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Calculation of glacial area change at Cilo mountain with Google Earth Engine

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Abstract

Global climate change has become an important natural phenomenon that threatens the world today, with the negative factors that occur in the ecosystem such as constantly developing cities, population growth and climatic conditions. Since active glacial areas are very sensitive to climate changes, it is one of the important areas that should be examined to reveal the extent of global warming. They grouped Turkey's current glaciers and regions of glaciation under three main groups: Taurus Mountains, Eastern Black Sea Mountains, Volcanoes and other independent mountains of Anatolia. Cilo Mountain, located in the Taurus Mountains group, constitutes one of the important glaciation areas with active glaciers and many glacial forms. In this study, the active glacier on Cilo Mountain is examined using Remote Sensing and Geographic Information Systems techniques. In the study, the numerical data used in the Normalized Difference Snow Index (NDSI) study were obtained with the Google Earth Engine tool and the analyzes created as a result of the algorithms made using satellite data.

1. Introduction

Since glaciers cover a large part of the earth's surface, their effects on living life are also quite high. The polar and high mountain glaciers play a crucial role in maintaining and stabilizing the world's climate system, sea level and temperature, ocean currents, freshwater resources and all habitats. Considering the climatic and environmental factors, losses in glacial areas cause serious problems in economic and social life as well as negatively affecting ecosystems.

The catastrophic global warming, which we can say the biggest we face today, and the gradual increase in greenhouse gases in the troposphere layer of the atmosphere cause a chain of events that threaten the life of all living things (Galip et al., 2013). Global warming causes many disasters such as melting of glaciers, rising sea levels, drought, floods, landslides and erosion. One of the disasters that will cause great chaos in the world is the rapid melting of snow and glaciers in the poles and high mountains (Galip et al., 2013). It is of great importance that the data be used quickly and effectively in the studies carried out. Considering the importance of remote sensing and geographic information systems, the use of developing technologies is increasing. In parallel with this, geographic information system software is also developing. Advances in remote sensing and geographic information systems have enabled detailed investigations using high-resolution data. These developments also enabled the data to be obtained numerically and to reach the user quickly and to use the data effectively. The use of data obtained from satellites and geographic information systems provide fast, comparable and updatable information about the changes that have occurred on the earth from past to present. In parallel with these developments, Google Earth Engine (N. Gorelick, 2017), which offers the opportunity to conduct research by combining large satellite images and data obtained from satellites, has provided a great advantage to users in recent years. Access to large data sets is made easy with Google Earth Engine. It contains a large number of data sets such as environment, climate, glacier, geology, population, disease, disaster. With this large data set, it provides the advantage of fast and effective change analysis and ease of use.

Cilo Mountain (37.5°N, 44°E, 4135m), which is the second highest mountain in Turkey after Ağrı Mountain in the study area, is located at the corner of the southeastern border of Turkey, on the highest peak of the Taurus-Zagros Mountains (Sarıkaya, 2009). The region draws attention with its height and snow masses that do

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not melt in summer. With more than 20 large and small glaciers, Cilo Mountain (Erinç, 1953; Günal, 2013) is Turkey's most important glacier area, with hot and dry summers and harsh continental climate characteristics. Global warming in recent years and glacial losses in the region are among the reasons for choosing the region as a study area. In this context, the glacial area changes of the region between 2013-2022 were investigated by monitoring with Google Earth Engine.

2. Method

In the study, with the help of satellite products in the Google Earth Engine Library, data for the years 2013-2022 were obtained and the effects of the results on glacial losses were investigated. Google Earth Engine is a platform that contains more than forty years of data archives and scientific datasets updated daily. A large number of analyzes can be made with the help of algorithms developed using satellite data with the data catalog open to everyone. Thanks to open source data, analyzes can be made easily, various filters can be made on the image to be studied through the code editor, and work can be done on the desired date and in the area. The data used for the study were obtained through images obtained from different satellites.

In the study, data between 2013-2022 were obtained by making analyzes related to NDSI. The aim of the study is to investigate the effect of these data on glacial losses.

