Validation of modeling the Tohoku 2011 tsunami and flooding

Marc Naeije, Haiyang Cui, Julie Pietrzak, Wim Simons, and Andy Hooper

m.c.naeije (altimetry), h.cui & j.d.pietrzak (tsunamis), w.j.f.simons (gps), a.j.hooper (slip), all @tudelft.nl

Delft University of Technology (TUDelft), Faculties of Aerospace and Civil Engineering, Delft, The Netherlands

Summary

The 2011 Tohoku-Oki earthquake, which occurred on 11 March 2011 at 05:46:32 UTC off the Pacific coast of Honshu, Japan, generated a huge tsunami with disastrous consequences. The Earthquake Joint Survey Group reported that the tsunami reached up to 40m inland. We simulated this tsunami with an unstructured finite volume model (HiOcean), with extensively tested accurate flooding algorithms. The initial uplift was computed from a large set of regional continuous GPS station data available from the International GNSS Service (IGS) before and after the earthquake. In a multi-disciplinary simultaneous approach also the slip has been estimated. It appeared that the combined vertical motion and horizontal motion of the ocean floor raised the water column by as much as 30m which led to the destructive tsunami. For the tsunami propagation two grids were generated: a Pacific wide grid (500 m to 10km resolution) and a local flooding grid with much higher resolution (30m) along the Japan coast. We ran the model with the Pacific wide mesh for 20 hours with a time step of 2s, to simulate the time evolution of the tsunami over the Pacific Ocean and to estimate the lid. The flooding simulation, with a finer mesh that has 3 million nodes, was only run for 2 hours and used a smaller time step, 0.1s. We compare the model results to sea floor pressure gauges (DAHT), satellite altimetry, tsunami inundation height and run-up data. Good agreement is found with both the pressure gauge and selected altimetry data. The model also gives accurate estimates of inundation height, however, under predicts the maximum run-up, likely due to the steep and narrow local coastal features, not available for our simulation, but increasing the run-up of tsunami.

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