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THE NECESSITY OF IMPLEMENTING A NEW TIDE GAUGE SYSTEM ON THE ROMANIAN BLACK SEA COAST

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Abstract: *The analysis of the sea level record at the Black Sea, reveals a significant rising trend. In this study there are presented the changes of the Black Sea level, analysing the data from nine tide gauges locations. Also, there is proposed the introduction of a new system of tide gauges at the Romanian Black Sea coast. The five sites where the tide gauges will be placed are: Sulina, Sfantul Gheorghe, Gura Portitei, Constanta and Mangalia. The information will be stocked on a computer and transmitted via a network. The main purpose of this study is to determine the datum.*
Key words: *Sea level, Black Sea, tide gauge.*

1. Introduction

Around 90% of international trade is carried in maritime transport industry.

During the last years we can observe an increase in the Black Sea level. This variation is due to the absolute and relative sea level rising. The absolute sea level rise is attributed to two factors:
a) thermal expansion of the water in the oceans;
b) melting of Ice sheets and glaciers in Antarctica and Greenland.

The relative sea level change usually affects a local or regional area. Its value can be positive or negative. It is determined mainly by long-term tide gauge measurements from stations along the coasts of oceans and seas.

The tide gauge measures sea level change relative to a benchmark on the land whereas the satellite altimetry provides the absolute change with respect to the geocentric reference frame.

There are four types of measuring sea level in common use:

• A stilling well and float: in which the filtering of the waves is done through the mechanical design of the well.

• Pressure systems: in which sub-surface pressure is monitored and converted to height based on knowledge of the water density and local acceleration due to gravity

• Acoustic systems: in which the transit time of a sonic pulse is used to compute distance to the sea surface.

• Radar systems: similar to acoustic transmission, but using radar frequencies.

Depending on the sea level we can talk about dangerous depths when the tide is low and navigable depths when the tide is high.

Therefore, choosing the reference plane depths is a very important hydrographic problem.

Conventional plan, to which depths are reported on marine map, is called datum.

There are no criteria recognized by all hydrographers establishing the datum. But the navigator, marine maps beneficiary must know that whatever the reference plane is, the actual values not be lower than those on the map. So, the reference plane chosen must be located below the low tide.

2. Black Sea level changes

Recent studies bassed on altimetry and tide gauge data have revealed the Black Sea level has risen. (Avsar et al., 2015; Cazenave et al., 2002; Kubryakov and Stanichnyi, 2013; Vigo et al., 2005). For the period 1993-2014, the satellite altimetry data analysed by Avsar et al. (2015) indicated an increasing trend of 3.16 +/- 0.77mm/year over the Black Sea.

In the present study 9 tide gauges sites from 6 countries (Romania, Bulgaria, Turkey, Georgia, Rusia, Ukraine) were chosen.The data from the following tide gauges: Constanta, Varna, Burgas, Poti, Tuapse, Sevastopol was provided by the Permanent Service for Mean Sea Levelwww.psmsl.org/data). For Igneda, Trabzon-II, Batumi, the data was offered by Tides and Currents - National Oceanic and Atmospheric Administration(https://tidesandcurrents.noaa.gov).

All the locations of the tide gauges used in this study are in the figure 1. The table 1 shows the latitude and longitude of the locations of all tide gauges, the time period of the observations and the sea level trend.

As it can be seen from the table, the sea level tendency is different in every station. The regional sea level changes in most of the cases differ from the global mean value.

