Spatiotemporal trends in flood hazards in the Pearl River Basin using MODIS time-series images, China

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Abstract

The Pearl River Basin (PRB), as one of the most prosperous and densely populated areas in China, is a flood-prone area in which huge casualties and big economic losses constantly happen. Therefore, it is of great importance for the study on the characteristics of flood hazards and spatiotemporal trends in the PRB. Based on Google Earth Engine, this study combined 873-phase Modis 8-Day composite (MOD09Q1.006) images with 30-meters SRTM DEM to monitor flood dynamics in the PRB from 2000 to 2018 using an integrated threshold method. The approach synthesized several key factors, including spectrum characters of water body, cloud and the slope (slope<1°) information derived from SRTM DEM. Moreover, Sentinel-2 images were used to validated the accuracy of flood inundation maps. The results indicated that, from 2001 to 2019, the flood area in PRB showed expanding trends , especially in the Pearl River Delta region; frequencies of most inundation(flooded) pixels are 1 and 2; Low-frequency flooding events showed expanding trends in PRB from 2001 to 2019, while high-frequency flooding events showed shrinking trends in PRB from 2001 to 2019

Introduction

The Pearl River basin (PRB) is controlled by subtropical monsoon climate zone and has good water vapor transport conditions (Wu et al, 2007), which are prone to large or severe rainstorms, easily causing flood. The Pearl River Delta region, including Guangzhou, Shenzhen, Foshan and other mega cities, is a densely populated region, constantly undergoing huge casualties and big economic losses due to flood hazards (Wei et al,2017). Therefore, it is of great importance to investigate the characteristics of flood hazards and spatiotemporal trends in the Pearl River Basin.

Research Objectives

The aim of this research is to analyze the spatiotemporal trends in flood hazards in the PRB form 2001 to 2019. Based on the Modis image, we will calculate the frequency of flooding of each pixel in the image to characterize the area and frequency of flooding in PRB.

Methods

Methods for water body monitoring using Modis

We selected Modis 8-Day composite MOD09Q1.006 product to monitor water body, because it has been corrected for atmospheric conditions and it has the highest resolution (about 250 meters) among Modis products. Band 2 in Modis images can distinguish between water body and other terrestrial object (Huang et al 2012). Figure 2 is the flowchart of water body monitoring.

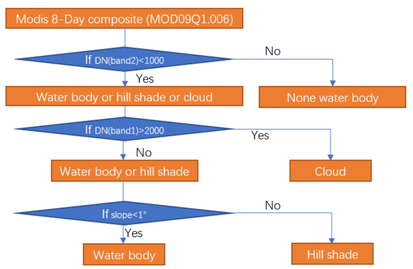
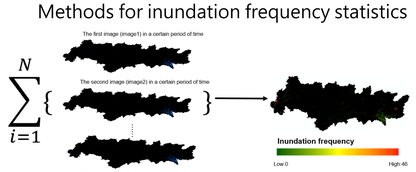


Figure 2 Flowchart of water body monitoring

Methods for inundation frequency statistics



N is the total number of images. For example, in 2014, there are 46-phase MOD09Q1.006 images. Then N is 46

Figure 3 Flowchart of Inundation frequency statistics

In order to calculate inundation frequency, we overlay different water body map together in specific period and let them accumulate together basing on each pixel. Here, value of water pixel is 1 and value of none water pixel is 0.

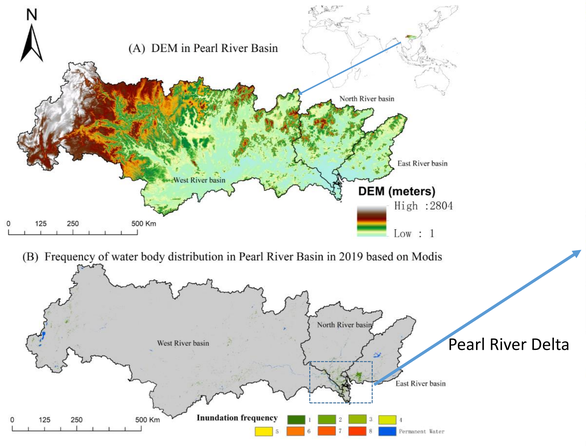


Figure 4 Location of Pearl River Basin

Results & Analysis

Validation for water body monitoring

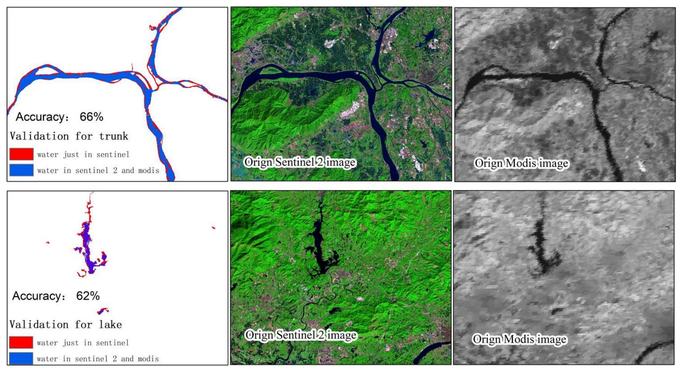


Figure 5 Using Sentinel 2 image validated the accuracy of water body monitoring based on Modis image

