Using Long-Term Percentage to Improve the Evaluation of Surface Water in Bangladesh.

Po-Hung Shih[1]and Kuo-Hsin Tseng[2]
[1]National Central University, No. 300, Zhongda Rd., Zhongli District, Taoyuan City 32001, Taiwan (R.O.C.),
Email: shih136900@gmail.com
[2] National Central University, No. 300, Zhongda Rd., Zhongli District, Taoyuan City 32001, Taiwan (R.O.C.),
Email: khteng@csrsr.ncu.edu.tw

KEY WORDS: Grace, Groundwater, Bangladesh, Altimetry, River-level

ABSTRACT:

Bangladesh has been distressed by freshwater issue for long. Every year the Indian monsoon and melting snow from the Tibetan Plateau has brought considerable amount of water. However it is inconvenient for Bangladesh to capture water resources because of flat terrain. Due to the lack of a complete monitoring network, using satellite image to measure surface water area/volume becomes a practical solution. However, during rainy seasons persistent cloud cover makes optical remote sensing less useful in surface detection.

This research focuses on using the knowledge of water occurrence derived from long-term MODIS images, to potentially bypass the cloud cover problem. We utilized the statistics of water occurrence and combined with cloudy images to improve the reorganization of surface water area. We firstly used MODIS 8-day composite data in 2000-2015, and assumed that in the same time period of each year the surface water distribution would be similar and the surface terrain remains unchanged. Thus, a weekly inundation model was constructed as a reference for images with limited surface pixels in cloud openings. We set the lowest chance of water occurrence that shown as water pixel in the image as threshold, and classified the rest of pixels with higher chance as water even if they are under cloud covered. For validation, we applied Sentinel-1A and obtain an overall accuracy as high as 70%. The accuracy can be further improved by using Landsat 30-m imageries with lower temporal resolution.

1. Introduction

1.1 Bangladesh

Due to the rapidly increasing population of the world, people’s demand for freshwater also rise day by day. How to acquire and retain water resources becomes a critical issue for many countries. As the No.7 large population density in the world, Bangladesh is one of the vulnerable countries that suffer from serious freshwater problems. Its main water resources are the heavy rain bring by monsoon and melting snow coming from mountains, specifically from the south edge of the Tibetan Plateau that form the Ganges- Brahmaputra-Meghna delta. The outline of the country and the major rivers are shown in Figure. 1. However, due to the low elevation of this area, freshwaters soon flow into the sea after entering the surface runoff/seepage system. It’s inconvenient to retaining water by building reservoirs, dams and other water storage facilities. Therefore, it is important for Bangal government to monitor surface water.

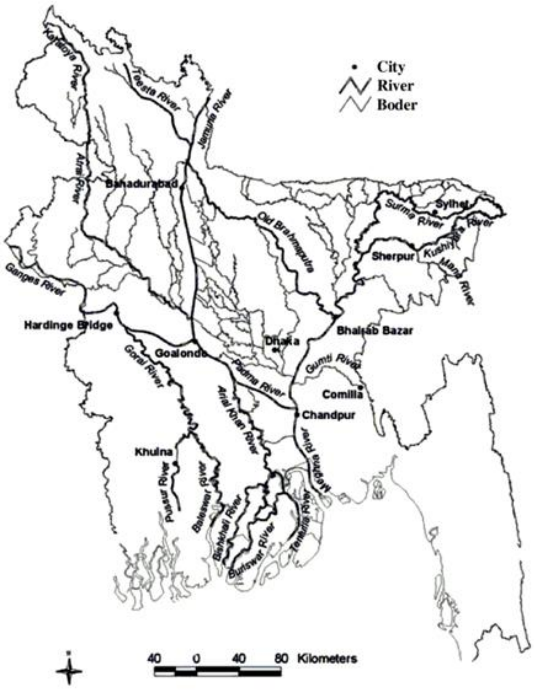

Figure. 1. Rivers, borders, and the major cities in Bangladesh. From Jakobsen et al.(2005). The map is bounded by 22 and 25˚N and 88 and 93˚E

1.2 Objective

Although monitoring surface water is very important, Bangladesh is actually lack of monitoring network. It turns out using satellite image to evaluate surface water become a practical solution. However, during rainy seasons persistent cloud cover makes optical remote sensing less useful in surface detection. Therefore, this research focuses on using the knowledge of water occurrence derived from long-term MODIS images, to potentially bypass the cloud cover problem. We utilized the statistics of water occurrence and combined with cloudy images to improve the reorganization of surface water area. For validation, we applied Sentinel-1A and obtain an overall accuracy as high as 70%. The accuracy can be further improved by using Landsat 30-m imageries with lower temporal resolution.

