Press Releases

January 29, 2015
JAMSTEC

Earth's Free Oscillations Excited by Small Earthquakes in Nankai Trough
-New Incessant Excitation Sources Found-

1. Overview

Dr. Takashi Tonegawa and his team at Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology (JAMSTEC: President Asahiko Taira) found for the first time that acoustic coupled Rayleigh (ACR) waves [*1] cause incessant oscillations of ocean-crust systems around the Nankai Trough subduction zone. They were retrieved by correlating ambient noise on a hydrophone array deployed across the trough, applying seismic interferometry[*2] techniques. Also, it became clear that the direction in which strong ACR waves propagate coincides with seismicity around the Nankai Trough subduction zone. It also provides strong evidence that earthquakes generate ACR waves.

It is known that fluid disturbances in the atmosphere and oceans constantly make incessant oscillations on the Earth. This phenomenon is caused by waves generated by fluid disturbances, which hit the solid Earth. However, we don't feel it because the cycle of oscillation is long with very small ground velocity.

Existing researches have considered that such oscillations are not excited from earthquakes, which occur only after seismogenesis, and earthquakes cannot be a factor of the Earth's incessant oscillations. However, this study's observation data demonstrated that frequent earthquake areas are sources of persistent ACR waves. In addition, their numerical simulations also showed that ACR waves are excited by earthquakes. The research team concluded that ACR waves are excited by small intermittent earthquakes near subductuion zones, which incessantly makes ocean and crust systems oscillate.

Observation of Earth's free oscillations will be a useful approach for developing structural studies of Earth as well as planetary bodies such as Venus and Mars. This new finding about incessant ACR waves is expected to play a significant role in examining seismic wave velocity and monitoring of crustal activity around subduction zones.

These study results have been posted on the online *Nature Communications* on January 29, 2015 (JST: 19 : 00).

Title: Ambient seafloor noise excited by earthquakes in the Nankai subduction zone
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*1 Seismic interferometry: It is a technique for highlighting and extracting background wavefields in noise. Signals and noise are detected from observation data, however, such noise may also include some background wave propagations. An application of this technique allows us to detect such waves propagating between two observation locations. It was first introduced by Campillo and Paul in 2003.

*2 Acoustic coupled Rayleigh (ACR) waves: These wave energies propagate through oceans and crust (several kilometers below seafloor). It is observed only in ocean areas, never on land. The dominant period is 0.2-2 seconds. This research found those waves excited by small earthquakes, however, they are also excited by mega earthquakes, and propagate a very long distance up to about 10,000km.

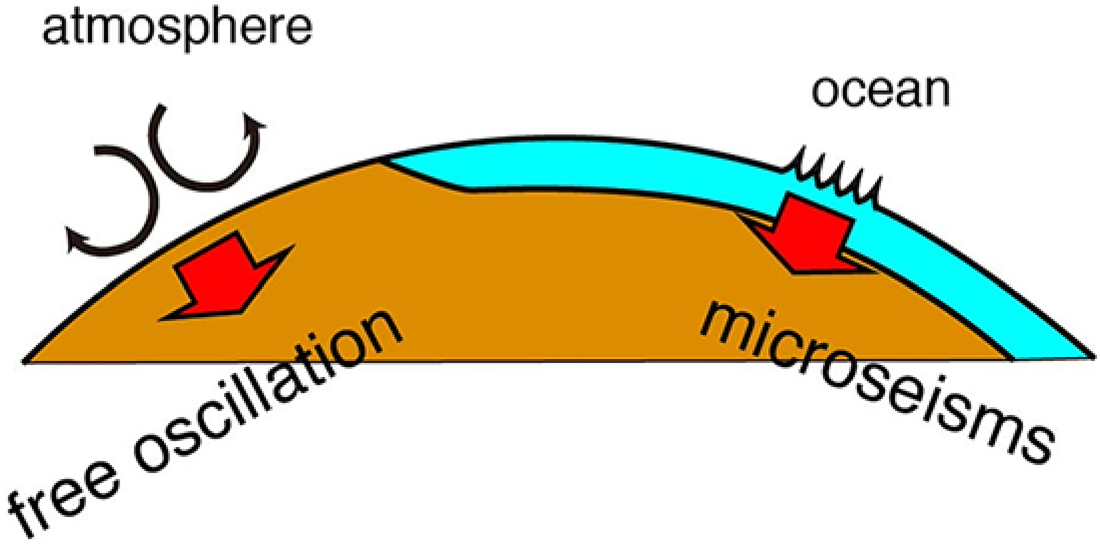


Figure 1: Earth’s free oscillations excited by fluid disturbances in the atmosphere and ocean (free oscillations and microseisms).

