Benchmark 7: Laboratory. Runup onto a complex 3-D beach.

A laboratory experiment, using a large-scale tank at the Central Research Institute for Electric Power Industry in Abiko, Japan, was focused on modeling runup of a long wave on a complex beach near the village of Monai (Liu et al., 2008). The beach in the laboratory wave tank was a 1:400 scale model of the bathymetry and topography around a very narrow gully, where extreme runup was measured. The incoming wave in the experiment was created by wave paddles located away from the shoreline, and the induced water level dynamics were recorded at several locations by gauges.

More information regarding this benchmark can be found in (Synolakis et al., 2007), at the web-site http://isec.nacse.org/workshop/2004_cornell/bmark2.html of the Inundation Science & Engineering Cooperative, or at the web-site http://nctr.pmel.noaa.gov/benchmark/Laboratory/Laboratory_MonaiValley/ of the NOAA Center for Tsunami Research.

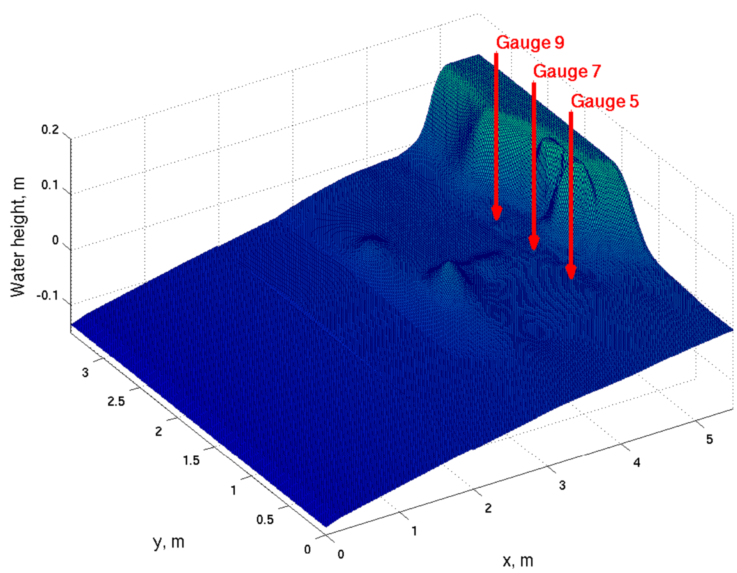

Figure 1: The 3-D view of the computational domain. Locations of gauges, at which the modeled and measured water level dynamics are to be compared, are shown by arrows. The inlet boundary is modeled at $x = 0$. At $y = 0$ and $y = 3.4$, the reflective boundary conditions are set.

The computational domain represents a 5.488 by 3.402 meter portion of the wave tank near the shore and is divided into 0.014×0.014 meter grid cells. The incident wave is prescribed at $x = 0$ for the first 22.5 seconds, after which a non-reflective boundary condition is recommended to be set at $x = 0$. The boundary conditions along segments $y = 0$, $y = 3.4$, and $x = 5.5$ are to be set completely reflective.

The primary theme of this benchmark problem is the temporal and spatial variations of the shoreline location, as well as the temporal variations of the water-surface variations at specified nearshore locations. To support comparison of the numerical and laboratory data, an overhead video focused on a narrow gully, where the highest runup was observed, was taken during the laboratory experiment. Since the video (stored in overhead.avi file) has the frequency of 30 frames per second, it is possible to select frames that are 0.5 seconds apart. Figure 2 displays five frames extracted from a video taken during the laboratory experiment. The lateral extent of the video frames approximately correspond to the region $4.7 \leq x \leq 5.2$ and $1.5 \leq y \leq 2.2$ of the computational domain. In the computer experiment, frame 10 approximately occurs at 15.3 seconds.

