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The Shrinking Toshka Lakes in the Google Earth Images

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Abstract: Toshka Lakes are lakes artificially created in the Sahara Desert of Egypt, by the water of the Nile, conveyed from the Nasser Lake through a canal in the Toshka Depression. From space, astronauts noticed the growing of a first lake, the easternmost one, in 1998. Then additional lakes grew in succession due west, the westernmost one between 2000 and 2001. The pictures of the Toshka Lakes taken by the crews of space missions and the satellite imagery can show the evolution of them. From 2006, the lakes started shrinking rapidly. The recent images, among them those of Google Earth, display that the surface of the lakes is strongly reduced and some of them entirely dried out.

Keywords: Satellite Images, Image processing, Google Earth

1. Introduction

"Toshka Lakes" is the name given to the lakes, artificially formed in the Sahara Desert of Egypt. These new lakes are endorheic, that is, the water can never flow out this region toward the sea. They are near the Nasser Lake, the huge lake created by the Aswan High Dam, built in 1964-1968. As Wikipedia is reporting [1], in 1978, Egypt began to build the Sadat Canal, originating from the Lake Nasser and passing through the Wadi Toshka, to allow the water, when it is overflowing a specific level, to be drained off to flood a depression located at the south end of a desert limestone plateau. This is the Toshka Depression. In fact, the Egyptian government decided to undertake a development project of the surrounding region [2], known as the "New Valley Project", originally intended to extend this waterway till the Kharga oasis. However, this task of creating a new agricultural region in Egypt is quite complex [3], such as the preservation a permanent water reservoir in the desert. Here we will discuss the evolution of the Toshka Lakes and the strong shrinking of their surfaces as we can see from the Google Earth images.

2. A history of the Lakes

It was in late 1990s [1] that the water started flowing in the Sadat Canal. This waterway, feeding the depression with the water from Nile, was specifically prepared to reduce the water losses. The water, in order to flow the Sadat Canal needs a pumping station, which is situated north of Abu Simbel. From space, astronauts noticed the growing of a first lake, the easternmost one, in November 1998 [1]. They saw the other lakes grown in succession westward. Let us note that NASA, through its "Gateway to Astronaut Photography of Earth" [3], provides a database with locations, supporting data and digital images, of the Earth surface. This database contains images starting from the Mercury missions. Today, the images are obtained processing those coming down from the International Space Station. The "NASA Earth Observatory" [4], created in 1999, has the same task. This is considered the principal source of satellite imagery and other scientific information on climate and environment, among the services provided by NASA, for the general public.

Therefore, a public source of information on Toshka Lakes is in the pictures taken by the crews of space missions. Starting from 2006, the images show that the lakes started shrinking, because of a reduction of water supply [5]. Some small lakes dried out. As reported in [6], the flooding of the Toshka Depression had created four wide lakes, with their maximum surface area in 2002, of approximately 1,500 km^2, having about 5×10^9 m^3 of water. Some of the water evaporated and some recharges the underlying aquifer [6]. At the beginning of the flooding, the fauna and flora of Nile invaded the Toshka valley [6], with a resultant very rich population of fishes. But, unfortunately, the water supply reduced. The western-most lake shows a rapidly increasing salinity. As the researches are observing, the zooplankton reacts to the increase of salinity by a striking impoverishment [6]. The life in the lake started to decline.

A publication [7] estimated the loss of water from the lakes using remote sensing and GIS, collecting a set of images and processing them to show the aerial extend shrinkage of these lakes from 2002 up to 2007. By means of a spatial analysis of bathymetry in a digital elevation model, the authors found that the loss rate is around 2.5 m/year. They noted that the lakes stored around 25.26 billion cubic meters of water in 2002, but in 2006 the stored water was reduced to 12.57 billion cubic meters. The authors concluded that the location of these lakes in such hyper-arid zone is responsible for a high loss rate, mainly caused by the evaporation, because they found the percolation of water through

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the ground quite limited. They told in [7], that "It is strongly recommended that measures must be taken to maximize the benefits of these huge, exceptional water resources before totally lost via evaporation. Additionally, geo-environmental problems are likely to arise from the concentration of salts when the lakes dry up".