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Fig.1. The tide gauges locations provided by Google Maps

Tide gauge station	Location		Time period	Trend (mm/year)
	Latitude	Longitude		
Constanta (Romania) Fig. 2.1.	44^{0}10'N	28^{0}40'E	1933-1997	1.37 (+/-0.97)
Varna (Bulgaria) Fig. 2.2.	43^{0}11'N	27^{0}55'E	1928-1996	1.22 (+/-0.85)
Burgas(Bulgaria) Fig. 2.3.	42^{0}29'N	27^{0}29'E	1928-1996	1.91 (+/-0.90)
Igneda(Turkey) Fig. 2.4.	41^{0}53'N	28^{0}01'E	2002-2009	2.19 (+/-1.66)
Trabzon-II (Turkey) Fig. 2.5.	41^{0}00'N	39^{0}44'E	2002-2009	-0.38 (+/-1.65)
Batumi (Georgia) Fig.2.6.	41^{0}38'N	41^{0}42'N	1882-2015	1.38 (+/-2.29)
Poti (Georgia) Fig. 2.7.	42^{0}10'N	41^{0}41'E	1874-2013	6.59 (+/-0.29)
Tuapse (Russia) Fig. 2.8.	44^{0}06'N	39^{0}04'E	1917-2013	2.44 (+/- 0.58)
Sevastopol (Ukraine) Fig. 2.9.	44^{0}37'N	33^{0}42'E	1910-1994	1.26 (+/- 0.78)

