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VISUALIZING THE CHANGES OF THE CASPIAN COASTLINE

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The purpose of this work is to present the sea level data of the Caspian Sea, through a web browser with an interactive approach. Caspian Sea Level has undergone significant fluctuations over the last century. In this project, we tried to reconstruct the long-term changes in Caspian Sea Level for the period from 1900 to 2018 and show forecasts up to 2050. As a supplement to the main goal, an animated video of the Caspian Sea Level changes was recorded and uploaded on the webpage.

Keywords: Caspian Sea, Caspian Sea Level, Caspian coastline, WEB map page, prognosis model

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INTRODUCTION

The Caspian Sea is the largest water body that is enclosed in landmass with an area of 376 000 sq. m at level minus 28 meters. Five countries have the access to a shoreline of the sea: Iran, Russia, Azerbaijan, Turkmenistan and Kazakhstan. These countries signed the Tehran Convention in 2003 in order "to protect the marine environment of the Caspian Sea from pollution, including the protection, conservation, restoration, sustainable and rational use of its biological resources" (Article 2 of the Convention). [1] The Caspian Sea lies within a land depression; the surface of the sea is about 28 meters below mean sea level. The sea is completely isolated; there is no connection to other oceans. The main feeder is the Volga River (80...85% of the Caspian's inflow); other inflows are the Ural, the Kura, and the Terek rivers. There is no discharge by any river; water leaves the sea only by evaporation. The sea is also known for its abundance of energy resources (oil and natural gas reserves in offshore fields and onshore on the coast of the sea), and all states around the Caspian exploit the reserves in cooperation with international oil companies. However, much of the offshore oil and natural gas resources in the Caspian Sea have not been tapped yet. [3] Throughout the previous centuries, the Caspian area has always been an interesting topic for various powers. The first map of the Caspian shoreline was developed by Lieutenant Captain Alexandr Bekovich-Cherkassky, a Russian explorer during his expedition to the Caspian Sea in 1715. The expedition was ordered personally by the Russian Emperor Peter I as part of his endeavor to find a trade route from Russia to India.

The Caspian Sea is the biggest inner water body of the world and there is a great deal of research, as well as projects, publications and webpages dedicated to it. During the last century, the Caspian Sea level (CSL) has changed by three meters. The aim of this thesis is to create a webpage that visualizes the Caspian coastline changes over time. I consider this important to represent, because there are no equivalent interactive representations of sea level changes on the web regarding the Caspian topic as it is designed in the webpage of this thesis. Another reason is that there is no common opinion regarding the reason for these sea level changes. While still there are debates regarding this topic, the web visualization would be quite helpful to project and represent corresponding alerts to the public.

In order to achieve my goal I had to adhere to several stages. Firstly, I created a reliable dataset of the Caspian region, including bathymetry data and the data of adjoining areas. The detailed algorithm is described in the Data Processing chapter. Secondly, I visualized the data in a web application.

This step is related to coding and uploading; the resultant dataset is described in the Web Map Page chapter. Thirdly, I created an animated video of the change of the CSL over time. This is a minor, additional step described in the Animated video chapter. This algorithm has been designed under the supervision of Dr. Gede Mátyás and was based on several datasets. The first dataset was obtained from the general catalog of the Caspian Sea level presented by the Coordinating Committee for Hydrometeorology and Pollution Monitoring of the Caspian Sea (http://www.caspcom.com/). The data itself was recorded at the measurement stations around the Caspian Sea. The second dataset of the Caspian Sea level prediction changes model was obtained from RSE "KAZHYDROMET" as the most pessimistic scenario. As a result, based on this data I reconstructed changes of the CSL over the last century and added the prognosis model for the next 50 years. The Caspian Sea Level changing model webpage will be a useful tool for visual representation of the spatial-temporal changes of the sea level for scholars, researchers, government associates and for general information for common citizens.

Importance of the regular observation

Sea level in the Caspian Sea is a topic of growing concern to all five surrounding countries. The Caspian Sea is subject to significant water level fluctuations, which have had serious consequences for low-lying and densely populated coastal areas, displacing thousands of people, destroying investments in industry and infrastructure and causing severe pollution threats via inundation of nearshore waste sites.

