Benchmark Problem 9: Field. 1993 Hokkaido-Nansei-Oki (Okushiri).

The goal of this Benchmark Problem is to compare computed model results with field measurements gathered after the 12 July 1993 Hokkaido-Nansei-Oki tsunami (also commonly referred to as the Okushiri tsunami), to meet the following

Objectives:

1. Compute runup around Aonae
2. Compute arrival of the first wave to Aonae
3. Show two waves at Aonae approximately 10 min apart; the first wave came from the west, the second wave came from the east
4. Compute water level at Iwanai and Esashi tide gauges
5. Maximum modeled runup distribution around Okushiri Island
6. Modeled runup height at Hamatsumae
7. Modeled runup height at a valley north of Monai

Data Files

Bathymetry/Topography and Source Data. The original Kansai University bathy/topo and seismic source grids were developed for the 1995 Friday Harbor Long Wave Runup Model workshop (Takahashi, 1996), and are available at the NOAA/PMEL Okushiri Benchmark Problem website http://nctr.pmel.noaa.gov/benchmark/Field/Field_Okushiri/index.html . These grids suffer from the apparent addition of rows and columns of "ghost cells" added to accommodate requirements of certain numerical models and significant horizontal and vertical misalignment of neighboring or embedded grids (see Appendix A).

Dmitry Nicolsky attempted to minimize these misalignments by adding or subtracting selected rows and columns at boundaries common to neighboring or embedded grids to produce the following grids:

OK24.xyz	(24 arc-second grid, around Okushiri)
OK08.xyz	(8 arc-second grid, around Okushiri)
OK03.xyz	(8/3 arc-second grid, around Okushiri)
AO15.xyz	(15 meter grid, around Aonae)
MO01.xyz	(1 arc-second grid, around Monai)
MB05.xyz	(~6 meter grid, around Monai)
HNO1993.xyz	(ocean bottom deformation)

The source function (Figure 1) corresponds to the Disaster Control Research Center solution DCRC17a described in Takahashi, et al., (1995) and Takahashi (1996). Also, Barry Eakins provided 500-m bathymetry surrounding Okushiri Island, downloaded from the Japan Oceanographic Data Center website at http://www.jodc.go.jp/data_set/jodc/jegg_intro.html . These data are stored as four 2-degree xyz tiles that provide coverage for the area 40 to 44 N and 138 to 142 E in WGS 84 geographic decimal degrees. Note that the meaning of the first column in each file is uncertain, but the entries of 1 or 0 may indicate that the cell was originally derived either from data or from interpolation. All files are stored in folder "BathyTopoSource".

Field Data. There are 5 tables of field data in the file "FieldData.xls", each on an individual worksheet:

"Tohoku". Collected by the University of Tohoku team. This worksheet was produced from the large table in Section 2 of DCRC (1944). Only the 125 entries with latitude 42 degrees were extracted from pp 13-25 of the table. Note that these data include tide information and both uncorrected and tide-corrected inundation values.

"UJNR". Collected by the United States-Japan Cooperative Program on Natural Resources team and presented as part of the larger data set published in HTSG (1993).

"Tsuji". Provided by Yoshinobu Tsuji, Tokyo University, and published in Kato and Tsuji (1994).

“Esashi”. Provided by Dmitry Nicolsky. The tide gage time series was digitized from the figure published on page 401 of Yeh, et al. (1996).

“Iwanai”. Provided by Dmitry Nicolsky. The tide gage time series was digitized from the figure published on page 401 of Yeh, et al. (1996).

Tidal excursions in the Okushiri/Hokkaido region are only on the order of 30-40 cm, and errors associated with the field observations, source specification and coastal subsidence estimates, and the uncertain reference datum for the bathy/topo grids (see Appendix A) are at least of the same order, so that no attempt was made to correct the UJNR and Tsuji field observations for the tides. If desired, however, tidal predictions can be obtained through the WWW Tide and Current Predictor, at http://tbone.biol.sc.edu/tide/ . This site provides an online interface for the program XTide (http://www.flaterco.com/xtide/), which uses the tide prediction algorithm employed by NOAA’s National Ocean Service.

