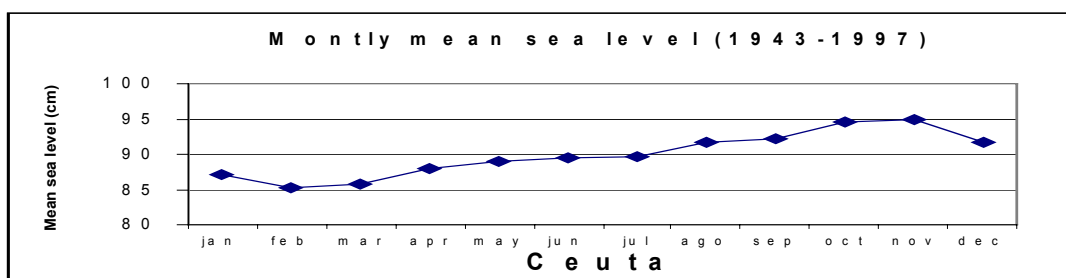
a) Trends:



The slope of the linear fit $y = ax + b$ is 0.61 mm/year.

This is the trend found with the all data but it can be analysed in more detail to find some cycles.

b) Monthly Variability



The sea level increase from February to October is in a range of 10 cm. This is a very representative monthly variability in the Strait of Gibraltar. The atmospheric pressure and the wind are the main factors that contribute to this variability.