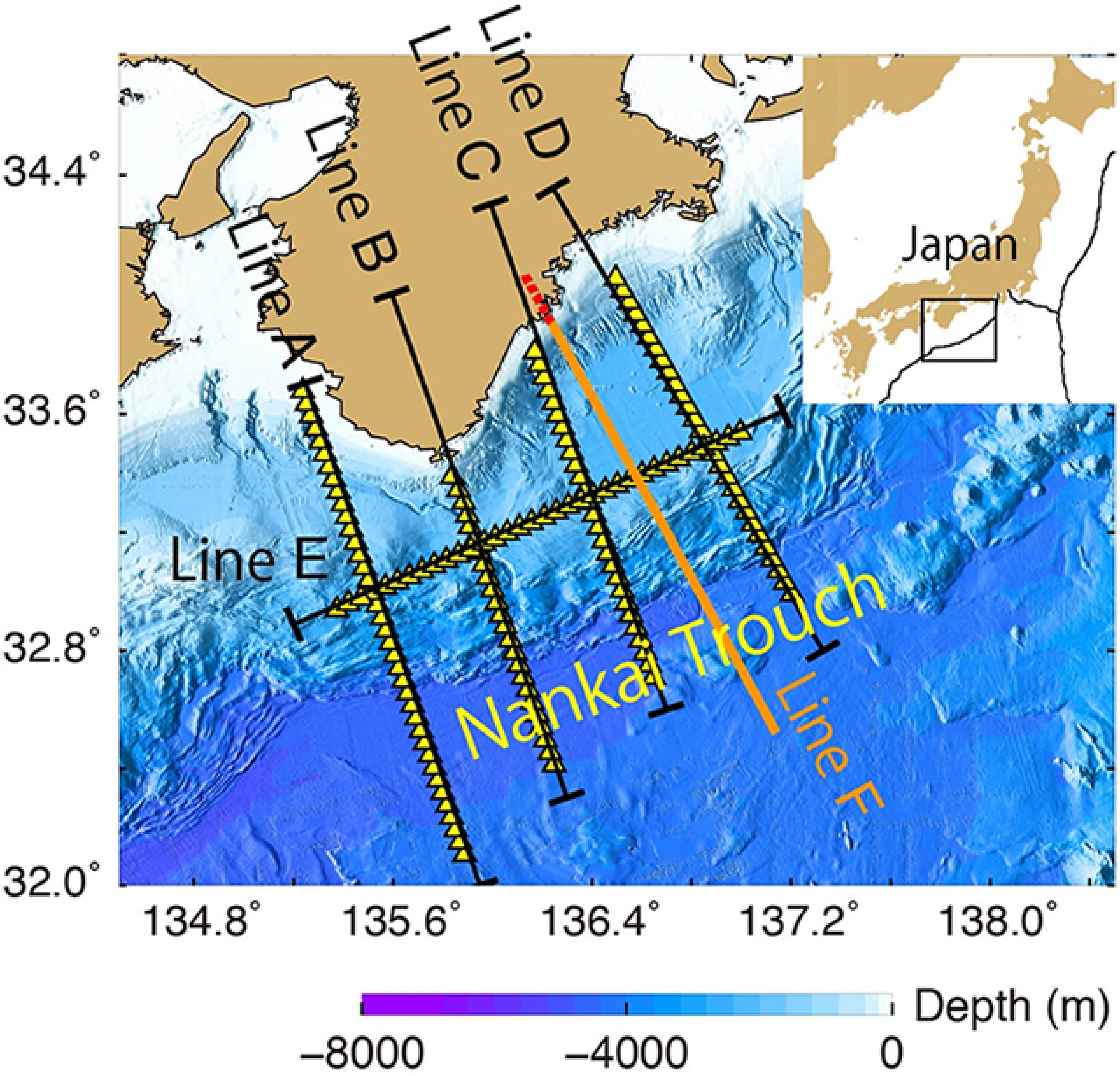


Figure 2: Hydrophones deployed around Nankai Trough (shown by yellow triangles)

