

Modern information on world ocean current eustasy

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Abstract

The eustasy, sea level climatic fluctuation, is a constant phenomena, which according the warm and cold climate cycles and fluctuations can be positive or negative. Nowadays, World ocean current eustasy is positive, which collaterally and together with climate warming causes its level elevation. In the beginning (1985-2010-th) of climate current 90 y. fluctuation, the eustasy is accelerated: at high latitude ice sheet acting zone at rate of 30-35% and 10-20% - at lower ones respectively. Mentioned phenomena significantly increased the inundation probability and disaster risk of population (~1, 5 billion), living on coastal lowlands and river mouths areas. The mitigation or reduction of probable disasters is possible by the way of early warning systems and appropriate hydro technical constructions application. For effective implementation and exploitation of the latter it is necessary to know the eustasy' local and regional parameters. The sea level statistical series is the best source of such parameters calculation, regressive analysis of which is one of the most operative and reliable way to receive their accurate values.

1. Introduction

Climate current warming is a natural process that significantly has increased since 1960-1980s. Such fluctuations in Holocene are noticed many times. As the drilling results of high latitude ice sheets, mountain glaciers and other data show their amplitude is 1.5-2.0⁰C, but period – 300-600 years.

Such rate of climate changing is accompanied by the several phenomena which are provoked by the latter. Among them there is the eustasy – sea level rising (during warming) and decreasing (during cooling down), which like the climate continuously takes place.

The eustasy has become as a critical factor since 1960, when the frequency of settlements hazardous inundation, situated in the coastal and estuarial zones, was much increased. Such catastrophic phenomena power and frequency were so increased, that the necessity of urgent preventive measures carrying out has arisen, which in its turn required of the phenomenon parameters determination at local level.

It is fact that impossible to stop the climate change and following to it eustasy process, but its forecasting with enough degree of accuracy and on the basis of results, to create of mitigation measures, can be done.

Nowadays, already has specified, that world ocean level elevation is significantly accelerated. If mentioned process will continue in the future with the accelerated velocity, then the 2 billion populations, living on the territory at 0.5 m below the ocean level, will get the serious life problems [1-3].

The eustasy is studied in several ways and directions [4, 5]. One of them is the analysis of permanent observation data on sea level. This information is presented by the sea level observation stations, total number of which more than 20 thousand units, allocated almost in all areas of World Ocean, beginning from the Arctic seas till the Antarctica. The advantage of

these data use is that it gives opportunity of eustasy research for the coast's definite areas, with highest degree of accuracy and descriptiveness. The latter appears as the basis for coast protection measures implementation. The sea level observation station results, after the exclusion of random and subjective errors and necessary processing, are grouped to statistical time series, which cover the period from several decades till 2 centuries.

The research goal is the calculation of current eustasy parameters (velocity, territorial propagation, and integral gain) from 1980 up to now, using the level series to determine its tendency, acceleration and critical areas under the highest risk of disaster, provoked by these phenomena.

2. The research methodology

For the eustasy research the level' long series, consisted of two, statistically enough length fragments, are used, out of which first one covers the period before the positive eustasy, but second one- the series of remained part [1].

$$H_1, H_2, \dots, H_k, \dots, H_{n-1}, H_n = \{H_i\}_{i=1}^k, \{H_i\}_{i=k+1}^n, \quad \text{here } i=1, 2, 3, \dots, k, \dots, n-1, n. \quad (1)$$

First fragment gives information on negative eustasy, which before the current climate warming (1880 year) was the result of acting cold fluctuation, but second- information on positive eustasy parameters.

For the determination of current eustasy absolute value, from the first and second fragments, by the approved method of regressive analysis the calculation of V_1 and V_2 trends value is made. Where V_1 is equal to negative eustasy annual velocity' - e mm/year ($e < 0$) and the coast vertical movement velocity's - C mm/year sum, but V_2 - to the positive eustasy $e > 0$ and the coast vertical movement sum.

$$V_1 = -e \pm c, \quad V_2 = e \pm c \quad (2)$$

The coast' vertical movement seriously impact on the accuracy of eustasy determination that is why while the absolute eustasy calculation its exclusion is necessary. Absolute eustasy phenomena research has scientific importance, particularly when it is necessary to determine the Ocean-Earth fresh water balance and its components with high grade accuracy.

