DETECTION OF FLOODED AREAS WITH RADAR IMAGE ANALYSIS

Nusret Demir, Neslihan Tuztaş, Nithiyanandam Yogeswaran

Ph. D., Nusret Demir;
Akdeniz University, Faculty of Science, Space Science and Technologies Dept;
Konyaalti, 07058, Antalya, Turkey;
+902423103826, nusretdemir@akdeniz.edu.tr;

Msc.Student, Neslihan Tuztaş;
Akdeniz University, Institute of Science and Technology, Remote Sensing GIS Graduate Prog.;
Konyaalti, 07058, Antalya, Turkey;
+902422274400, neslihantuztas@gmail.com

Ph. D., Nithiyanandan Yogeswaran;
Teri School of Advanced Studies, Department of Natural Resources;
Plot No. 10 Institutional Area, Vasant Kunj, New Delhi - 110 070 , India;
+91 11 71800222, nithiyanandam.y@terisas.ac.in;

Abstract
Storms and tornados generally occurs naturally without much of human intervention, and cause severe damage to life and property. They will be on a very short timeline and will not be stopped by people after they occur. For this reason, speed is an important factor in determining the damages that occur. In this regard, radar satellites are advantageous because they can capture data in all weather conditions. Within the scope of the project, India Channai region was selected, which experienced a major flood disaster in November-December 2015. In this study, it is aimed to determine disaster losses by texture analysis on the Image. Five different images were used to analyze the flood damages; Backscatter values for radar images were analyzed in all magery. The scattering differences between before and after the disaster were calculated and statistically analyzed. The results are visualized in Google Earth Engine Cloud Platform.

Keywords: Flood Mapping, Remote Sensing, Google Earth Engine

INTRODUCTION
Storms and tornados are among the significant disasters generally occur naturally without much of human intervention. They cause severe loss to the life of people and their property. The long-term forecasting and controlling the intensity of these disasters are impossible. During November and December 2015, many parts of Southern India had been severely affected due to floods. An extensive land portion was inundated in which agricultural fields and buildup lands are the most impacted land-use types. The severe flood disrupted the daily activities of people and even caused the death(Web1). The impact could have been minimized if the extent of flood and its intensity is observed timely. Remote sensing technology plays a crucial role in disaster early warning, especially in the case of flood caused due to cyclonic storms and tornados. In which Microwave remote sensing technology is quiet handy in estimating the extent of flood and its intensity compared to other remote sensing technologies (e.g. Optical). The traditional option is proven ineffective due to its limitation to work under clouds and rains. The active remote sensing system outpost the performance of passive sensors during extreme weather conditions. One of such kind is Synthetic Aperture Radar (SAR), studies (Ayala-Silva and Twumasi, 2004; Aosier et al., 2007; Wang et al., 2010; Richards et al., 1987, Fransson et al., 2002, Ermert et al., 2012, Eriksson et al., 2012, Gokaraju and Turlapaty, 2015) used radar imaging and performed flood analysis based on the backscattered values.

On the other hand, the processing of remotely sensed data requires high-performance computing environment. Which generally occupy ample storage space and needs a powerful software package for performing analysis. Since the time consumes in processing is crucial and preferred to be the least. An adequate system which maps the extent of flooded areas at near real-time is essential for timely response and management. Cloud computing is suitable for the
requirement, which only requires an active internet connection leveraging the requirement of advanced hardware and softwares. With the help of this technology disaster, mapping studies can be performed with minimum infrastructure. In this study, the researchers have used Google Earth Engine platform to process, visualize and analyze the data obtained during the floods in Chennai happened during November and December 2015.

MATERIAL AND METHODS

Material

We have used Google Earth Engine cloud computing platform (shortly known as GEE) to process the data, to visualize the results. GEE is an open-source tool available for the research community by Google LLC. The users can work on the JavaScript language coding platform which allows user to store and process a large volume of data using its machines. The processed data can easily be visualized on Google Maps. There is also an option to export the processed or unprocessed data to the user's cloud drive or directly downloadable to the user's Personal computer. The data catalogue of GEE contains many types of data including satellite imagery, meteorological, topographical and demographic data.

![Google Earth Engine code editor](image)

In this study, we have Synthetic Aperture Radar Imagery Sentinel 1 images. Sentinel 1 images are made available to the public for free by the European Space Agency's Copernicus Program. The data can also be downloaded through Sentinel Hub service. However, in our case, we have directly called the output data in GEE without downloading them in our m

The properties of the used Sentinel SAR image is shown in Table 1.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Sentinel 1 A &amp; B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image type</td>
<td>Synthetic Aperture Radar</td>
</tr>
<tr>
<td>Ground Sample Distance</td>
<td>10 m.</td>
</tr>
<tr>
<td>Data type</td>
<td>Ground Range Detected</td>
</tr>
<tr>
<td>Orbit</td>
<td>Descending</td>
</tr>
<tr>
<td>Polarization</td>
<td>VH</td>
</tr>
</tbody>
</table>

The images acquired before and after the flood were used in the study in order to identify the extent of inundation during November and December 2015.
Method

The whole process is performed in GEE. The process workflow is shown in Figure 2.