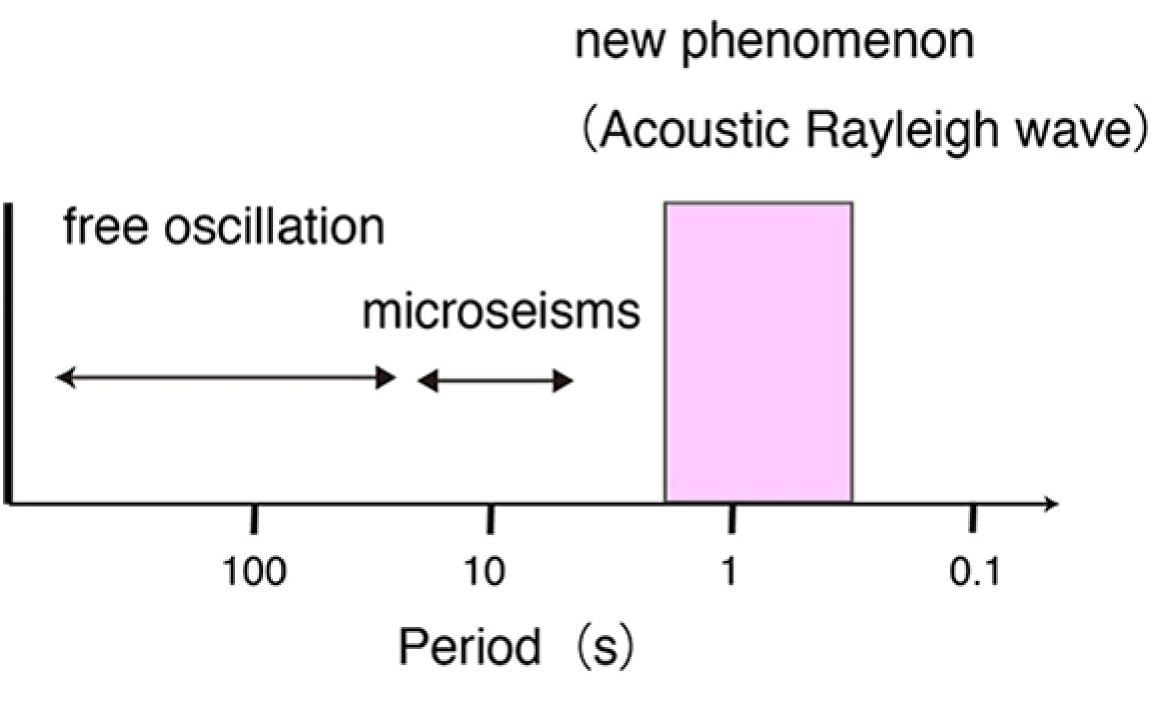
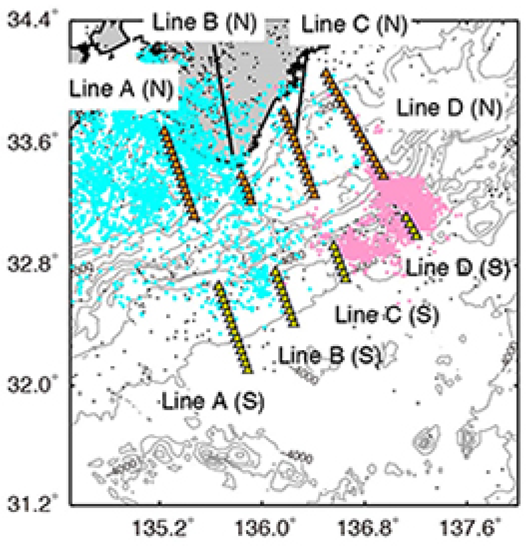


