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Potential of Sentinel-1 and 2 to Assess Flooded Areas

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Abstract

This paper illustrates the potential of Sentinel-1 and -2 for flood detection, mapping and characterization with the aim of establishing policies and procedures that need to be followed in order to lower the impact of future floods. The study area is located in Ras Baalbeck, where highlands meet vast plain area. As it relatively contains poor infrastructures and where income is mainly based on agriculture, flood prevention and mitigation initiatives are much needed. Multiple field visits were conducted to identify the affected areas. Based on the later and while computing thresholds, we did classify multiple satellite imageries into damaged and un-damaged areas. The results achieved were produced under Geographical Information System (GIS)-based software. The adopted methodology is described followed by an analysis of future perspectives. The flooded areas extended 5.08 km2 and over two major villages. While Sentinel-2 generated acceptable results, Sentinel-1 did not show any difference between affected and non-affected area in term of soil water content. Still, with their high spatial and temporal resolutions, these two satellites, particularly when coupled, could have the potential to identify the affected areas and to deliver compensations based on it.

Keywords: Flooded areas; Sentinel-1; Sentinel-2; Lebanon

Introduction

Flood is generally regarded as the most devastated natural hazard [1]. It is claiming the largest amount of lives and property damage worldwide [2]. The usage of remote sensing datasets in flood-related studies enables the reconstruction of recent history of the land surface as well as predicting future hazardous events. Thus, several previous studies have focused on obtaining information using remote sensing imageries [1,3-5], with the proposal of different approaches. Some of them used visible and infrared bands [6,7], Other preferred passive microwave [8,9], or radar (active microwave) satellites [10,11]. Furthermore, various previous studies have discussed and implemented remote sensing techniques in river stage and discharge [12-14]. High spatial and temporal resolution satellite data such as Sentinel-1 and -2 are particularly useful for the spatial and temporal analysis of the flooded areas [5]. Generally, when remotely sensed images are available before and after such event, identification of these region would be much easier.

This paper proposes a straightforward approach to assess and map flood-affected area. It is mainly based on the usage on both sentinel satellites, namely Sentinel-1 and -2, having a 10-m spatial resolution and a revisit time of six days. The importance of such study lies in delimiting the affected agricultural parcels which were distracted following the flood in 2018. This information is important for both local government body as well as dweller to help them better shape future policies and management plans.

Study Area

Ras Baalbek is a Lebanese local authority, which is located in Baalbek District, an administrative division of Baalbek-Hermel Governorate. It is located 125 km northeast of the capital Beirut. The average elevation in the area is 1000 m. This region is considered as one of the main areas that are highly vulnerable to desertification due to the intense solar radiations coupled with very low annual precipitation. Main economic activity in the region is based on agriculture. Furthermore, Ras Baalbek was in the recent years a hot conflict area mainly because its proximity to the Islamic State of Iraq and the Levant (ISIS) in the nearby village of Arsal.

More recently, heavy rain in the heights of Anti-Lebanon mountain chains on June 13th, 2018 resulted in torrential floods that took the life of a woman and led to enormous damage in the region (Figure 1).

Figure 1: Some of the Ras Baalbek flood images (Courtesy: www.the961.com).

Methods

Flood monitoring, similar to other natural hazards, could be conducted from space using remote sensing imageries and Geographic Information System (GIS) techniques. The environmental risk assessment experts of the National Center for Remote Sensing, part of the National Council for Scientific Research (CNRS-L), the flooded area in the corresponding region was identified using both radar and optical satellite images. Using radar, more precisely Sentinel-1 datasets with a spatial resolution of 10 m, soil wetness and other related physical properties could be highlighted. On the other hand, the usage of the optical remote sensing images, represented by the Sentinel-2 datasets with a 10 m spatial resolution, enables the classification and mapping of the flooded and submerged regions.

Using several images before and after the event, we delineated affected and non-affected areas. The selection of the final sample is then validated by several field visits conducted following the flooding event as well as based on dwellers information. This approach is straightforward and save on time and resources. As for the satellite imageries, Sentinel-2 datasets were downloaded from ESA official website and processed using SNAP software. Sentinel-1 datasets were retrieved from Google Earth Engine via a specialized script. These data are generally processed within few minutes and could be directly downloaded.