Table 1

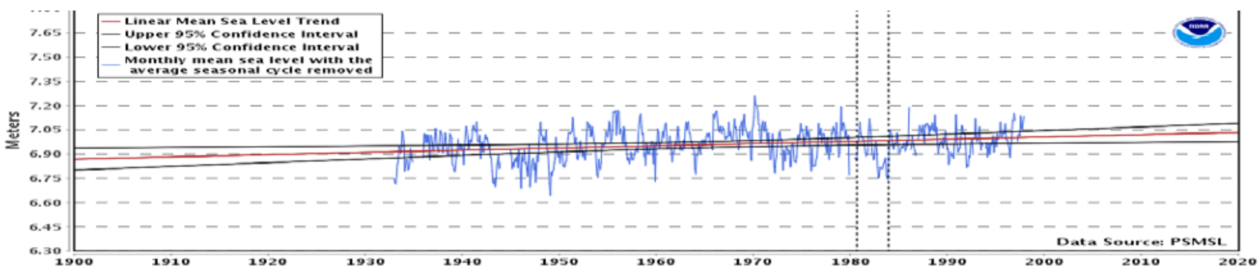

Fig.2.1. The data from tide gauge station Constanta provided by PSMSL

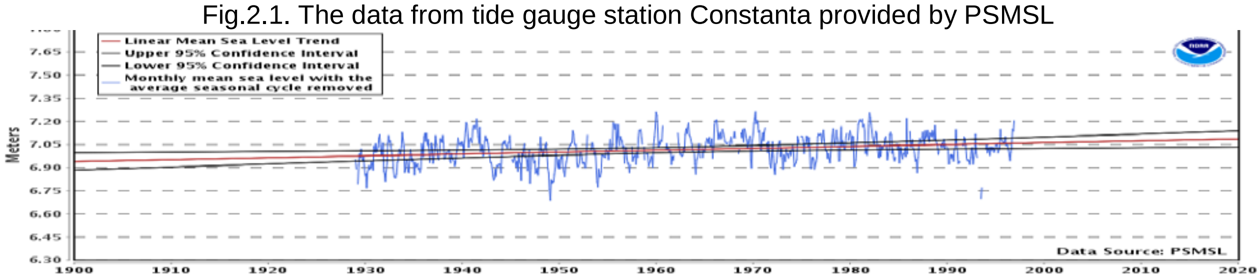

Fig.2.2.The data from tide gauge station Varna provided by PSMSL

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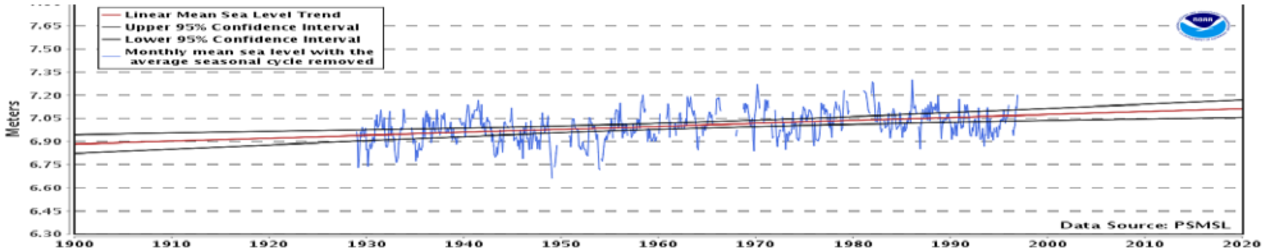