Egypt had already experienced a similar situation, but on a longer period and more than two thousand years ago. It concerned the Lake Moeris, an ancient saltwater lake in the northwest of the Faiyum Oasis. During the prehistory, the lake had freshwaters due to the high flood of Nile. From the XII Dynasty, in 2300 BCE, the natural waterway from the river to the lake was widened and deepened to make a canal which is now known as the Bahr Yussef, "the waterway of Joseph" [8]. This canal served for the purpose of controlling the flooding of the river and help in irrigating the surrounding area. Moreover, the kings of the twelfth dynasty used the water of the natural lake of Faiyum in the dry periods. In fact these kings transformed the lake into a huge water reservoir, giving the impression that the lake was an artificial excavation, as reported by Pliny the Elder. He is writing, when discussing the pyramids in his book [9], that two of them are "in the place where Lake Moeris was excavated, an immense artificial piece of water, cited by the Egyptians among their wondrous and memorable works". As the surrounding area changed, since the local branch of the Nile shrank, from about 230 BCE, the Bahr Yussef became neglected and Lake Moeris began to dry up, creating a depression in the modern province of Faiyum.

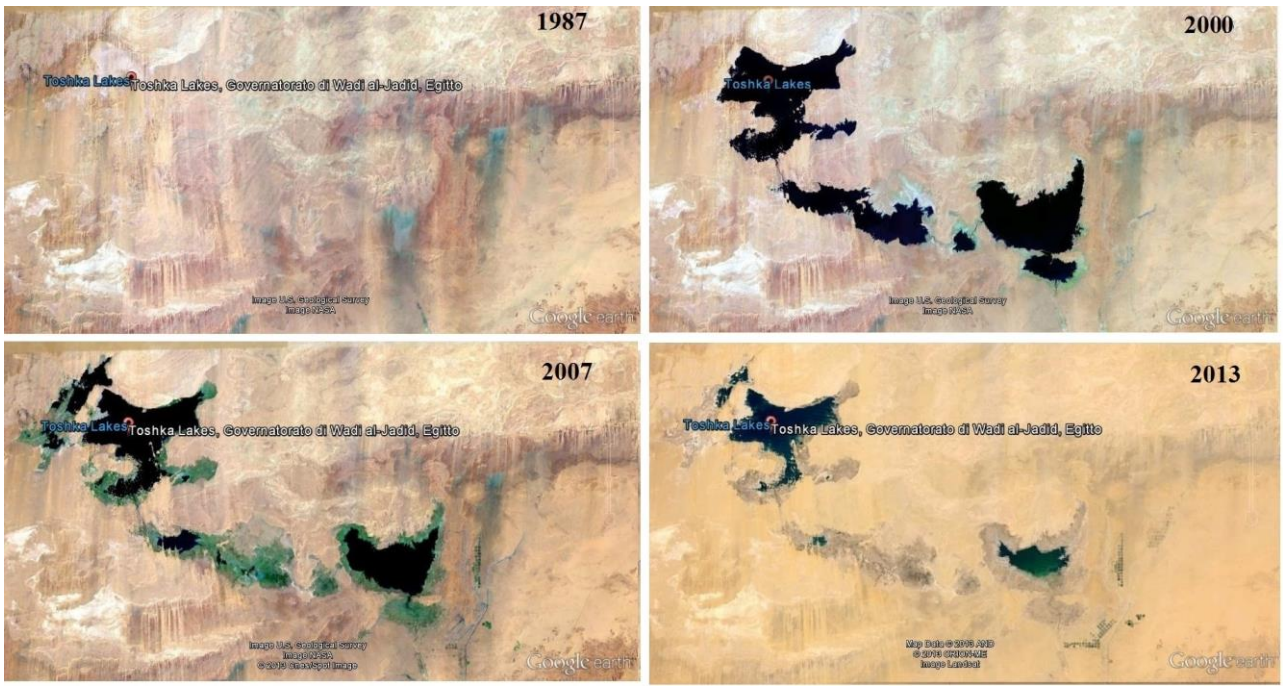

Figure 1 – The Toshka Lakes as we can see in the time series of Google Earth: the Toshka depression in 1987 before they were created, the lakes as they were in 2000, and their rapidly shrinking (2007 and 2013).