Results and Discussion

As shown in Figure 2, the flooded areas extended 5.08 km^2 from Ras Baalbek to Qaa. More precisely, on the flood day, several areas were traversed including Bsatine Al Ras, Mandjakiyeh, Ouadi Al Qaa, and then across the Lebanese-Syrian borders to Riblah in Syria. This satellite image corresponds to June 15th, 2018, two days following the flood. Thus, some flooded areas could not be well documented. Even though, it appears that many agriculture fields, added to urban areas, have been impacted by the flood. Figure 3 highlights the 3D spatial distribution of the flood, which appears to be headed from two major itineraries in the nearby mountains. It also shows how this flood has entered the Ras Baalbek town, resulting in major damage along the moving with high velocity front.

Photos (Figures 4-6) captured in field visits show that at the proximity of the flood stream several crops' types exist. Even though it has a relatively huge stream, the last flood event has reached these plots affecting local crops. Moreover, an ancient wall (Figure 5), considered last seen in the middle of the last century, reappears mainly due to the erosion that coincided with the flood. Because of that, the stream width has widen up to three meters. Also, a new soil layer appears following the flood (Figure 6). According to local residents, it was transported from the nearby high mountains (namely, Younin) and traveled a long distance. This soil layer shows low adaptability to the high temperature and dryness in the area, rendering it inadequate for agriculture. More precisely, the fine sediments formed are capping with cracks when drying and interfering with the emergence of new seedlings.

This phenomenon has damaged the cultivated lands, mainly in terms of fungal diseases and mites infestation. More importantly, due to the large quantity of sediments brought by the flood, the affected regions show a drop in pH, leading to a more acidic soil. As a result, the major plant nutrients may be unavailable, or available in insufficient quantities, thus deficiency syndromes may be obvious in several local plants. Moreover, the increased moisture, resulted from the flood event, has resulted in the proliferation of various species of fungi and other insects, including Phytophthora (or water molds) and mites.

In order to minimize the losses, as well as to avoid short- and mid-term effects on productivity, farmers had to take prompt corrective measures. For instance, fungicides were applied, especially to overcome Powdery mildew, affecting a wide range of cultivars. As for mites, acaricides were adapted as chemical pesticides shall probably eradicate the natural predators of mites, thus causing a major problem.

Furthermore, the pruning of infected leaves and stems is done manually, whenever possible, by farmers. As for soil treatments, farmers had applied water mixed with soap or liming, as it helps the increase of pH towards 6~6.5.

While using the previous information deduced from the optical remote sensing imageries, we selected several affected and non-affected areas to check on the state of soil moisture in the flooded areas. As it appears in Figure 7, the difference in decibels (dB) between flooded (in orange) and non-flooded (in blue) areas was marginal, particularly when comparing before and after the flood in five different locations. However, it is important to note that the Sentinel-1 image after the flood was taken four days later, which could greatly affect the dB, thus rendering the usage of the radar remote sensing in our case impractical. Moreover, the studied flood differs from other floods because it was highly composed of soil-related grains carried away from the high mountains.

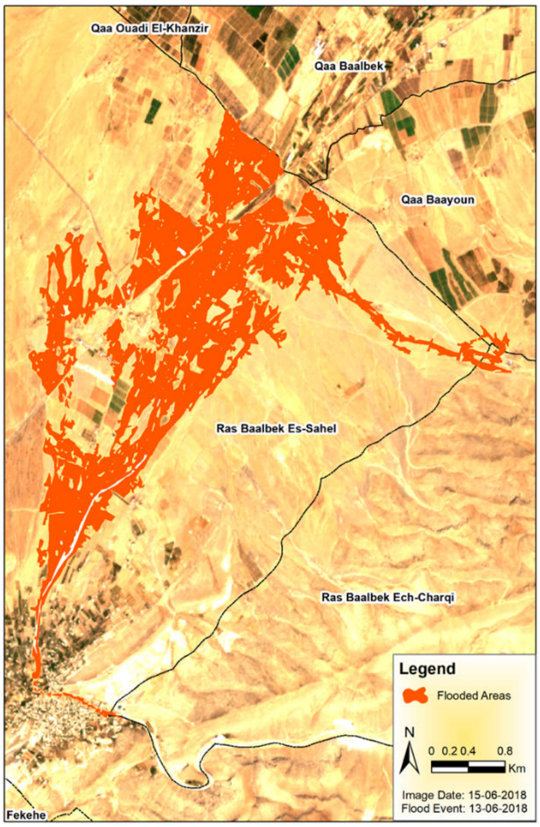

Figure 2: Flooded areas as classified by Sentinel-2 optical datasets.