Because the resolution of the Modis image is about 250 meters, the Modis image cannot detect water bodies smaller than 250 * 250 meters. In the Pearl River Basin, the width of the main river can reach about 400 meters, and the width of some lakes are more than 250 meters . Therefore, the Modis image can monitor the river trunk and large lakes.
Here, we used Sentinel 2 image (20 meters resolution) to validate the accuracy of water body monitoring based on Modis image. The results showed that the accuracy in validation for river trunk was 66%, and the accuracy in validation for lake is 62%. According to figure 4, Sentinel 2 showed higher accuracy in water body monitoring due to its higher resolution. Even in river trunk and relatively bigger lake , there are some narrow parts in these water body where the width are less than 250 meters. Therefore, Modis couldn't monitor the water body in some narrow parts in river trunk and lake, causing offset to water body monitoring.
However, according to aforementioned state, we can know that Modis image can monitor water body larger than 250 * 250 meters, which implies that Modis can catch wide flood event. Therefore, Modis images are suitable to be applied to monitor flood hazard in such a big region like PRB.

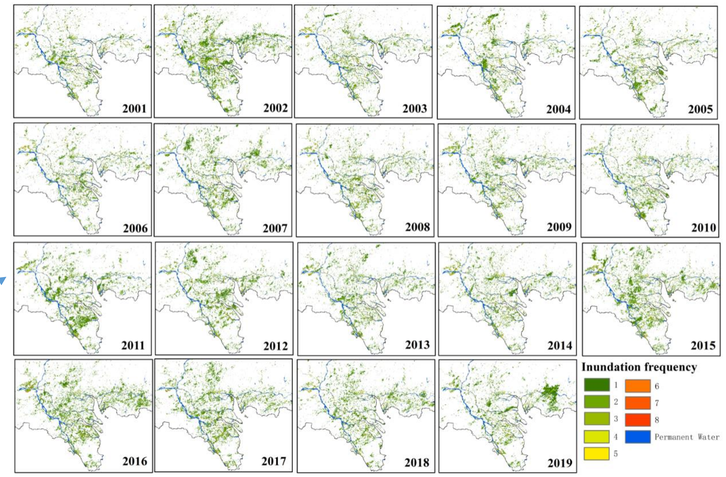


Figure 6 Distribution of inundation frequency from 2001 to 2019 in Pearl River Delta

Distribution of inundation frequency over the years

Preliminary Results

According to figure 4, we can know that inundation pixel densely distributed in Pearl River Delta (PRD). Therefore, for better understanding of the pattern of inundation frequency in PRD, as a case in PRB, we mapped the distribution of inundation frequency from 2001 to 2019 in PRD. Here, if inundation frequency is larger than 8, we consider the corresponding pixel is permanent water body. According to figure 6, overall, inundation pixel showed slightly expanding trends in PRD from 2001 to 2019. From 2001 to 2019, In submerged flood pixels, most of the frequencies are 1 and 2.

Trends in inundation frequency over the years

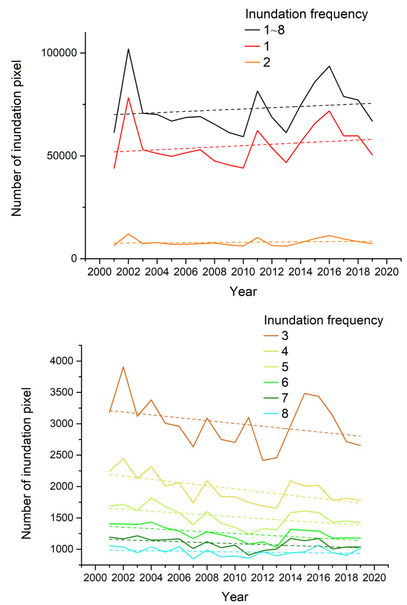


Figure 7 Trends in Inundation frequency in Pearl River Basin from 2001 to 2019

According to figure 7, overall, in whole Pearl River Basin, the total number of inundation pixels with frequencies from 1 to 8 showed slightly increasing trend from 2001 to 2019, which meant that flood area showed expanding trends in PRB from 2001 to 2019. Similarly, number of inundation pixels with frequency 1 and frequency 2 showed slightly increasing trends from 2001 to 2019, which meant that low-frequency flooding events showed expanding trends in PRB from 2001 to 2019. On the contrary, number of inundation pixels with frequency 3,4,5,6,7 and 8 showed shrinking trends from 2001 to 2019, which meant that high-frequency flooding events showed shrinking trends from 2001 to 2019 in PRB. Further statistical analysis are on processing.

Final Remarks

- Modis can monitor flood events larger than 250*250 meters.
- In PRB, frequencies of most inundation (flooded) pixels are 1 and 2.
- Flood area densely distributed in PRD.
- Low-frequency flooding events showed expanding trends in PRB from 2001 to 2019, while high-frequency flooding events showed shrinking trends in PRB from 2001 to 2019.

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