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Disaster Information Dissemination During Emergency Event: An Experiment in OGC Disaster Resilience Pilot

Li Lin, Liping Di*, Eugene Yu, Chen Zhang, Haoteng Zhao
Center for Spatial Information Science and Systems (CSISS), George Mason University
Fairfax, VA 22030, USA.
* ldi@gmu.edu

Abstract— **Flood is one of the major natural hazards in the world, especially during extreme weather conditions. This research proposes two approaches to help decision-makers and the general public make better decisions during such events. The decision-maker could utilize the maps generated by the CSISS sentinel toolbox and CSISS DVDI index to get a better idea of the damage during the event. The flood map was generated using Sentinel 1 Synthetic Aperture Radar (SAR) which provides 10m spatial resolution. The DVDI was developed with MODIS Surface Reflectance and could help people get a rough idea of the event damage.**

Keywords— Disaster; Flood; OGC; DVDI

I. Introduction

Flooding is one of the most common disasters in the world [1]. Depend on the formation process, flood could be grouped into four common types [1]. Fluvial floods (also known as river floods) usually happen due to a heavy overflowing water body due to rainfall or snow melting. Pluvial floods are the result of extensive water in urban drainage systems, or water from higher elevations where vegetation loss the ability to retain water. Flash flooding commonly occurs after heavy rainfall in a short time period. Coastal flood is common for coastal regions to experience frequent hurricanes and heavy windstorm. Among various types of flooding, flash flood and coastal flood during (and after) hurricanes causes devastating damages to economy and human life. Flooding in a hurricane is usually hard to predict due to few reasons [2]. First of all, it is hard to collect accurate flood information during a hurricane as it is challenging and dangerous for fieldwork during the event. Secondly, the lack of a good model on reliable cyberinfrastructure creates a delay in information transfer between scientists and disaster decision-makers. Moreover, suppose information has been collected and delivered to emergency response. It is still difficult for decision-makers to make the right decision if the information is not interoperable with other data sources. The traditional way of understanding flooding has been researched from many different aspects [1][3]. Research has been conducted on understanding the source of floodwater, the formation of events, and different flood stages [4]. In contrast, thanks to the rapid development of remote sensing techniques and several Earth Observation Satellite programs, scientists are able to understand flooding much better from space [4]. This paper introduced two methods to provide information about the flood to the general public and scientists for the decision-making process.

II. Data

One satellite is not able to provide a full picture of flooding damage [4]. In fact, multiple satellite imageries were used in this research. For example, MODIS was used to generate near real time damage map [4]. By overlying the near real time 250-meter resolution large-scale damage map with demographic datasets, the data provided good indication for resource planners to plan where resources should go [1] accurately. Sentinel SAR data was used for producing high spatial resolution images [5]. The high spatial resolution is critical for emergence response as rescue teams need to know inundate situations to plan the route in advance for resource delivery. Detailed information about data used in this research is listed in table 1. To evaluate the data and method, the paper selected 29 countries in the state of Texas state. Hurricane Harvey in 2017 was the largest hurricane in the past decade in the U.S. Flooding cause most of the damages from the storm. FEMA declared this event (DR-4332).

TABLE I. Data and their providers used in this research.

Data	Provider
MOD09GQ - MODIS Surface Reflectance (Terra)	NASA EOSDIS Land Processes DAAC
MYD09GQ - MODIS Surface Reflectance (Aqua)	NASA EOSDIS Land Processes DAAC
VNP09_NRT - VIIRS/NPP Surface Reflectance	NASA Suomi-NPP Land Science Team/MODIS Adaptive Processing System (MODAPS)
Sentinel 1 Synthetic Aperture Radar (SAR) -	ESA Copernicus Open Access Hub
SRTM DEM	USGS EROS Archive - Digital Elevation - Shuttle Radar Topography Mission

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III. METHOD

This research combined two empirical approaches of flood identification and monitoring. Research has been conducted to measure the possibility of flooding risk using STRM DEM data [1]. Figure 1 illustrates the slope and aspect map generated by SRTM DEM. This research utilizes this knowledge to remove the false classification of inundation to improve the accuracy of flood identification. In addition to eliminating false classification, the team developed a sentinel toolbox to process Sentinel imageries for flood events [6]. Detailed steps of the toolbox could be found in Figure 2. Flooding information alone is not sufficient for flood event evaluation since same flood cause different level of damage to various targets (e.g., different crop types affect by same flooding event could experience a different level of damage) [7]. DVDI was an index invent to represent the level of damage caused by disaster [3][5]. DVDI calculation uses a modified VCI, mVCI:

