Tsunami run-up heights of the 2004 off the Kii peninsula earthquakes

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(Received November 30, 2004; Revised February 24, 2005; Accepted February 25, 2005)

A tsunami height survey was conducted immediately after the 2004 off the Kii peninsula earthquakes. Results of the survey show that the largest tsunami height was about 4.6 m locally at Kiho-cho, Mie prefecture. Numerical simulation of the tsunami due to the earthquake was carried out using the model parameters estimated by NIED. The distribution pattern of the observed tsunami heights along the coast cannot be explained by the computed heights, because the model equation is linear long-wave theory and the run-up computations with a finer grid system are not included in this simulation. In order to explain tsunami run-up heights, it is necessary that the non-linear and run-up computation model should be used with a finer grid system.
Key words: The 2004 off the Kii peninsula earthquakes, tsunami height survey, tsunami numerical simulation.

1. Introduction

On 5 September 2004, two earthquakes occurred at sea off the Kii peninsula in Japan. The Japan Meteorological Agency (JMA) estimated the source parameters as follows: for the foreshock: origin time, 19:07 (JST); epicenter, 33.2N degrees, 136.9E degrees; depth 10 km; JMA magnitude, M_j 7.1. For the mainshock: origin time, 23:57 (JST); epicenter, 33.2N degrees, 137.1E degrees; depth, 10 km; JMA magnitude 7.4. The seismic moment of the second earthquake was 8.81×10^{19} Nm, or M_w 7.3 estimated by the National Research Institute for Earth Science and Disaster Prevention (NIED) in Japan. Immediately after the earthquakes, tsunami surveys were conducted by researchers from all over Japan. Several survey teams covered all the coasts of the eastern Kii peninsula. In this paper, observed tsunami run-up heights of the 2004 earthquakes off the Kii peninsula are compiled. The result of a numerical simulation of the 2004 tsunami is compared with the observed tsunami run-up heights.

2. Tsunami Height Survey

A tsunami assessment was conducted immediately after the earthquakes. The survey was compiled by 7 September, two days after the earthquakes. A quick survey is particularly important for a moderate tsunami of which the run-up heights are less than 2 m. Most of the deposits from such a moderate tsunami existed in the surf zone, although they were quickly disturbed by high waves. The results of the tsunami height survey are shown in Fig. 1 and Table 1. The heights are measured from various objects that the tsunami left behind or from eyewitness accounts. The observed tsunami heights due to the 2004 earthquakes in Table 1 are calculated from the tide level at the time of the maximum tsunami. The largest tsunami height was about 4.6 m locally at Kiho-cho, Mie. It seems that the tsunami height was higher there because of the shallow slope. Photo 1 shows the place where the tsunami height is the largest, at Kiho-cho.

3. Numerical Simulation of the Tsunami

The model parameters are estimated by NIED (2004) (see Table 2). The vertical seafloor-displacement was computed using Okada's (1985) equations and used as an initial condition for tsunami numerical computation (see Fig. 3). A finite-difference computation of the linear long-wave equations was carried out. The grid size was 1 km. The time step of the computation was 1 sec so as to satisfy the stability condition. The results of the tsunami computation are shown in Fig. 2 along with the observed tsunami heights. The computed heights largely underestimate the observed ones because the run-up computation using a finer grid system is not included in this simulation. The distribution pattern of the observed tsunami heights along the coast cannot be explained by the computed heights.

4. Conclusion

A tsunami height survey was conducted immediately after the 2004 off the Kii peninsula earthquakes. The results

Photo 1. Two photos when tsunami run-up heights were measured at Kiho-cho, Mie Prefecture.

