PACIFIC TSUNAMI: CONTINUING RESEARCH AND FORMATION OF A MUSEUM EXHIBIT

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ABSTRACT

The Sumatran tsunami was one of the biggest tsunamis to occur in fifty years and in many ways mirrored the tsunami that struck Hilo, Hawaii in 1946. Both of these tsunamis were generated by a large earthquake, came without warning, took the lives of many, and caused millions of dollars of damage. Unlike the 1946 tsunami, the Sumatran tsunami was one of the first large tsunamis to be observed and recorded by modern remote sensing instruments. Today's technology allows for better assessment and prediction of tsunami, and the community response to them can be vastly improved. In Hawaii, tsunamis are very common and can be very dangerous, which is why the development of a 'Science of Tsunamis' exhibit at the Pacific Tsunami Museum is very important. The exhibit not only informs the public of the danger of tsunamis, but also instructs the public what to do during a tsunami. Until now, the museum was lacking information on new technology being used to study tsunamis and implement mitigation. Now, a large portion of the material in the exhibit is based on the satellite images acquired by the NASA satellite, ASTER, which are now being used during post-tsunami field surveys. The new permanent tsunami exhibit is an exceptional way to inform the public of the work that NASA and the Pacific Tsunami Museum is doing in research and education of tsunamis.

INTRODUCTION

On December 26, 2004, a M_w 9.2 earthquake occurred off the northern coast of Simeulue Island, Sumatra and generated a colossal tsunami that struck the coasts of Sumatra, Thailand, and India and claimed over 300,000 lives. The Sumatran tsunami was one of the biggest tsunami to occur in fifty years and in many ways mirrored the tsunami that struck Hilo, Hawaii in 1946. Both of these tsunami (in Japanese, the plural for tsunami is tsunami) were generated by a large earthquake, came without warning, took the lives of many, and caused millions of dollars of damage. In 1946, there was very little knowledge about tsunami; however, the loss of life caused by the Sumatran tsunami could have been greatly reduced if the people were educated about tsunami and early warning and communication systems had been implemented in that region. Unfortunately, great natural hazards such as tsunami are eye-openers for people in the general public, as well as the scientific and political communities. Both the 1946 Hilo and the 2004 Sumatran tsunami resulted in the establishment of early warning systems and agencies that perform research on tsunami generation in their perspective regions.

Hawaii is located in the middle of the Pacific plate and is surrounded by active volcanic and seismically active subduction zones situated on the edges of the Pacific plate in what scientists call the 'Ring of Fire' **(Figure 1).** Tectonic activity occurring in the 'Ring of Fire' that is large enough to generate a tsunami can affect the Hawaiian Islands. In addition, any large-scale landslide, earthquake, or volcanic eruption on one island can generate a tsunami for the other islands. Therefore, constant research is being done on tsunami in the Pacific basin to continually improve the warning systems in place to make sure that the people on the islands have ample evacuation times. As scientists learn more about tsunami, they inform the public through outreach programs and museums to educate people about the warning signs of a tsunami and how to protect themselves from the dangers of tsunami. Education is probably most important in saving lives because any near-island generated tsunami will probably arrive at the coastline before it arrives at the warning system. The University of Hawaii has been working closely with the Pacific Tsunami Warning Center (PTWC) and the Pacific Tsunami Museum (PTM) trying to educate the public about the hazards of tsunami and how to live on islands with such natural hazards.

