

STEPS Students Report

Yifei Wu (M2)

Department of Earth and Planetary Science

During my 7 weeks stay in Prof. Nosov's lab of Faculty of Physics, Lomonosov Moscow State University, my research topic focused about the generation of gravity waves in the ocean by seismic surface waves.

Gravity waves in the ocean generated by sources of static displacement are well studied. (Most of the usual tsunami belong to this kind of gravity waves) Although dynamic generation of gravity waves is also possible, this topic is not much studied because the amplitudes are thought to be small. However, it is not necessarily that the amplitude will always be small. Therefore, ignoring the importance of this kind of gravity waves may be dangerous. Meanwhile, studies of gravity waves of this origin may also provide us insights of information such as the seismic source or the later coming tsunami, which will be greatly helpful to hazard assessment or early warning.

As a great step forward in observation, during the 2011 Tohoku Earthquake, gravity waves that arrived earlier than tsunami were recorded by DONET stations near Kii peninsular (Nosov et. al. 2015) with period of the order of 100s and amplitude of a few centimeters. They discussed about the mechanism of its generation and concluded that the source was mainly horizontal component of seismic surface waves, interacting with local bathymetry.

To better understand the properties of gravity waves generated by seismic surface waves, numerical simulation is an excellent tool. In order to simulate these waves, velocity of ocean bottom as boundary condition is needed. Unfortunately, the velocimeters of DONET were saturated during the event. Using the velocity obtained by integrating the acceleration data suffers the problem that there exists systematical error in the acceleration data.

While nowadays, GPS data plays a key role in Geosciences. In Japan, there is a dense network with 1 Hz sampling rate called GOENET. So it is worthwhile to try to utilize these high quality GPS data to simulate the gravity waves.

First I have learned the basic physics of gravity waves with Prof. Nosov through "Physics of Tsunami", a textbook of which he is one of the authors. Then with the GPS data collected by colleagues in the lab, I constructed velocity field of ocean bottom movement using 2 different methods. With the obtained velocity field, numerical simulations are conducted, using a numerical model developed at Prof. Nosov's lab, which applies potential theory. The results obtained from simulations firstly show clear excision of gravity waves, thus gives a certification of possibility that gravity waves may be generated by seismic surface wave. Also the gravity waves are of period of the order of 100s and of amplitude of several centimeters, which agrees with the observation of DONET. Meanwhile, we can find that near where the steep slopes are located, stronger gravity waves are generated. Therefore, these gravity waves, as suggested by Nosov et. al. in 2015, is mainly generated by the horizontal movement of the ocean bottom with horizontal gradients.

Because of many potentials of going further on the topic, although the 7-week stay are quite short, it opened for me a new gate, and the collaboration will continue. Besides, I am glad to announce that the paper that includes my 7-week research is accepted by Moscow University Physics Bulletin (title: Numerical simulation of the gravity waves, excited in the ocean by low-frequency surface seismic waves, based on the GPS-stations recordings, author: K.A. Sementsov, M.A. Nosov, S.V. Kolesov, Y. Wu). So finally I want to thanks STEPS program for offering me such a good opportunity.