MAPPING MAJOR FLOODS WITH OPTICAL AND SAR SATELLITE IMAGES

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1. INTRODUCTION

Floods are one of the major natural disasters that occur almost every year in many countries of the world. It causes heavy losses to lives, property, infrastructure, agriculture, land and overburdens the countries' budget and resources [1]. It immediately disrupts, impairs and adversely affects the human's activities as well as local economy. Effectively dealing with such natural disasters and minimizing the losses to life and property requires both long and short time preventive measures. For the long time measures, it is essential to correctly model and map the flood prone and flood hazards areas accurately and keep the floodplains boundaries updated after every new flood event. It is also essential to formulate flood action and preparedness plans based on the floodplain information (flood maps), and to disseminate and train the residents on safety and remedial actions. The short time measures include rapid response from relevant agencies and institutions to trigger immediate rescue, relief and rehabilitation activities. Rapid response to the flood events can only be generated if the relevant agencies have the latest information about the flood extent. However, the assessment of actual flood extent cannot be practically mapped through field visits due to the vastness of the affected areas and the mobility restrictions caused by flooding. In such a case, remote sensing data acquisition techniques, both spaceborne and airborne, can be most suitable due to large coverage and relatively short revisit time of multiple systems. Therefore, remote sensing data from optical and/or radar systems acquired during or immediately after actual flood events are valuable and accurate sources for mapping the floods. Besides, the combined use of both optical and radar sensors allows us to observe and respond to floods more reliably and timely under cloudy weather conditions.

2. THE INTERNATIONAL CHARTER – SPACE AND MAJOR DISASTERS

The purpose of this charter is to promote cooperation among its member space agencies (mostly commercial firms all over the world) in the use of disaster related satellite data having valuable information about its extent and impact [2]. This charter facilitates the provision of relevant data to the affected countries or regions at the world level to enable them to effectively manage rescue, relief and rehabilitation efforts during and after disasters. When any major disaster occurs anywhere in the world, the charter's mechanism is activated by the authorized users within or outside member countries or when a cooperating body requests assistance. In such situations, member space agencies look for the appropriate data, either in archive or recently acquired, or plan appropriate priority spacecraft tasking for new acquisition over the disaster areas. Satellite data are quickly made available to the project managers. The project managers ensure data distribution to the users and to the trained handlers such as researchers/analysts at universities, government agencies and the emergency response centers. The project managers ensure the quick processing of the available data, extraction of the valuable information and its immediate provision to the end users. The provision of data and the services provided by the project managers, analysts, and researchers are free of any charges. Since its inception in 1999, the charter has been activated more than 200 times in response to various natural disasters and proved to be very successful in providing useful information. In addition to the International Charter program, Landsat and MODIS images are also made available free of charge to the public. They have played an important role in recent historic floods in the US, e.g., the ones in the areas of Indiana (June 2008 and March 2009), Minnesota & North Dakota (March 2009), and Georgia (September 2009).

3. FLOOD MAPPING WITH SATELLITE IMAGES

Remote sensing images can be used to map the flood extent provided they are acquired at the time of the occurrence or immediately after the flood. Such timely data acquisition largely depends upon satellites pass and the climatic condition over the flood affected areas. Some of the satellites data acquisition can be planned and controlled even if not exactly passing over to the area of interest. Passive optical remote sensing is only possible under clear weather conditions, however, active remote sensing data through radar based sensors offset the weather condition and can acquire data under any weather conditions during day and night. To correctly process and extract useful information about the flood event, remote sensing data from different sources can be used separately or combined. Another associated problem is the need to precisely geo-register the input images since they may have an offset from tens of meters to hundreds of meters with reference to the correct location.

3.1. Flood mapping with optical images

Due to very distinct water reflectance, it is relatively easy to separate water from other land covers in optical images. The reflectance from turbid and muddy flood water is different from the normal water, but it can be extracted by intelligent use of optical band combinations. Since mostly the flooding occurs at the rivers and streams, ancillary gauge data on rivers and streams provided by USGS [3] can be very helpful. The quality and accuracy of the flood mapping depends upon the spatial resolution and the time of the images acquisition. To exactly map the flood water extent, pre-flood images over the same areas are needed to extract normal water conditions and then compared to the water extent during the flood time. Figure 1 shows the Landsat TM pre flood image (June 2007), during flood image, flood extent, and affected crops for the 2008 June Indiana floods (from left to right). The crop damage map was produced by combining the USDA crop inventory data in early 2008 [4]. Besides Landsat, MODIS is also a suitable free data source for rapid flood mapping due to its high temporary frequency (every day).