Figure 3: Predominant period of the Earth’s free oscillations, microseisms, and ACR waves



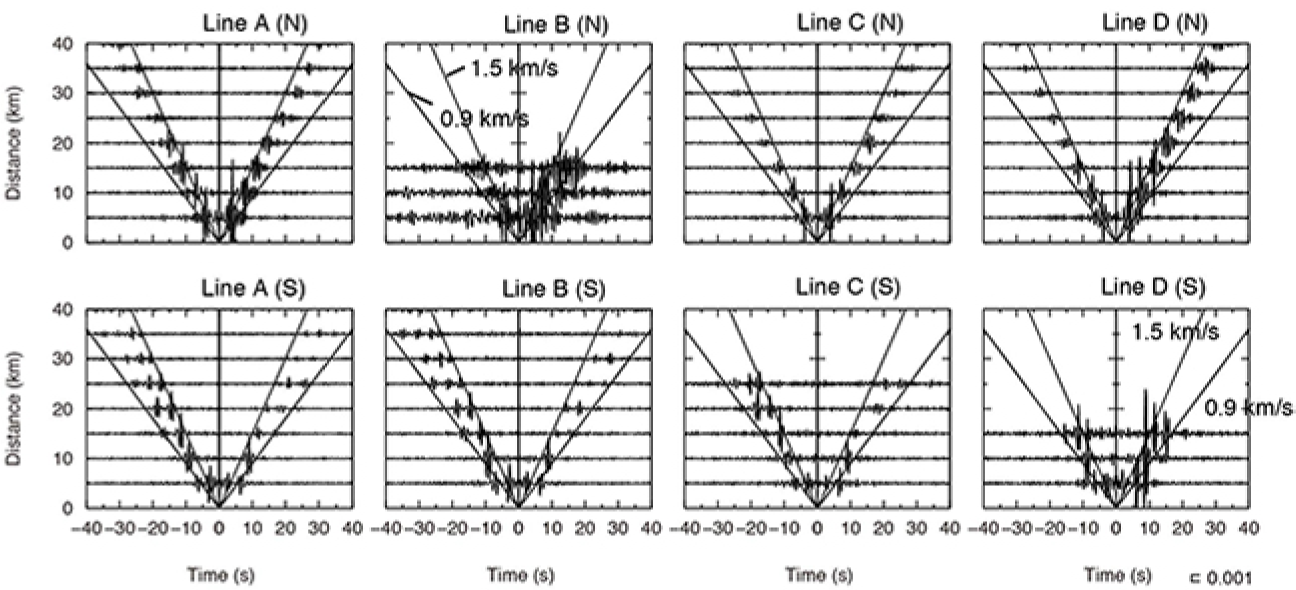


Figure 4: Propagation directions of the ACR waves estimated based on seismic interferometry.
(Top) Data obtained from hydrophones (as shown in fig.2) were divided into eight groups. For these data, the seismic interferometry technique was applied. Pale-blue and pink dots represent the seismicities that occurred around the Nankai Trough.The “N” and “S” indicate north and south, respectively.
(Bottom) Propagation directions of the ACR waves. Positive lag time indicates wave propagating northwards while negative one southwards. Two solid lines in positive and negative lag times represent the reference velocities of 1.5 and 0.9 km s–1, in which the observed ACR waves propagate. At Line A (N), northwards and southwards wave propagations are strong, while only northwards propagation is strong at Line C (N) and Line D (N). At Lines A–C (S), southwards propagations are remarkable.

