Simulation of Recurring Earthquakes along the Japan Trench

*Kenichi Fujita[1], Fuyuki Hirose[1], Kenji Maeda[1]

1.Meteorological Research Institute

1. Introduction

Magnitude (M) 7-8 earthquakes have been known to occur repeatedly along the Japan Trench by historical evidences. Recently the occurrence of the 2011 off the Pacific coast of Tohoku earthquake has proved the possibility of recurrence of M9 class earthquakes.

Basing on these data of the past earthquakes, we try to make the numerical simulation model reproducing magnitude (about 7-9) and recurrence interval (T) estimated for earthquakes recurring along the Japan Trench.

2. Methods

The target earthquakes that are known to occur repeatedly and we aim to simulated are the northern Sanriku earthquake (M~8.0, T~100 years), the Miyagi-oki earthquake (M~7.5, T~40 years), the near trench southern Sanriku earthquake (M~8.0, T~110 years), the Ibaraki-oki earthquake (M~7.0, T~20 years), and the type of The 2011 off the Pacific coast of Tohoku earthquake (M~9.0, T~600 years). In addition, we tried to reproduce the characteristics of earthquakes near trench northern Sanriku (1896 Meiji-Sanriku earthquake of Mt~8.6-9.0) and around Fukushima-oki (1938 Fukushima-oki earthquake swarm of M~7.4) whose repeatability, however, is not clear.

We used the equation of motion considering shear-stress reduction (Rice (1993)), and adopted the composite law (Kato and Tullis (2001)) for the rate- and state-dependent friction law. Analysis region was set largely enough to surround all asperities of the target earthquakes. We used the three-dimensional plate configuration of Nakajima and Hasegawa (2006), and set 17,507 triangular cells of the seize about 5 km. Subducting rate of the Pacific plate against land plate was put 8.0-8.2 cm/year from south to north referring to Wei and Seno (1998) etc. Frictional parameters (a, b, L) were chosen to reproduce magnitude and recurrence interval of the earthquakes by trial and error. We basically consider two types of parameter sets: Case 1 (background stable slip model), region surrounding asperities (background) is velocity strengthening ($a-b > 0$), Case 2 (hierarchical model), background is velocity weakening ($a-b < 0$).

3. Results

Magnitude and recurrence interval of earthquakes we simulated in our model as follows. In the case 1, the northern Sanriku earthquakes are (M~8.0, T~61-103 years), the Miyagi-oki earthquakes (M~7.4, T~30-74 years), the near trench southern Sanriku earthquakes (M~7.9, T~104-130 years), the Ibaraki-oki earthquakes (M~6.8, T~14-52 years), and the type of The 2011 off the Pacific coast of Tohoku Earthquake (M~8.3, T~203-232 years (the latter half magnitude of M8 class earthquakes occurred once every few times). It is noteworthy that near trench northern Sanriku earthquakes occurred a few years after the northern Sanriku earthquakes, and swarm-like Fukushima-oki earthquakes occurred in some cases.

In the case 2, the northern Sanriku earthquakes (M~7.9, T~66-140 years), the Miyagi-oki earthquakes (M~7.3, T~31-149 years), the near trench southern Sanriku earthquakes (M~7.8, T~120-216 years), and Ibaraki-oki earthquakes (M~6.8, T~9-51 years), and the type of the 2011 off the Pacific coast of Tohoku earthquake (M~8.5, T~294-526 years (M9 earthquakes occurred once every few times). In this case, near trench northern Sanriku earthquakes didn't occur, but swarm-like Fukushima-oki earthquakes occurred in some cases.

In the future studies, we will examine frictional parameters further in order to make more realistic numerical simulation models.

Keywords: Simulation of Recurring Earthquakes, The 2011 off the Pacific coast of Tohoku Earthquake

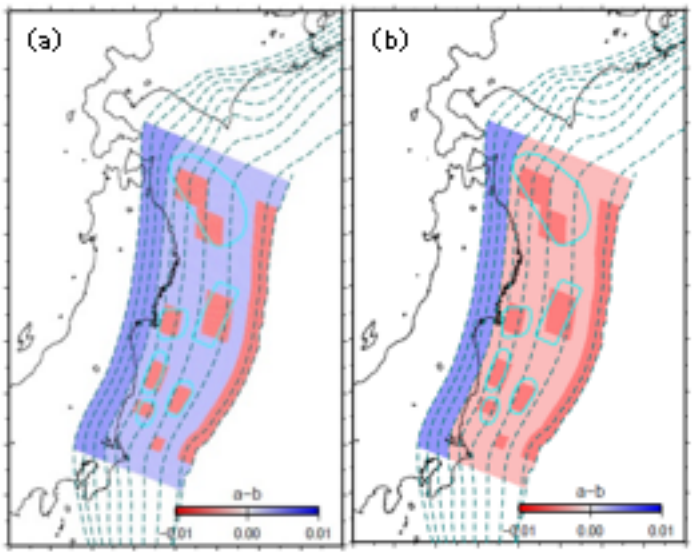

Figure 1. Friction parameter (a - b) (a) background stable slip model (b) hierarchical model

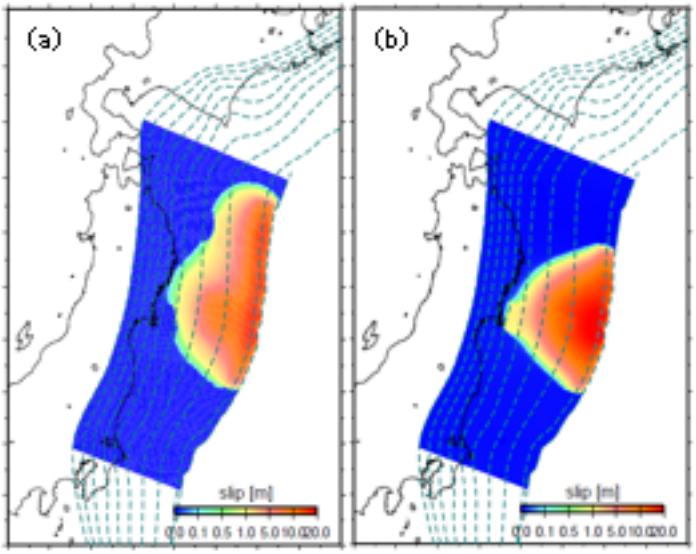

Figure 2. Slip distribution (a) background stable slip model (b) hierarchical model