$$VCI = (NDVI-NDVImin) / (NDVImax-NDVImin) \quad (1)$$

$$mVCI = (NDVI-NDVIm) / (NDVImax-NDVIm) \quad (2)$$

$$DVDI = mVCIa - mVCIb \quad (3)$$

In emergence events, information needs to be delivered to users as soon as possible [8][9]. For this reason, the processing tools are hosted in a standardized information dissemination system to test the feasibility of information sharing in a disaster resilience pilot [10][11][12]. Figure 3 is the state-of-art web services used in the pilot system, and figure 4 is the screenshot of the geo-platform.

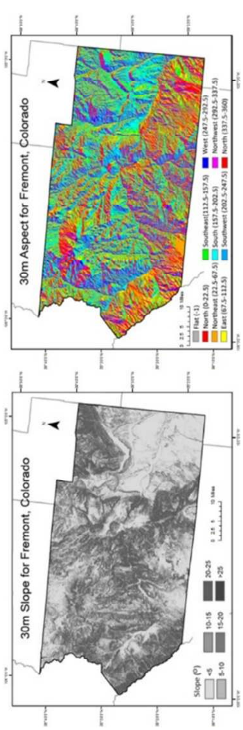

Fig. 1. Slope and aspect map generated from Sentinel 1 SAR [1].

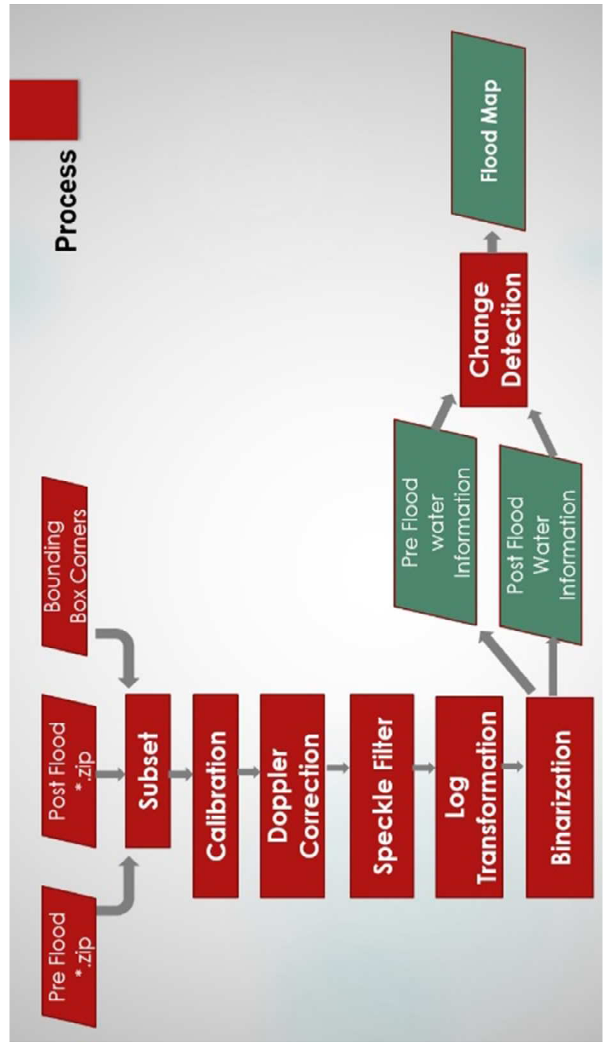

Fig. 2. Graph illustrates CSISS Sentinel toolbox two-steps flood identification [6].

