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Accessing satellite imagery for disaster response through the International Charter: Lessons learned from the 2011 US Midwestern Floods

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ABSTRACT

The International Charter ‘Space and Major Disasters’ (“Charter”) is a collaboration among Earth observation satellite owners and operators to provide remotely sensed (RS) data following natural and man-made disasters. Charter members provided post-flood and pre-flood or archived RS data after the April 2011 floods in the Midwestern US. These multispectral and RADAR images provided valuable information to end users and first responders in the flood affected states for their planning and relief efforts. This effort was successful because of the process established by the Charter for soliciting requests, and acquiring and distributing data through a network of international and national agencies, and data vendors. This paper describes the a) role played by the Charter to acquire and distribute RS data through six of its members, b) value of archived satellite data, c) need for image processing experts to process these near real-time data, and transfer them in a timely manner, and d) data acquisition and distribution policies of the Charter. Lessons learned from this response along with the policy recommendations will be helpful in future activations for maximizing the value of RS data and services provided by the Charter.

1. Introduction

The International Charter Space and Major Disasters (Charter) was created after the third United Nations Conference on the Exploration and Peaceful Use of Outer Space (UNI-SPACE III) held in Vienna, Austria in 1999 [1]. The Charter serves as “an international collaboration between the owners and operators of Earth observation missions (www.disastercharter.org)”, to provide remotely sensed data at no cost in response to requests from users in civil protection agencies of the disaster impacted countries [2–4]. Maps derived from satellite images showing the spatial extent of the disaster and generating information from pre- and post-disaster is a common example of how remotely sensed data are used for disaster management efforts [5]. The Charter serves as a single point of contact between agencies or companies that operate remote sensing satellites, and national civil protection agencies for requesting, tasking, acquiring and delivering satellite images following natural or man-made disasters [1].

Following a disaster, a request is submitted to the Charter containing details of the event, its geographic extent, and remotely sensed images requested. After review and approval of the request, the Charter issues an activation in response to that disaster. The data request is transmitted to the members, i.e., space agencies. Members will then

task, acquire, and deliver the appropriate satellite data. Based on availability and request, members may also provide pre-event imagery from their archives for mapping pre-disaster conditions. During the early stages of an activation, the Charter also nominates a Project Manager (PM) to oversee the activation, and coordinate communications and data delivery between the space agencies and users in civil protection or emergency management agencies. The PM, if necessary, may also identify image processing experts who can generate value-added products such as digitally enhanced satellite imagery, extracted thematic information (land cover maps), or combine other geospatial data such as administrative boundaries, population etc. All data and services are provided free of cost and users have to agree to limit their use of the data only for the intended purposes. All personnel involved with activations including those who generate value-added products volunteer their time to support Charter activities [6,7].

Since 2002, the Charter has been activated more than 510 times (as of 29 Oct 2016) and the satellites owned and operated by its members have provided thousands of remotely sensed images in response to earthquakes, floods, hurricanes, landslides, mudslides, tornadoes, wildfires and other disasters (Fig. 1). Also the number of member agencies have increased and remote sensing satellites have grown tremendously and the remotely sensed data have provided valuable,

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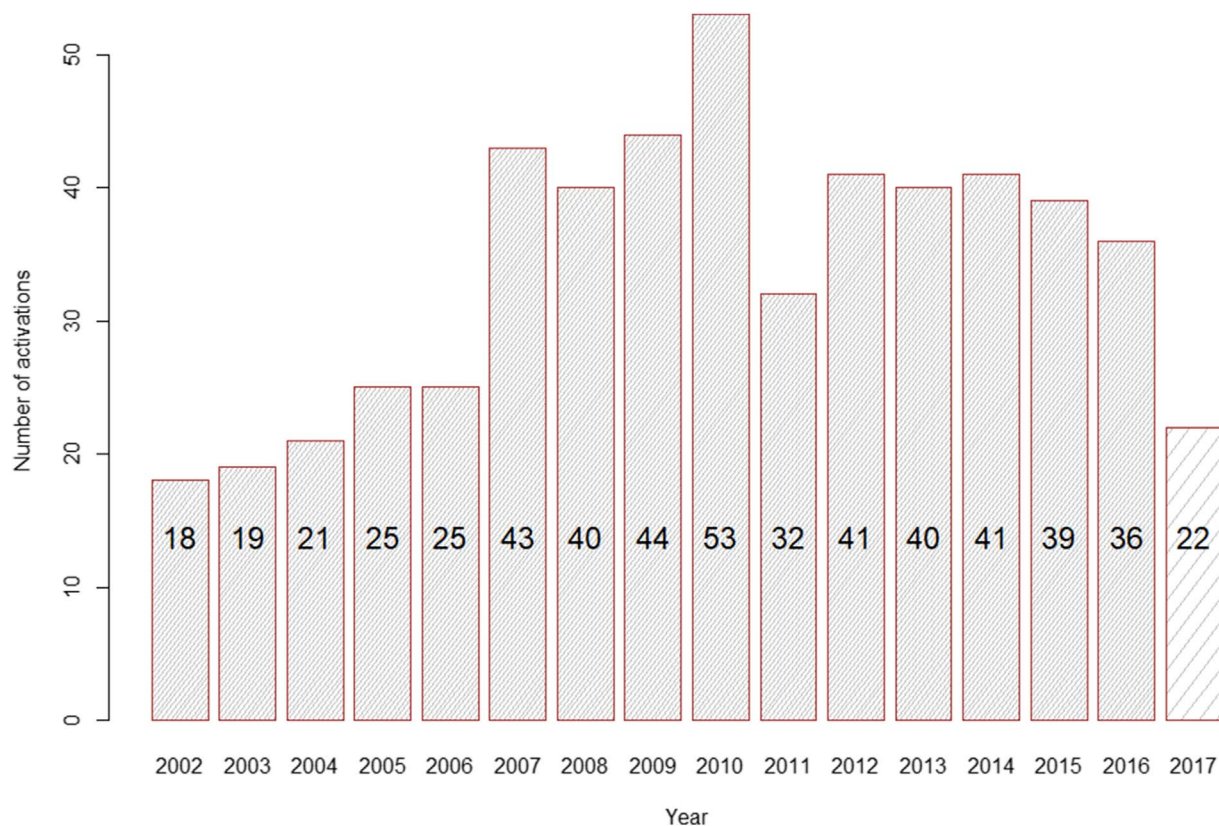