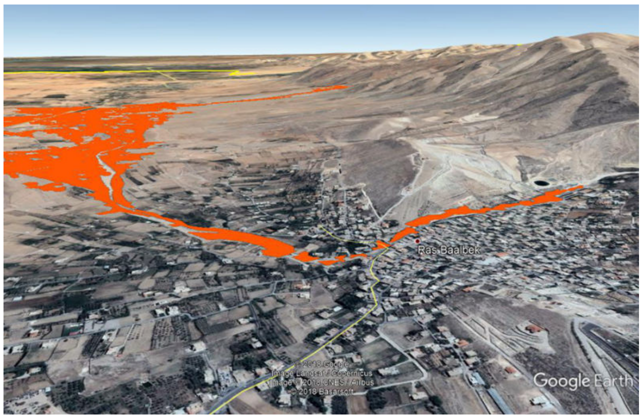

Figure 3: A 3-D representation of the flooded areas.

Figure 4: Photos of the flood stream as well as some crops cultivated nearby.

Figure 5: The ancient wall near the flood stream that few remembered its existence.

Figure 6: The dried new soil layer that appears following the flood.

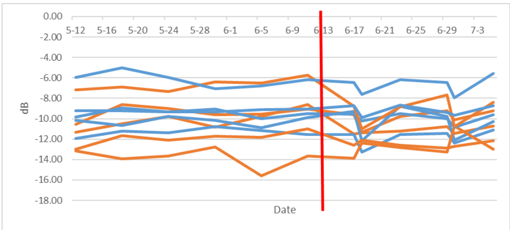

Figure 7: Flooded (in orange) and non-flooded (in blue) areas backscattering values (in dB) using Sentinel-1 radar imageries (the red line marks the flood occurrence).

Conclusion and Outlook

The usage of remote sensing imageries and GIS techniques was an essential tool to map the flooded areas while having the potential to derive the affected land cover types. Some limitations may occur mainly related to the availability of these images as close as possible to the flooding event date. Moreover, choosing the best adequate method to classify this land feature is essential to remove any bias or error. For future studies, it is recommended to develop an approach to identify flood events occurring outside the river banks and estuaries. Also, it is advised to study the effect of such event on the local community, but more importantly on the agriculture lands.

References

1. Sanyal J, Lu XX (2004) Application of remote sensing in flood management with special reference to monsoon Asia: a review. Natural Hazards 33: 283-301.
2. Tralli DM, Blom RG, Zlotnicki V, Donnellan A, Evans DL (2005) Satellite remote sensing of earthquake, volcano, flood, landslide and coastal inundation hazards. ISPRS Journal of Photogrammetry and Remote Sensing 59: 185-198.
3. Smith LC (1997) Satellite remote sensing of river inundation area, stage, and discharge: A review. Hydrological Processes 11: 1427-1439.
4. Bates B, Paul D (2004) Remote sensing and flood inundation modelling. Hydrological Processes 18: 2593-2597.
5. Schnebele E, Cervone G (2013) Improving remote sensing flood assessment using volunteered geographical data.
6. Deutsch E, Vedanta A (1973) A philosophical reconstruction. University of Hawaii Press.
7. Morrison RB, White PG (1976) Monitoring flood inundation. US Geol Surv Prof Pap 929: 196-208.
8. Choudhury BJ (1991) Passive microwave remote sensing contribution to hydrological variables. Surveys in Geophysics 12: 63-84.
9. Hamilton SK (1999) Potential effects of a major navigation project (Paraguay-Paraná Hidrovía) on inundation in the Pantanal floodplains. Regulated Rivers: Research and Management: An International Journal Devoted to River Research and Management 15: 289-299.
10. Sippel SJ, Hamilton SK, Melack JM, Choudhury BJ (1994) Determination of inundation area in the Amazon River floodplain using the SMMR 37 GHz polarization difference. Remote Sensing of Environment 48: 70-76.
11. Melack JM, Hess LL (2010) Remote sensing of the distribution and extent of wetlands in the Amazon basin. In Amazonian floodplain forests, pp: 43-59.
12. Guzkowska MAJ, Gasse F (1990) Diatoms as indicators of water quality in some English urban lakes. Freshwater Biology 23: 233-250.
13. Birkett MA, Day SJ (1994) Internal pilot studies for estimating sample size. Statistics in Medicine 13: 2324.
14. Le Traon PY, Gaspar P, Bouyssel F, Makhmara H (1995) Using Topex/Poseidon data to enhance ERS-1 data. Journal of Atmospheric and Oceanic Technology 12: 161-170.