In contrast to it, the relative eustasy research outcomes have a practical use, since they show the sea level elevation rather the coast. This phenomenon' research particularly important in negative tectonic zones and river mouths, as the coast subsides, but the ocean level increases there. As a rule, the hazardous inundation risk, caused by the storm surge and flash flows power and frequency increment, is the highest in such areas.

3. Analysis outcomes

The research material was grouped according to the observation stations allocation in: A. Arctic ice sheet zone; B. Antarctic ice sheet zone and, C. inter sheet area. The most accurate and rich information out of them belongs to arctic zone stations among of which at highest latitude acts Aberdeen station (Table. 1) and at lowest - Brest' one. On European Northern Coast, for eustasy research, 18, double fragment series was used.

Table 1

World ocean current eustasy according to the sea level long series of the basic sea level stations

Station	Ocean, Sea	Coordinate, nn ⁰ mm'		Observation period, year	Start of Positive Eustasy	Relative Eustasy	
		Latitude	Longitude			Till 1985	1985-2010
Arctic Ice Sheet zone							
Aberdeen	North Atlantic	57 15	-2 08	1862-2008	1896	2.7	3.0±0,46
Sheerness		51 45	0 75	1832-2008	1905	2.2	2.2±0,10
Brest		48 38	-4 50	1807-2008	1906	2.0	2.3±0,42
Inter Ice Sheet zone							
Vancouver	East Pacific Ocean	49 29	-123 12	1910-2009	1906	3.3	3.6±0,17
Seattle		47 60	-122 33	1899-2009	1907	3.0	3.4±0,48
San Francisco		37 80	-122 47	1854-2010	1901	0.8	1.1±0,21
Tonoura, Hamada II	West Pacific Ocean	34 90	132 07	1894-2010	1930	1.6	1.8±0,26
Poti	Black sea	42 17	41 68	1874-2010	1925	2.0	2.4±0,46
Batumi		41 63	41 70	1882-2010	1925	2.6	3.1±0,38
New York	Central Atlantic	40 70	-74 02	1856-2009	1906	1.3	1.8±0,38
Buenos Aires	South Atlantic	-34 60	-58 37	1905-1991	1906	0.9	1.1±0,21
Honolulu	Central Pacific Ocean	21 32	-157 87	1905-2009	1905	1.4	1.6±0,21
Antarctic Ice Sheet zone							
Syowa	South Ocean	-69 00	39 57	1980-1990		5.0	
Argentine Island		-65 25	-64 27	1958-2008		4.0	
Sydney - Fort Denison		South Pacific ocean	-33 85	151 23	1897-2009	1949	0.7

According to the data analysis outcomes in Northern Antarctic the negative eustasy change by positive one was begun since 1890, in Northern Europe seas it was propagated in 1906-1908 (Delft, Brest) and in 1914-1917 – Southern-Cascais-New York latitudes. In doing so its speed value till the 1980-th were the follows: in Aberdeen – 2.7 mm/year (tabl. 1), Brest – 2.0, but in lower latitudes 1.0-1.2 mm/year. Using the eustasy speed extrapolation method to North direction till the Greenland, its value at Southern coast of the island should to be 4.0-4.5 mm per year.