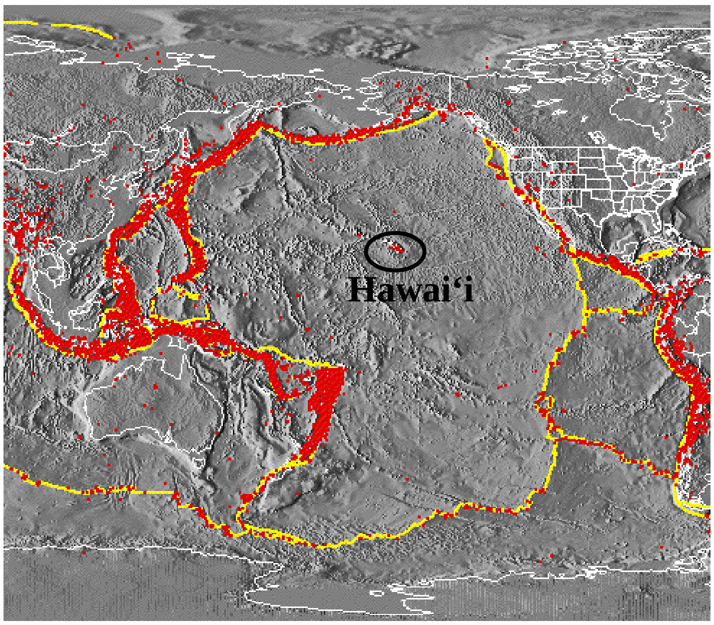


Figure 1. Image of the Pacific Basin and the location of the Hawaiian Islands within the ‘Ring of Fire.’ The tectonic plates are outlined and the dark dots represent the earthquakes with magnitudes of 5.0 or higher that have occurred from 1980-1990. Image courtesy of the National Oceanic and Atmospheric Administration (NOAA).

Developing a new exhibit on the ‘Science of Tsunamis’ in the Pacific Tsunami Museum will educate people on the causes and hazards of tsunami, however, it will also inform about the new technology being used in warning systems and tsunami damage assessment. The prior exhibit lacked information on the new ways that scientists are assessing damage caused by tsunamis, such as using satellite images to survey the damage in areas inundated by tsunami waves. Many of the images used to survey tsunami damage are acquired by NASA using the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) satellite. Before and after images acquired by ASTER are used to look at the areas damaged by tsunami and can be used to predict where future tsunami run-up will occur.

METHODS

My first goal in creating a new exhibit was to decide what information is crucial and what can be discarded. This was harder than I had anticipated because as a scientist, I felt that most of it was important. However, in order to incorporate the new information into the science of tsunamis exhibit, the current information on display needed to be revised because the space for the new exhibit is smaller; therefore, the display had to be redrafted and condensed to make room for the new information. I spent most of my time on this project revising the old exhibit and researching new information to be placed in the exhibit. There was a gross lack of new technologies and procedures that scientists are using to study the effects of tsunami, especially the damage caused by large tsunami; therefore, extensive research was conducted in order to incorporate this new information into the new display.

When revising the old display, it was difficult determining what portions of the display could be edited out because cutting too much information would leave the public confused about the content and unable to understand the subject matter in the display. Along with the editing, many visual aids were added in order to make the content easier to understand **(Figure 2)**. Many people are visual learners; therefore visual aids help reinforce the material being presented and support the text in the display.

