

Modification of the Precomputed Tsunami Database for JMA's Real-time Tsunami Forecast in Response to the 2016 off Fukushima Earthquake

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An intraplate normal-fault earthquake with a magnitude (M_{JMA}) of 7.4 and the tension axis in the northwest–southeast direction occurred off Fukushima Prefecture, Japan (2016 off-Fukushima earthquake) on November 22, 2016¹). On the other hand, the tsunami database²), which contains the precalculated tsunami data used for real-time tsunami forecasting by the Japan Meteorological Agency (JMA), has prepared north–south oriented reverse fault type earthquakes for this region. Prior to the 2011 Tohoku earthquake (moment magnitude: 9.0), numerous reverse fault earthquakes occurred within the plate on the landward side and at the plate boundary of the subduction zone in the coastal area of Fukushima Prefecture; however, after the 2011 Tohoku earthquake, the proportion of normal fault and lateral displacement earthquakes increased in this region³). According to the previous study⁴), among the differences in earthquake mechanism between that assumed in the tsunami database and that of the 2016 off-Fukushima earthquake, the misforecast between normal and reverse faults did not affect the real-time tsunami forecast, while the difference in the strike angle of the fault plane was the main cause of the underestimated height forecast in Miyagi Prefecture.

Based on the concept that an efficient scenario arrangement can be achieved when the forecast differences of adjacent scenarios in the tsunami database are similar, and the results of sensitivity analyses of the tsunami height distribution to fault parameters for the 2016 off-Fukushima earthquake, it is reasonable to add tsunami scenarios with different fault plane strike angles and the same simulation point near the epicentral area. We compared the centroid moment tensor solutions for earthquakes of moment magnitude 5.5 or greater that occurred in coastal areas around Japan with the fault parameters assumed in the tsunami database. We then added scenarios to the tsunami database for areas where the difference in strike angle was 30° or more (Figure 1). Our performance tests with historical scenarios indicate that the underestimation of tsunami warnings for the 2016 off-Fukushima earthquake can be avoided by using the modified database (Table 1), and that new scenarios will be frequently referenced in future tsunami warning operations. The modified tsunami database has been used by JMA for real-time tsunami warning operations. Details of our study will be published in our research paper⁵).

1) Japan Meteorological Agency: Monthly Report on Earthquakes and Volcanoes in Japan, November 2016, pp. 56-76, 2016. (in Japanese)

- 2) Kamigaichi, O.: Tsunami forecasting and warning. in *Encyclopedia of Complexity and Systems Science*, Meyers, R.A. (ed.), Springer Science+Business Media, New York, 2015.
- 3) Earthquake Research Committee: Evaluation of Seismic Activities after the 2011 off the Pacific Coast of Tohoku Earthquake. <https://www.jishin.go.jp/main/index-e.html>, 2013. (accessed on 9 August, 2024)
- 4) Hayashi, Y: Sensitivity of tsunami height distribution to fault model parameters: Case study based on the 2016 off Fukushima Earthquake. *Jap. J. JSCE*, **77**(2), I_187-I_192, 2021. (in Japanese with English abstract).
- 5) Hayashi, Y., M. Kiyomoto, G.Tange, K. Noguchi, S. Harada, and Y. Nishimae: Modification of the pre-computed tsunami database for real-time tsunami forecasting by the JMA: Response to the 2016 off-Fukushima earthquake by the unexpected mechanism, *J. JSCE*, **12**, in print, 2024.

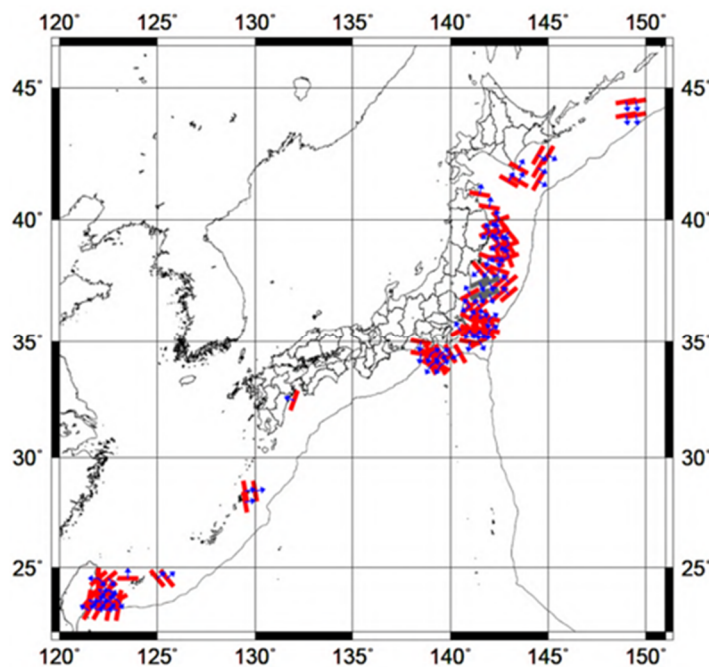


Fig. 1 Distribution of additional scenarios in the near-field tsunami database of JMA⁵⁾.

Forecast area	Actually issued tsunami warning categories after the earthquake		Observed maximum tsunami height	Test results with new scenarios
	3 min after	130 min after		
Pacific coast of Aomori Pref.	Advisory	Advisory	22 cm	Advisory
Iwate Pref.	Advisory	Advisory	79 cm	Advisory
Miyagi Pref.	Advisory	Warning	144 cm	Warning
Fukushima Pref.	Warning	Warning	83 cm	Warning
Ibaraki Pref.	Advisory	Advisory	49 cm	Advisory
Kujukuri and Sotobo Area	Advisory	Advisory	0.3 m	Advisory
Uchibo Area	-	Advisory	27 cm	-
Izu Island	-	Advisory	0.3 m	Advisory

* Warning and Advisory are categories indicating expected tsunami heights are up to 3 m, and 1 m, respectively.

Table 1. Results of performance test based on 2016 off-Fukushima earthquake: comparison of tsunami warning categories issued and those by the test with improved tsunami database.