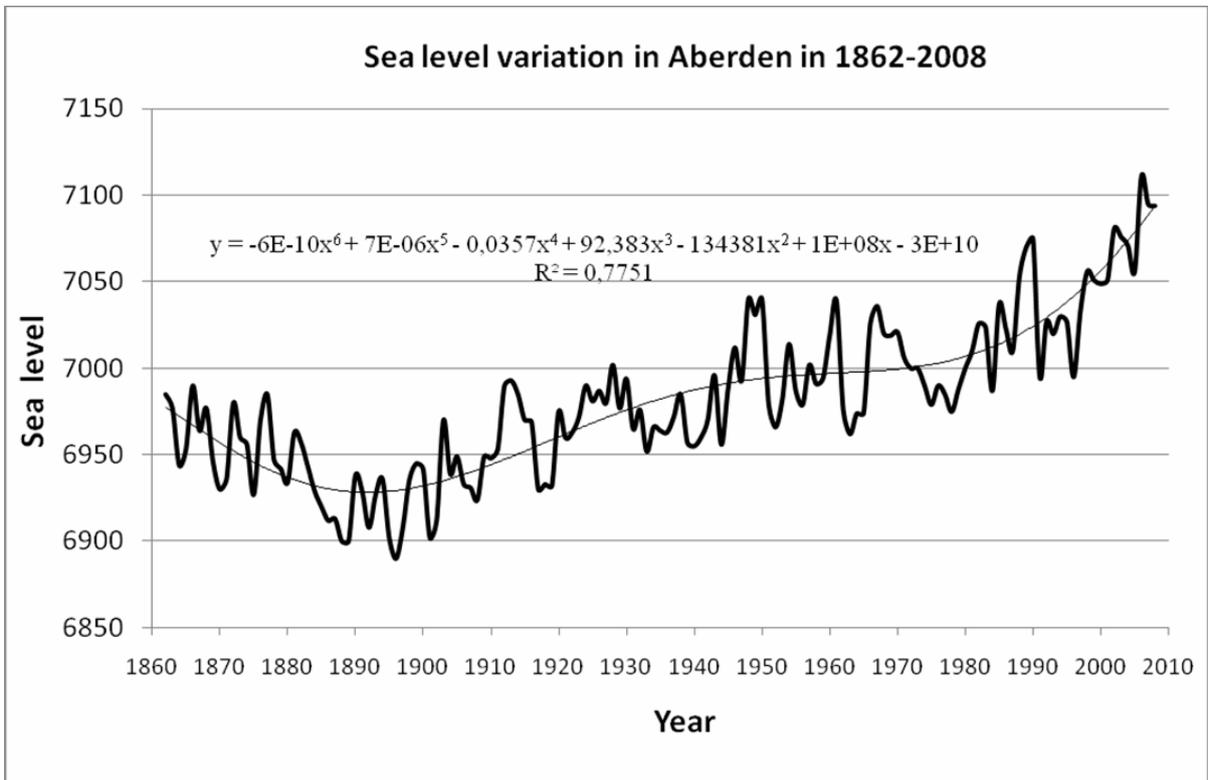
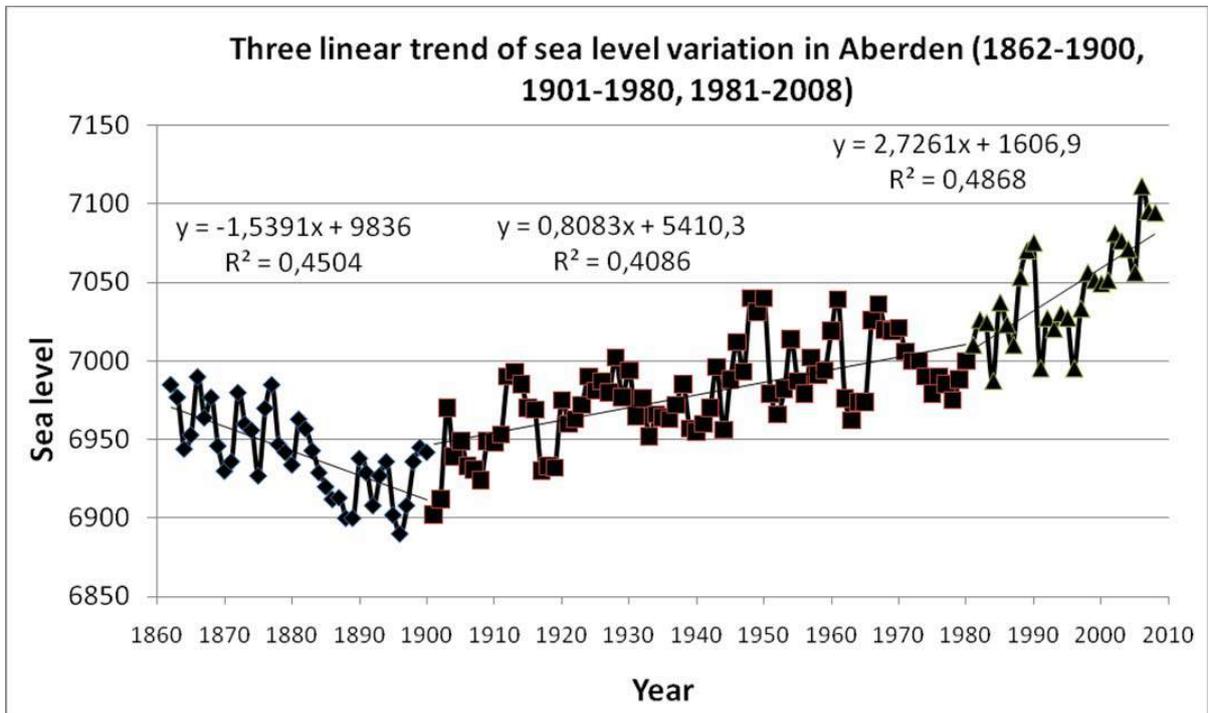


