

Reconstruction of earthquakes and tsunamis in the Japan Sea using sedimentary deposits in the Primorye coast, Russia: implication from numerical modeling

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The coasts of the eastern margin of the Japan Sea has repeatedly been affected by earthquakes and tsunamis, such as the 1983 Sea of Japan and the 1993 southwest-off Hokkaido earthquakes. Risk assessment of earthquakes and tsunamis has been carried out over years based on historical and geological records. However, both records found from Japan are too sparse to reconstruct the recurrence and magnitude of earthquakes and tsunamis, because of the geological and geomorphological settings in the active margin. On the opposite side of the Japan Sea, the continental tectonic settings of Primorye, Russia, may offer a higher preservation potential of geological records. Recent surveys in the coastal marshlands of Primorye, including Kit and Valentin Bays (Fig. 1), discovered sandy event layers from several locations (Ganzey et al., 2015). Past tsunamis from the eastern margin of the Japan Sea have been known to have inundated the coasts of Primorye. For example, tsunami height of 5 m was recorded at the time of the 1993 southwest-off Hokkaido earthquake. Some of the earlier sand layers in the Primorye coasts are likely associated with tsunamis caused by the past earthquakes in the eastern margin of the Japan Sea.

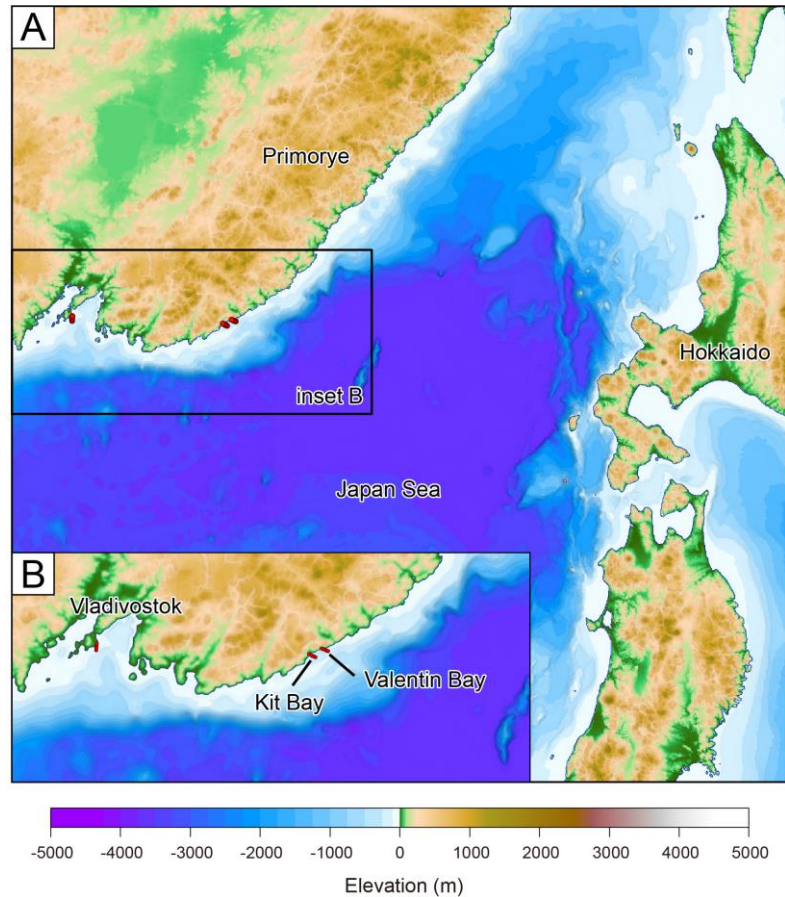


Fig. 1. Location map of Kit and Valentin Bays in Primorye, Russia

In this study, tsunami characteristics at Kit and Valentin Bays in the coast of Primorye are investigated by means of numerical modeling of tsunami sediment transport (e.g. Yamashita et al., 2016). Tsunamis by the historical earthquakes, including the 1983 Sea of Japan and the 1993 southwest-off Hokkaido earthquakes, are examined in addition to the projected tsunami scenarios. Tsunami heights and periods, as well as onshore sediment erosion and deposition, are compared with the available data.

The numerical simulation of the 1983 Sea of Japan earthquake tsunami showed that the nearshore wave period of the tsunami was 150 s and the tsunami height 1-3 m at Kit and Valentin Bays (Fig. 2). In

Valentin Bay, the tsunami on the coastline reached 3 m in height and inundated the land up to 200 m from the coastline, and deposited thin (~0.05 m) sand layer. The nearshore wave period of the tsunami by the 1993 southwest-off Hokkaido earthquake was 200-300 s, and the tsunami height was computed at up to 4 m (Fig. 3), which is comparable to the measured heights of 4.34 m and 4 m at Kit and Valentin Bays, respectively (Ganzev et al., 2015). The tsunami inundation reached 300-400 m from the coastline, and deposited thicker (0.1-0.4 m) sand layer at Kit Bay. The tsunami inundation at Valentin Bay reached 400 m from the coastline, and deposited much thinner (0-0.03 m) sand layer. Thus, tsunami inundation and sand deposition by the 1993 southwest-off Hokkaido earthquake are generally consistent with the available data of the tsunami height and the sand layer near the surface (Ganzev et al., 2015).