The process starts by downloading datasets. The method used in this study is different from the methods given in the literature. Here, the first Image is generated by using all available Sentinel 1 SAR data during the reported flooding period between '2015-11-05' and '2015-12-17. The median value of the pixels from each dataset is calculated, and a new flood image has been created. The other Image which represents non-flood case has been created using the same idea with the use of any time period which has no flood between '2015-08-01' and '2015-08-30'. Again, the median value of each pixel has been calculating and generated a new non-flood image. Then, the speckle filter is applied on both image sets with calculating the mean focal value of the pixel value in 50 m circles for all images.

The areas which have already water surfaces and the regions where the slope is high should be excluded from the process. For exclusion of the already existing water surfaces (lakes, rivers etc.), a water mask has been created. To eliminate these water surfaces from the result, we have used the dataset of JRC Global Surface Water Mapping Layers, v1.1. This dataset is stored in GEE, and created with the use of Landsat images with the use of 3,865,618 frames from Landsat 5, 7, and 8 from the dates between 16 March 1984 and 31 December 2018 (GEE referans). The second mask is created to mask out the areas where the slope is higher than 5% which is not expected to have flooded. The used dataset is HydroSHEDS which contains provides hydrographic information with three arc-second resolution.

After masking out the existing water surfaces and the steepest areas, for detection of the flooded areas, the ratio between the first and second-period images is calculated. The pixels which have the ratio larger than 1.25 are selected as flooded areas as suggested by UNI-SPIDER(Web3). The calculated affected area is calculated with multiplying 10 m resolution value with the total number of pixels found as flooded areas.

RESULTS

First, the images used to detect the flooded areas have been created. One Image has been created with the use of the all available images from the dates during the flooding disaster. And other is from the time when no flooding event has been occurred during August 2015. The median values of all pixels are calculated. The calculated median images for the disaster and non-diaster period are shown in Figure 3.
As shown in Figure 3, the flooded areas appear darker than the predisaster Image because of the radar energy absorption happened over the water surface hence creates a darker appearance on the images. The existing water surfaces The used water mask is created with JRC Global Surface Water Mapping Layers (JRCGSWML) data and can be found in Figure 3. The occurrence band is selected, and the parameter is set as %50, which means the water content on the surface is present more than half a year.

As shown in Figure 4, the water surfaces are detected, and they were excluded from the result of the flooded area. On the other hand, the areas where the slope is higher than 5% are excluded as well (Figure 5).
The ratio between the flooding and pre-flood images gives the change rate for each pixel. The ratio image is shown in Figure 5.

A shown in Figure 5, the affected areas appear brighter with a higher rate of change. A threshold is used to separate the flooded and non-flooded areas. The threshold 1.25 is recommended by United Nations Spider program for disaster mapping studies. A part of the detected flooded regions is found in Figure 6.

CONCLUSIONS

India, as a country faces severe floods frequently, and quick detection of flooded areas has a critical role in the management of the post-disaster situation. Radar images have more significant potential with their capabilities to operate and acquire datasets in all weather conditions, which is a significant advantages for the flood mapping studies. Thus without any limitation, the areas affected can be detected with active remote sensing technology. The processing time is also critical for quick management in the affected regions. Therefore, cloud computing environments are useful sources. In this study, we have used and recommend to use Google Earth Engine platform to load, process, visualize the data, results and calculate the total affected area in the region of interest. The assessment is somewhat tricky since the ground truth of the damaged areas is almost impossible. Therefore we share the code to allow the reproduce the results, which is available through following link:

ACKNOWLEDGEMENTS

This research has been supported by the Turkish Council of Higher Education, the project-based Mevlana Exchange program.
REFERENCES


BIOGRAPHY

Nusret Demir

Nusret DEMİR currently works as a associate professor at the Department of Space Science and Technologies, and as vice dean at Faculty of Science of Akdeniz University. He received his bachelor's degrees in Geodetic and Photogrammetric Engineering and Industrial Engineering, Msc degree in Geodetic and Photogrammetrical Engineering from Yildiz Technical University in 2001, 2003 and 2005 respectively. He had obtained his PhD degree at the Department of Geomatics Engineering from ETH Zurch in 2013. He worked as training systems specialist at Pilatus Aircraft Ltd, and founded ETEN R&D Ltd. company to research and development service to aviation industry in 2013. His research interests are remote sensing, mainly active systems LIDAR and RADAR, cultural heritage documentation, citizen science.

Neslihan Tuztaş

Neslihan TUZTAŞ has been graduated from Geophysical Engineering Department of Kocaeli University, and now she is a Msc student at Remote Sensing and GIS Graduate Program of Akdeniz University in Antalya-Turkey.
Dr Nithiyanandam is an interdisciplinary researcher. Primarily a physicist, he is currently working in the field of applied Geo-informatics. He joined the Department of Natural resources, Teri School of Advanced Studies in 2014, and has since been teaching advanced courses in remote sensing and GIS to Masters Students pursuing Geoinformatics and Urban Development programme. His current research projects are focused on various aspects of urban heat including urban heat island and its impact, thermal comfort, anthropogenic heat emission, and the heat wave and its impact. His primary research interests include, inter alia, satellite-based thermography for studying urban micro-climate, algorithm development for remote sensing applications, LIDAR application, application of remote sensing in ocean and urban areas, GIS applications for water and land resources management, numerical modelling of heat, water quality monitoring, wastewater management, and UAV mapping.