Fig. 1. Sea level variation at Aberdeen (North Atlantic Ocean).

The World ocean level eustatic elevation on North-Eastern coast of North America was begun in 1906-1910th, with the speed of 2.5-3.0 mm/year, at high latitudes. Since the double fragment series is limited, the calculations was made using the method of extrapolation. It is definitely known that at New-York coast the eustasy speed equal to 1.3 mm/year, but more Southern to – 1.2-1.0 mm annually (Fernandina, Key West etc.)

There are no double fragment series ocean level observation stations in Antarctic ice sheet zone, except operating ones at South-Eastern coast of Australia (Sidney, Adelaida etc.), located at the zone border.

In different regions around the antarctic operate the following stations: Syowa, Mc Murdo and Antarctic peninsula ones. Out of them Syowa station' data are more interesting, as the earth glacio izostatic elevation is the highest there. According to the observation data over the sea level in 1980-1990th the island freed from ice sheet was elevated over the sea level almost at 0.5 metres.

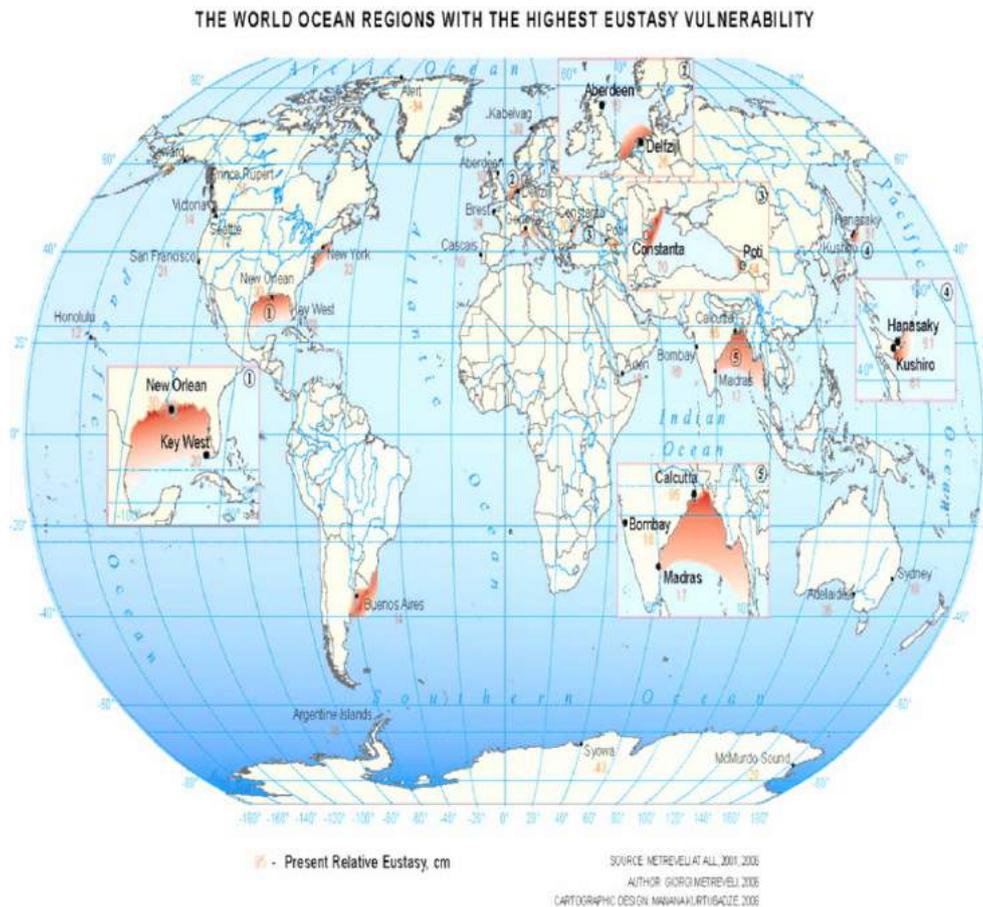


Fig. 2. The World ocean regions with the highest eustasy vulnerability.

It is natural, that glaciers intensive melting at Antarctic coastal zone should provoke the sea level accelerated elevation. Probably, Antarctic eustatical effect should be exceeded the Arctic ice sheet one at least of 30-40% rate [6]. Therefore, in Syowa Station area the eustasy probable speed can reach the value of 5.0-6.0 mm per year.

According to the data of remaining stations the glacio izostatic elevation is high everywhere, particularly in the areas, which were freed from glaciers during the last decades.

On the basis of operating in Southern Australia stations data the eustasy speed there does not exceed 0.7-1.0 mm per year, which means that Antarctic glacier waters do not or can not impact on this region.

The inter icesheet area covers the remaining part of World Ocean- in Pacific Ocean from Bering Strait till Australian Southern coast, central and Southern parts of Atlantic ocean and Indian ocean, including internal and marginal seas. There is high density of double fragment stations' network in Black-Azov and Mediterranean seas, also at both coasts of Northern America and at central coast of Asia (Japan).