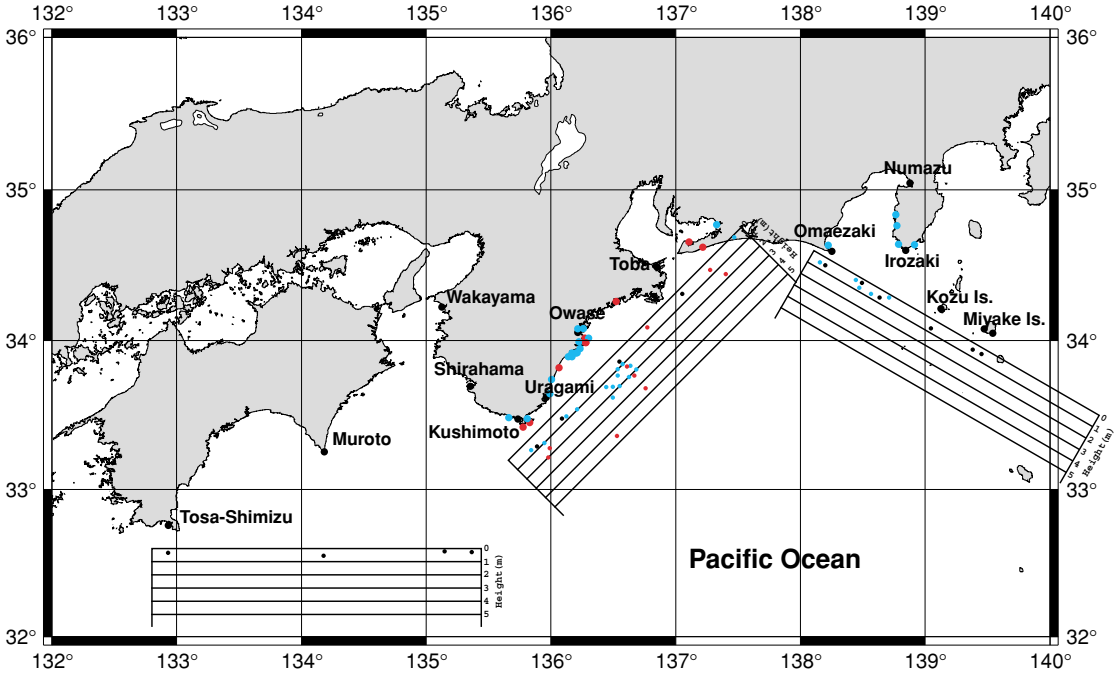

Fig. 1. The measured tsunami heights for the 2004 off the Kii peninsula earthquakes.

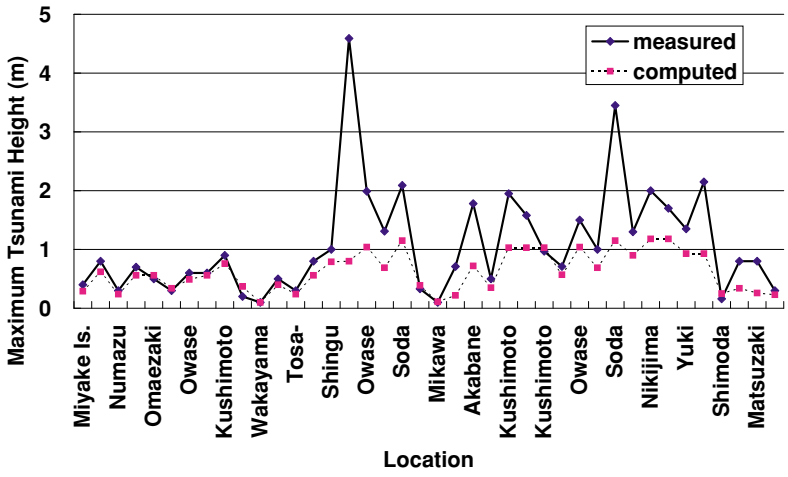

Fig. 2. Comparison of the measured and computed tsunami heights for the 2004 off the Kii peninsula earthquakes.

Table 1. Tsunami height survey results.

