Tsunami Disaster Detection

Team 41, Justice Code

New Mexico Super Computing Challenge

Final Report

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Abstract

Purpose of the Experiment

Tsunamis are giant waves that are usually caused by an earthquake or volcanic eruption. Depending on the size of the event, a tsunami can easily reach speeds of up to 500mph. In addition to the extensive amount of damage they bring, tsunamis can also be quite deadly when they hit land, killing thousands of people. There is no way to stop a tsunami from happening, so the next best action would be an early detection system. An early detection system would at least alert the residents of the best way to prepare for an incoming tsunami. The purpose of this experiment is to produce an algorithm that will assist in the detection of the strength of an underwater earthquake, the type of the tsunami as a result of the earthquake, and the level of warning that would need to be issued to the coastline community.

Data

We reviewed data from multiple websites, most notably the National Oceanic and Atmospheric Administration (NOAA). Although the data was sufficient, it honestly was too detailed for the purposes of our experiment. We ultimately designed an algorithm that would input seismograph buoys in certain locations, and then randomly generate earthquakes that would produce shockwaves that traveled at different speeds.

Procedure

Modify an existing StarLogo Nova program that would ultimately produce random earthquakes and shockwave speeds that would determine the type of warning necessary that needs to be issued.

Conclusions

We believe our model makes sense and our logic is sound. The stronger and faster the shockwave, the higher degree of warning.