The majority of the analyzes in the study were obtained through the Google Earth Engine code editor. In the Google Earth Engine data library, there are studies and algorithms related to many areas such as glacier, climate, environment and atmosphere. Various algorithms created using satellite images form a basis for work in many areas. Algorithms developed on a global scale in each area can be developed and used by filtering according to the scale of work, the desired date, and the desired unit. In the study, each analysis was carried out between the dates determined by cutting according to the study area called roi with the algorithms selected according to the subject. In addition, while graphical data were obtained by using different code sequences, maps were also obtained.

2.1. Study area

The study area consists of 3 glaciation areas (Cilo Mountains, İkiyaka Mountains, Kavuşşahap Mountains) located in the Southeast Taurus range, and the area covering the border of the Cilo (Glacial) Mountains, which is the most important (Figure 1). The Cilo (Glacial) Mountains are the second highest peak of Turkey with an altitude of 4135 meters. In the Cilo Mountains Geographical Coordinate System, located in the north of the Turkey-Iraq border; It is located between 37°29´54.9996"N and 43°57´34.9956"E.

In the Universal Transverse Mercator (UTM) Coordinate System, it is located in the 38S Grid and is between the values of East 382363 - 437033 (meters) and North 4128843 - 4174418 (meters). (Reşat GEÇEN, 2017). It is located in the Eastern Anatolia Region of Turkey, Hakkari Section, within the borders of Hakkari province. Although the Cilo Mountains have many high peaks, the most important peaks are Reşko (Uludoruk) 4135m and Erinç (Suppa Durek) 4060m. Active glaciers in the study area; Gelyaşin (İzbırak) Glacier, Mia Hvara Glacier, Suppa Durek (Erinç), Poyraz Hill glaciers. These are also the most important areas of glaciation.

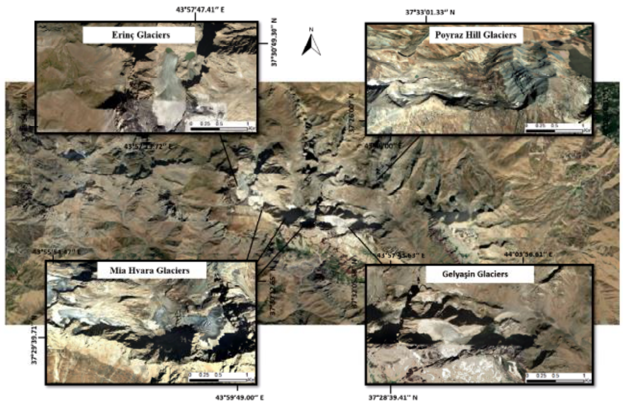

Figure 1. Study area

2.2. Google Earth Engine (GEE) system

Google Earth Engine (GEE) is a cloud computing platform designed to store and process large data sets (at petabyte scale) for analysis and final decision making. After the Landsat series became available for free in 2008, Google archived all datasets and linked them to its cloud computing engine for open source use. The current data archive includes Geographic Information Systems (GIS)-based vector datasets, social, demographic, weather, digital elevation models, and climate data layers, among other satellites.

The easily accessible and user-friendly front-end provides a suitable environment for interactive data and algorithm development. GEE provides a lot of data on a global scale over the last 40 years. The platform not only provides data but also includes very powerful tools that enable analysis.

Landsat 8 data was used in this study. Landsat8 data used in the study are presented in 3 different preprocessing levels; Surface Reflectance, Top of Atmosphere and raw images. In this study, atmospheric corrected surface reflectance data were used. In the study, the NDSI index was calculated.