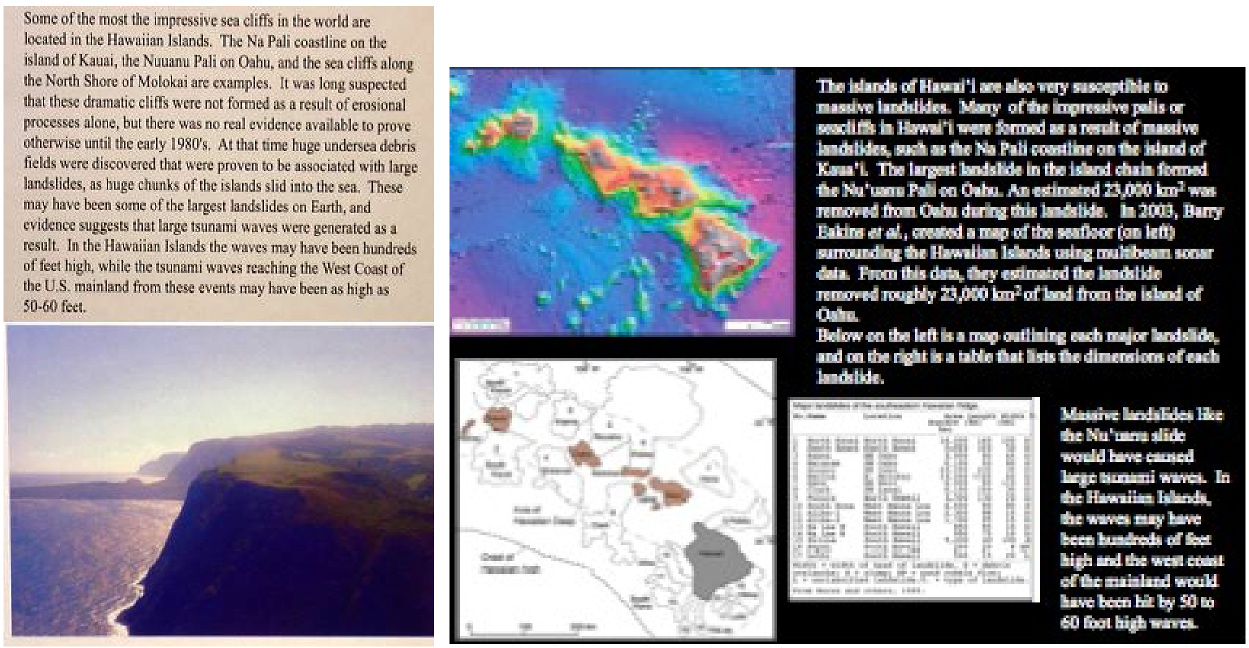


Figure 2. On the left is an image of part of the old display explaining that massive landslides that occur in Hawaiʻi can trigger large local tsunamis. On the right is an image of the new display, which explains the same phenomena; however, it is displayed in an eye-catching way and uses visual aids to help clarify the information. In this new format, more information is given, but in a more clear and concise display.

Revising the old display was a very time consuming process because first, someone else developed the previous exhibit, therefore I had to make sure that all the information was correct. Even with my existing knowledge of tsunami, I had to research some of the information to confirm that it was accurate. Second, I had to condense the information, keeping enough information to make the content concise while trying not delete too much information which would make the display confusing. Third, I added new visual aids to the condensed content making sure that all the permissions were properly attained in order to display the images in the new exhibit. Some of the images used were copyrighted and needed permission to use them in the exhibit and it took some time to get permission. Finally, the arrangement of the original exhibit was hard to follow so the information was arranged differently in order to enhance the content flow from one section to the next.

After finalizing the content of the display, preparation of the room and fabrication of the display was started. The room that accommodates the new display needed to be prepped, which included painting and building the housing unit for the touch screen computer. After the room was prepped, the display was then fabricated. Fabricating the display involves printing the content on high quality photo paper and checking for any and all errors. The printed image is then mounted on foam core using professional-grade adhesive and the foam core is then cut to the appropriate size. The display is then taken to a professional to seal the pieces with laminate to extend the life of the display. After all the images are mounted, the arrangement of the display is determined before mounting on the wall to ensure of the space needed for the display and that it will be placed in the best possible way for maximum visibility and flow of content.

Finally, in order to enhance some of the text in the display, animations and simulations are incorporated into the display via a touch screen computer. The animations and simulations are used with permission and were downloaded onto the computer so that the public can use them to enhance their knowledge of the content in the text display. The public is directed to use the computer in certain portions of the exhibit and watch the animations to get a greater understanding of the content. The computer is located in a central position in the room so that all the visitors can easily access the computer at any time.

RESULTS

The work applied during these two semesters resulted in a new ‘Science of Tsunamis’ exhibit in the Pacific Tsunami Museum in Hilo, Hawai‘i. The exhibit is more concise, has more visual aids, and is more appealing to the eye **(Figures 3-5)**.