On the basis of mentioned network' data, the 80-85% of this zone eustasy speed varies between 0.7 and 1.8 mm/year. The abnormal high speed is noticed in Alaska bay and at Northern America Western coast' adjoining part, including Vancouver-Seattle coasts. The eustasy at mentioned coasts, is activated precisely by the mountain glaciers melting (caused waters replenishing), particularly of McKinley' massif ones. Besides, important role plays the

snow melting waters gain in the river flow discharge, which in the mentioned river mouths, particularly in Hakata bay, significantly accelerates eustasy, approximately (3.0-3.7 m/year).

In the Mediterranean Sea the eustasy, mean speed is equal to 1.4 mm/year, but maximal – 1.7 mm per year, in Black sea 2.5 and 3.0 mm/year and in Azov Sea 3.0 and 3.2 mm/year respectively.

The eustasy' research was made in every sea, where that phenomena intensive process is going on. Exception is made for Baltic Sea, which level is changing so slightly that does not exceed an error of the method.

On the basis of research materials analysis outcomes the generalization was found out that current eustasy was developed according to the current fluctuations changes (90 years from 1895 till 1985), but with the delay of 15-20 years. The current fluctuations, which probably is continuing during 1985-2050 years coursed the air temperature and sea level increment in first half of 1985-2020th, can be the result of man-made economic activity impact. These facts are confirmed by the observation outcomes received. The warming and eustasy process will be sharply accelerated during the mentioned time that will course more disaster to population living on coastal lowland and river mouths. The probability of such regions inundation (Fig.1) and disaster risk is increased according the time. Such assumption is confirmed by the fact of settlements inundation number increment, caused by the storm surges and floods.