Survey point	Latitude (N)	Longitude (E)	Tsunami height (m) (corrected from tide)
Miyake Is. (tide gauge)	34 03	139 33	0.4
Kozu Is. (tide gauge)			0.8
Chichi Is. (tide gauge)	27 06	142 11	0.4
Numazu (tide gauge)	35 01	138 53	0.3
Irozaki (tide gauge)	34 37	138 51	0.7
Omaezaki (tide gauge)	34 37	138 13	0.5
Toba (tide gauge)	34 29	136 49	0.3
Owase (tide gauge)	34 05	136 12	0.6
Uragami (tide gauge)	33 33	135 54	0.6
Kushimoto (tide gauge)	33 29	135 46	0.9
Shirahama (tide gauge)	33 41	135 23	0.2
Wakayama (tide gauge)	34 13	135 09	0.1
Muroto (tide gauge)	33 16	134 10	0.5
Tosa-shimizu (tide gauge)	32 47	132 58	0.3
Katsuura (in the port)	33 37 33	135 56 43	0.8
Shingu (river mouth)	33 43 22	136 00 33	1.0
Kiho	33 46 09	136 01 45	4.59
Owase (in the port)	34 04 20	136 12 10	1.99
Kuki (Owase city)	34 01 02	136 16 53	1.31
Soda (Owase city)	33 59 56	136 13 25	2.09
Yoshizu	34 16 33	136 30 07	0.33
Mikawa (in the port)			0.1
Akabane (in the port)			1.78
Omaezaki (in the port)			0.5
Kushimoto (in the port)	33 26 47	135 46 22	1.95
Kushimoto	33 26 52	135 47 24	1.58
Kushimoto	33 26 47	135 46 22	0.97
Tanami (Kushimoto town)	33 29 07	135 46 22	0.71
Owase (in the port)	34 04 39	136 12 20	1.50
Kuki (Owase city)	34 00 52	136 15 09	1.00
Soda (Owase city)	33 59 52	136 15 35	3.45
Atashika (Kumano city)	33 55 28	136 08 58	1.30
Nikijima (Kumano city)	33 56 16	136 10 50	2.00
Nikijima (Kumano city)	33 56 21	136 10 55	1.70
Yuki (Kumano city)	33 55 34	136 10 21	1.35
Yuki (Kumano city)	33 55 35	136 10 26	2.15
Shimoda	34 36 44	138 49 39	0.80
Matsuzaki	34 45 00	138 46 41	0.80
Kamo	34 49 22	138 46 41	0.30

Table 2. Model parameters used for numerical computation.

Longitude (deg.)	Latitude (deg.)	L (km)	W (km)	Strike (deg.)	Dip(deg.)	Slip(deg.)	Dislocation (m)
33.2	137.1	60	30	277	52	96	1.8

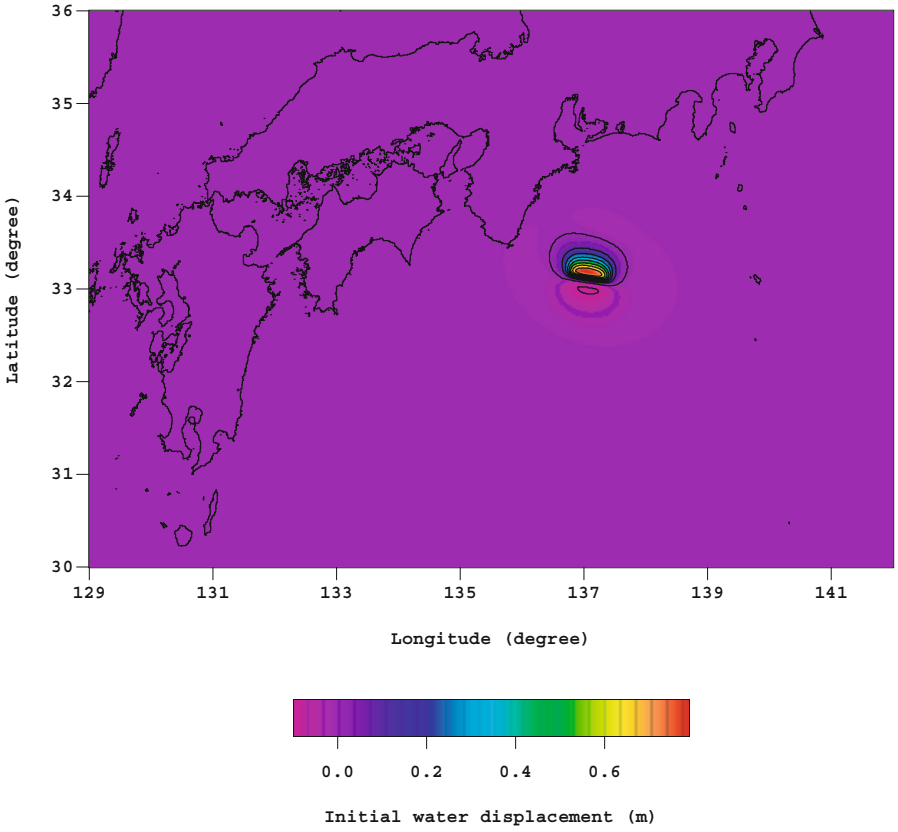

Fig. 3. Initial water displacement by model parameters of Table 2.

of the survey revealed that the run-up heights cannot be explained by computation using the linear theory and a large grid system. It seems that the heights are affected by the non-linear effect and a mild slope.

Acknowledgments. We would like to thank the tsunami and coastal researchers from all over Japan.

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