Long-term observation of coastline evolution with Google Earth Engine: A case study of the Jiangsu Coast, China

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ABSTRACT

In this study, a total of 34 annual composited coastlines of Jiangsu Province (China) were extracted from the Landsat series imageries. With the help of the GEE (Google Earth Engine) platform, the MNDWI (Modified Normalized Difference Water Index) band ratio cooperating with the Otsu Thresholding Method and Canny Edge Detector could significantly improve the classification accuracy. In the past three decades, the coastline in Jiangsu has shown the ensemble tendency of accretion dominated by human activities. The results of this study can be useful in revealing the trends of coastal evolution in Jiangsu Province, China and contributing to making management policies for the government. This case study demonstrates the potential and advantage of the GEE in coastal research.

KEY WORDS: Coastline evolution; Landsat; Google Earth Engine

INTRODUCTION

The coastal region is broadly defined as the interface or transition area between land and sea. It is one of the most frequent and active areas of interactions between the atmosphere, biosphere, hydrosphere and the lithosphere on the earth. Since several hundreds of million people live in the areas hundreds of miles from the sea, the coastal region also suffers the disturbance from human beings. Therefore, the environment and the ecology ecosystem are fragile in the coastal zone and need careful management and protection.

The coastline (also namely shoreline) is defined as the edge of the land where it meets the sea. It is one of the most important linear features of the earth surface, as it provides feedback on the interactions between the land and the sea and the various processes that happen in the transition zone. The change of the coastline can be used to investigate the coastal erosion and deposition (Addo et al., 2011), the environmental change (Cazenave and Cozannet, 2014) and monitoring the sea-level rise. It could also help coastal management, e.g., provide fundamental information for land use planning and sustainable development (Muttitanon and Tripathi, 2005; Shalaby and Tateishi, 2007; Xu, 2018).

Numerous techniques have been developed to monitor the coastline morphology, including the traditional technologies, e.g., the RTK-GPS (the Real-time Kinematic-Global Positioning System) and the ATV (the All Terrain Vehicle), and newly developed technologies, e.g., the UAV (the Unmanned Aerial Vehicle), the Video-based remote sensing, the Fixed scanning lidar, and the Satellite remote sensing (Splinter et al., 2018). The traditional technologies have some limitations such as high consumption of time, money and human resource, as a result, they are not suitable for large-scale and long-term series monitoring. As a new developing technology, satellite remote sensing has the unique advantages of large-area data acquisition and real-time dynamic monitoring. It has shown incomparable advantages in the development of coastal resources, environmental monitoring and management, planning and evaluation of coastal land. Satellite imagery provides data on a global scale with a moderate spatial resolution (~30 m) and a frequent revisit time (every 5–16 days) (Hagenaars et al., 2017). The terrain data obtained by satellite remote sensing are time-continuous, which could be used to analyze the shoreline changes.

In the past several decades, the utilization of satellite data in the environmental monitoring field has been limited by data access restrictions, inconsistent data structures and formats (Bishop-Taylor et al., 2019). All those restrictions require time- and energy-consuming pre-processing. Besides, the rapidly increasing data volume makes the desktop-based analysis impractical (Kopp et al., 2019). Recently, A technology of high-performance earth observation has been developing fast, e.g., the Australian Geoscience Data Cube (the AGDC, Lewis et al., 2017) and the Google Earth Engine (the GEE, Gorelick et al., 2017), which has revolutionized the method of analyzing the extremely large and complex remote sensing datasets (Kopp et al., 2019). The Google Earth Engine (The GEE) is a multi-petabyte sized, cloud-based platform providing parallel computation and data catalogue services for planetary-scale geospatial analysis. The computations are automatically parallelized. The public datasets include the whole United States Geological Survey (USGS) Landsat archives, Landsat Surface Reflectance datasets, Sentinel datasets, various global land cover data, climate datasets, etc. The GEE provides various integrated methods to help pre-processing images in a simple way. Furthermore, it has a repository of vast functions such as masking, logical operators, sampling data etc., which can be used to perform various operations on images and vectors. Additionally, the GEE also allows users to