# Improvement of ability of coastal regions to withstand large-scale tsunami

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*(Key words) Large-scale tsunami, marine radar, tsunami evacuation*

## 1. Introduction

The Nankai Trough Giant Earthquake Model Research Committee established in the Cabinet Office has defined the maximum class tsunami that could possibly occur as a tsunami with maximum height of 34m inundating a maximum of 100,000 hectares of land. The Central Disaster Prevention Council published Nankai Trough Giant Earthquake Countermeasures (Final Report) in May 2013, in which, concerning its basic views concerning tsunami it states, “The goal of tsunami countermeasures is to ‘protect human life’ from tsunamis. And premised on building and maintaining coastal preservation facilities etc., focusing on the evacuation of residents by including establishing information transmission systems, evacuation sites, evacuation facilities, and evacuation routes, with their most important goal being ensuring that every resident voluntarily, promptly, and correctly evacuates. This requires that comprehensive measures including disaster prevention education, evacuation training, and support for persons requiring assistance during disasters be promoted”.

The legal framework concerning measures for protection from large-scale earthquakes and tsunami was established with the proclamation in November 2013 of the *Act* For Special Measures Against a Capital Inland Earthquake (Capital Inland Earthquake Measures Act) and Act to Partially Revise the Act on Special Measures concerning Advancement of Countermeasures against Disasters of Tonankai and Nankai Earthquakes (Tonankai and Nankai Earthquake Measures Act), followed in December with the proclamation of the Basic Law to Strengthen the National Land to Contribute to Prevent or Mitigate Disasters to Realize Strong and Flexible Life for the People (Strengthening the National Land Act).

In the future, earthquake and tsunami countermeasures will be taken in conformity with the Capital Inland Earthquake Measures Act, Tonankai and Nankai Earthquake Measures Act, and Strengthening the National Land Act. So to prepare for tsunami, it is considered important to ensure that evacuation be performed and that it be effective in saving human lives by ensuring a stipulated level of protection based on facilities that prevent the occurrence of damage. To technologically support these, the Coastal, Marine and Disaster Prevention Department is making efforts to develop [1] tsunami measurement technologies based on marine radar, and [2] tsunami evacuation simulation technologies.

## 2. Measuring tsunami with marine radar

The NILIM successfully used marine radar to clarify the flow velocity field of the tsunami triggered by the Great East Japan Earthquake (2011). This verified tsunami detection using marine radar, which had been theoretically and numerically studied by many researchers since the 1970s. The NILIM analyzed the data from marine radar installed in the Minato District of Wakayama City, areally clarifying the height, speed of advance etc. of the tsunami, and determining that tsunami waves 1 to 3 were traveling waves, and that it is highly likely that later waves were caused by secondary undulations in the channels.

If it were possible use marine radar to stably measure approaching tsunami or secondary undulations in real time, this ability would be extremely useful in preparing tsunami countermeasures. For example, if tsunami traveling offshore could be measured, it would be possible to use the results to prevent over or under-estimation of Meteorological Agency predictions or to support residents’ evacuation. In coastal seas (channels or enclosed inner bays), water level fluctuations caused by secondary undulations continued for several days after the earthquake. In the Kii Channel, there are places where the maximum water level was measured the next day on March 12. In this way, along the coast, monitoring secondary undulation is useful for judging the correct time to cancel alerts or start work to reopen channels. The fact that the earthquake or tsunami caused the discharge of heavy oil or chemicals from shoreline industrial zones into coastal waters is also considered. To clarify these dispersions, it is important to measure wind-blown currents, density currents, or tidal currents, which fluctuate on time scales ranging from several hours to several days, rather than tsunami or secondary undulations. This means that it is necessary to simultaneously measure short-cycle tsunami or secondary undulations and long-cycle flows.

## 3. Evacuation simulation

In ports and fishing harbors, outside the seawall there are sections used for loading and unloading or boarding or getting off ships, for parking vehicles visiting the port, disposing or storing cargoes or fish products, and sections where shoreline business offices stand. These sections are submerged even by tsunami that would not be described as huge, so it is important to plan them carefully considering evacuation from tsunami and to closely follow this plan.

In December 2004, a giant magnitude 9.1 earthquake struck offshore west of the northern part of the Island of Sumatra in Indonesia, causing large-scale tsunami that resulted in about 300,000 fatalities or missing in the countries surrounding the Indian Ocean. In August 2005, large-scale Hurricane Katrina struck the southeastern United States. It breached the dykes in the City of New Orleans, submerging 80% of the city. More than 1,400 people died in the center of New Orleans and more than 1 million were forced to evacuate, making it one of the most destructive natural disasters in American history.

In response to such tragic events outside of Japan, the NILIM has developed tsunami evacuation simulation technology. Thanks to later research, in 2011, it became possible to perform a specified level of tsunami evacuation simulations. An investigation of the reproducibility of tsunami evacuation simulations developed to obtain actual tsunami evacuation data based on the tsunami caused by the Great East Japan Earthquake has confirmed that it they can perform highly realistic reproductions.

Tsunami evacuation must be strengthened to prepare for the feared Tonankai and Nankai earthquake tsunamis. In order to ensure more reliable tsunami evacuations, it is necessary to enact effective tsunami evacuation plans, to execute them, and increase the effectiveness of evacuations by providing regular training or by constructing facilities. Tsunami evacuation simulations are tools of great use when conducting studies or performing verifications to enact effective tsunami evacuation plans, or plans for evacuation training or evacuation facilities. At this time, we are making improvements to more realistically reproduce evacuation activities in port and harbor districts.

## 4. Responding to mega-risk type coastal disasters

In response to the Indian Ocean tsunami of December 2004 and to the Hurricane Katrina disaster of August 2005, the NILIM conducted “research on evaluation of countermeasures with diverse effects taken to deal with low-frequency mega-risk type coastal disasters”, and completed the manuscript of a project research report immediately before the Great East Japan Earthquake of March 2011.

When a tsunami with extremely low probability of occurring actually does occur, it inflicts catastrophic damage in regions it strikes, endangering the lives and economies of the people of the region. Concepts of response were organized assuming that such damage is a “low-frequency mega-risk type coastal disaster”.

Firstly, regarding a tsunami that causes catastrophic damage even though its occurrence frequency is extremely low, it is not the case that countermeasures for it are not studied only because its occurrence frequency is extremely low. Secondly, excessive investment is not made in order that it be impossible to accept later that it was investment matched to needs, just because it was done to prepare for a giant tsunami. Considering the result of combining these two administrative policies to be a Japanese version of a “No regret policy”, it was the foundation of studying countermeasures in preparation for giant tsunamis. In order to realize preparations for giant tsunami, considering the various problems which Japan faces, application to policy development with a high degree of freedom and double-track organization use with priority on workability is probably more necessary than ever.

## 5. Conclusions

Fears of the occurrence of a giant tsunami following the Nankai Trough Earthquake and people’s shared memories of the tsunami triggered by the Great East Japan Earthquake of 2011 have increased public interest in strengthening the ability of coastal regions to withstand giant tsunamis. The tsunami which would be caused by the predicted Nankai Earthquake would be far higher than any tsunami considered up till the present time. How to protect people’s lives and property and regional economies and industries from this tsunami, and how to overcome the time against time scale said to be once every thousand years, are questions which are not easily answered. Concrete initiatives to deal with such problems from a number of perspectives are beginning. It is difficult to take initiatives predicting the answer from the beginning, but we wish to exercise our imaginative powers and apply our capabilities to proceed one step at a time to resolve the problems.