2. Methodology

2.1 Statistics of water occurrence

We choose the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA's Earth Observing System (EOS) series Aqua and Terra be our remote-sensing image data. As a 36 bands sensor, MODIS receives a wide spectrum covering visible light, NIR, MWIR, and LWIR. Its high spectral resolution and high temporal resolution is more useful than optical sensors such as SPOT and Landsat to delineate water bodies in basin scale. Besides, it has a wider swath with acceptable 250–500 m resolution that is sufficient for this study area. We firstly used MODIS 8-day composite data in 2000-2015 to calculate the Modified Normalized Difference Water Index (MNDWI). This index use green band and middle infrared to detect water as Equation. 1. (Xing and Niu, 2014).

$$\text{MNDWI} = \frac{green - MIR}{green + MIR} \qquad (1)$$

Then we assumed that in the same time period of each year the surface water distribution would be similar and the surface terrain remains unchanged. Thus, a weekly inundation model was constructed as a reference for images with limited surface pixels in cloud openings like Figure. 2. We set the lowest chance of water occurrence that shown as water pixel in the image as threshold, and classified the rest of pixels with higher chance as water even if they are under cloud covered. Thus, we can gather more complete data.

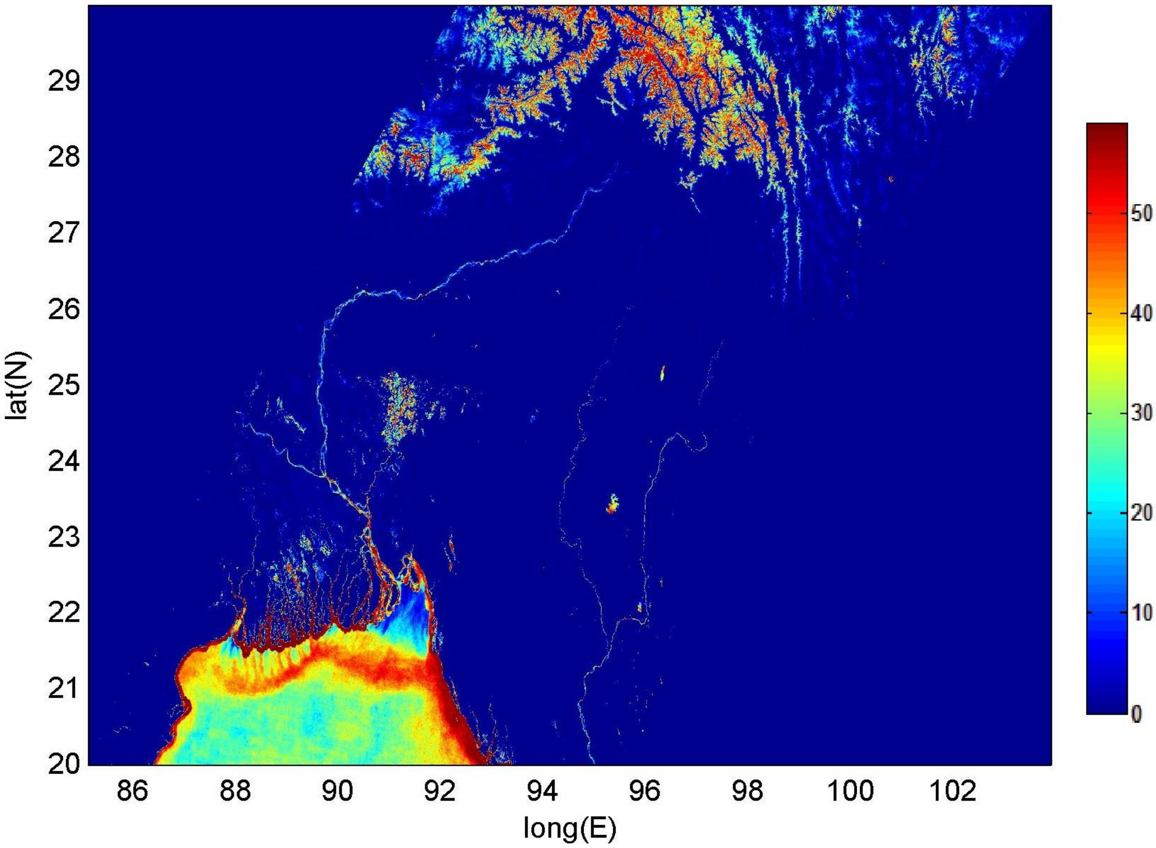

Figure. 2. The occurrence percentage of first week in Bangladesh and its nearby area.