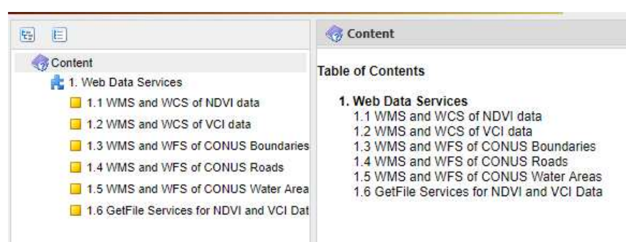

Fig. 3. Web services used in flood event-related information dissemination

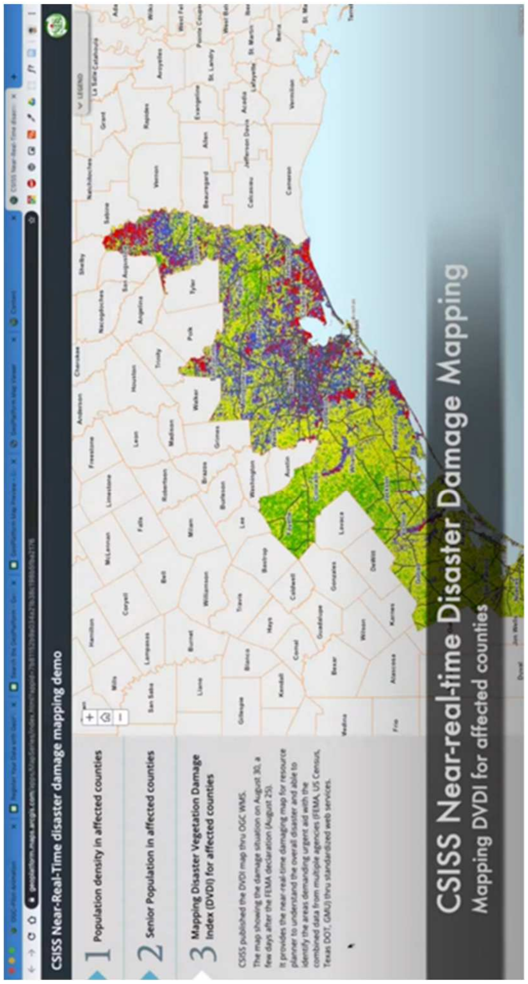

Fig. 4. Screenshot of the OGC disaster (flood) demonstration on the geo-platform system.

IV. RESULT AND DISCUSSION

Many different satellites support scientists when studying floods and hurricanes, from fine temporal resolution to fine spatial resolution [1][4]. Sentinel satellites are among the most popular satellites that provide high spatial resolution (10m) imagery to the public at no cost [4]. Coarse temporal resolution satellite such as Moderate Resolution Imaging Spectroradiometer (MODIS) allows scientists to acquire rapid ground information. Although the spatial resolution is 250m, it costs less than three hours from observation to analysis-ready with the NASA's Land, Atmosphere Near-real-time Capability for EOS (LANCE) Near Real Time (NRT) MODIS Archive. Vegetation Condition Index (VCI) calculated from Normalized Difference Vegetation Index (NDVI) is a widely adopted index to measure vegetation health. By comparing the VCI before and during/after the event, Disaster Vegetation Damage Index (DVDI) is able to represent the overall damage map for the severe event at the regional scale. Center for Spatial Information Science and Systems (CSISS) of George Mason University (GMU) has years of experience in flood monitoring and loss assessment and developed flood-related operational systems [3]. This research utilized the scientific models, Open Geospatial Consortium (OGC) standards and the Geospatial Platform (GeoPlatform) (https://www.geoplatform.gov/) to test the feasibility on resolving above difficulties in OGC Disaster Resilience Pilot (DRP-2019) [10],[11],[12],[13],[14]. Every step during data acquisition, processing, analyzing, and delivering requires good management in resources and easy-to-use interoperability systems. The paper delivered two experiments in the geo-platform system:

1. CSISS sentinel toolbox two-steps flood identification demo: https://www.geoplatform.gov/resources/applications/8d5f2bb5033484e21f0468f64fcdc10c/

2. CSISS near-real-time disaster damage mapping demo: https://www.geoplatform.gov/resources/applications/b8dc42c26b8bab0731c48c32b5821cb4/

The final deliverables are summarized and presented in YouTube by OGC:

https://www.youtube.com/watch?v=Xq1PuHT-Vk0

V. CONCLUSION AND FUTURE WORK

Flood is one of the major natural hazards in the world, especially during extreme weather conditions [4]. This paper aims to establish such workflow to deliver disaster supporting information by adopting state-of-art standards and an interoperable geospatial platform.

Making an objective decision on resources dissemination is only possible when data is available, and the information is ready for the resource planner to use. Using the powerful online GIS server – geo-platform, data, and method were able to be communicate and generate meaningful data for resource planner at the right time. CSISS has developed two algorithms to support decision-making for resource managers. DVDI was invented to capture the ongoing disaster damage at a large scale near real time during flooding events. In addition, a toolbox was implemented to capture flood extend from high-resolution satellites imagery.

Decision-makers for emergency response (e.g., to decide where the resource should be sent) can use this system for decision-making. The general public impacted by the disaster (e.g., trapped in home) could use this information to understand the surrounding environment and escape from dangers. This work demonstrates the feasibility of utilizing the system to reduce life and economic loss from floods.

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