The Tide Gauge Network of N.T.U.A.: Development and First Results

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Abstract: This paper presents the N.T.U.A. tide gauge recording Network, covering a major part of the Aegean Sea and the Corinthian Gulf. The Network consists of seven complete and reliable tide gauge recording systems that achieve the natural filtering of high frequencies, which are due to the waving. The basic characteristics of the system are the simple, plain and low cost structure, the calibration of the main recording instrument and the remote control of the system through the net of mobile telecommunication. The main recording instrument of the sea level is Thalimedes of OTT which operates based on the mechanical principal (floater-counterweight). The two-year (2009-2010) period data recording of the sea level measurements are analyzed and the first results of hourly values are presented.

1. Introduction

Over the last four (4) years the National Technical University of Athens has started the deployment of a tide gauge Network along the coasts of Greece. The main purpose of the project is to provide the sea level data, necessary for hydrological and geodynamic studies and also for satellite altimetry calibration. At the moment seven (7) instruments are continuously operating, suitably situated so as to cover a major part of the Aegean Sea and the Corinthian Gulf. A map of the tide gauges permanent stations is shown in Figure 2.

Two of the tide gauge stations, namely Palekastro and Kastelli, are already equipped with continuous, connected to the internet GNSS receivers (Fig. 1), in order to provide accurate reference for the sea level data, while all of the tide gauges are planned to be equipped with cGNSS receivers in the future. Those two instruments are situated at the westernmost and easternmost areas of Crete, one of the most geodynamically active areas in Europe and in the long term, the combi-

Figure 1. Combination of tide gauge and cGPS in Palekastro.