2.2 Sentinel-1A validation

As we use the weekly inundation model as a reference to recover the information of cloud covered area, we use Sentinel-1A data to validate it. Sentinel-1A use C-band to monitor land and ocean and has high spatial resolution about 10m. Also, as a radar satellite, Sentinel-1A can avoid cloud covered problem. The reason why we don't use Sentinel-1A data as our research data is because the temporal resolution is too low and the swath cannot cover all Bangladesh area. Therefore, it can only use for validation. We firstly convert the DN value of the original image into backscattering coefficient. Then use Lee filter to remove the noise. (Lee, 1983). After removing noise, we use 2 degree Gaussian distribution to fit the histogram of the backscattering coefficient such as Figure. 3. And use the second mean and standard deviation to decide the threshold and use this threshold to classify water. In the end, we use the classification result to calculate the overall accuracy with MODIS data.

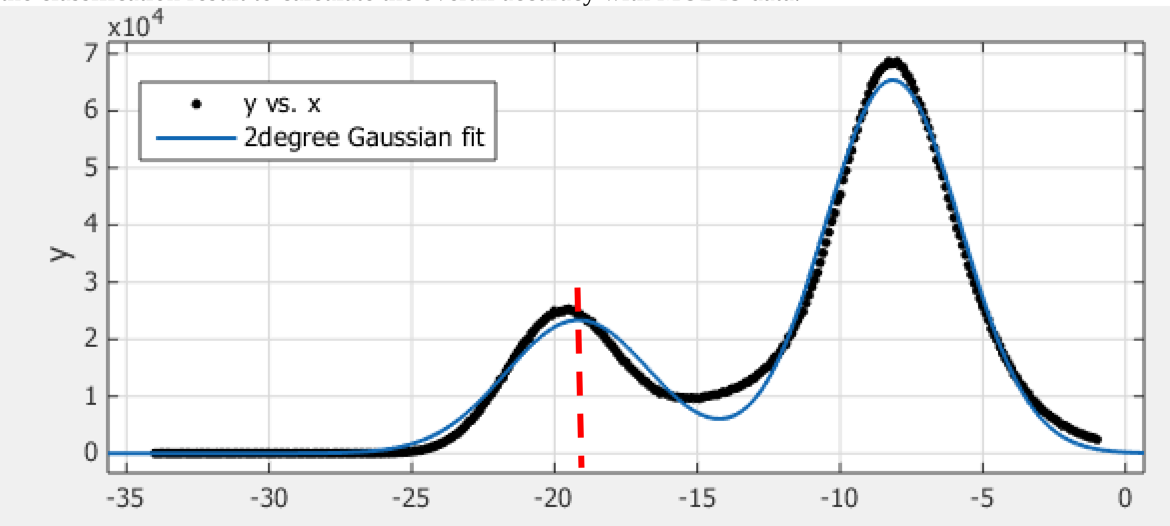

Figure. 3. The fitting of 2 degree Gaussian distribution and histogram of Sentinel-1A data. We set the second mean (the red line) plus half of standard deviation as threshold.

3. Preliminary result

As we have MODIS recovered data and Sentinel-1A data, we use Sentinel-1A data as master image to calculate the overall accuracy. And we obtain an overall accuracy as high as 50-70%, shown in Table. 1. The reason why the overall accuracy is not very is because the classification of Sentinel-1A would have some mistake that overestimate the water area and in the pre-processing of MODIS data we have removed some information that we consider as noise but actually is water.

4. Future work

4.1 Image pre-process

Since Sentinel-1A image will make mistake in classification, we need other data to correct it. Therefore, we will try to use 30m Landsat image as a reference data. Because Landsat and Sentinel-1A has similar spatial resolution, we can use Landsat image to correct the classification result of Sentinel-1A data. After correcting Sentinel-1A data, we can use Sentinel-1A's data to decide the threshold that use to remove the noise in MODIS image. Furthermore we can also apply Landsat image as our data source.

4.4 Water volume evaluation

As we use the idea of statistics of water occurrence to improve surface water detection, this idea can also be applied to evaluate the water volume. In the future, we will try to combine MODIS and Landsat image with altimetry data to decide the water height. By integrating height and area information, we can evaluate the water volume.

5. Reference

Jakobsen, F., Hoque, A. Z., Paudyal, G. N., & Bhuiyan, S. (2005). Evaluation of the short-term processes forcing the monsoon river floods in Bangladesh. Water international, 30(3), 389-399.

Xu, H. (2005). A study on information extraction of water body with the modified normalized difference water index (MNDWI). JOURNAL OF REMOTE SENSING-BEIJING-, 9(5), 595.

Lee, J. S. (1983). Digital image smoothing and the sigma filter. Computer Vision, Graphics, and Image Processing, 24(2), 255-269.