Middle East Technical University
Civil Engineering Department

METU Ocean Engineering Research Centre

ICCE2014 Seoul, Korea June 15-20 2014

DISPERSION OF LONG WAVES ON VARYING BATHYMETRY

Rozita Kian, Middle East Technical University, Ankara, Turkey, kian.rozita@metu.edu.tr
Ahmet Cevdet Yalciner, Middle East Technical University, Ankara, Turkey, yalciner@metu.edu.tr
Andrey Zaytsev, Special Research Bureau for Automation of Marine Research, Yuzhno-Sakhalinsk, Russia, aizaytsev@mail.ru

Abstract

Coastal dynamics of swell and long waves is important for morphological changes, near shore circulation, wave amplification, transport of sediments and pollutants, and also comfort of the boats in harbors and bays. There are different models computing near shore behavior of long waves and tsunamis under different input wave and bathymetric and morphological conditions. NAMI DANCE (developed in collaboration with METU, Turkey and Special Bureau of Automation of Research Russian Academy of Sciences, Russia) and FUNWAVE (developed by James T. Kirby et al., University of Delaware) are two of the selected models for simulations of waves, computations of hydrodynamic characteristics of waves such as water velocities and directions. Both models have the capabilities of solving tsunami propagation considering dispersion. As the case studies these models are applied to two different problems for comparisons, tests and generalization.

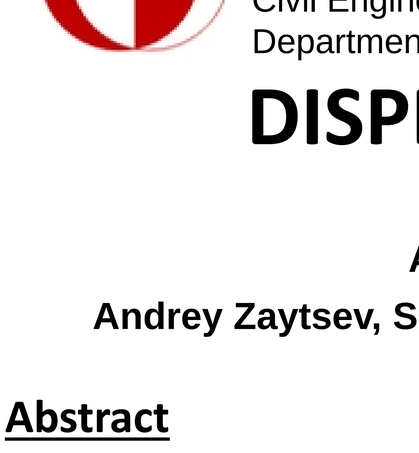

Fig 2. Comparison for dx=3000m, h=1500m, dt= 3sec, (NAMI DANCE (disp) with FUNWAVE ibe=1)

Figure 1. Flat Bathymetry for depth of 1500m and dx=3000m (similar flat bottom bathymetry is used in all simulations with different dx and dt). There are 8 Gauge points

Problem 1

In one of these problems the simulations are performed in regular shaped flat bottom basins under the specified Gaussian shape input wave condition (Yoon et al.,, 2007). The basin depth is taken as 500m, 1000m, 1500m, 3000m. The performance of both models has been tested with different grid size and time step using momentum equations with and without dispersion. According to simulations it is found that in the case of using Nonlinear Shallow Water Equations the results are in agreement in both models. However in the case of dispersion the fairly well agreement is when grid size is selected as double of maximum water depth (Fig.1-9) in all figures horizontal axis represents time in mitnutes and vertical axis represents water surface level in meters.

ibe=4, NLSW ibe=1, Nwogu's (1993)

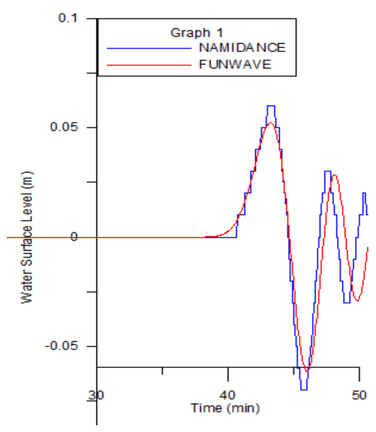

Fig 3. Comparison for dx=3000m, h=1500m, dt= 3sec, (NAMI DANCE (disp) with FUNWAVE ibe=1)