Fig. 1. Annual number activations since 2002 in response to disasters worldwide. Additional details about these activations can be found on the Charter website (<https://disasterscharter.org/web/guest/activations/charter-activations>). Notes: Number of activations for year 2017 are as of 7 Aug 2017. Approximately 50% of the activations were associated with floods and ocean waves.

timely information for many activations [8]. For example, more than 5000 images were provided by the Charter members for the earthquake that struck the Tohoku-Kanto region of Japan in March 2011 to aid rescue efforts [4].

As the number of Charter activations and the volume of delivered data continue to increase, it is important to share the experiences gained from each activation from both operational and policy perspectives [4,9,10]. Durrieu and Nelson [11] concluded that satellite-based systems are the only way to collect data globally. The conditions associated with each activation vary in terms of the data provided, and civil protection agencies and personnel involved, resulting in different outcome. For example, if data are not processed and delivered with certain content or format, it might not be useful for the civil protection agencies. Feedback about the effectiveness of the remotely sensed data is valuable for Charter members to gain insights for improving their responses for future activations.

From a policy perspective, feedback obtained from activations could also help the Charter to evaluate its existing policies pertaining to data distribution and its overall operations. For example, there are no contracts between the Charter members and the countries affected by disaster in terms of how many images will be provided. This means the response from members could vastly vary from one disaster to another.

The goal of this paper is to describe the Charter's role in coordinating data requests, tasking and acquiring data, and also the lessons learned while delivering these data to agencies that were responding to the disaster. However few users in the emergency management agencies provided feedback to the Charter on the effectiveness of the images. This could be due to the fact that large amount of data was collected and provided to these agencies by other US federal and state agencies, private companies, and individuals. Hence this paper focuses on the operations of the Charter following the activation and how data requests were received and fulfilled. Lessons learned from

this activation will become part of the disaster management 'know-how' [3] and provide valuable insights to the Charter for revising its existing policies and as a follow up to the overview paper published by Ito in 2015 [3]. Experiences gained from this activation can help guide future activations related to flooding and to a certain extent, other types of disasters. In order to limit the focus on the Charter's role, data that were acquired through other sources or and protocols are not discussed in this paper.

2. US Midwest floods of 2011

Above normal precipitation in the winter and spring of 2011 resulted in severe flooding in the Mississippi and Red River basins [12]. Several rain gages reported more than 200 mm of rainfall between 18 and 28 April 2011, which resulted in peak streamflow records in 105 streamgages and annual runoff volume records in 47 streamgages [13]. The water level exceeded the National Weather Service (NWS) flood stage at 40 US Geological Survey (USGS) streamgages in the state of Illinois, and moderate to major flooding occurred in the Kaskaskia, Big Muddy, Illinois, Little Wabash, Wabash, Mississippi and Ohio rivers. Thirty three fatalities and damages totaling approximately 4.2 billion USD were reported in these river basins [13]. Additional information about the 2011 floods can be found in the NWS United States Flood Loss Report [14].

3. Charter activation

On 28 April 2011, the USGS submitted a request for activating the Charter in response to the flooding, on behalf of the US Army Corps of Engineers and the emergency management agencies of the states of Illinois (IL) and Missouri (MO). The Charter approved this request for activation and a call number and name was assigned (#362 – Flood in

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