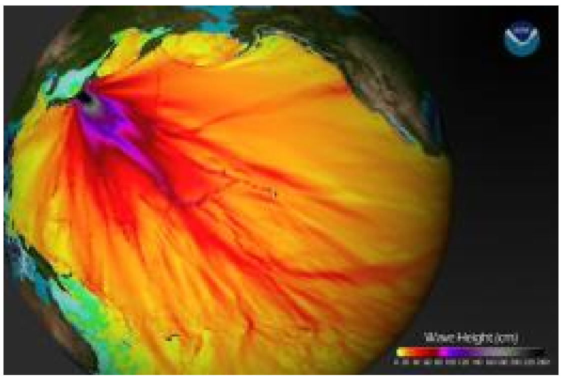
The science behind a tsunami

March 14 2011, By Nancy Atkinson



Model projections of wave heights from the Japan quake on Friday. Credit: NOAA

The massive magnitude 8.9 earthquake that struck off the east coast Japan's main island on March 11, 2011 set in motion a fierce tsunami that may have claimed thousands of lives, and sent tsunami warnings all across the Pacific basin, thousands of kilometers away from the quake's epicenter. How do earthquakes trigger such enormous tsunami events, and how can scientists predict where these massive waves might travel?

Universe Today talked with Anne Sheehan, who is a professor of geological sciences at University of Colorado at Boulder, and is also affiliated with the Cooperative Institute for Research in Environmental Sciences, as well as getting input from David Admiraal, an associate professor of Engineering at the University of Nebraska Lincoln.

Universe Today: How does an earthquake trigger a tsunami?

David Admiraal: Tsunamis are formed when you have an earthquake, and when there is a shift in the bottom of the ocean which causes displacement of the water, and that displacement causes a wave to form.

UT: Does an earthquake need to be a certain magnitude to cause a tsunami?

Anne Sheehan: It depends on where it is more than magnitude. It has to be something that displaces the sea floor – a big earthquake in Colorado will not cause a tsunami, for example. And sometimes there are earthquakes that cause a big tsunami, and the earthquakes aren't all that big — they just happen to be ones that have moved more seafloor. So, there is not a hard and fast magnitude limit, but it has to take place under the ocean, and has to move the ocean floor vertically – if it moves it side to side it doesn't matter as much.

UT: How fast do tsunami waves travel?

Sheehan: They travel about 800 km per hour, (500 miles per hour). That seems fast, but compared to a seismic wave it is slow. It is said tsuanmis travel the speed of a jet plane, but it still takes hours and hours to fly from Tokyo to Hawaii, and it took about 7 hours for the tsunami to reach the shores of Hawaii, which is a good thing because that gives people time to evacuate and prepare. But still, that is a fast speed for traveling on the ocean, and it can travel that fast because of the depth of the ocean.

The speed of seismic wave, the P wave (or primary wave, which is the fastest kind of seismic wave) is about 8 km per second, or 30,000 km per hour. So that is quite a bit faster, and it can take just minutes for the seismic wave to travel that same distance.

UT: How are tsunamis different from normal waves we have in the ocean?

Sheehan: They are different because they don't have a peak and a trough that are fractions of seconds long. With tsunamis , the peak and trough are about 15 minutes long. The size of the wave is huge – even though its amplitude, or its height is not much bigger than what you would find when you are surfing, but there is a whole wall of water that is going out behind it for 15 minutes into the ocean. It might not be perceptible from the surface — there may be just a small rise on the surface. For ships on the oceans, the waves are barely noticeable, but in harbors they can get tossed around quite a bit.

Admiraal: So, in the ocean, you may just have a small rise in the surface, but the rise contains a lot of energy. When it gets to shore, where the ocean is shallower, then the wavelength of the wave decreases a lot because the speed of the wave decreases. And when the front end of the wave slows down when it hits shallower water and the short, the front end is traveling much slower than the back end and so the back end of the wave catches up with the front end and the wave starts to develop a high amplitude. When it reaches the very shallow depths where it breaks, and the back end catches up with the front end, the height can be so high that it can cause damage to anything on the land surface that is next to the ocean.

Sheehan: The difference between tsunami and an ocean wave is that a tsunami is like a whole river that shows up — a tsunami is like a Class 4 rapids that just shows up and all of a sudden you have a river of water that wasn't there before.

UT: Why can't the height of tsunami waves be predicted very well before they reach shore?

Sheehan: While we can predict the speed and the direction pretty well, the height at a given location is can be pretty hard to predict.

There are DART buoys (Deep-ocean Assessment and Reporting of Tsunamis) in the ocean and on the bottom of the ocean to measure the sea floor pressure, and it measures the tsunamis to see how big they are, and they have models to predict what the amplitudes will be. Ways to improve monitoring would be to have more buoys and more detailed maps of the seas floor, because the patterns of the sea floor topography have a big effect on how the waves might focus. So, that is something that NOAA is actively working on for the US, New Zealand, and Japan. So if you have a better sea floor map, you have a better estimate of the tsunami model and if you have more data from the waves out in the open ocean, you will have a better height estimate as well.

Also, for predicting an ensuing tsunami, to have data on the earthquake itself — getting its epicenter located and knowing its size as accurately as possible plays a big role, and the USGS plays a big role in getting that information out as quickly as possible.

Source: Universe Today

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