“The 7.7Ma Canada earthquake Investigation through Infrared and Thermal Data”

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Abstract

Natural hazards that have the characteristics of posing danger to social stability at worldwide scale; the magnitude of the effects will be personal, economical and infrastructural losses linked to the preparedness time. The development of new tools that contributes to the disaster risk management cycle is strongly important nowadays and is mainly investigated with interdisciplinary approaches. Remote sensing has been identified as a novel risk assessment model that can contributes in the quantification of the exposure of natural hazard and the available time to mitigate a location under a natural treat. Infrared and thermal images from the Advanced Very High Resolution Radiometer (AVHRR) by the National Oceanic and Atmospheric Administration (NOAA) were obtained was processed using ENVI. A result of the modeling includes the location of the earthquake, the change in LST and a possible estimation of the preparedness time before the event occurs. The proposed model will contribute to the prevention, mitigation, preparedness and recovery, by risk identification of the coastal areas, to public and private sectors, including the communities.

Key words: Natural Hazard, Disaster mitigation cycle, Remote Sensing, thermal-infrared data, ENVI

Introduction

Rapid transformation of the actual population, infrastructure development, economical and social characteristics has been creating an increase concern about environmental issues, sustainable science and technologies. As a consequence of these changes, an increased interest to protect and preserve the human lifestyle has been developed in order to mitigate disasters. Current techniques needs to exploit the available date in a effective and rapidly way to accurately obtain a improved emergency services and decision making in a timely manner (Joyce et. al., 2009).

In the last two decades, an increase in the occurrence and magnitude of natural phenomena has been reported globally (Alcantara-Ayala, 2002; Perez-Lugo, 2003). The tragic loss of life associated with the Indian Ocean tsunami (2004), Java (2009), Haíti (2010), Samoa (2010), Chile (2010), Sumatra (2011) and Japan (2011) raises the global awareness of the hazard, demonstrating to the world how natural events can be a significant threat to the safety, security and economy (Wood, 2007; Wood et al., 2007; Wood and Soulard, 2008; Wood and Schmidtlein, 2012; Wood and Schmidtlein, 2013). Worldwide jurisdictions and agencies are continuously developing strategies in order to safeguard their population in order to prevent disasters.

Remote sensing has emerged a useful tool to monitor natural hazards and disasters. The application of this technology becomes increasingly common due to its ability to provide up-to-date imagery to the public through the media and internet (Joyce et. al., 2009). As this technology continuously grow, the expectation for near-real-time monitoring and visual images to be relayed to emergency services and the public in the event of a natural disaster (Joyce et. al., 2009). Remote sensing has a role to play in each phase of the disaster management cycle. The four phases of the disaster management cycle comprehended of: mitigation, readiness, response and recovery.

The research presented in this paper is intended to expose the remote sensing technology as a tool capable of assist in the disaster management cycle. As main objective, is intended to predict the origin of an earthquake that can produce a tsunami wave. This work is intended to observe changes in the LST in order to predict a possible emergency situation with several days of advance. This project will develop, test, implement, and disseminate novel and cost-effective remote sensing methods in order to prevent the most economical and personal losses in the case of a tsunami event.

Materials & Methods

Study site

A recent major earthquake in October 28, 2012 at 8:04pm, hits Queen Charlotte Islands of Canada region producing a small tsunami (about ~0.46m of height) in Alaska and Oahu, Hawaii. The United State Geological Services (USGS) inform an earthquake of 7.7 Ma have an epicenter at 52.77° N and -131.93° W with 15.7 km of depth. The last earthquake with a magnitude of 7.0 or higher in Canada was in June 24, 1970 and the epicenter was located in Queen Charlotte Island.

http://www.vancouversun.com/news/magnitude+aftershock+hits+south+Haida+Gwaii+after+earthquake+tsunami+alert+issued/7459506/story.html

Sensor

The sensor used for this research is the Advanced Very High Resolution Radiometer (AVHRR), which contains a six channel imaging system with a 1.0km of spatial resolution for local area coverage, with a daily repeated cycle and, polar, equatorial and geostationary orbiting at ~870km of altitude. All six channels are calibrated to measure the energy in the same spot and measure the reflectance of the Earth. The six channels or spectral bands are concentrated in the red, the infrared region of the spectrometer and thermal radiation.

Parameter	Ch.1	Ch.2	Ch.3A	Ch.3B	Ch.4	Ch.5
Spectral Range (μm)	0.58-0.68	.725-1.0	1.58-1.64	3.55-3.93	10.3-11.3	11.5-12.5
Detector type	Silicon	Silicon	InGaAs	InSb	HgCdTe	HgCdTe
Resolution (km)	1.09	1.09	1.09	1.09	1.09	1.09
Temperature Range (K)	-	-	-	180 - 335	180 - 335	180 - 335

Data Products

Since the earthquake was reported in October 28, 2012 at 8.04pm with a magnitude of ~7.7Ma, the data was selected from October 25, 2012 to October 31, 2012 around the same hour and the same satellite for the first set of images to compare the changes in temperature before, during and after the event.

For a second set of images, the data selected were from the same day (October 28, 2012), at every hour of the day and from different satellites to compare the change in temperature along the day of the event.

