Overview

This paper presents numerical simulations, obtained using high-resolution nonhydrostatic inundation modeling, which attempts to better understand the occurrence of the extreme runup of about 32 m height near the village of Monai in Okushiri Island, Japan, due to the 1993 Hokkaido Nansei-Oki earthquake tsunami. Using a very realistic initial condition and several nested numerical grids, a 3D hydrostatic regional model is applied to simulate tsunami wave propagation through stepwise refinement of the spatial scale and one-way dynamic nesting. The results from the regional model are transferred in an offline manner to the high-resolution inundation model with a grid of at least 10 m resolution. The modelling methodology the authors use is not novel in the sense that the authors have already tested successfully this approach to reproduce other known extreme runup values from two more recent tsunamis on Japanese coasts. Considering the presence or absence of the two islands near the Monai valley, the authors compare extensively the characteristics of the 1993 Hokkaido Nansei-Oki earthquake tsunami, such as the occurrence and the time of maximum runup in the flooded area, the inundation area, water depths and velocities in the inundated zones, among others. In each case, the wave runup near Monai valley was simulated using the 3D fully nonlinear Reynolds-Averaged Navier–Stokes equations (k-ε turbulence closure) and very detailed bathymetry and land topography data. The results obtained in the presence of islands show convincing evidences that local coastal effects are a very important issue for numerical modelling of extremes runup values and characteristic velocities during runup and rundown phases. Given that hydrostatic models usually underestimate the modeled runup near the village of Monai, this paper presents important results for the tsunami modeling community. In particular, these results emphasize the need for high-resolution non-hydrostatic inundation modeling over steep or rapidly varying topography, when high vertical acceleration occurs.

General comments

As a first general comment, the overall presentation of this paper is well structured, clear and easy to understand by a wide and general audience. In the light of the significance of this work for subsequent investigations of local effects on tsunami-induced inundation, especially around islands or over steep topographic features, and their influence on the accuracy of actual tsunami models, this study is necessary and useful. Though the authors do generally well in describing the overall methodology, used data and the results of their simulations, I find (i) that there is lack of information on how the runup and more generally the inundation modeling is treated with the regional model; (ii) it is regrettable that the authors did not consider running the regional model on the finest grid to see whether the increase of resolution improves the comparison with observed runup values in the region of interest; and (iii) that the authors do not discuss the potential impact on their results, had they considered using other turbulence closure for the local model.

- *An attempt to apply the hydrostatic model was made to the smallest domain (D4) however the computations in 3D were found to be unstable. The hydrostatic 2D simulation in D4 did not make any problems but the run-up results were similar with those on the domain D3. That is, the increase in the resolution of the hydrostatic model hardly contributes to the improvement in the reproduction of extreme run-up heights. We guess that the hydrostatic model used here is developed basically under the assumption that the inundation area has a mild slope and hence its application to the region with vertical velocity larger than 5m/s might result in underestimation of the run-up height and sometimes cause instability problems. We note that k-e turbulence model is used in the non-hydrostatic regional model.*

- *Regarding comments i) to iii) by the reviewer, we have included future studies in the conclusion. "It may be worthy of comparing performance between hydrostatic and non-hydrostatic models with different turbulence schemes." The subject will be left for the future study.*

Despite these minor points, which I expect to be commented by the authors, it should be emphasized that their approach decouples the propagation modeling and the high-resolution inundation simulation, and further provides flexibility to use input from one propagation model for several inundation coastal sites.

- *Regarding the comment "it should be addressed that their approach decouples the propagation modeling and the high-resolution inundation simulation", we clarify the related statement by splitting (see Technical corrections #1 below). And we added following sentence near the end of the introduction.*

- *It is addressed that the hydrostatic model in a series of regional domains is used for the propagation of tsunami waves and the non-hydrostatic model is used for the reproduction of extreme run-up heights on the local domain with high resolution.*

Thus, I recommend this manuscript for publication after minor revisions. Technical corrections and suggested revisions follow.

Technical corrections (or clarifications)

1. p.6910 l.5 I find this phrase very long and suggest to either rephrase it with correct punctuation or to split it.

- *That phrase was split for better understanding.*

- **Original**: To reproduce the extreme run-up height the three-dimensional non-hydrostatic model (Flow Science, 2012) denoted by NH-model has been locally applied with open boundary conditions supplied in an offline manner by the three-dimensional hydrostatic model (Ribeiro et al., 2011) denoted by H-model which is sufficiently large to cover the entire fault region with one-way nested multiple domains.

- **Modified**: *To reproduce the extreme run-up height the three-dimensional non-hydrostatic model (Flow Science, 2012) denoted by NH-model has been locally applied with open boundary conditions supplied in an offline manner by the three-dimensional hydrostatic model (Ribeiro et al., 2011) denoted by H-model. The area of H-model is sufficiently large to cover the entire fault region with one-way nested multiple domains.*

2. p.6913 l.26 replace "grids" by "grid cells"

- *Replaced according to the reviewer's suggestion.*

3. p.6915 l.19 repetition: suppress "based...Navier-Stokes"

- *We deleted "based…".*

4. p.6915 l.21 repetition: suppress "based...hydrostatic equations"

- *We deleted "based…".*

5. p.6916 l.5-23: Though the authors focus their investigation in the Monai valley region, I do not consider the results from Domain D3 to be "fairly comparable with observed values except for the observations near Monai Valley". Figure 5 shows there is a substantial disagreement (a factor 2) way up north Monai valley and down south near Aonae town. Hence I suggest to rephrase this sentence.

- *The factor is not a relation between observation and calculation; it is related to possibility of occurrence of the unexpected extreme runup.*
- **Original**: Considering the results from the sub-domain D3, we can see that the numerical simulation results are fairly comparable with observed values except the observations near Monai Valley. The observed values near the Monai Valley range from about 13 to 31.7 m (observed maximum), while the simulated values on the sub-domain D3 are less than about 12 to 24 m (computed maximum).
- **Modified**: *Considering the results from the sub-domain D3, we can see that the numerical simulation gives considerable disagreements in regions north Monai valley and south near Aonae town as well as in front of Monai Valley where extreme heights of 23 m and 31.7 was observed.*

6. p.6916 l.24-28 this sentence is too long; suggest splitting.

- *That sentence was rephrased for better understanding.*
- **Original**: As a way to examine the local topographic effects we have introduced a local amplification ratio which is the ratio of the highest value to the mean value of the maximum run-up heights in the neighboring region about 200 m to 1 km away from the highest maximum run-up point to the North and South directions
- **Modified**: *As a way to examine the local topographic effects we have introduced a local amplification ratio, which is estimated using the highest maximum run-up height by dividing the mean value averaging the maximum run-up heights in the peripheral region. The peripheral region is defined in the neighboring region of 1 km from the highest maximum run-up point to the North and South directions excluding the nearby region of 200 m*

7. p.6918 l.23 subject is missing in "...as goes..."

- *We deleted "as goes".*

8. p.6919 l.16 suggest to rephrase "can be in more detail"

- *Missing verb "shown" is inserted, giving "can be shown in more detail"*

9. p.6920 l.13 suppress "the" in the group "...in the more focusing..."

- *We deleted "The".*

10. Figures 3,6,7 - please specify units for the color bars.

- *Three figures are modified by including Unit (m) in the scale bars.*