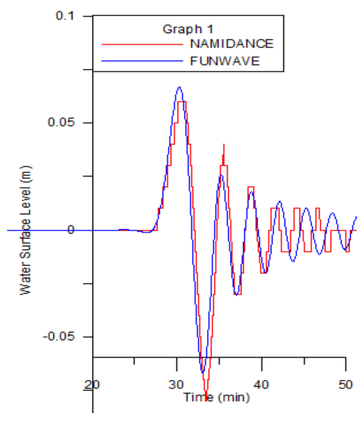

Fig 4. Comparison for dx=6000m, h=3000m, dt= 3sec, (NAMI DANCE (NLSW) with FUNWAVE ibe=4)

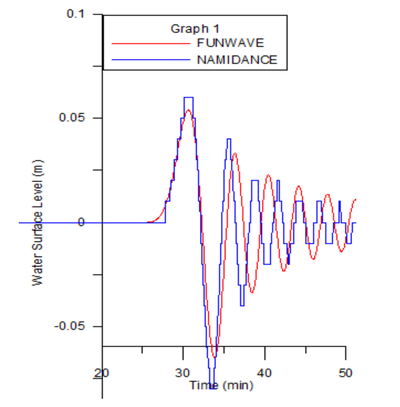

Fig 5. Comparison for dx=6000m, h=3000m, dt= 3sec, (NAMI DANCE (disp) with FUNWAVE ibe=1)

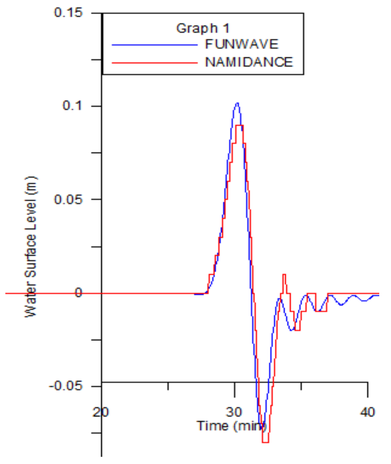

Fig 6. Comparison for dx=3000m, h=3000m, dt= 3sec, (NAMI DANCE (NLSW) with FUNWAVE ibe=4)

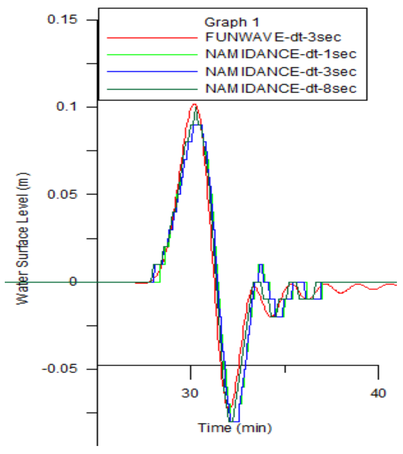

Fig 7. Comparison for dx=3000m, h=3000m, dt= 1, 3, 8sec, (NAMI DANCE (NLSW) with FUNWAVE ibe=4)

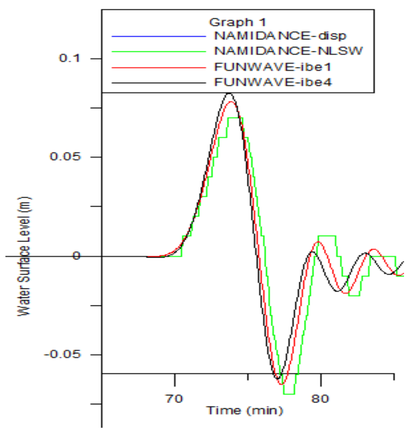

Figure 8. Comparison for dx=2086m, h=500m, dt=3sec, NAMI DANCE (NLSW& disp) with FUNWAVE (ibe=1 & 4)

Problem 2

In the second problem the 1500m depth flat bottom bathymetry with circular submerged shoal (Yoon et al., 2007) is used (Fig.10) The results are also in agreement with the conclusion obtained in the first problem (Fig.11-15).