Fig.2.3.The data from tide gauge station Bourgas provided by PSMSL

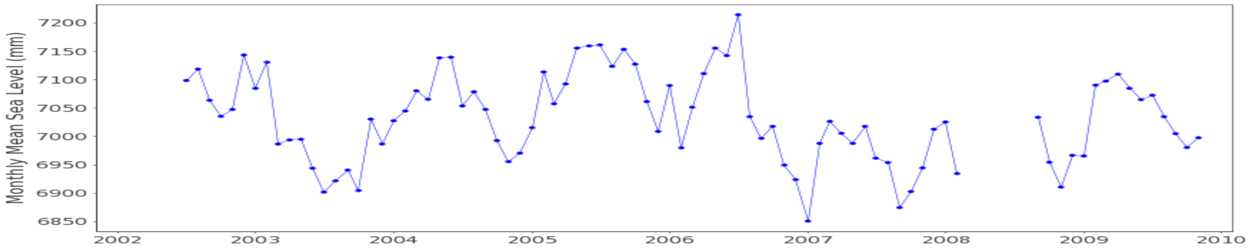

Fig.2.4.The data from tide gauge station Igneda by NOAA

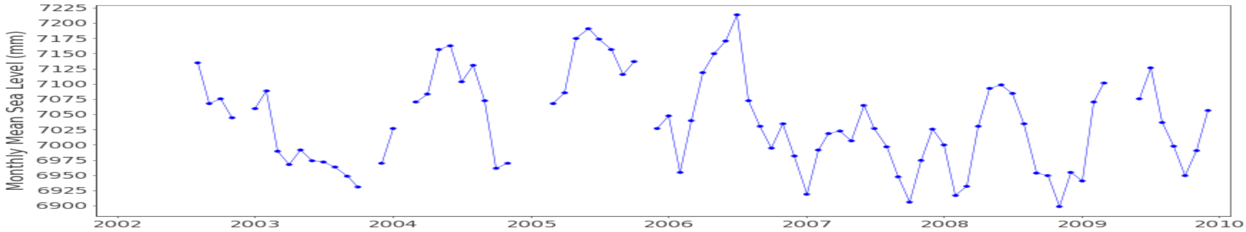

Fig.2.5.The data from tide gauge station Trabzon provided by NOAA

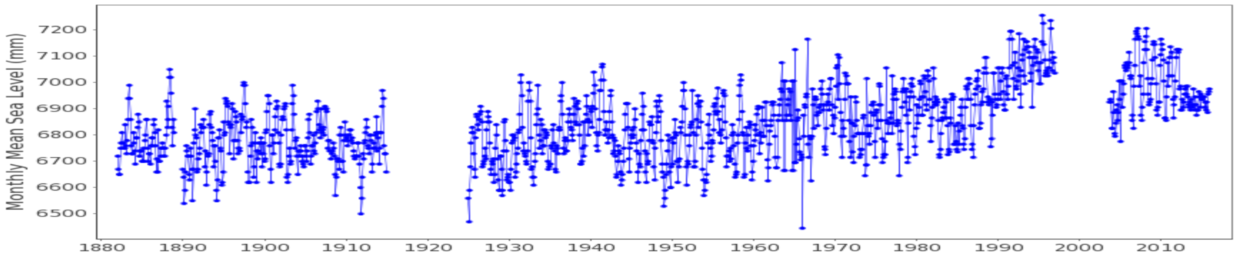

Fig.2.6. The data from tide gauge station Batumi provided by NOAA

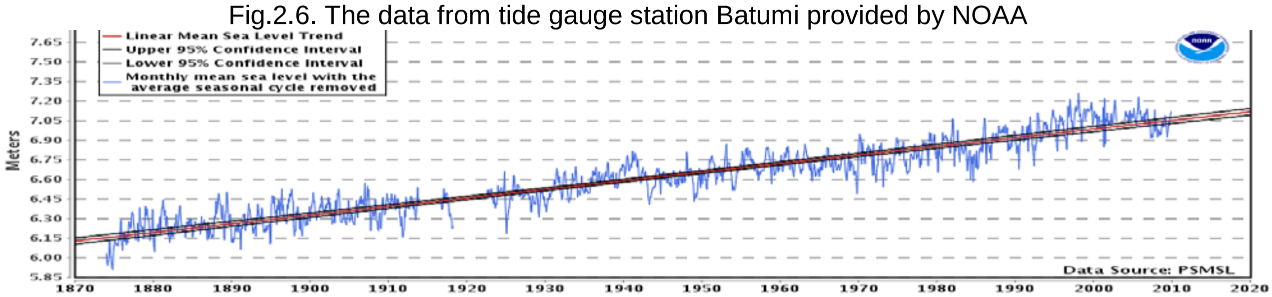

Fig.2.7.The data from tide gauge station Poti provided by PSMSL

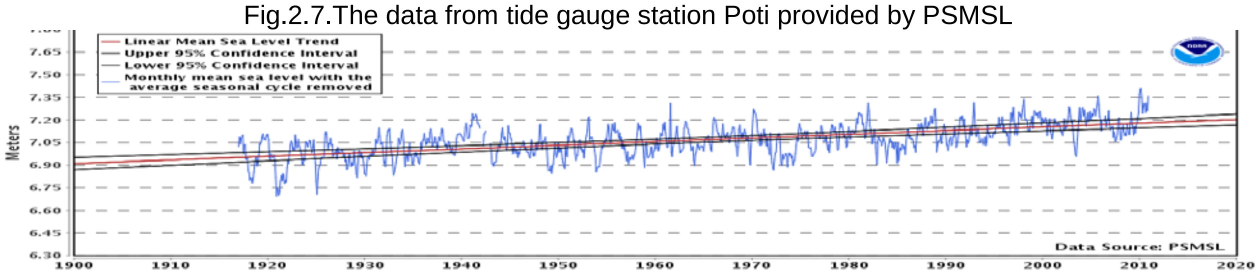

Fig.2.8.The data from tide gauge station Tuapseprovided by PSMSL

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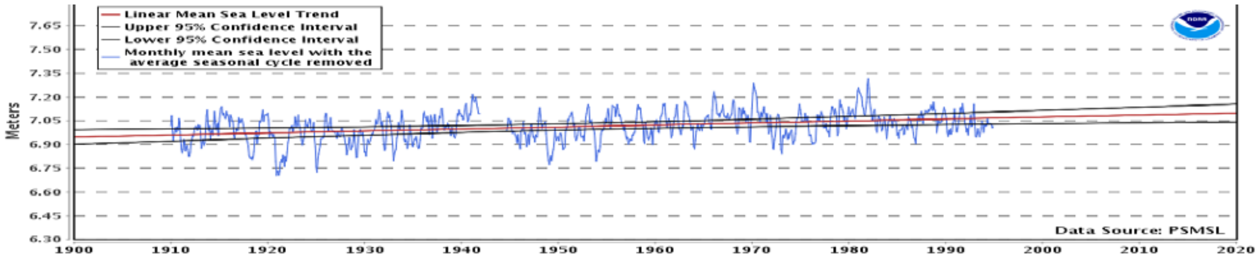

Figure 2.9.The data from tide gauge station Sevastopol provided by PSMSL

3. The implementation of a new tide gauge system at the Romanian Black Sea coast

The sediment discharge in the Black Sea evaluated at 68 million tonnes per year contributes to the rise of the mean sea level. About 75% of the sediment discharge belongs to the Danube (51.2 mil.t /year).

