Use Remote Sensing to Detect the Geomorphologic Change and its Effect around Barrow, Us Area

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Abstract. The erosion issue in the north coastal area in Alaska, US has increasingly serious. Landsat image has been downloaded to analyze the erosion. Several image analysis methods in remote sensing are used in this paper to analyze the water body erosion in study area. Erosion in the study area has a significant effect along the river and around the lake. It is inconspicuous in the urban area. The geomorphology in study area is temporarily steady due to the man-made anti-erosion construction. More attention should be paid to the erosion between the coast and lake; it can damage the whole city of Barrow once the erosion connects the sea and lake. By using analysis method discussed in this paper, it can help other coastal area in the world to prevent erosion issues.

1. Introduction
Global warming is the phenomenon of average temperature raise in global environment. It is due to the excessive emissions of greenhouse gases. The most direct impact of global warming is the raise of sea level. When the sea level rises, it will enhance coastal erosion. Global warming will also impact the speed of glacial migration [1]. It can change the geomorphology significantly.

The carbon dioxide accumulation is the phenomenon that the carbon dioxide content increases in the atmosphere. It will affect the acid-base property of the air, so it can make rain and snow become more erosive. This will be enhanced a lot in polar region due to the all year round snow. Due to the global warming and the carbon dioxide accumulation, the erosion issue in areas near water body has increasingly become a problem in the world.

Barrow is the largest city of the North Slope Borough in Alaska, US. It is a very important city for oil industry, tourism, and academic research. It is the most northern city in United States. Due to the special location, the geomorphologic change and erosion issue may affect the development of the city. Previous research showed that both short-term and long-term has provided that there is erosion happened in area near Barrow [2]. This paper focused on using remote sensing to detect the geomorphology around Barrow and its effect of the geological potential of the development of Barrow.

2. Contemporary issues
As the economic and academic demands of polar area increases, cities like Barrow, Alaska becomes more and more important to develop and consider. Geology in polar area is always complex and engineers are always looking for application that can be done in those area in order to develop the city of Barrow [3]. As the global warming problem becomes more and more significant to the migration of glacier, the study of Barrow area is urgent. The erosion in past 30 years is big concern of further development area. Whether the development is safe in geological prospect needs to be determined.
This paper is focusing on using remote sensing method to detect if the erosion will affect the development of Barrow as the first step to study if the development is safe.

3. Objective
The overall objective of this paper is to use remote sensing method to compare different images of the study area in the past 30 years to see the geomorphology change. Then determine the erosion in study area by using the geomorphology change we got.

The specific objective of this paper is providing a rough prediction of the geomorphologic alteration in the study area for future 20 years. The study area locates near Barrow, US, so this paper can be used as a reference when planning the future development of Barrow.

4. Research area
Figure 1 shows the study area, which is located at the north coastal area of Alaska. The study area is in the North Slope Borough of Alaska, around Barrow city. The approximate coordinate is 71°17′44″N 156°45′59″W. Figure 1 is a rough view of the study area. There are several water bodies in the study area, including sea, river and lake. The erosion caused by water bodies can affect a lot in the study area. Due to the special location of the study area, the glacial migration will also be a problem for the geomorphologic alteration [4]. Because of the location of study area, the sea breeze in the north coastal area is also a reason to cause the geomorphologic alteration.

![Figure 1](image1.png)

**Figure 1.** Overview of the study area (Image taken from Google Earth)

The Landsat images being used were from the USGS. The images were taken by Landsat 4 TM in 1985, 1992, and 2011. All the images were taken at the same month each year so that when we are doing the comparison, it can help avoiding the error cause by the weather. Figure 2 are the true color image of the study area taken from each year.

![Figure 2](image2.png)

**Figure 2.** True color image of study area in year 1985, 1992, 2011

5. Methodology
The images are in single bands, so the first step is to stack them together so that we can attempt different band combinations to enhance the area and objectives we are interested in this paper, which are the water/land boundary, urban development, sediment erosion and transportation. The original images are in true color which has a combination of band 3,2,1 [5]. ERDAS suggests a band combination involved band 6 which is thermal IR for separating water and land. However, in these images, band 6 does not work so well since the temperature difference is not very significant in cold region [6], especially in these images, so the combination that has been chosen for this paper is band7,4,3. Compared with the original image, this combination provides a good view for separating water and ice from other land-covers since water and ice have really low reflectance in band 7,4,3. Figure 3 shows the comparison between image in band 7,4,3 and image in true color.