3. Google Earth images

In a previous paper [10] we have discussed the evolution of the Toshka Lakes by means of the NASA satellite imagery, because in 2011 only the "NASA Earth Observatory" allowed us to see the evolution of them. In [10], we concentrated in particular on the evolution of the easternmost Toshka Lake and observed its shrinking after 2005. Today we can use the Google Earth images.

As we have previously discussed [11,12], the Google Earth satellite images, in particular its time series, are quite important for geophysics studies and applications, such as the analysis of moving sand dunes. Here, in the Figure 1 we can see four images showing, in 1987, the regions of the lakes before they creation, then the lakes as they were in 2000, and their rapidly shrinking in the images of 2007 and the present situation.

In 2000, the eastern lake had its largest surface. We can evaluate it using, for instance, the ruler of Google Earth and a grid on the image, obtained by means of GIMP, the GNU Image Manipulation Program [13]. In the Figure 2, we can see such a processing; the main part of the lake has a surface of approximately 350 km^2 in 2000 and of 214 km^2 in 2007. The image displayed by Google Earth for 2013 has a poor resolution, not suitable to calculate the existing surface. However it is showing that the lake is drying out.

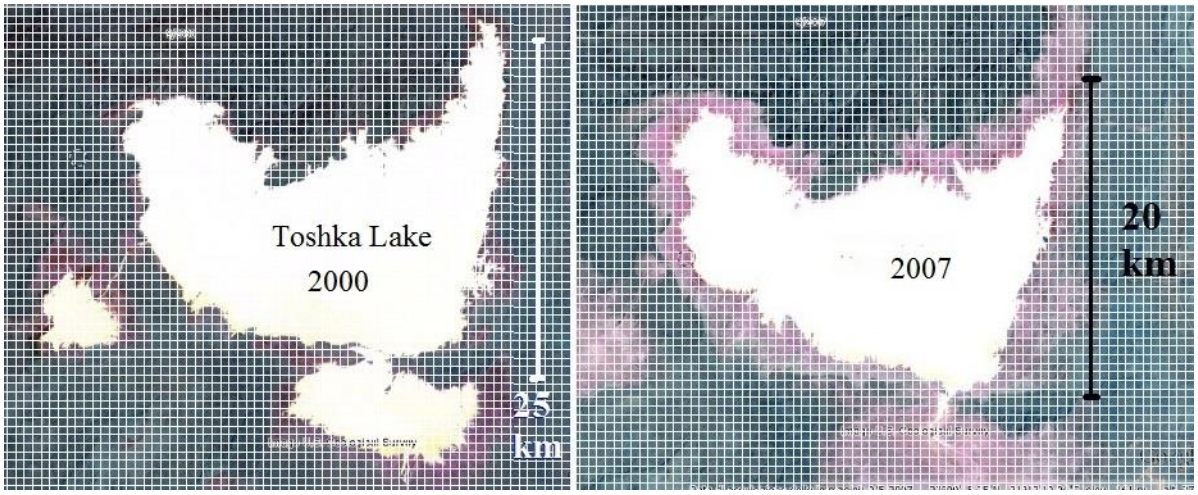

Figure 2 – After processing the satellite images using GIMP, we can evaluate the surface of the lake and its shrinking from 2000 to 2007. It was of approximately 350 km^2 in 2000 and of 214 km^2 in 2007. In using the grid for measurements, it is better to invert the colours of the images.

The region of the Toshka depression hosted a prehistoric megalake, as obtained from radar data of Egypt taken by the Space Shuttle Radar Topography Mission [14]. This lake was formed some 250,000 years ago by the Nile River, that, near Wadi Toshka, flooded the eastern Sahara. The researchers found that the megalake had a surface of more than 42,000 square miles. At the time, the region had more rainfall; moreover, the heavy rain in highlands to the south, from where the Nile flows, caused the megalake to grow. According to [14], the lake oscillated in size, over multiple thousands of years. Just northeast of where the huge paleolake once was laying, the new artificial Toshka Lakes have been created. In [15], it is told that they were deprived from water since 2003, and therefore some of these lakes have since entirely dried out. As we have previously told, the authors of [7] in 2007 recommended to undertake measures to preserve these water resources, but, from the satellite images, it seems that the destiny of the lakes is that of disappearing completely in a few years.

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