Figure 3 shows plots of the measured water level dynamics at gauge 5 ($x = 4.521, y = 1.196$), gauge 7 ($x = 4.521, y = 1.696$), and gauge 9 ($x = 4.521, y = 2.196$) for the first 25 seconds, during which the maximum runup occurs. Locations of all gauges employed in the laboratory experiment are listed in Table 1.

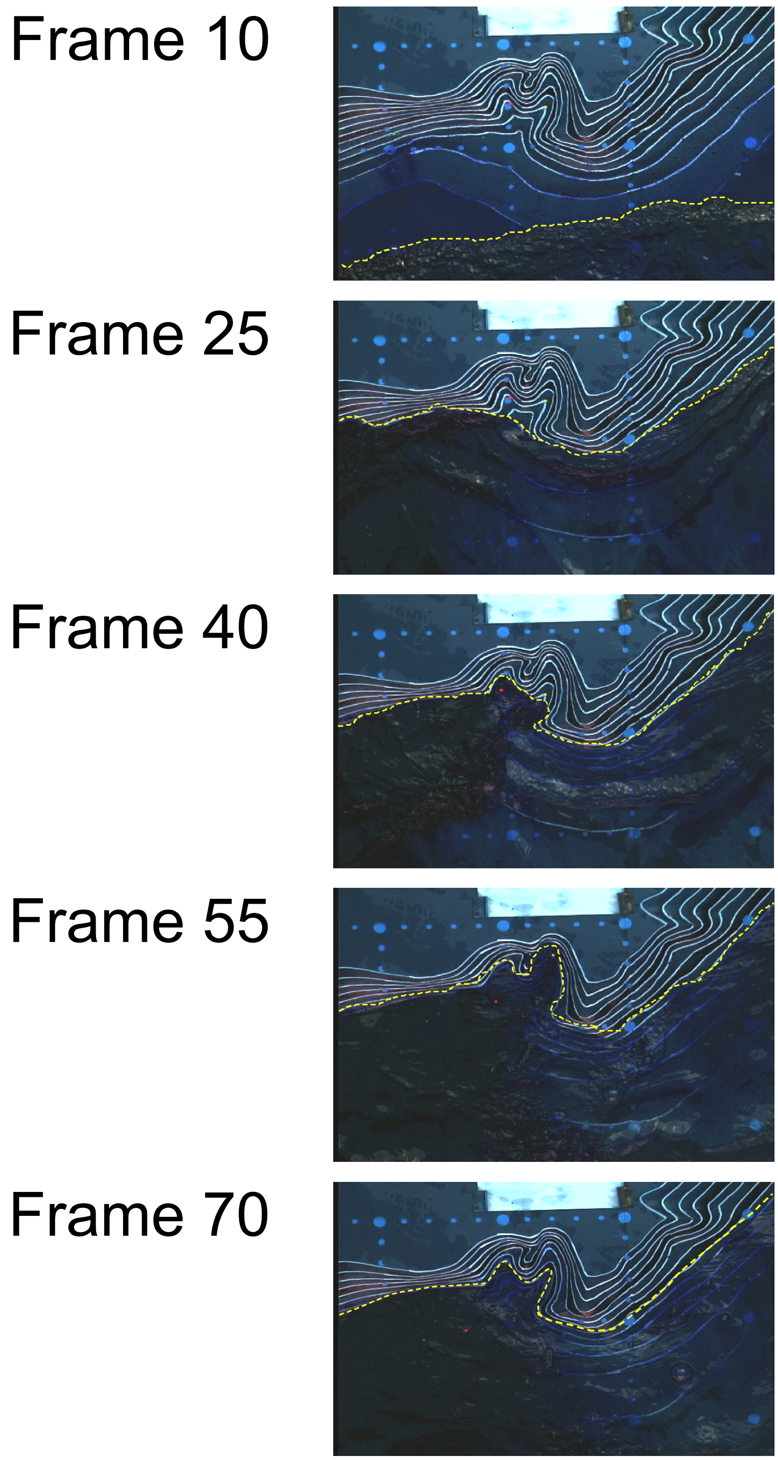

Figure 2: Extracted movie frames 10, 25, 40, 55, and 70 from the overhead movie of the laboratory experiment. The time interval between frames is 0.5 seconds. The dashed yellow line shows the instantaneous location of the shoreline.