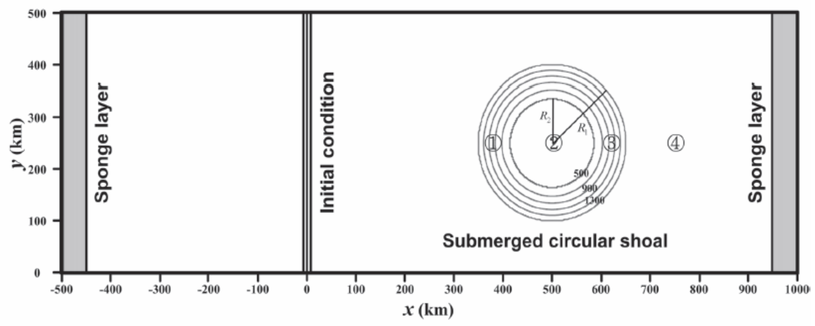

Figure 10. Schematic diagram of a submerged circular shoal, numerical wave gauges and initial condition. (Yoon et al. 2007)

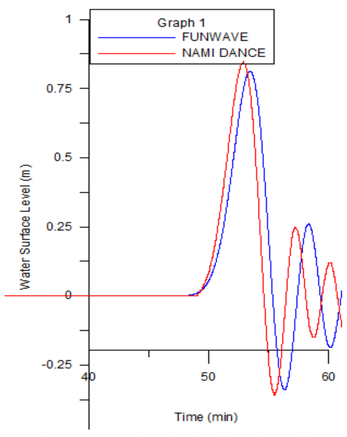

Fig11. Comparison for dx=3000m, h=1500m, dt=0.5sec, NAMI DANCE (disp) with FUNWAVE (ibe=1)

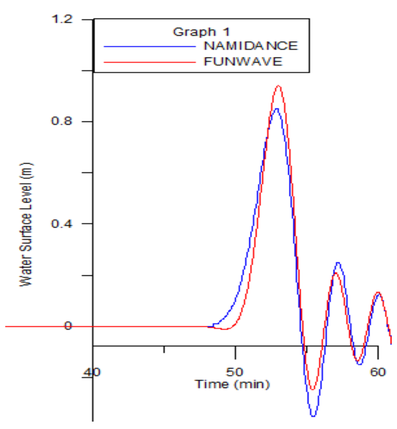

Fig12. Comparison for dx=3000m, h=1500m, dt=2sec, NAMI DANCE (NLSW) with FUNWAVE (ibe=4)

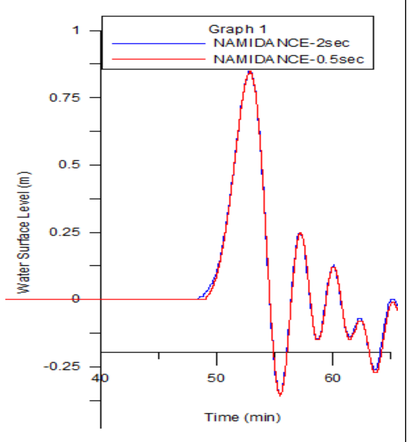

Fig13. Comparison for dx=3000m, h=1500m, dt=2sec, NAMI DANCE (NLSW & disp) with FUNWAVE (ibe=1 & 4)

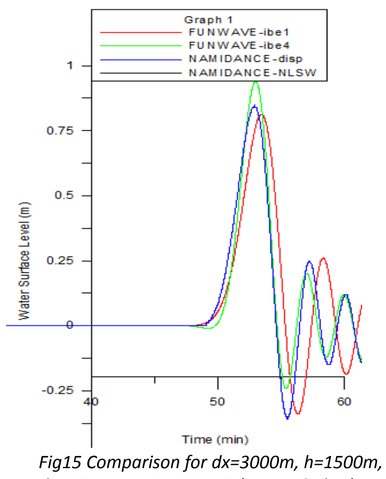

Fig15 Comparison for dx=3000m, h=1500m, dt=0.5 sec, NAMI DANCE (NLSW & disp) with FUNWAVE (ibe=1 & 4)

Figures 11- 15 present the water surface profile for gauge 4 with water depth of 1500 m and show that the results are in agreement with the conclusion obtained in the first problem, and similarly the results are not so sensitive to the time step. Also in this problem NAMI DANCE results for NLSW and dispersion are very close to each other.

