Extract Flood Duration from Dartmouth Flood Observatory Flood Product

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***Abstract*— Climate change has become a hot topic in recent years. Flood is one of the most common natural hazards caused from extreme climate change. Scientists have spent a lot of money and time on monitoring flood in past decades. The development of Remote Sensing and Geographic Information System (GIS) brings new ways for scientists to analyze, monitor, and predict floods. Remote Sensing provides an alternative method to traditional flood survey with very fine temporal resolution data with much lower cost. Scientists have been utilizing data from MODIS satellite to detect flood in a lot of research. In this paper, flood duration layers are generated with utilizing Remote Sensing based flood data from Dartmouth Flood Observatory. The flood event layers provide detail view of flood events at pixel level. Flood data is currently processed and managed by RFCLASS website which developed by Center for Spatial Information Science and Systems. Few experiments have been designed to explore the possibility of minimizing cloud impact. Result indicated that there is a huge decrease in total events. Flood data generated in this research is ready to serve further research such as crop loss from flood. However, flood data is not fully accurate due to the similarity of spectral pattern between shadow and water surface. Further study is needed in order to remove error caused by shadow.**

Keywords—Remote Sensing; MODIS; Remote sensing based Flood Crop Loss Assessment Service System; flood duration

I. Introduction

Climate change has become a hot topic in recent years. From research with long term historical climate data (about 5000 years), scientists have found out that droughts and floods are listed as the two of the major consequences of extreme climate change [1], [2]. Drought is long term climate hazard and people need to wait long time to see the real damage from it. On the other hand, floods are shorter, quicker and sometime create great number of loss than droughts [2], [3], [4].

Research shows that there is an increasing of flood risk due to global warming [5], [6]. Scientists have spent a lot of money and time on monitoring flood in past decades. Reference [7] reviewed a few systems and models which predicting flood event from water flow estimation. These traditional flood assessment systems and models are able to record historical runoff information and predict flood from simulation models [7]. However, most of these models work for small areas due to the model limitations [7]. In addition, flood data is not always available or accurate by traditional survey [8], [9], [10]. Moreover, traditional post flood assessment is not able to reflect the spatial variation during flood [11], [12]. The development of Remote Sensing and Geographic Information System (GIS) brings new ways for scientists to analyze, monitor, and predict floods. Flood detection benefit from Remote Sensing and GIS techniques by saving significant human and economic efforts on collecting fine temporal resolution flood data [13].

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II. Data

A. MODIS

Normalized Difference Water Index (NDWI), which was developed based on red and near inferred channels, is frequently used in water detection on Remote Sensing images [14]. Scientists have been utilizing data from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite to detect flood in a lot of research [15], [16], [17]. Fine temporal resolution of MODIS is suitable for flood monitoring, while moderate spatial resolution (250 meter) will not affect the result very much since flood is large scale events [16, [17], [18]. As a result, although MODIS does not provide long term and fine spatial resolution data like Landsat, there are a lot of ongoing studies on flood relying on MODIS's fine temporal resolution.

B. Dartmouth Flood Observatory flood product

Dartmouth Flood Observatory (DFO) developed a system and algorithms to capture flood from MODIS satellite [19], [20], [21]. The algorithm defines water surface by taking the ratio between MODIS band 1 and 2 with applying as threshold value in band 7 [20], [21]. Daily data was downloaded from NASA NRT (Near Real Time) Global Flood Mapping website. Original flood data was formatted with 10 degree by 10 degree grid in shapefile. Daily data is available since March in 2011 at NASA NRT Global MODIS Flood mapping archive.