Recommendation for Improvement of this Benchmark Problem

This event remains one of the most important and thoroughly documented cases of extensive tsunami runup available to the tsunami community. But the bathymetric/topographic computational grids are flawed by severe horizontal and vertical misalignment errors. We therefore make the following recommendation.

- ***Recommendation.*** The NTHMP should fund the NGDC to build improved, nested coastal digital elevation models (DEMs) of the Okushiri, Japan area to replace the 8 existing DEMs that have large, known inaccuracies that negatively impact tsunami modeling results. The best publicly available bathymetry and topographic data should be obtained through collaboration with Japanese institutions and both structured and unstructured nested DEMs should be developed, to support multiple tsunami modeling codes.

References

DCRC (Disaster Control Research Center), 1994: Tsunami Engineering Technical Report No. 11, Tohoku University, March 1994.

HTSG (Hokkaido Tsunami Survey Group), 1993: Tsunami devastates Japanese coastal region. Eos Trans. Am. Geophys. Union, 74(37), 417, 432.

Kato, K. and Y. Tsuji, 1994: Estimation of Fault Parameters of the 1993 Hokkaido-Nansei-Oki Earthquake and Tsunami Characteristics, Bull. Earthq. Res. Inst., Univ. Tokyo, V 69, 39-66.

Takahashi, Tomo., Take. Takahashi, N. Shuto, F. Imamura and M. Ortiz, (1995) : Source Models for the 1993 Hokkaido Nansei-Oki Earthquake Tsunami, Pure and Applied Geophysics, Vol.144, pp.747-767.

Takahashi, T.: 1996, ‘Benchmark Problem 4. The 1993 Okushiri tsunami—Data, Conditions and Phenomena’. In: H. Yeh, P. Liu, and C. Synolakis (eds.): Long wave runup models. Singapore: World Scientific Publishing Co. Pte. Ltd., pp. 384–403.

Yeh, H., P.L.-F. Liu, C. Synolakis, 1996. Long-Wave Runup Models. World Scientific, 403 pp.

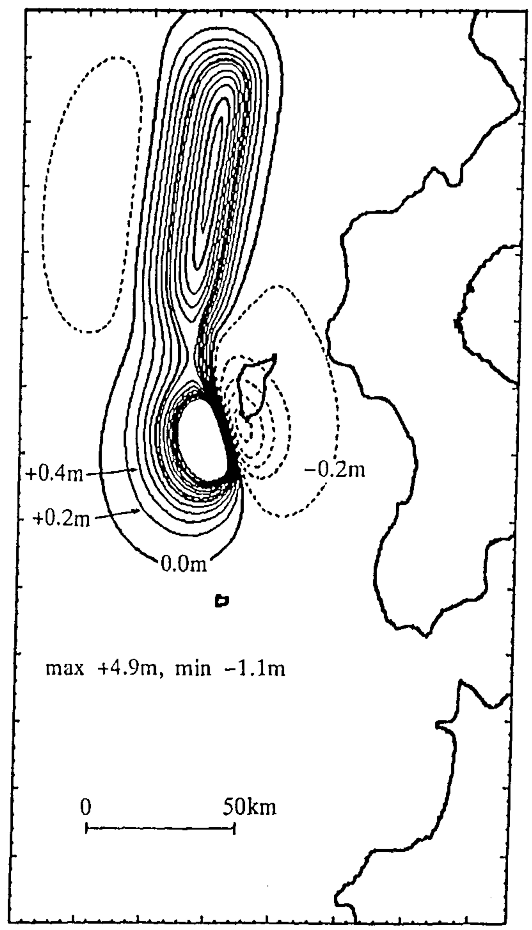

Figure 1. Source model DCRC 17a. Figure taken from Takahashi et al., 1995.