Understanding its variability at all scales is a complicated task due to a combination of several factors such as climatic (atmospheric variations), anthropogenic (e.g., river drainage and water use, especially Volga), and geologic (e.g. subsidence) [6].

For the North Caspian Sea, the chance of level fluctuation appears to be more dramatic and might be more catastrophic regarding environmental sustainability, social impact, and industrial crisis. This is due to its physiographic features of the extensive lowland areas along the coast, for example, the Caspian Depression. The North Caspian is a shallow basin with a depth of not more than 10 to 15 meters, and about 20 % of its area has a depth of <1 meter. Due to this, the variation in the mean Caspian Sea level by 2 to 3 meters (for example, in 1974 to 1994) leads to the colossal changes in the hydrological and dynamical regimes. [4]

At this time, the water level has been monitored since 1900. Thus, according to observations from 1930 to 1977, the sea level decreased by 2.7 meters, and from 1977 to 1995, it increased at the rate of 15 centimeters per year. However, numerous transgressions and regressions of the Caspian Sea have occurred in the recent past. The Holocene sea-level history has been reconstructed based on a marine terrace section along the Dagestan coast. Five transgressional phases have been described and dated around 8000, 7000, 6000, 3000 and 200 BP. The lowest documented sea level is estimated at -50 meters below global sea level at the very end of the Pleistocene or very early Holocene (Mangyshlak regression) [5].

Many scholars have dedicated their research to the topic of Caspian Sea level variability. The enormous models simulate the statistical data of tides, meteorological data, and wind stress and so on. Still there is no consensus about the reason for theses level changes.

Sea level contradiction

That was the most interesting part of contradicting raster set values. The SRTM dataset (date of creation is Feb 2000) distinguishes the water level at the point of -29 meters, however, according to scientific monitor data, the last time the CSL was at the point of 29 meters below mean sea level was from 1976 to 1978 years. For the last decade, it is considered to have stayed at –28 meters.

Web map interface

As the goal of this thesis is a visualization of the Caspian coastline changes through overtime, this webpage can be considered as the result. One may access this webpage following this link http://terkeptar.elte.hu/caspian/ .

Under the title Caspian Sea Level Changing Model, there is a button, pressing which will display a short description about the thesis project. The most important tools that were created for the visualization are Sea level and Date sliders in the left-bottom corner. These features have two options for modification. For example, one may use a slider to change the year or the level of the sea; or, it is possible to type a desired value in the appropriate text box. The Sea level parameter may be changed from 26 to 1020 meters below the mean sea level. The interval is half a meter. However,

by default after starting the page the Caspian Sea surface appears at the level of -28 meters. The Date parameter can be changed between year 1900 and 2050. If the year is changed the surface of the sea displays the 21 level that was recorded for that year. The data of the CSL from 1900 to 2018 is taken from the general catalog. For the year 2019, the value is transferred the same as in 2018. The data of the CSL from 2020 to 2050 is a pessimistic prognosis that was modelled by RSE "KAZHYDROMET". Under the sliders, there is a button download map, which produces results in png format without additional elements. The next link is Animated video. This is a new tab with a video of CSL changes from 1900 to 2050. Another link is Thesis, a new tab of this document in pdf format. On the upper right corner, there are the layer switcher and zooming tool.