III. Method

A. Flood Duration

Daily flood data was processed in order to generate flood duration layers. 10° by 10° flood tails were merged into one shapefile for daily data. After finish processing daily flood layer, hundreds of daily flood shapefiles were then imported into ArcGIS geodatabase. ArcGIS geodatabase was used as intermediate data storage since shapefile is not able to store more than 255 columns. A layer, which was generated with using ArcGIS tool "Union", was used to store daily flood information for each calendar year. With using a program to identify flood events, start and end dates for each flood event becomes the only information stored in the annual flood event layer. Maximum flood event was set to 50 because 50 flood events is unlikely to be reached. For instance, if 50 events are reached, there will be more than 300 flooding days since DFO flood data is 3 day composite data (minimum 5 days per event, and plus 1 day non flood gap). In total 100 columns contain flood start and end days were stored in the geodatabase. Figure 2 illustrates the steps of processing flood duration data.

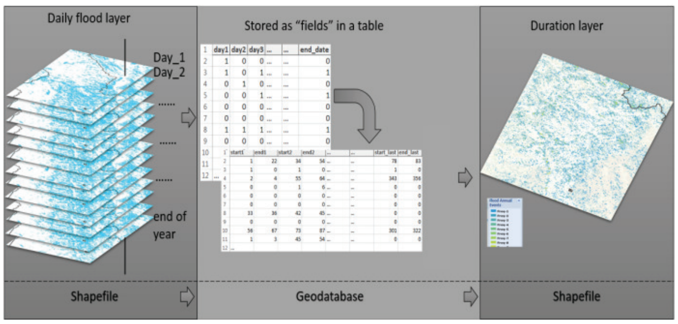

Fig. 1. Architecture of flood duration algorithm

B. *Flood duration data improvement*

Flood duration data from above method contains a lot of noises. Many single day events were detected from the dataset. These single day events may cause by the cloud coverage during flood. Reference [22] discussed the limitation of cloud penetration for optical sensors. Due to the design of optical sensors, they are not able to see through cloud and collect ground information [22]. In order to solve this problem, a post processing method was introduced in this paper.

Two different range of composition days was adopted: 3-day composition, and 5-day composition. The smoothing window will add two days at the beginning and ending of each flood date, new events were calculated based on the smoothed data. 5-day composition ran the same logical with a larger moving window. The multiple day smoothing window help to reduce the influence of cloud and other uncertainties.

One pixel with high flood events was selected as an experimental target. In additional to above smoothing method, another method was introduced by modifying the rule for moving window. Within same 3-day window, at least two days of flood data is needed to change the third day from non-flood to flood.

IV. Result and Discussion

With utilizing ArcGIS Geodatabase, annual flood duration layer was generated from daily data with having start and end dates stored in the attribute table. Annual flood duration layers provide details of individual flood events at pixel level. Flood duration for year 2012 to 2015 was prepared in this research. Daily flood data was acquired from NASA NRT Global MODIS Flood mapping archive. As shown in figure 2, data are currently processed and managed by RFCLASS website which developed by Center for Spatial Information Science and Systems.

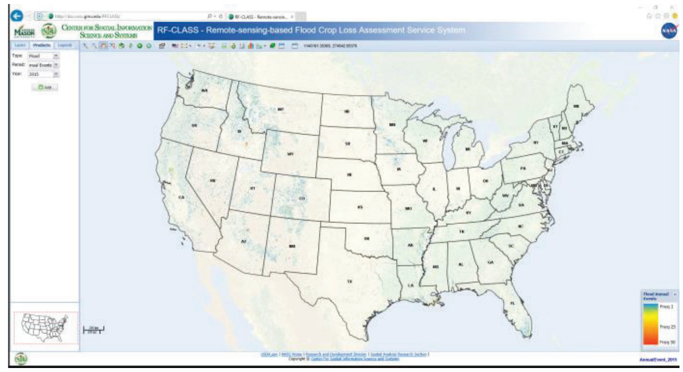

Fig. 2. Flood duration on RFCLASS portal

An experiment of post processing method was introduced in order to minimize noise in the data. The result indicated there is a significant decrease in flood events after processing. The experimental pixel has 20 event in total for year 2015 before post processing. Total number of events reduced to 12 and 4 for 3-day and 5-day smoothing window respectively. As a result, flood information was over generalized with using 5 day moving window. Moreover, the 3 day moving window with at least 2 days of flood reduced the flood events to 11, which is similar to the original 3-day window while the new method ignored many one day events. Detail information between original and smoothed data has been illustrated in figure 3, 4 and 5.