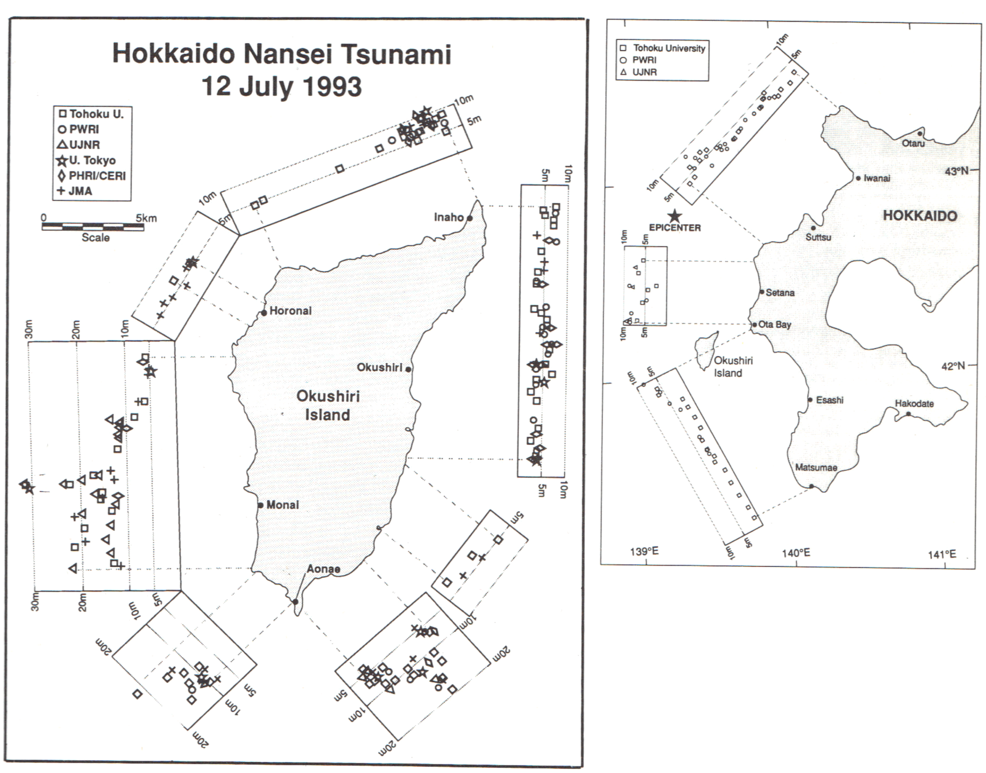

Figure 2. Field observations acquired by the Hokkaido Tsunami Survey Group (HTSG, 1993).

Appendix A. Kansai University Bathymetry/Topography Grids

Bathy/topo data were provided by Tomoyuki Takahashi, Kansai University, for the 1995 Friday Harbor Workshop, and they are described in Takahashi (1996). The README.txt file identifies regions A, B, C, D and E and the overlapping cells for neighboring or embedded grids. Additional information on map development was obtained through personal communication with T. Takahashi.

Data were produced by digitizing the following maps, with the geographical reference datum as indicated.

Region A:

Chart No.6311 by the Japan Maritime Safety Agency, Reference datum Tokyo97
http://www.jha.or.jp/shop//index.php?main_page=product_info&products_id=2324
Chart No.6658 by the Japan Maritime Safety Agency, Reference datum Tokyo97
http://www.jha.or.jp/shop//index.php?main_page=product_info&products_id=2347

Region B:

Chart No.32 by the Japan Maritime Safety Agency, Reference datum WGS84
http://www.jha.or.jp/shop//index.php?main_page=product_info&products_id=495

Region C:

Chart No.32 by the Japan Maritime Safety Agency, Reference datum WGS84
http://www.jha.or.jp/shop//index.php?main_page=product_info&products_id=495
Charts by the Hokkaido Development Bureau (Chart numbers and datum are not known at this time.)
Maps of "Aonae" and "Akaishi" by the Japan Geographical Survey Institute, Reference datum WGS84
http://watchizu.gsi.go.jp/watchizu.html?meshcode=63390355
http://watchizu.gsi.go.jp/watchizu.html?meshcode=63391305

Regions D and E:

Existing charts were not used for topography. Rather, a surveying company provided the data, which was then overlain on the coarser grid by matching the respective shorelines. (Reference datum is not known at this time.)

No corrections were made for differing horizontal and vertical geographical reference datum, and "ghost cells" were added to grid boundaries to accommodate model computational grid requirements. An example of the misalignment between grids is presented here (figure courtesy of Bill Knight).