DISCUSSION

Nowadays many scientists are concerned about global climate change, so it is increasingly important to regular observe and monitor the level change of the biggest inner water body – the Caspian Sea. The real factors of sea level fluctuations are still under discussion, so the effects that global warming or other climatic cataclysms will have on these levels is still unpredictable. It is a vital topic, because much scientific research predicts a long-term increase in surface temperature, which would lead to dramatic ecosystem consequences. The history of the nearby Aral Sea over the past several decades shows how long-term water flux imbalance altering the level of an enclosed lake can lead to dramatic ecosystem consequences. While similar consequences in the Southern Caspian Sea are unlikely, the shallow (~5 meter depth) northern part of the sea and the Kara-Bogaz-Gol Gulf are much more vulnerable [2]. For this reason, this thesis is aimed to represent the data of the previous sea level fluctuations and visualize it with the help of the online, interactive map. Although the principle of this project is not sophisticated, there are still some problems and contradictions during the editing process. The problem is related to the areas of the depressed lands that could be left after the water level of the sea itself shrinks. Such water bodies can remain for long period before they evaporate completely, but the case of evaporation time is harder to predict, even for big areas. For example, in the case of Kara-Bogaz-Gol Gulf, scientists forecasted complete evaporation in 25 years after installation of the dam. In fact, this process took 10 times faster. This possibility is not taking into consideration in our project. For instance, if the water level drops to -30 meters, the gulf disappears. Ignoring this phenomenon that cannot be foreseen, the webpage has the only straight visualization of the bathymetry and adjoining area. Manipulation of the new algorithm may lead to a new topic and subsequent research. This particular case shows that the GIS system and designed database is not appropriate for the drying effect in order to represent clear, appropriate conditions of the separated water bodies while the water is in the process of drying and separating from the main body.

Due to fast-paced development of new technologies and software, there are many ways to display monitoring data of phenomena or process throughout time. In particular, it is much easier now to propagate it through the web. More and more sources on the web are in development and becoming free of charge for use. Because of this, I offer several ideas to implement in a future:

1. Button for measuring located on the webpage, like a ruler. This implementation will be useful to measure distances on the map from point A (settlement) to a coastline;
2. Opportunity to calculate the area of the water surface;
3. Opportunity to calculate the volume of water of the particular sea level. In reality, this data will be very approximate, but for the general vision and understanding it will be enough;
4. Any vector data to add as a layer. For example, height and direction of tides or velocity and direction of the wind.

CONCLUSION

As a result, using data recorded from measurement stations in the past and scenario-predicted figures, I have reconstructed long-term CSL changes during a 150-year period, from 1900 to 2050. This project has a number of advantages. First, as it is implemented in the web browser, the bigger audience is able to see and use this information. Second, visualization of the Caspian Sea bathymetry is possible from the present level of the sea at the point -28m to the deepest point of the sea. Third, the webpage has a slider tool that corresponds CSL with the year. Using this

interactive tool, you may find and see the CSL in a particular year. Fourth, in the webpage there is a short video demonstration of the CSL changes over the last century. As there are many opportunities to create fascinating webpages, we anticipate new data to be upload and accessed along with what we can see now.

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КАСПИЙ ТЕҢІЗІНІҢ ЖАҒАЛАУ СЫЗЫҒЫНДАҒЫ ӨЗГЕРІСТЕРДІ ВИЗУАЛИЗАЦИЯЛАУ

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Бұл жұмыстың мақсаты интерактивті тәсілмен веб-браузер арқылы Каспий теңізінің деңгейі туралы деректерді визуализациялау болып табылады. Каспий теңізінің деңгейі соңғы жүз жылдықта айтарлықтай ауытқуларға ұшырады. Бұл жобада біз 1900 жылдан бастап 2018 жылға дейінгі кезеңде Каспий теңізі деңгейінің ұзақ мерзімді өзгерістерін реконструкциялауға және 2050 жылға дейінгі болжамдарды көрсетуге тырыстық. Негізгі мақсатқа қосымша ретінде Каспий теңізі деңгейінің өзгеруі туралы анимациялық бейне жазылып, веб-бетке жүктелді.

Түйін сөздер: Каспий теңізі, Каспий теңізінің деңгейі, Каспий жағалау сызығы, веб-карта беті, болжам моделі

ВИЗУАЛИЗАЦИЯ ИЗМЕНЕНИЙ БЕРЕГОВОЙ ЛИНИИ КАСПИЙСКОГО МОРЯ

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Целью данной работы является визуализация данных об уровне Каспийского моря через веб-браузер с интерактивным подходом. Уровень Каспийского моря за последнее столетие претерпел значительные колебания. В этом проекте мы попытались реконструировать долгосрочные изменения уровня Каспийского моря за период с 1900 по 2018 год и показать прогнозы до 2050 года. В дополнение к основной цели было записано и загружено на веб-страницу анимированное видео об изменениях уровня Каспийского моря.

Ключевые слова: Каспийское море, Уровень Каспийского моря, береговая линия Каспия, страница ВЕБ-карты, модель прогноза