In the previous chapter was showed that the local sea level is different from the global sea level.

The implementation of a tide gauge system at the Romanian Black Sea coast gets a necessity, watching the amount of sediments discharged by the Black Sea.

To obtain the datum for the Romanian Black Sea coast was proposed a tide gauge system. The distance action between two hydrometric stations was set with the formula:

$$d_{ad} = \frac{\delta}{z_B - z_A} \cdot D$$

Where:

d_{ad} -distance permitted between stations;

δ -the reading accuracy of the depths;

$z_B\, and\, z_A$ -the levels height instant and simultaneous above the datum of the positions;

D - distance between stations.

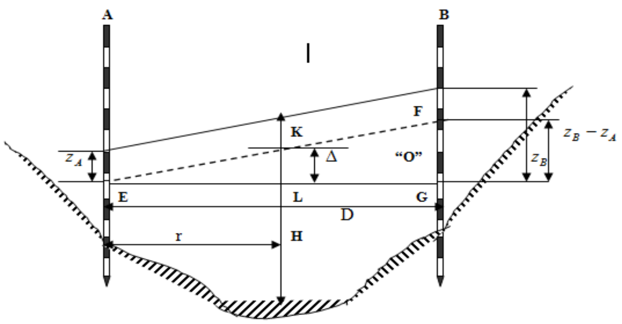

Figure 3. The calculation of the distance between two hydrometric stations

After doing the calculations resulted 5 tide gauges sites: Sulina, Sf. Gheorghe, Gura Portitei, Constanta, Mangalia. The map with the potential location of the tide gauge systems is illustrated in Fig. 4.

The proposed tide gauge system (Fig.5) consists of:

-tide house;

-tide gauge;

-recording and transmission data system.

The tide gauge is composed basically of:

•a metal tube provided at the bottom with holes through which water can circulate. The tube is mounted on pillars or walls of hydraulic structures.

•the oscillations transmission mechanism consisting of: the float; cable; pulley and counterweight;

•the registration mechanism comprises:

- The cylinder on which is wound chart recorders, the pen. By means of the sheave, a deformable wire and a counterweight, take the movements of the pulley.

• horology mechanism, which moves evenly cylinder.

The transmission of the observations from the tide gauge to a laptop will be realised with an Arduino system. The data stocked in the laptop will be transmitted to the Maritime Hydrographic Directorate Romania via Internet.