4. Conclusion

The current eustasy research outcomes can be generalized as follows:

Current eustasy is the continuing process, characterized by the similar cyclicity and has fluctuations like climate.

Under the current eustasy the World Ocean is represented as an asymmetrically expanded hydrosphere, particularly in Arctic ice sheet' zone, on which the glaciers and snow waters, nourished the river mouths, spatially increasing water cones are imposed. The current eustasy causes the serious hazard to population living at lowland or closed to river mouths area, located at a height of 0.5 m above the sea level. The probability of mentioned settlements inundation and disaster risk respectively is too high in subsiding zones. The World Ocean eustasy is significantly accelerated after 1980th. Probably, the mentioned tendency will continue till the 2025-2050th.

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Новейшая информация о современной эвстазии Мирового океана

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Резюме

Эвстазия, климатическое колебание уровня моря, есть непрерывный процесс, который в зависимости от теплых и холодных циклов и флуктуацией климата, имеет положительное (повышение) или отрицательное (понижение) значения. Текущая эвстазия положительная и параллельно потеплению климата повышает уровень Мирового океана. В положительной части современной климатической флуктуации (1985-2010 гг.) эвстазия ускорила: в зоне высокоширотных гляциальных щитов на 30-35%, а в зоне между ними на 10-20%. Акселерация этого феномена резко повысила вероятность затопления населений (численность около 1,5 млрд.) и риск катастрофы для проживающих на прибрежных оседающих низменностях и в устьях рек. Предотвращение бедствия или уменьшение его последствий возможно путём создания систем раннего оповещения населения и сооружения защитных гидротехнических конструкций. Для успешной реализации этих проблем, необходимы знания локальных и региональных параметров эвстазий. Для их определения с необходимой точностью одним из наиболее оперативных и надежных средств является метод регрессионного анализа длинных (двухфрагментных) уровненных статистических рядов.

უახლესი ინფორმაცია მსოფლიო ოკეანის მიმდინარე ევსტაზიის შესახებ

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რეზიუმე

ევსტაზია, ზღვის დონის კლიმატური რყევა, არის უწყვეტი პროცესი, რომელიც კლიმატის თბილი და ცივი ციკლებისა და ფლუქტუაციების შესაბამისად დადებითია ან უარყოფითი. მსოფლიო ოკეანის თანამედროვე ევსტაზია დადებითია და კლიმატის დათბობის პარალელურად იწვევს მსოფლიო ოკეანის დონის აწევას. მიმდინარე კლიმატური 90-წლიანი ფლუქტუაციის საწყის ნაწილში (1985-2010 წწ.) ევსტაზია დაჩქარდა: მაღალი განედების მყინვარული ფარების მოქმედების ზონაში 30-35%, დაბალ განედებში 10-20%-ით. ამ პროცესმა მკვეთრად გაზარდა ზღვისპირა დაბლობებისა და მდინარეთა შესართავების მცხოვრებთა (რაოდენობა 1,5 მლრდ.) დატბორვის ალბათობა და კატასტროფის რისკი. ამ უბედურებათა აცილება ან შერბილება შესაძლებელია ადრეული შეტყობინების სისტემების და ჰიდროტექნიკური ნაგებობების გამოყენებით, რომელთა შექმნისა და წარმატებული ექსპლოატაციისათვის საჭიროა ევსტაზიის ლოკალური და რეგიონული პარამეტრების ცოდნა. ამ პარამეტრების გაანგარიშების ყველაზე საიმედო წყაროა ზღვის დონეთა სტატისტიკური რიგები, რომელთა რეგრესიული ანალიზი მათი რეალური მნიშვნელობების მიღების ერთერთ ყველაზე ოპერატიულ და საიმედო საშუალებას წარმოადგენს.