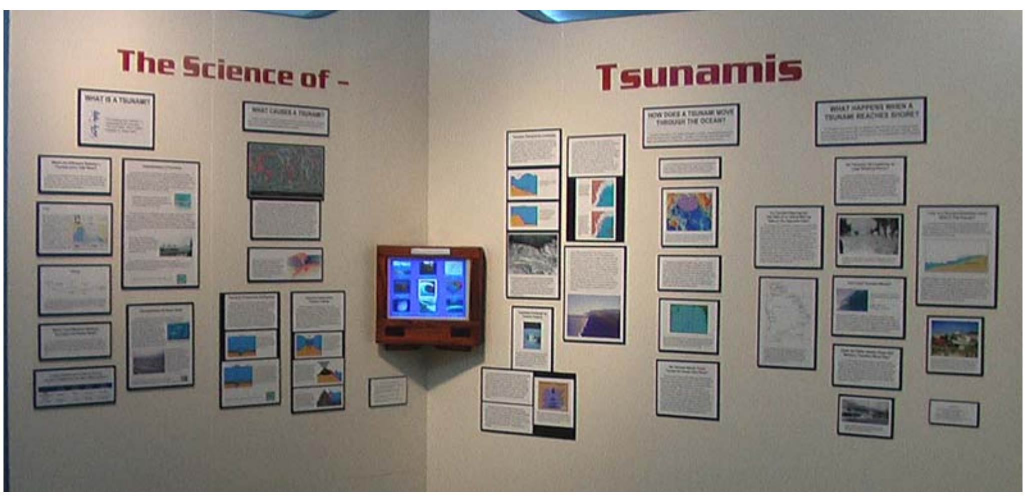


Figure 3. Image of the previous ‘Science of Tsunamis’ exhibit. In this old exhibit, there was no mention of the new technology used in post-tsunami field survey work.

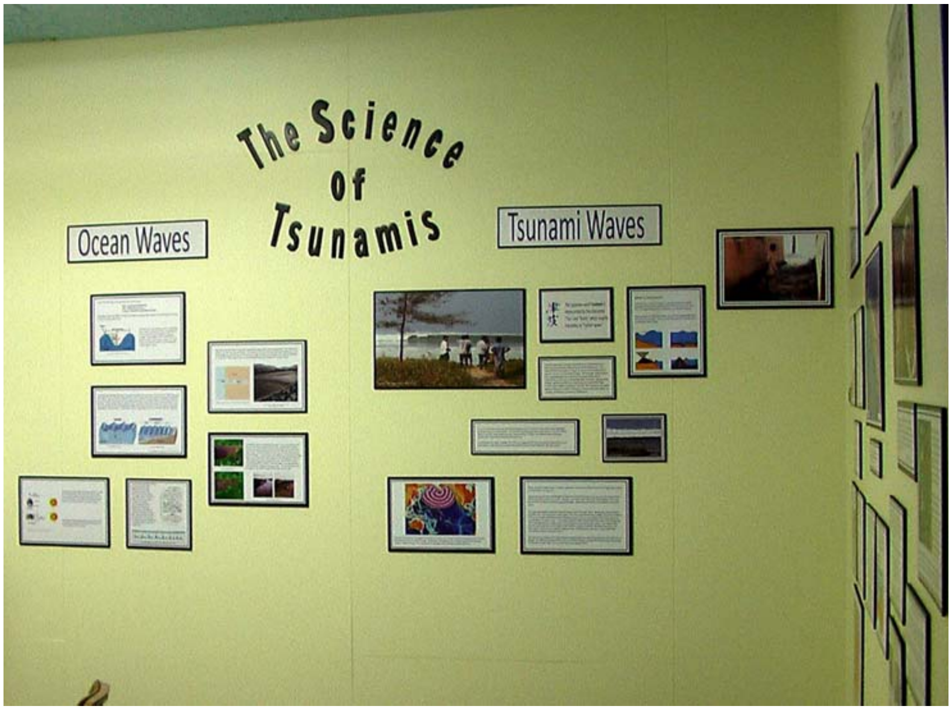
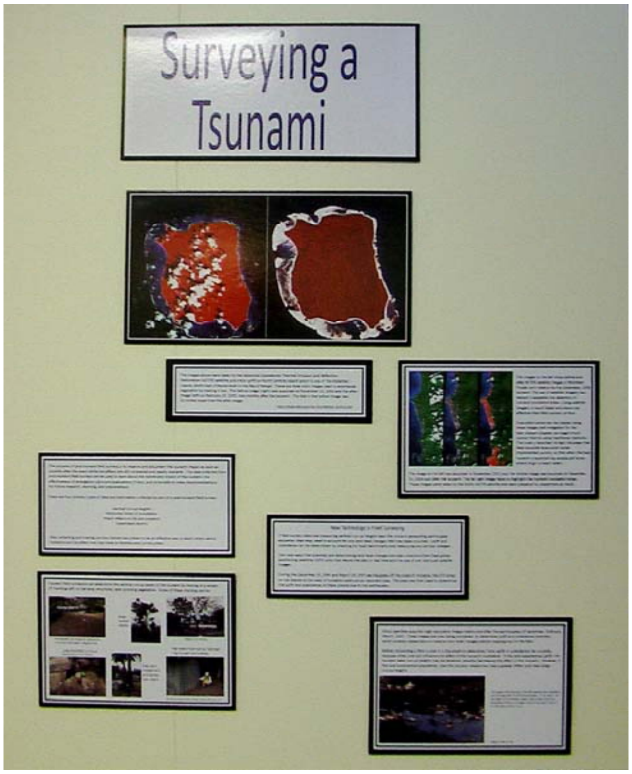
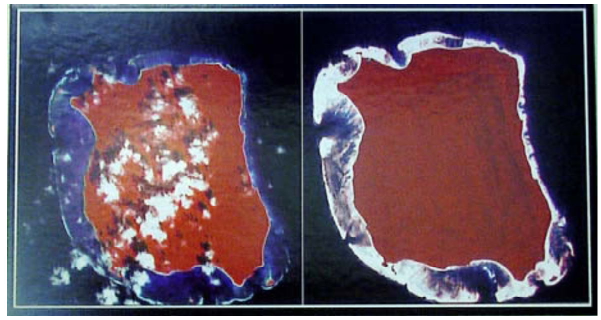