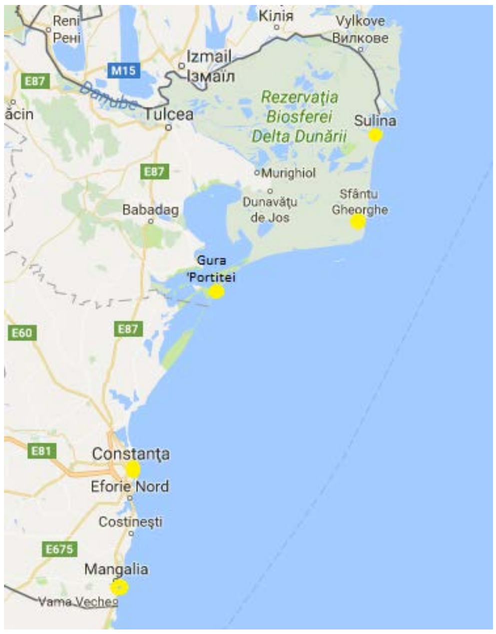

Figure 4. The potential locations of the tide gauges provided by Google Maps

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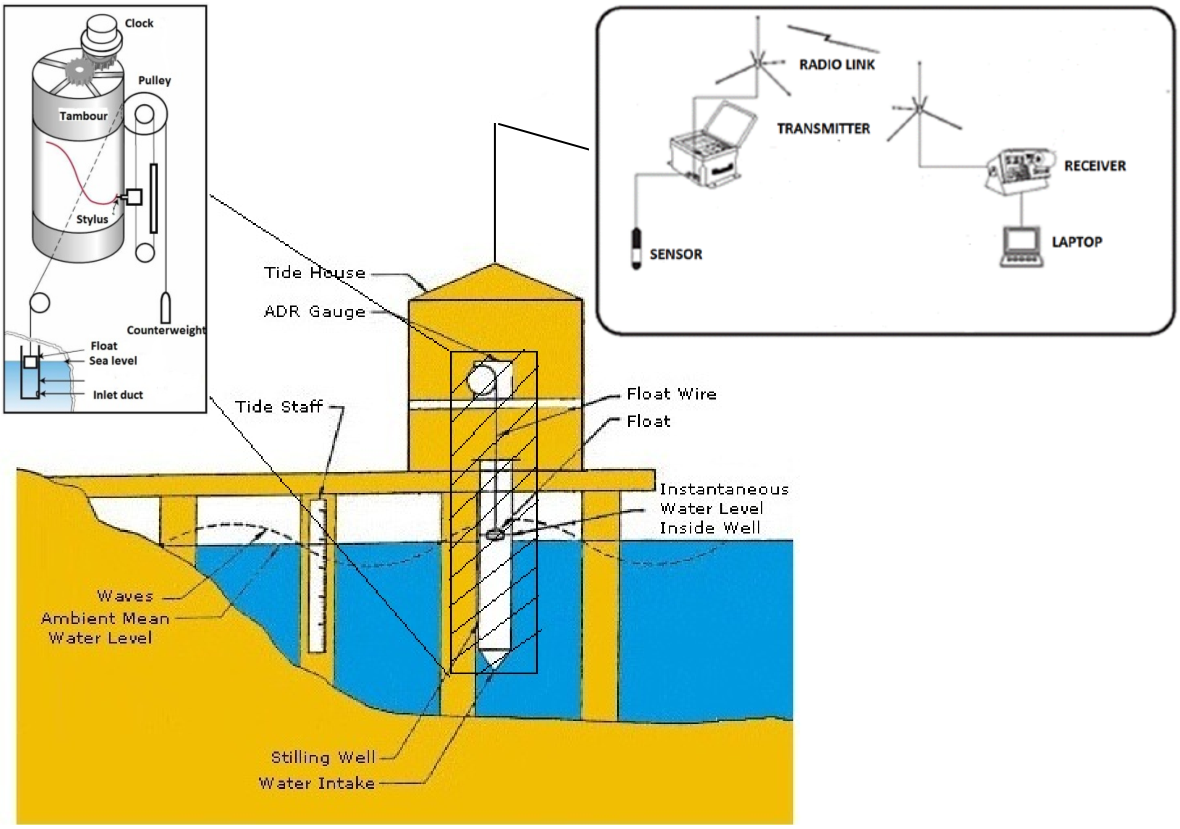

Figure 5. The proposed tide gauge system diagram

Conclusions

Sea level is a dynamical parameter related to lots of factors. In this study, coastal sea level change of the Black Sea is represented by data of 9 tide gauges selected from PSMSL and the NOAA.
The results point out that the sea level estimations depends on how long the data have been recorded.
Unfortunately some data outliers will appear because the periods of time of observations do not coincide.
The advantage of this tide gauge is that it will function with and without electricity, because the data will be stocked on a tambour and transmitted to a laptop. In this case the information will be very accurate.
The system is recommended to be implemented as soon as possible because the data for creating a datum is required to be registered for 18.6 years.

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