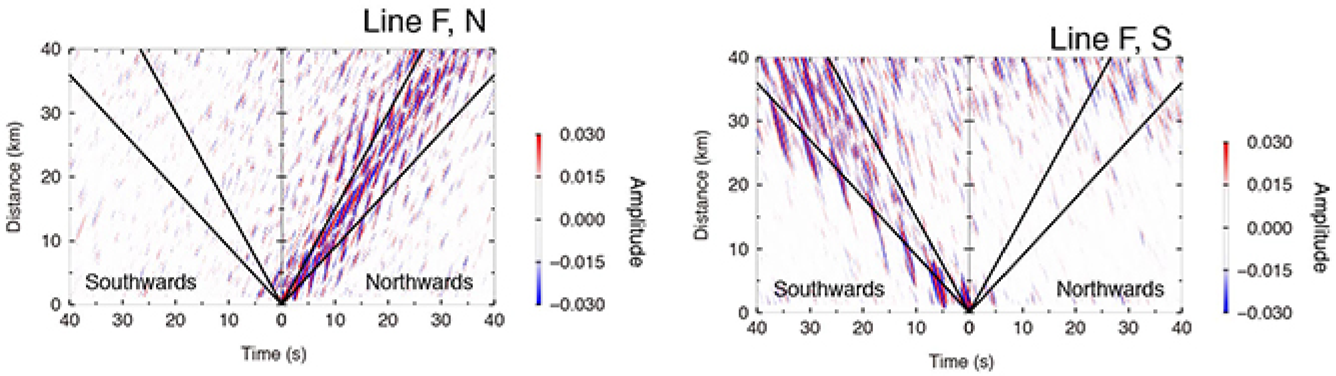


Figure 5: Numerical simulation results
(Left) An observation station was set on the north side of Line F ([fig. 2]()), and reproduced northwards propgation of Line C and Line D with sub-seafloor sources.
(Right) Southwards propgation between Line C and D were produced.

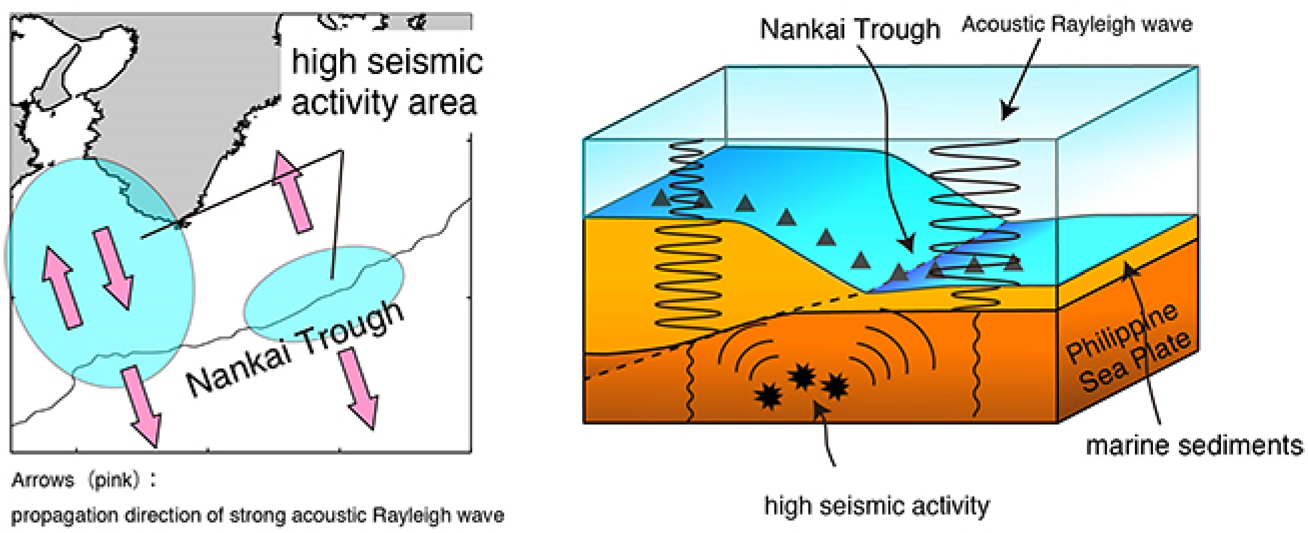


Figure 6: (Left) ACR waves (shown by pink arrows) are excited in frequent earthquake areas (shown in light blue). (Right) Earthquakes occurred below the seafloor generate seismic waves. These are converted to ACR waves with their energy at ocean and below seafloor, which incessantly oscillate oceans and crust system.

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