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Tsunami Disaster Detection

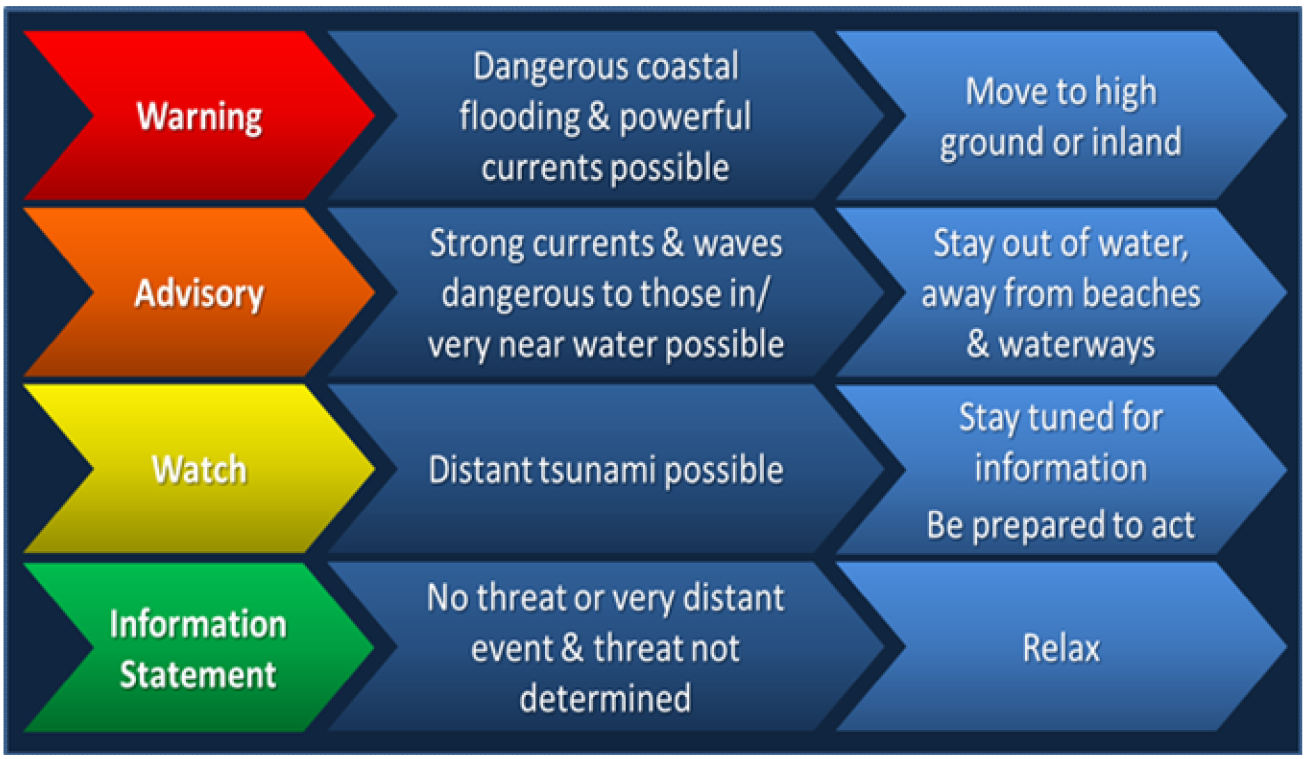
Introduction

Problem Statement

Tsunamis are a series of giant waves that can be caused by underwater earthquakes or underwater volcanic eruptions. When this happens, the vibrations from underwater cause a series of waves. As the waves move closer to the shores, they can become massive in size. Once they reach the shores, the destruction caused by the waves can be both catastrophic and deadly to the shoreline cities in its path. While a tsunami is occurring, it builds up energy over the distance until it hits land, thereby generating a great amount of force. One of the larger tsunamis occurred as recently as 2004 in the Indian Ocean in which 283,000 people perished. Tsunamis have been recorded to be as high as 100ft with speeds up to 500mph so one could imagine the deadly impact it would have on a coastline. One way to combat the effects of a tsunami is to install a system in which the residents would be warned when a large earthquake occurs in the ocean relative to their location. A detection system based on seismographic reading could detect significant movement in the ocean and based upon certain criteria, would alert the residents of their need to evacuate. In this project, we will use StarLogo Nova to create an algorithm that a city can use to provide different levels of alert if needed. The warning will be based upon the speed of the shock wave when it contacts the seismographic buoys.

Problem Solving Approach

Ocean based sensors are the primary source for reporting significant movement along the ocean floor. The preliminary seismic data consisting of magnitude, location, and depth is what is used to determine the necessity of whether a tsunami warning should be implemented as shown below.



Deep Ocean Assessment and Reporting of Tsunami (DART) systems are buoys that are strategically scattered throughout the Pacific Ocean, Atlantic Ocean, Indian Ocean and the Gulf of Mexico. The buoys are anchored to a device on the sea floor called a tsunameter. The tsunameter is a device that continually gathers information like rain rates, wind and wave data, along with underwater pressure and background noise. This information, combined with seismological data that occurs after an event such as an earthquake, is what is used to determine tsunami conditions.