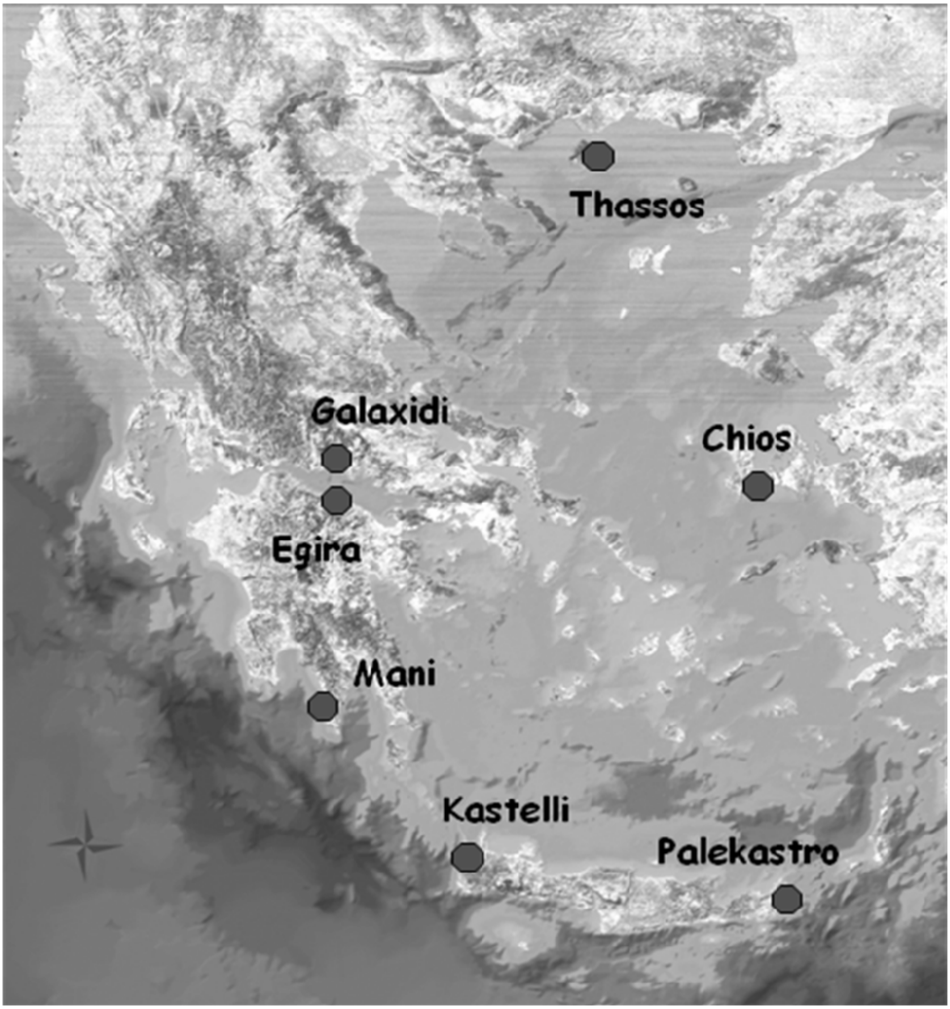

Figure 2. The N.T.U.A. tide gauge Network.

nation of their data can be proved precious for the detection of possible vertical movements of the island (Milas and others, 2010).

The basic structure of the tide gauge recording system used for the Network is simple, plain and of low cost, which comes in contrast to heavy and expensive structures used by corresponding public authorities; the accuracy achieved though remains at the same high level. The main recording instrument is a fully autonomous float type system (Thalimedes-OTT) with solar panel and mobile communication. This way the instrument can be directly connected to a pc through a mobile phone via bluetooth (or a stable telephone line) in order to remotely control it and download its data. The final accuracy of the sea level recording reaches 1-2 mm.

2. Description of the Integrated Tide Gauge System

The main idea of the integrated tide gauge recording system structure is placing a heavy PVC pipe (of 35cm diameter and about 3m length) into the water, resistible at both time and bad weather conditions. The layout of the different parts of the system allows the natural filtering of the waves and the cutoff of very high frequencies, while all the useful frequencies are recorded without any deformations.

The main recording instrument of the sea level variations is Thalimedes - OTT, which operates based on the mechanical principle (floater-counterweight) (Fig. 3). The instrument is situated on a metal plate at the upper part of the plastic pipe (Fig. 4). The vertical movements of the floater caused by the sea level variations, are being recorded via a sensor on the recording unit of the instrument every 1min at the most, while the recording memory is enough for saving 30000 records.

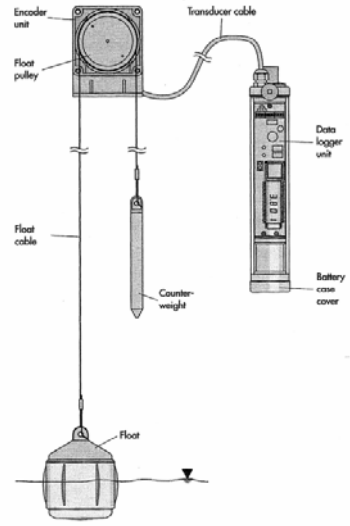

Figure 3. The main recording instrument and the recording unit.

The recording unit of the instrument is connected to a GSM modem; both of them are charged by a12V battery loaded by a small solar collector, which makes the system fully autonomous (Fig. 4). The GSM modem can be called by a pc connected either to a mobile phone via bluetooth or to a modem through a stable telephone line. This way the instrument can be remotely controlled; the user can download the data, watch the real time sensor values, change some parameters, etc.

Figure 4. Left: The instrument with the solar collector in operation – Middle: The recording instrument fixed on the pipe – Right: The recording unit, the modem, the transformers and the battery.

The calibration of the system is the most important procedure, due to the fact that the relative values measured by the instrument must be correlated to the corresponding absolute values, which means introducing into the instrument the real distance between the sea level and the reference point. The last one is situated on the metal plate at the upper part of the pipe, while the distance between it and the actual sea level is measured using a digital distance meter of high accuracy. The final accuracy of the calibration is estimated 1mm (Milas, 2010).