2.3. Obtaining NDSI data

For the detection of glacial areas, NDSI data obtained by Landsat8 Satellite Collection 2 Tier 1 TOA Reflectance calibrated above-atmospheric reflection was used. NDSI is an index in which image transformation operations are performed using Band arithmetic operations. This method is obtained by dividing the green bands (GREEN) and short wave infrared (SWIR) bands of satellite images by the sum of their differences. Analysis was done with Google Earth Engine Code Editor. It is calculated with NDSI (1) equation.

$$NDSI = \frac{(\text{Green} - \text{SWIR})}{(\text{Green} + \text{SWIR})} \quad (1)$$

The values resulting from the formula are between -1 and +1, and areas with high index values are determined as areas with snow cover.

2.4. Analysis of NDSI Values

The graph of NDSI values between 2013 and 2022 is given in Figure 2. When Figure 2 is examined, it is seen that the NDSI values are in a decreasing trend.

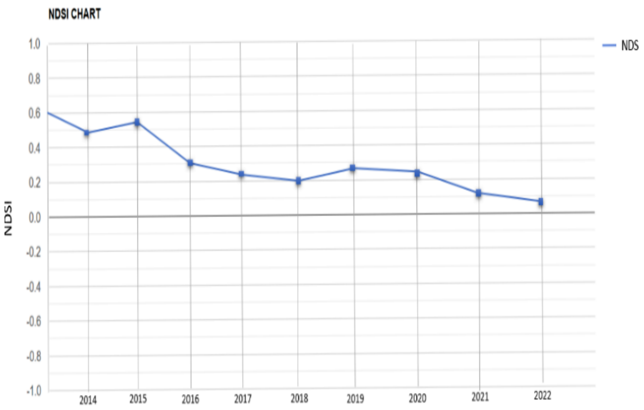

Figure 2. Hakkari Cilo Mountain NDSI Values Analysis Chart

3. Results

In the study, the changes of the active glaciers in the Cilo Mountains between 2013 and 2022 were examined using the Geographical Information Systems and Remote Sensing techniques. With the NDSI used in this study, it is seen that snow surfaces are decreasing due to climate change and global warming (Figure 3,4). The calculated glacier area for 2013 is 1.82 km^2. The calculated glacier area for 2022 is 1.22 km^2.

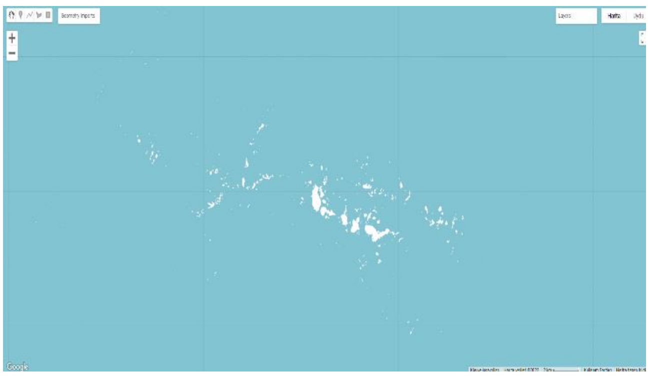

Figure 3. Hakkari-Cilo Mountain NDSI image (2013)

Figure 4. Hakkari-Cilo Mountain NDSI image (2022)

4. Conclusion

Within the scope of the study, glacial losses due to global warming in Hakkari between the years 2013-2022 were examined and the criteria that could affect these losses were analyzed and evaluated through Google Earth Engine datasets and code editor. Within the scope of the study, NDSI data for the years 2013-2022 were calculated and graphics and visuals were revealed.

In this study, revealing the temporal changes in glacial areas is of great importance in terms of future planning. Along with monitoring the temporal changes of glacial areas, the causative factors should also be investigated. Changes and developments in geographic information systems and remote sensing methods are also important in the rapid and effective use of data in such studies. The rapid and effective use of the data that will form the basis for the planning to be made is possible with geographic information systems. Especially in recent years, increasing glacial losses underline the importance of the problem. It is of great importance to follow the increase in urban areas in the protection of the natural environment. Considering all these criteria affecting glacial losses in the study, it is of great importance to control these negativities for a livable nature. In the study, the lost glacier area for the Hakkari Cilo region between 2013-2022 is 0.6 km^2. which means a meltdown of about 33%.

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