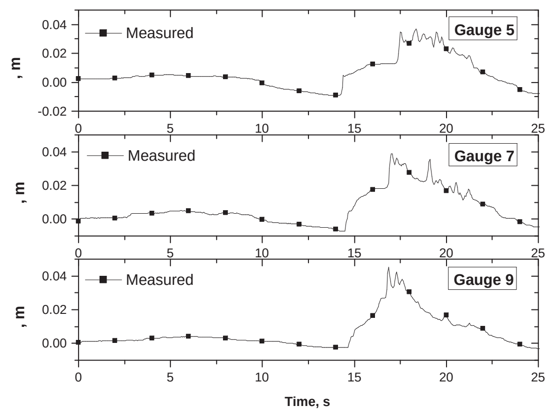

Figure 3: The measured water level dynamics at gauges 5, 7, and 9. The measurements are provided courtesy of the Third International Workshop on Long-Wave Runup Models (Liu et al., 2008).

To accomplish this benchmark, it is suggested to:

1. Model propagation of the incident and reflective wave according to the above-specified boundary condition,
2. Compare the numerical and laboratory measured water level dynamics at gauges 5, 7, and 9,
3. Show snapshots of the numerically computed water level at times synchronous with those of the video frames; it is recommend that each modeler find times of the snapshots that best fit the data,
4. Compute the maximum runup in the narrow valley.

Description of the data files

The beach bathymetry is provided in Benchmark_2_Bathymetry.txt file in an XYZ format. The first and second columns represent x and y coordinates, in meters, respectively. The third column is the still water depth, in meters.

The in-coming wave dynamics is provided in Benchmark_2_input.txt file. The first column is associated with time, in seconds. The second column is the water level, in meters. The measured water level at gauges 5, 7, and 9 is stored in output_ch5-7-9.xls file. The first column is related to the time, in seconds. Other columns provide the water level at the gauges.

The frames 10, 25, 40, 55, and 70 from the overhead movie of the laboratory experiment are saved in Frame_10_line.bmp, Frame_25_line.bmp, Frame_40_line.bmp, Frame_55_line.bmp, and Frame_70_line.bmp, respectively. The yellow line represent an instantaneous location of the shore line.

Observed runup data by Matsuyama and Tanaka (2001) is provided in "OBS_RUNUP.txt".

References

Liu, P. L.-F., Yeh, H., Synolakis, C., 2008. Advanced Numerical Models for Simulationg Tsunami Waves and Runup. Vol. 10 of Advances in Coastal and Ocean Engineering. World Scientific, Proceedings of the Third International Workshop on Long-Wave Runup Models, Catalina, 2004 Benchmark problems, pp. 223–230.

Synolakis, C., Bernard, E., Titov, V., Kânoğlu, U., González, F., 2007. Standards, criteria, and procedures for NOAA evaluation of tsunami numerical models. OAR PMEL-135 Special Report, NOAA/OAR/PMEL, Seattle, Washington,, 55 pp..

Matsuyama and Tanaka, 2001. An experimental study of the highest run-up height in the 1993 Hokkaido Nansei-Oki earthquake tsunami. In Proceedings of the Internatinal Tsunami Symposium 2001, Session 7, Seattle, WA, 7-10 August 2001, 879-889.

Table 1: Locations of ten gauges measuring the water level.

Gauge	x, meters	y, meters
1	4.521	0.196
2	4.521	0.446
3	4.521	0.696
4	4.521	0.946
5	4.521	1.196
6	4.521	1.446
7	4.521	1.696
8	4.521	1.946
9	4.521	2.196
10	4.521	2.446
11	4.521	2.969
12	4.521	2.946
13	4.521	3.196