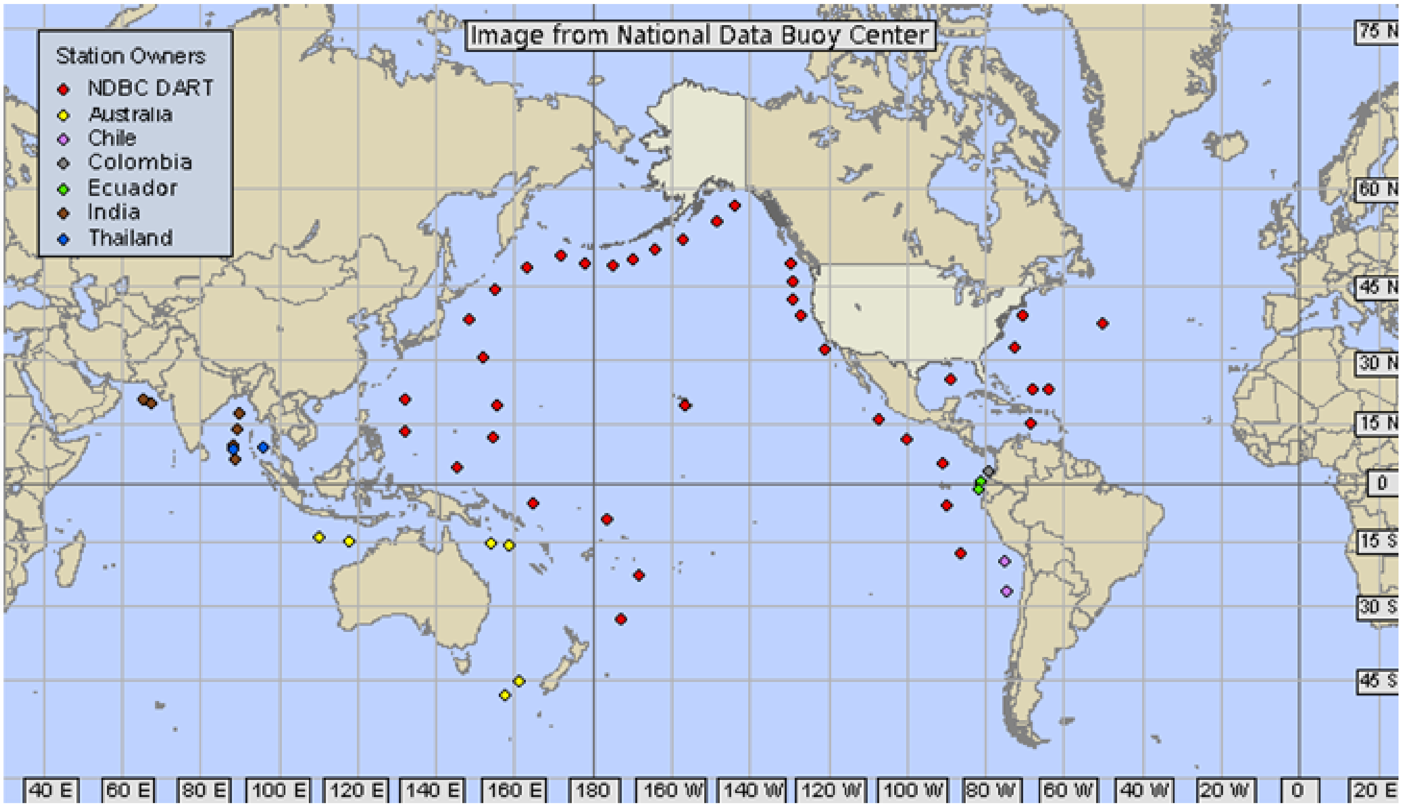


Figure 1. DART system locations of tsunameters around the world

Hypothesis

Our project is designed to test the hypothesis that the strength of the underwater event (earthquake or volcano) will determine how fast the shockwave will reach the buoys. That measurement will help authorities determine the likelihood of a possible tsunami and the size of it. At that point the authorities would then be able to determine what type of warning would need to be issued to the public for their safety

Materials & Methods

Computational Model Selection & Modifications

We decided to use a base model via StarLogo Nova entitled "Locating the Epicenter of an Earthquake". From this base model, we were able to modify the algorithm so that it would produce random earthquake events. We also were able to input an algorithm that placed seismographic buoys in specific locations. The buoys are designed to track the speeds of shockwaves from one to the next. Once executed, the program tracks the speed in which the shockwave travels and contacts multiple buoys. Ideally, the data from the buoys is what would be used to warn the people inland if they should either…

- Relax
- Stay tuned for more information and be prepared to act
- Stay out of water, away from beaches and waterways
- Move to high ground or inland

The pictures below show an example of the shockwave from a random earthquake as it travels and hits the buoys. The blue circle represents where the shockwave originated (the epicenter of the earthquake), while the red circle represents the travel pattern of the initial shockwave.

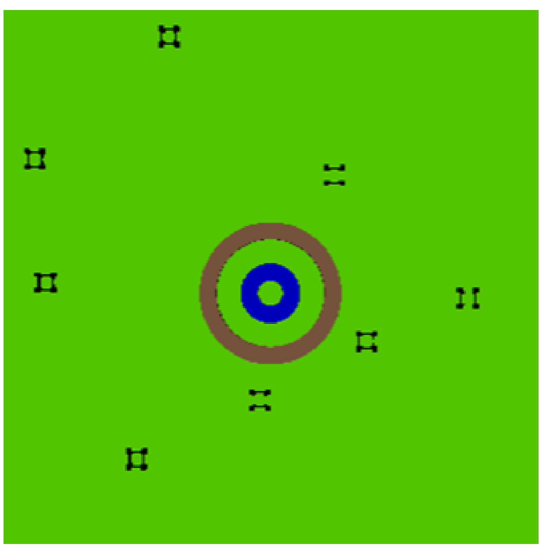


Figure 1. Event happens (earthquake, volcano)