3. Data Records

Today there are seven (7) tide gauge permanent stations sponsored by the Laboratory of Higher Geodesy, N.T.U.A. covering a major part of the Aegean Sea and the Corinthian Gulf. The tide gauges in Galaxidi and Egira at the Corinthian Gulf are operating since 2006, while the tide gauges in Mani (Karavostasi), Thassos (Skala Potamia), Chios (Emporios), Kastelli and Palekastro in Crete are operating since the end of 2008-beginning of 2009 (Pavlis et al., 2009).

The figures below (Fig. 5) demonstrate the full TG registrations (every 1min) for one year period (2010) as well as the slow sea level variations (daily values), mainly due to meteorological effects, for the tide gauges operating in Galaxidi and in Palekastro. It is obvious that the general variation of the sea level is about the same, but the width of values during a day differs a lot. At the Corinthian Gulf (Galaxidi) it is of the order of 50 cm, while at Palekastro (Crete) it reaches 15 cm.

Table 1. M.S.L. from TG reference point (TG_0) and hourly readings used for the harmonic analysis.

TG name	TG code	Readings	M.S.L.(m) from TG_0
THASSOS (Skala Potamia)	THAS	17504	-1.449
CHIOS (Emporios)	CHIO	14627	-0.864
MANI (Karavostasi)	MANI	17492	-1.304
KASTELLI (Kissamos)	KAST	16817	-1.399
PALEKASTRO	PLKS	16750	-1.116
GALAXIDI	GALA	17518	-1.440
EGIRA	EGIR	17518	-1.317