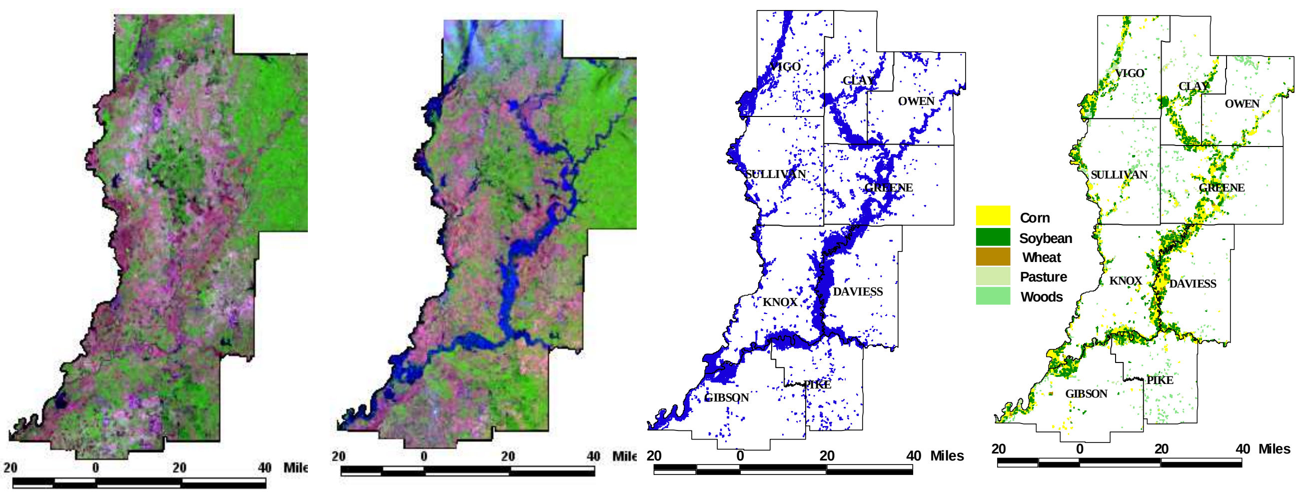

Figure 1. Pre (left) and during flood (middle left) Landsat images, flood extent map (middle right) and the flood affected crops map (right)

3.2. Flood mapping with radar images

Prolonged rains and cloud coverage during flooding period may not allow the acquisition of clouds free optical images. ALOS PALSAR, Envisat ASAR and Radarsat-2 satellites are widely used radar data, which are not affected by weather conditions. Though radar data can have a reasonable spatial resolution (3-100 meters), land cover identification and extraction is extremely difficult. In radar data, it is hard to visually differentiate ground features as many of them reflectively appear similar, e.g. forest, road, and water. Flood extents derived from radar data alone are difficult to validate in the absence of additional information, such as optical imagery. To extract flood information from radar data and to separate the non-water features from water, clouds free optical imagery of the same area acquired at a time closer to the flood event can be very helpful. It can help map other ground features such as vegetation, trees and permanent water bodies. Using the vegetated, trees and water layers extracted from optical remote sensing data as a mask to the radar image processing outcome, one can precisely and reliably map the actual flood water extent. At the same time, this process requires more expertise and experience as compared to the analysis of optical remote sensing data. Subsets of the ALOS PALSAR and Radarsat-2 with extracted flood extents overlay (blue) in Northern Indiana and Georgia are shown in Figure2.

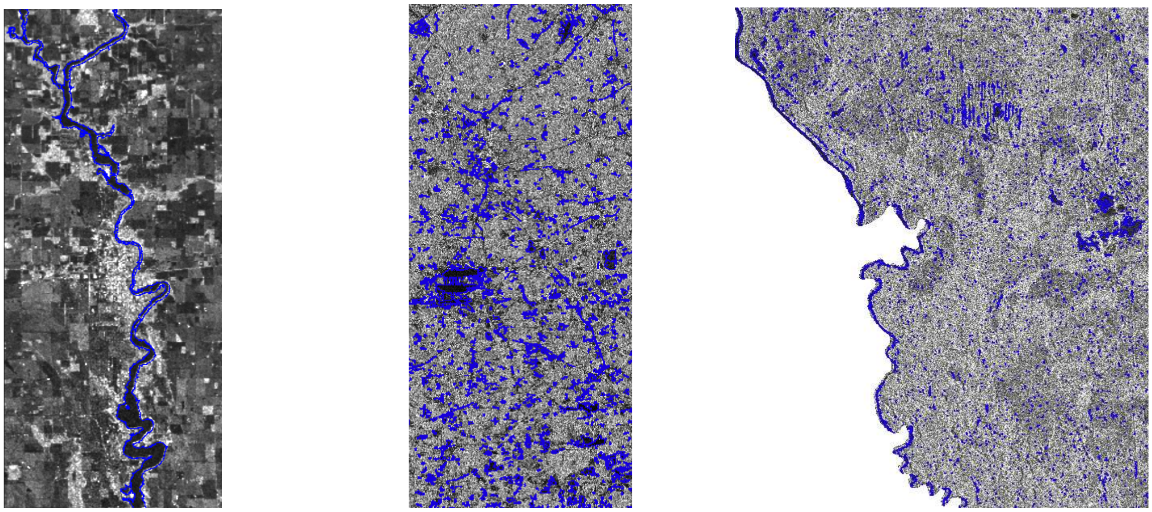

Figure 2. ALOS PALSAR in Indiana (left), in Georgia (middle), and Radarsat-2 data in Georgia (right). Courtesy of JAXA for ALOS PALSAR image and Canadian Space Agency for Radarsat-2 image.

4. CONCLUSION

Timely available remote sensing imagery and its derived products help quickly understand the disaster impact and support disaster response activities during and after the floods. The analysis of remote sensing data acquired during the peak flood times greatly helps examine, inventory and incorporate changes to the extents of the floodplains and other flood prone areas. Both optical and SAR images are helpful for this purpose. Optical flood imagery helped greatly during the June 2008 Indiana floods and so did the combined optical and SAR images during the September 2009 Georgia floods. Besides, the produced flood maps can be published immediately on the Internet as a service for the general public.

5. REFERENCES

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