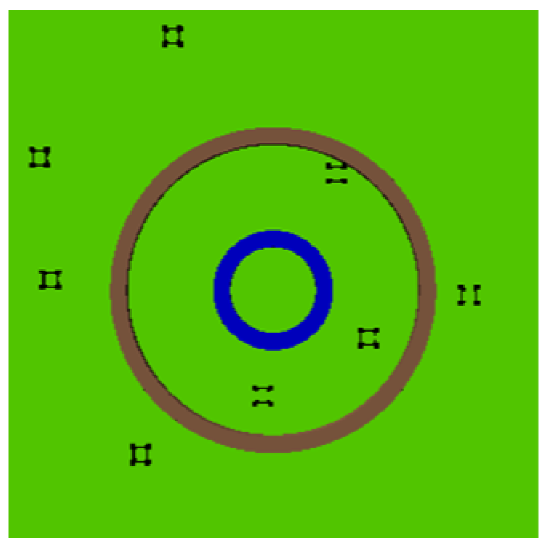


Figure 2. Shockwave hits 3 buoys at a certain speed

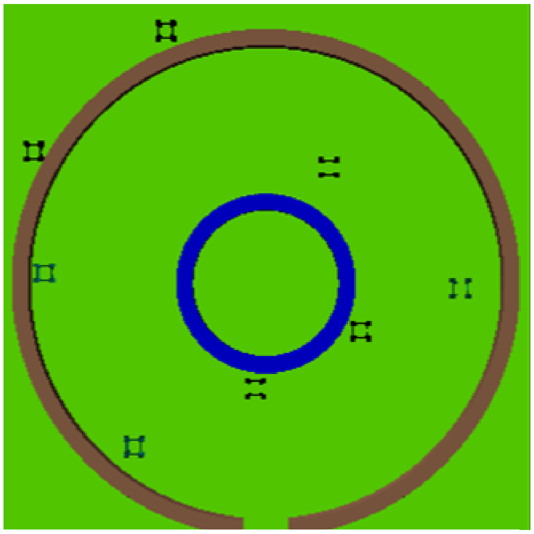


Figure 3. Shockwave continues to spread making contact with more buoys. The speed is recorded and relayed.

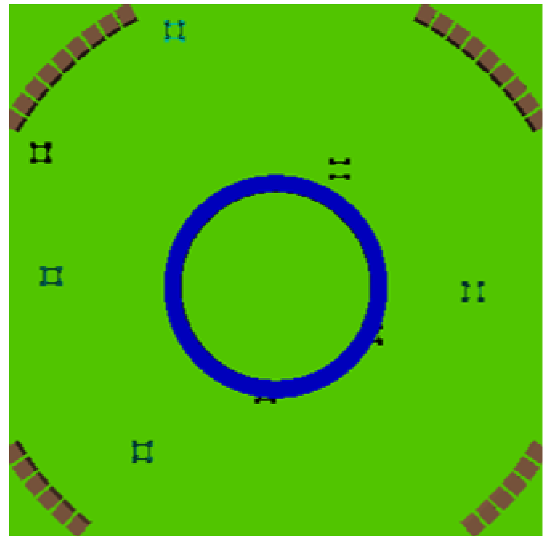
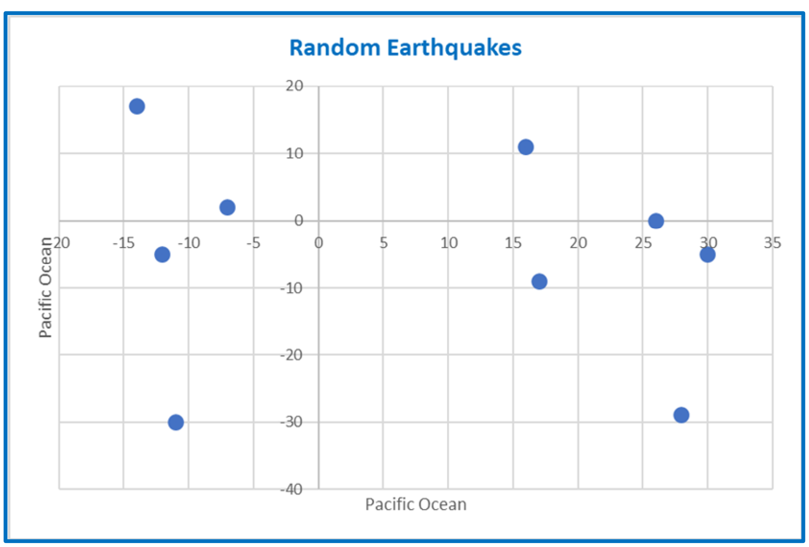


Figure 4. Shockwave has hit most of the buoys in a certain direction. At this point we can determine the severity of the possible tsunami and issue warning as needed.

Problem Solving Method

We hypothesized the stronger and more powerful the earthquake, the faster the shockwave would travel. To prove this, we coded the program to put in random earthquake locations along with random levels of impact. We also programmed the buoys to remain in one place. We figured that if we recorded the speed of the shockwave as it hits each buoy that it would give us a good sense of how powerful and fast a possible tsunami would end up traveling. Below is a graph showing random earthquakes that happened when we ran the program.