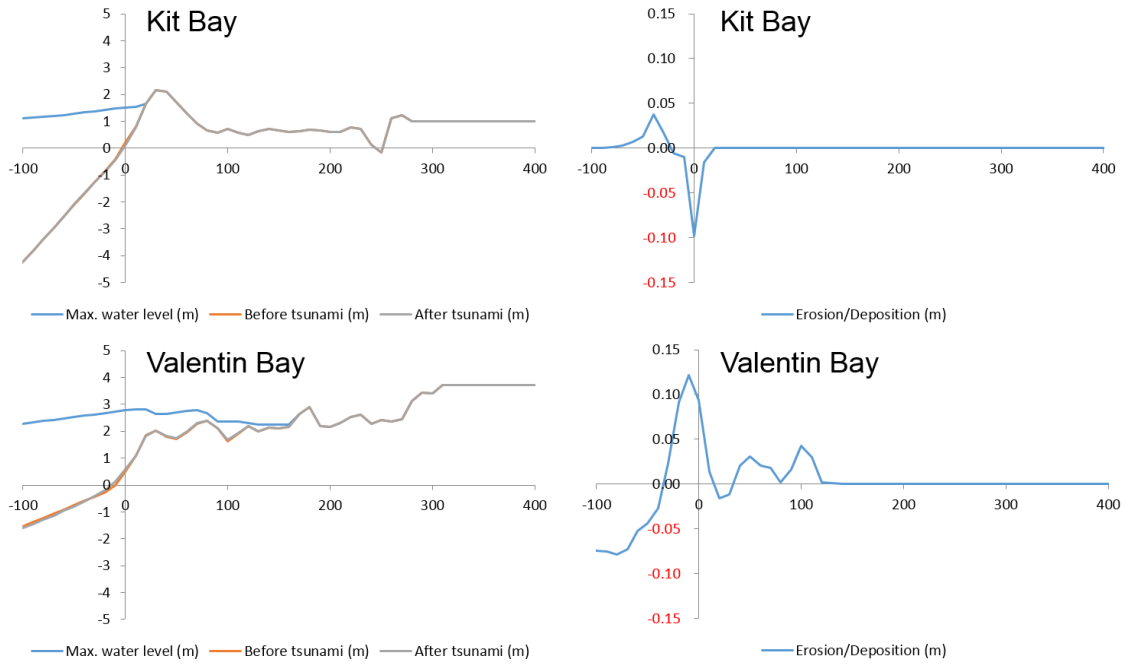


Fig. 2. Simulated maximum water level and sediment erosion and deposition by the 1983 tsunami

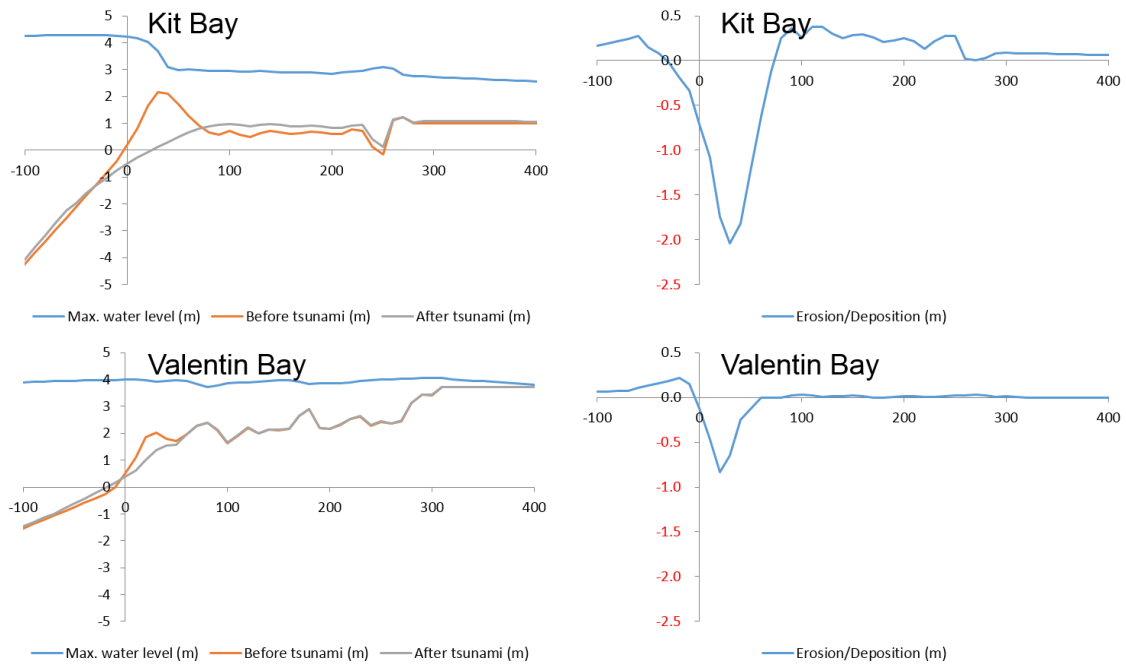


Fig. 3. Simulated maximum water level and sediment erosion and deposition by the 1993 tsunami