Figure 4. Image of the new 'Science of Tsunamis' exhibit. This is the North wall seen as you walk into the room.

Figure 5. Image of the new 'Science of Tsunamis' exhibit. This is the East wall, or the wall to the right as you enter the room.

Most importantly, the exhibit displays new material discussing the importance of new technology in the study and mitigation of tsunami **(Figures 6 & 7)**.





Figures 6. On the left is an image of the post-tsunami survey portion of the 'Science of Tsunamis' exhibit. This section displays some of the new technology being used, including the satellite imagery acquired by the NASA satellite, ASTER. **Figure 7.** Above is a larger image of the satellite images used in the display. The ASTER images are courtesy of Mike Abrams at the Jet Propulsion Laboratory (JPL).

DISSCUSION

In the final display, more attention was given to post-tsunami field survey work, which is very important for the understanding of tsunami and mitigation of future impacts. During post-tsunami field surveys, various data are collected such as: vertical run-up heights, horizontal limits of inundation, major effects on life and property, and eyewitness reports. The most important data for future mitigation of tsunami is the vertical run-up heights and horizontal limits of inundation. In order to collect this type of data, scientists need to spend many hours in the field locating areas with tsunami damage and measuring the run-up heights and vertical inundation limits using instruments such as global positioning systems (GPS) or precise land level survey transits. These time-consuming techniques may take several weeks if not months to gather enough data to help with evacuation plans for future tsunami. In some cases, this may be too long because it is possible that the causes of the tsunami, such as earthquakes, may occur frequently with little time between events to allow for long field surveys to aid in mitigation processes. This is evident in Indonesia, where the earthquakes triggering tsunami have occurred within months of each other; too little time for surveys on foot to aid in evacuation plans. Therefore, scientists are beginning to use satellite imagery to speed up the damage assessment and to determine the inundation areas and aid in the planning of evacuation routes **(Figure 8)**. Images acquired by the NASA satellite ASTER can be used to determine inundation areas within hours as opposed to days or weeks of fieldwork to determine approximately the same inundation areas. Of course, fieldwork will always be more precise; however, preliminary work done with the use of satellite images can save lives if multiple events occur like those in Sumatra in 2004 and 2005.