Data Processing

After obtaining the Advanced Very High Resolution Radiometer (AVHRR) images from National Oceanic and Atmospheric Administration (NOAA) web site, the images were openly, processing and analyzed in Environmental for Visualizing Images (ENVI) program. Once they were open, a Sea Surface Temperature (SST) was calculated using the default algorithm of ENVI tools.

To locate more easily the epicenter, a subset was created using the image option of a selected line from 0-1024 for NOAA-16 and NOAA-19, and a line from 1024-2048 for NOAA-18. Once the subset was created, color mapping, color ramp and a rectangular to locate the epicenter were added to the image for a best visualization.

Results & Discussion

In order to demonstrate the effectiveness of remote sensing technology to predict natural phenomenon a case study was established. The case of study selected was a recent major earthquake in October 28, 2012 at 8:04pm, hits Queen Charlotte Islands of Canada region producing a small tsunami (about ~0.46m of height) in Alaska and Oahu, Hawaii. The event was selected because it was a major earthquake, produce a tsunami and the needed data for it analysis can be obtained. The obtained data were thermal and Infrared images from the NOAA sensor Advanced Very High Resolution Radiometer (AVHRR).

Multichannel Sea Surface Temperature (MCSST) Algorithm

Daytime pass:

$$SST\ (°C) = a*T4 + b*(T4 - T5) + C$$

Nighttime pass:

$$SST\ (°C) = a*T3 + b*(T3 - T5) + C$$

Where:

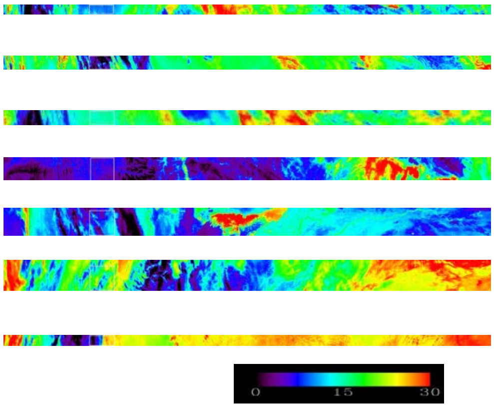
T3 = Brightness Temperature at Channel 3

T4 = Brightness Temperature at Channel 4

T5 = Brightness Temperature at Channel 5

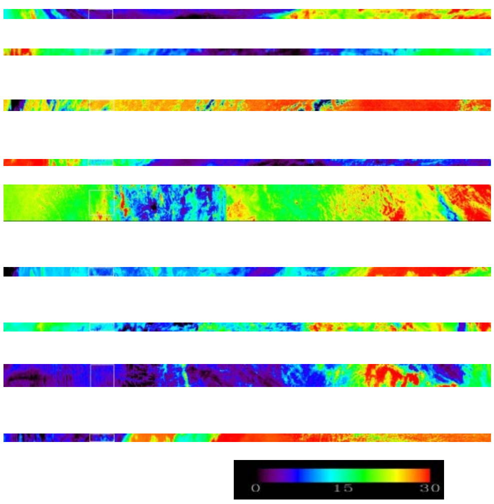
a,b,c = weighting coefficients

For the purpose of this project, two sets of images were created to analyze the changes in sea temperature in the epicenter of an earthquake. The first set of images was created using images from October 25, 2012 to October 31, 2012 with the purpose to analyzed how the temperature changes before, during and after the seismic event. The images were selected around the same hour and the same satellite to reduce other factors that can affect the study.



The set of images above illustrated the change in temperature along 7 days (3 before, the day that occurred the event and 3 days after the event). The images illustrated that the lower temperature register was the day of the event.

The second set of images was created using the images from the same day (0ctober 28, 2012). The set is composed of 9 images (A-I); every 3 images were obtained from the different satellites available.



The set of images above illustrated the change in temperature along the day of the event. They also illustrated that temperature were dropping during the day but the lower was register just after the event.

With processed satellites images by ENVI, the difference in temperature can be observed. Also, it is possible to use the information available in satellites to see the changes in temperature before, during and after an event.

Conclusion

Remote sensing can assist with interdisciplinary sciences in order to contribute in the integration of communities to natural hazards in their living places. One of the key aspect of this interrelationship with the communities are the assistantship in the reduction of natural and human vulnerability by enriching theoretical knowledge, developing prediction models for different processes, and diversifying approaches of applied sciences in order to mitigate disasters. For that reason a comprehensive analysis based on mathematical and theoretical models to predict an mayor earthquake and the possibility of tsunami generation was studied.

In conclusion, satellite images connected to ENVI can be used to observer LST. A change in temperature was observed during the time of study. The change in ocean temperature can be used as a novel tool in order to investigate earthquakes located on open seas. This analyze can be a tool to mitigate and predicting future events of earthquake and tsunamis in the ocean.

Recommendations

For future work it would be more efficiency to include and compare the data with images from geostationary satellites to increase the precision. Geostationary satellites collects data every 30 minutes both day and night, and they always monitoring the same area along its orbit. Also, it would be more useful to use more data inside every day to improve the Local Surface Temperature (LST) at different day of the study and consider the direction of flow of the ocean. Besides, it would be interesting to study other epicenters around the world to validate the methodology and the results of this report.

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