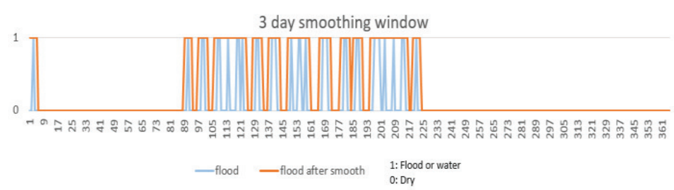

Fig. 3. Flood events between before and after 3 day smoothing methods

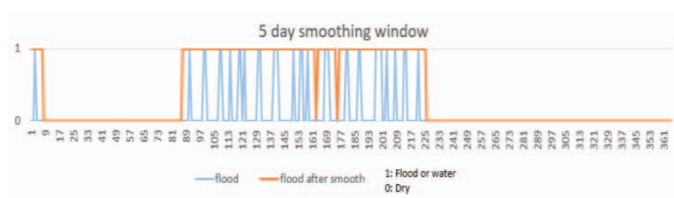

Fig. 4. Flood events between before and after 5 day smoothing methods

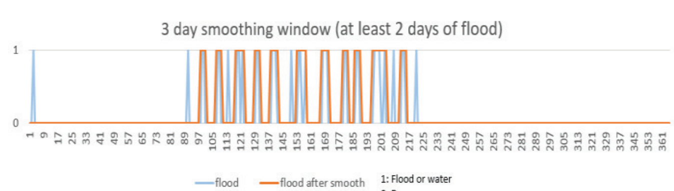

Fig. 5. Flood events between before and after second 3 day smoothing methods

V. Conclusion and Future Work

As one of the natural hazards that lead to huge damage, flood has been studied for many years. Traditional paradigms of flood assessment are both time and economical consuming. Moreover, most traditional assessment methods are not able to provide fine temporal resolution results. The development of remote sensing provides an alternative to do flood assessment faster with less economy effort. High temporal resolution of the flood product from MODIS provides the ability of near real time flood monitoring. Near real time flood data could become one of the reference sources for risk management and emergency response agencies [23], [29], [30].

Annual flood duration was introduced in this research. Annual flood duration data provides a way to understand each flood event at pixel level. Flood event characteristics, such as start/end time, have been recorded. Flood data generated in this research is ready to serve other research such as crop loss from flood [28].

Few experiments have been conducted to decrease the impact from cloud. Both two moving windows perform a good job on reducing the flood event and group close events. Moreover, the modified 3-day composition method may help to ignore single day events in order to capture only meaningful floods. Result indicated that there is a huge decrease in total events. Although there is no quality measurement for the result, the experimental smoothing method might provide a way to help improving the quality of flood data.

Scientists have discovered that spectral pattern of cloud and terrain shadow is similar to water body [21], [24], [25], [26], [27]. For this reason, it is hard to distinguish shadow from water due to the similar spectral patterns. Cloud and mountain are two main sources of shadow in the dataset. Although spectral patterns for cloud shadow and mountain shadow are similar, these two shadows have different behaviors in spatial distribution. Shadow from cloud is randomly distributed since cloud moves with wind. On the other hand, mountain shadow is not randomly distributed like cloud since mountain does not move. For this reason, noticeable error caused by mountain shadow could be found at annual flood frequency layer. Most mountain shadow has been identified as flood area with very high annual flood frequency. This provides a strong visual content to identify terrain. More research on removing mountain shadow from the flood data is need to be done in the future.

Acknowledgment

This study was supported by a grant from NASA Applied Science Program (Grant # NNX14AP91G, PI: Prof. Liping Di).

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