Figures 15 shows the comparison for flat bathymetry h=1500 m with circular submarged shoal for the dx= 3000 m and dt=0.5 sec. Here is also good fitness for NAMI DANCE (NLSW and dispersion) results with FUNWAVE (ibe=1).
In all cases the leading NLSW wave is taller and shifted forward in space in relation to the dispersive solutions.

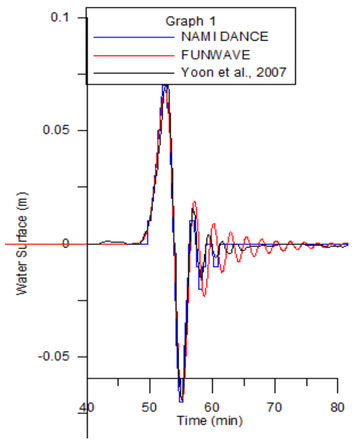

Fig 9. Comparison for dx=2086m, h=1000m, dt=3sec, NAMI DANCE (disp) with FUNWAVE (ibe=1) and Yoon et al., 2007

Figures 2-3 show the simulation results for flat bathymetry with water height of 1500 m and, grid size of 3000 m (twice the height). The comparisons done for NAMI DANCE by momentum equations considering numerical dispersion with FUNWAVE, ibe=1, Nwogu's (1993) in figure 2 and for NAMI DANCE solving Nonlinear shallow water equations (NLSW) with FUNWAVE (ibe=4), figure 3. The results are compatible. Figures 5 and 6 include similar comparison for h=3000 m and dx=6000 m showing good fit.

Figures 6 and 7 contain comparison for h=3000m and dx=3000 m for time steps 1, 3 and 8 sec showing that the results are not so sensitive to time step.

In figure 8, comparisons are for dx=2086 and h=500 m due to both equations with and without dispersion considering.

Figure 9 summarizes the comparison result of simulations for dx=2086 m, h=1000 m with NAMI DANCE and FUNWAVE and also the (Yoon et al., 2007, Fig . 7c). There is a good match among the results of models.

Conclusion:

According to simulations it is found that in the case of using Nonlinear Shallow Water Equations (without dispersion) the results are in agreement in both models. However in the case of dispersion the fairly well agreement is obtained (between two models) when grid size is selected as double of maximum water depth.

NAMI DANCE dispersion fits well with FUNWAVE Dispersion (either Nwogu, or Wei or Peregrine) if dx is selected as double of dmax.

The second problem, depth flat bottom bathymetry with circular submerged shoal, NAMI DANCE simulations for NLSW fits so well with the numerical dispersion.

The results for Linear momentum equations here are same as Nonlinear because they are in deep water.

Results for ibe=1, 2 and 3 are the same, so we just used ibe =1 to compare with numerical dispersion in NAMI DANCE.
In all cases the leading NLSW wave is taller and shifted forward in space in relation to the dispersive solutions.

Reference:

Yoon, S. B., Lim, C. H. and Choi, J. Dispersion-correction finite difference model for simulation of transoceanic tsunamis. Terr: Atoms. Ocean. Sci., 18(1):32-53, 2007

Acknowledgments

The authors thank Prof. James T. Kirby, Ge Wei, Qin Chen, Andrew B. Kennedy and Robert A. Dalrymple for providing FUNWAVE for this study. This study is supported by TUBITAK 2215 Grant for PhD Fellowship for Foreign Citizens, B.02.1.TBT.0.06.01.00-215.01-82/16157