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Quantitative comparison of the 2011 Tohoku earthquake and past tsunami heights

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The tsunami heights from the 2011 Tohoku earthquake were on the average 1.5 times the 1896 Meiji Sanriku tsunami, 3 times the 1933 Showa Sanriku tsunami, 4 times the 1960 Chilean tsunami, and 14 times the 2010 Chilean tsunami along the Sanriku coast. The Sanriku coast is a typical ria coast, a sawtooth-shaped irregular coastal shape, and the local variation of tsunami heights is very significant. We carefully selected the sites where the past measurement points are known, and comparisons were made at the same villages or small-scaled bays (roughly a km scale).

Along the Sanriku coast, the median value of 1896/2011 tsunami height ratio at 83 measurement points is 0.69, and a correlation coefficient is 0.34. The median 1933/2011 ratio at 94 points is 0.33 with a correlation coefficient of 0.47. The 2011 tsunami was higher along the southern Sanriku coast (Miyagi prefecture). In the central Sanriku coast (Iwate prefecture), the 2011 tsunami was 1.2 times the 1896 tsunami and 2 times the 1933 tsunami. The comparison was made at 98 points for the 1960 tsunami with a median ratio of 0.25, and at 12 points for the 2010 tsunami with a median ratio of 0.07. The correlation coefficients are lower, 0.17 and 0.14 for the 1960 and 2010 Chilean tsunamis, than the past Sanriku tsunamis. All the Sanriku tsunamis (1896, 1933 and 2011) had different earthquake source area and types, but the tsunami height distributions were similar, indicating that the tsunami heights are more sensitive to the local topography for the near-field tsunamis. The lower correlation with the Chilean tsunami may be due to the fact the dominant period of incoming tsunami was more than twice longer for the trans-Pacific tsunamis.

Comparisons with the two Chilean tsunamis were also made on the Ibaraki and Chiba coasts. The tsunami heights were compared at 24 points for the 1960 tsunami and 14 points for the 2010 tsunami. The median 1960/2011 ratio is 0.62, while the median 2010/2011 ratio is 0.28. The correlation coefficients with the 2011 tsunami heights are higher, 0.63 and 0.41 for the 1960 and 2010 Chilean tsunamis. The high correlation may be due to general decrease of tsunami heights toward south, and the fact that the tsunamis were locally high near peninsula such as Asahi city in Chiba prefecture.

We used the 2011 tsunami heights at 120 points measured and reported by Tsuji et al. (2011 BERI); the 1896 tsunami heights reported by Yamana, Iki and Matsuo, the 1933 heights by Matsuo, Kunitomi and ERI, the 1960 heights by Comm. Field Investigation and Japan Meteorological Survey, and the 2010 heights by Tsuji et al. and Imai et al. The full data and reference are given in Tsuji et al. (Pageoph in press).

Keywords: The 2011 Tohoku earthquake, tsunami, 1896 Sanriku tsunami, 1933 Sanriku tsunami, 1960 Chile tsunami, 2010 Chile tsunami