Meanwhile, urban constructions are also considered objectives. To enhance the urban constructions, a linear contrast method is applied on this image in band combination 7,4,3 [7]. The slope has been set as 3.0 and the shift has been set as 15. Figure 4 shows the comparison between image that has been applied the linear contrast method and image that has not been applied. The urban constructions are enhanced in the image in order to determine critical area of Barrow, for instance, the airport. Knowing the critical area, we can analyze the effect of geomorphologic change around those critical areas.

In order to study the change around Barrow, two methods have been applied. Since the study is focused on the erosion and urban development, band 5 has been selected. Band 5 has separated water from other land cover which by differencing two images from two different times can help us to determine the change between water body and land area. First, subtraction method, which is using one image’s digital numbers of pixels minus the other image’s digital numbers of pixels, has been applied.
Figure 5 shows the comparison between subtraction images and band 7,4,3 combination image of year 2011 and 1992. However, the erosion cannot be observed, so the image difference has been applied on these three images as well to detect and highlight the changes between image of 2011 and 1992 and between 2011 and 1985. The threshold has been set as 10%, and green color is increasing on digital numbers and red color means decreasing on digital numbers. To show the exact location of those changes, the images that applied image difference method have been stacked with original band 5 of image of 2011.

![Comparison of images](image)

**Figure 5.** Compared image of subtraction image of Band 5 between 2011 and 1992, 2011 and 1985, and enhanced image of 2011

### 6. Result and discussion

Using ERDAS, the subtraction images of 2011 image and each of 1985 and 1992 images have been produced. After image subtraction, the bright area means more land covers or deposits in this area. The subtraction images showed the changes of sediment deposit along the coast and the development of urban area.

For image difference method, green color means increasing on digital numbers which indicates sediment deposits or urban development. In contrast, red color means decreasing on digital numbers which indicates erosion. The difference highlighted images showed that erosion in past 30 years mainly occurred around the kettle lakes and rivers in the study area. This erosion may affect the development of Barrow since it may connect the rivers with the kettle lakes and enhances the erosion along rivers and around kettle lakes. The green color in urban area in highlight image is mainly caused by the construction and slightly affected by weather changes. There are some differences between image difference of 2011 and 1985 and image of 2011 and 1992. The reason may be the weather changes between 1992 and 1985. The precipitation was very low in 1992 which caused the kettle lake to be drier and for band 5 this means the pixels have high digital numbers. After image difference, there should be redder color occur because of the high digital numbers of pixels in 1992. In the urban area, there is no significant erosion occurs. Some minor erosion along the river near the urban area may be considered for further construction.

### 7. Conclusion

Remote sensing is a common method for geological engineering analysis and design. Using remote sensing, the change of geomorphology can be detected. Applying image enhancement, contrast method and image differencing method, the change of geomorphology around Barrow area and development of urban area can be analyzed, and the effect of those changes on the further development can be predicted.

Compared image was taken through over 30 years, some changes have been revealed. The coast along urban area of Barrow does not erode significantly, and the erosion mainly takes place in the kettle lakes and rivers associated with glacial migration. The urban area has been developed a lot, for instance the airport has been enlarged. The concern about the development of Barrow in geological prospect is the potential of connection between those rivers and lakes that erosion has been found. Other major
concern is the erosion of the river near the urban area and this may affect the further plan of development of the city [8].

The low resolution of images may affect the results, and high resolution images will make this study more precise. Further engineering applications are also required for more analysis on Barrow area due to the complex geological environment, for instance, geophysics test. In order to determine the potential development of Barrow, more prospects like economy, military, need to be focused on as well.

The method discussed in this paper can also be used in other coastal area, especially in polar region. Human intervention, such as anti-erosion contracture, is highly recommended for high erosion-possibility areas to prevent significant terrain changes.

8. References
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