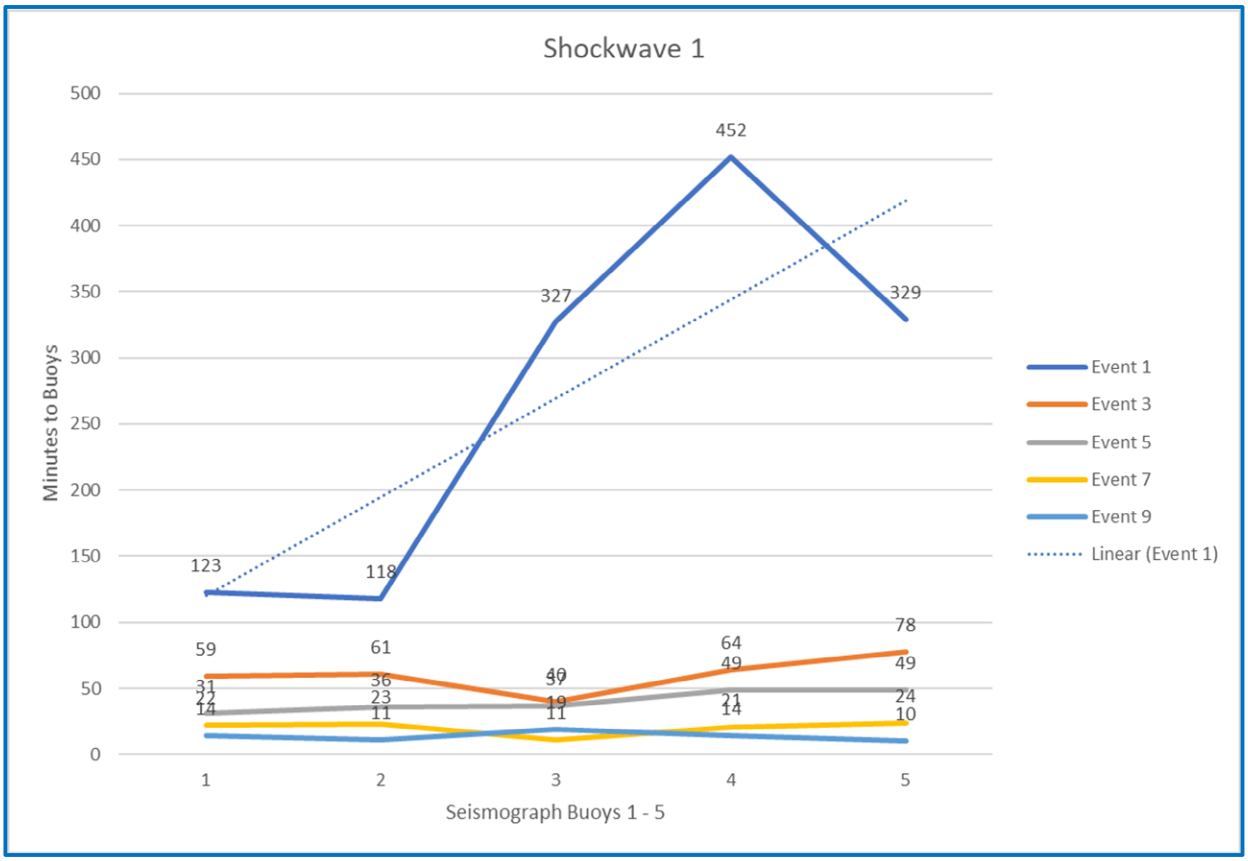


Verification

The program ran successfully. Although we ran the program more than 50 times, we chose to get data from a total of 9 runs. The table below shows the impact of the event (earthquake) and the speed in minutes in which the shockwave travels from one buoy to the next (S1 – S5).

Event#	Event Impact	S1	S2	S3	S4	S5
1	0.15	123	118	327	452	329
2	0.5	129	111	148	42	50
3	0.85	59	61	40	64	78
4	1.2	55	53	43	31	44
5	1.55	31	36	37	49	49
6	1.93	33	33	20	27	33
7	2.28	22	23	11	21	24
8	2.63	19	16	22	13	12
9	2.98	14	11	19	14	10

When we tried to plot the data, the graph was too jumbled, so we chose to use data from events 1, 3, 5, 7 and 9. The graph below shows that information.



Results

The algorithm performed as expected. We were able to program random earthquakes that produced shockwaves at different speeds. However, the time that it took the shockwave to travel from buoy to buoy did not coincide with the level of the first impact. We found that regardless of the size of the impact or the position of the earthquake, that there was no real consistency with the travel time of the shockwaves. Some sped up as well as slowed down during travel. We also realized that adding up the difference in travel time between the buoys didn't help that much either. We had planned to use that information to help us decide what type of warning would need to be issued.

Conclusion

In closing, early detectio006E systems are necessary to aid in the prevention of loss of property and more importantly, loss of life. Our model was an attempt to modify currently existing detection methods to help in the advance warning of a possible tsunami. Our model didn't give us the results we expected, but we believe it is because we don't have enough information. We are confident that our model can be used for different possible natural disasters, we would just need to keep working on it. As long as there will be natural disasters, there will be a need for a model such as ours.

Acknowledgements

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