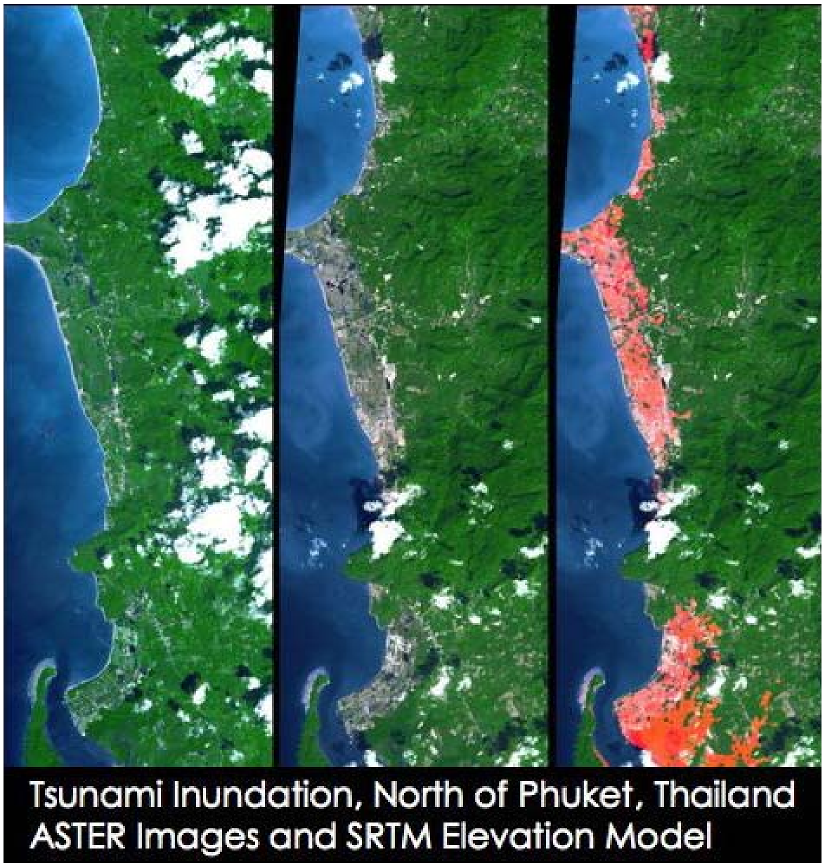


Figure 8. Satellite images of the December 2004 tsunami inundation areas in Thailand. The image on the far left was acquired before the tsunami occurred. The image in the middle was acquired after the tsunami and the image on the far right has been enhanced by NASA to represent areas of inundation. All images are courtesy of NASA and have been acquired by the ASTER satellite.

Finally, ASTER satellite images are being used to determine land level changes that occur during large earthquakes, such as the December 2004 and March 2005 earthquakes in Indonesia. Determining land level changes in tsunami-prone areas will aid in the assessment of the inundation caused by tsunamis. If subsidence occurs in a region following an earthquake, then the tsunami inundation could be far worse than if there was no land level change. Similarly, if there is uplift in a region, then the tsunami inundation could be less than that if there was no land level change (Briggs *et al*. 2006, Meltzner *et al*. 2006). In **Figure 7**, the image on the left is the pre-earthquake image and the image on the right is the post-earthquake image; there is significant uplift in the post-earthquake image. If a tsunami occurred on this small island, then the effect may not have been as great as if there was no land level change. After determining whether a region experiences land level changes, then these changes can be anticipated during the next large earthquake and incorporated into the possible tsunami inundation areas and evacuation routes.

CONCLUSION

This project relates to NASA's goals as part of NASA's Earth science program as a way to understand Earth's ever-changing systems. The assessment and prediction of tsunami, and the community response to them can be vastly improved with today's technology. Satellite images are good examples of how technology can change the way scientists perform research. Before and after images from the ASTER satellite are used to look at the areas damaged by tsunami and land level changes caused by tsunami-generating earthquakes. This knowledge is now used to predict where future tsunami run-up will occur and to predict how any land level changes in the region will affect the impact of the tsunami in certain areas. Most importantly, this new information is being passed to the public through the creation of exhibits such as this one in the Pacific Tsunami Museum. Education of the public is vital to save lives in the event of tsunami, either locally in Hawai‘i or elsewhere on Earth.

ACKNOWLEDGEMENTS

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