The tsunami simulations by the projected tsunami scenarios (F01 to F60), which were proposed by the Cabinet Office of Japanese Government, demonstrated the Primorye coast receives tsunamis from various sources from the west of Hokkaido to the north of Niigata, Japan. Among the examined 60 scenarios, F19

generates highest tsunami at Valentin Bay. The simulated tsunami reached 6 m in height on the coastline and inundated the land more than 500 m from the coastline, and left thicker (0-0.16 m) sand layer (Fig. 4). It is possible that some of the sand layers of the older ages in Kit and Valentin Bays (Ganzev et al., 2015) can be associated with the tsunamis from such sources without any historical accounts. Thus, tsunami deposits in Primorye may offer the clue to reconstruct past tectonic activities in the eastern margin of the Japan Sea.

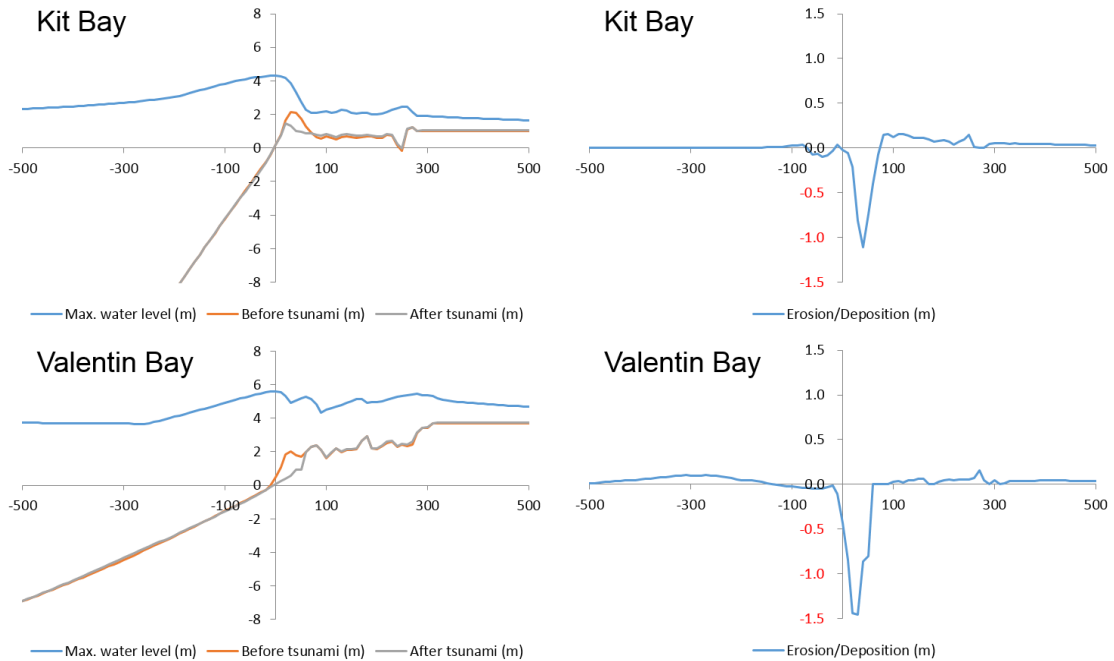


Fig. 4. Simulated maximum water level and sediment erosion and deposition by scenario F19

References

- Ganzev, L. A., Razjigaeva, N. G., Nishimura, Y., Grebennikova, T. A., Kaistrenko, V. M., Gorbunov., A. O., Arslanov, K. A., Chernov, S. B. and Naumov, Y. A., Deposits of Historical and Paleotsunamis on the Coast of Eastern Primorye: *Russian Journal of Pacific Geology*, 2015, Vol. 9, Pp. 64-79.
- Yamashita, K., Sugawara, D., Takahashi, T., Imamura, F., Saito, Y., Imato, Y., Kai, T., Uehara, H., Kato, T., Nakata, K., Saka, R. and Nishikawa, A. Numerical simulations of large-scale sediment transport caused by the 2011 Tohoku Earthquake Tsunami in Hirota Bay, Southern Sanriku Coast: *Coastal Engineering Journal*, Vol. 58 (4), 1640015, P. 28.