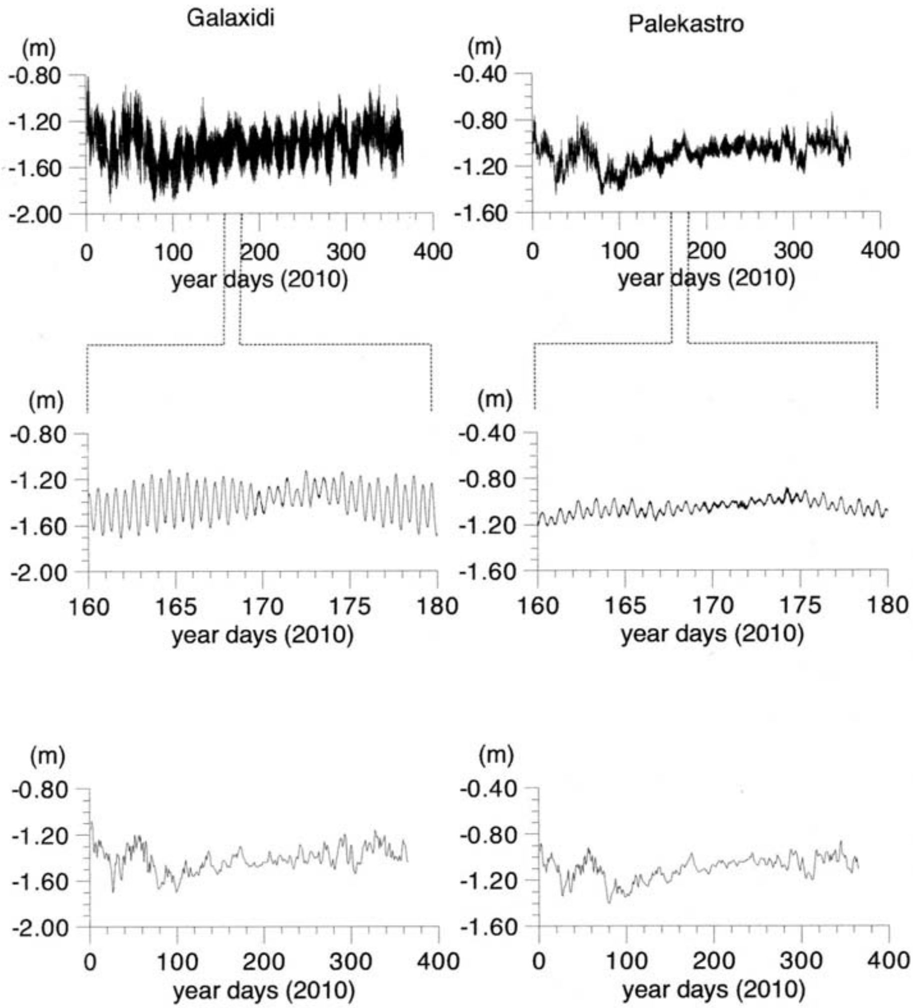

Figure 5.. Top: Sea level variations (per minute) in Galaxidi and Palekastro. - Bottom: Slow sea level variations (daily values).

4. First Results of the Analysis of the Data

The two year period 2009-2010 recording data (every one min) was smoothed (Milas, 2003) and the hourly values were extracted for all seven tide gauges of the network. The harmonic analysis of the data was done using a special software developed for this purpose (Milas, 1999), which computes directly the amplitudes and phases of several tidal constituents, using a least square adjustment. In addition, the Mean Sea Level (M.S.L.) relative to the Tide Gauge reference point is computed (Tab.1). The waves used are part of the complete Cartwright-Tayler-Edden tidal potential development (1973). Thirty nine (39) basic constituents plus others, necessary for nodal corrections (Godin, 1972) were used, capable of determining the amplitudes and phases (mainly diurnal, semi diurnal and third diurnal) for a period of one year data.

The amplitudes of the main tidal constituents that result from the harmonic analysis of the data are shown at the corresponding Table 2. The estimated amplitudes of M2 are about 135 mm for the Corinthian Gulf, while for the Aegean Sea they vary from 14 mm at Kastelli (Crete, South Aegean) to 74 mm at Thassos (North Aegean), with an exception at Palekastro, which is situated at the East edge of Crete. Generally these results, especially the amplitudes, are in good accordance with those of the Hellenic National Hydrographic Service (HNHS, 1992), as well as with those of Spatalas (Spatalas, 2001). As far as the phases are regarded there are some differences which can be explained by the fact that the previous data of HNHS result from analog recordings, that generally presented time problems (HNHS, 1992).

Table 2. Main tidal constituents amplitudes and phases.

TG codes	O1		K1		M2		S2	
	ampl. (mm)	phase (deg)	ampl. (mm)	phase (deg)	ampl. (mm)	phase (deg)	ampl. (mm)	phase (deg)
THAS	13	315	26	342	74	64	52	82
CHIO	12	299	23	324	31	26	20	48
MANI	5	324	13	351	28	42	14	45
KAST	6	291	15	333	14	5	8	351
PLKS	9	271	16	306	36	245	25	257
GALA	8	341	19	6	136	92	89	106
EGIR	8	349	19	15	134	113	90	125

5. Conclusions and Proposals

The integrated tide gauge recording system described above is, compared to heavy and expensive corresponding systems (used for example by the HNHS), without doubt reliable and equally, if not more, precise. Its main advantage is the simple, low cost structure, which can be set up and be fully operative in maximum two (2) days.

It is worth noticing that the whole structure can be easily moved at another position if necessary, as it only needs a few screws to be fixed. The remote control of the tide gauge recording instruments is also very easy to handle via a pc and a mobile phone. In addition to that, today the sea level data are automatically downloaded to a server.

Today seven (7) permanent tide gauge stations are fully operative, covering a major part of the Greek coastline; two of them are already connected to a continuous GNSS receiver in order to provide accurate reference for the sea level data. In this way, the sea level data refers to a geocentric system (ITRF) above the ellipsoid GRS80, while in a next step the estimated values will be compared to those of the EGM08 model.

It is planned that in the near future the Network will be expanded, so as to cover both North and South East Aegean Sea, while all of the tide gauge recording systems are planned to be equipped with continuous, connected to the internet GNSS receivers.

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