Nesting FUNWAVE in a large-scale wave-averaged model

1. The idea

Nesting FUNWAVE in a large-scale wave-averaged model has three steps
1) interpolate the results (u, v, η), from the large-scale model into the FUNWAVE grid.

As shown in Figure 1, the output region(grid point, red dots) of the large-scale model should cover the entire FUNWAVE grid, which avoids any extrapolation. The grid of the large-scale model should be a structured grid, either curvilinear or rectangular grid. Values at A are obtained from interpolations within the angle (1,2,3) marked in the Figure (see detailed in the next section).
2) incorporate the large-scale model results into the sponge layer

Figure 2 shows sponge layers for example. The sponge layers can be configured in any of the four boundaries. In the current case, WEST, SOUTH, and NORTH sponges are specified.
3) make waves at the wavemaker location

An internal wavemaker should be used for this application. The west boundary wavemaker CANNOT be used due to the application of the WEST sponge.

2. Interpolation

Interpolation or extrapolation (not suggested) is employed between a structured grid of a large-scale model and the FUNWAVE grid. A linear interpolation method is performed. As shown in Figure 3, an interpolation value at point A in the FUNWAVE grid is evaluated by the values at three points, $1, 2$ and 3, of a triangle in the large-scale model grid which surrounds point A. Four triangle areas $S_{\alpha\beta\gamma}$, i.e., $S_{123}, S_{12A}, S_{31A}$ and S_{23A} are calculated using the following formula:

$$S_{\alpha\beta\gamma} = \begin{vmatrix} x_\alpha & y_\alpha & 1 \\ x_\beta & y_\beta & 1 \\ x_\gamma & y_\gamma & 1 \end{vmatrix} \tag{1}$$

where (x_α, y_α) represents coordinates of point $1, 2, 3$ and A. For interpolation, (α, β, γ) are counter-clockwise for all the four triangles and thus $S_{\alpha\beta\gamma}$ are positive. For extrapolation, clockwise (α, β, γ) results in negative $S_{\alpha\beta\gamma}$. The following formula is used for both interpolation and extrapolation:

$$F_A = (F_1 S_{23A} + F_2 S_{31A} + F_3 S_{12A})/S_{123} \tag{2}$$

where F_1, F_2, F_3 and F_A represent any converted variables at point $1, 2, 3$ and A, respectively.

To save computational time for interpolation/extrapolation, $S_{\alpha\beta\gamma}$ values are stored in the initialization stage (only calculated once).

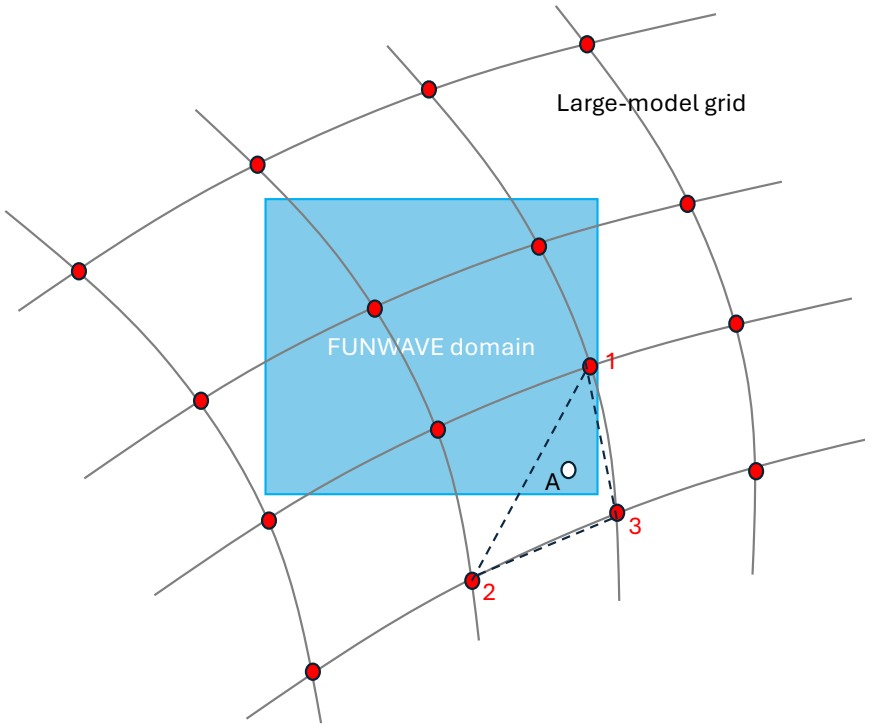

Figure 1: Interpolation triangle

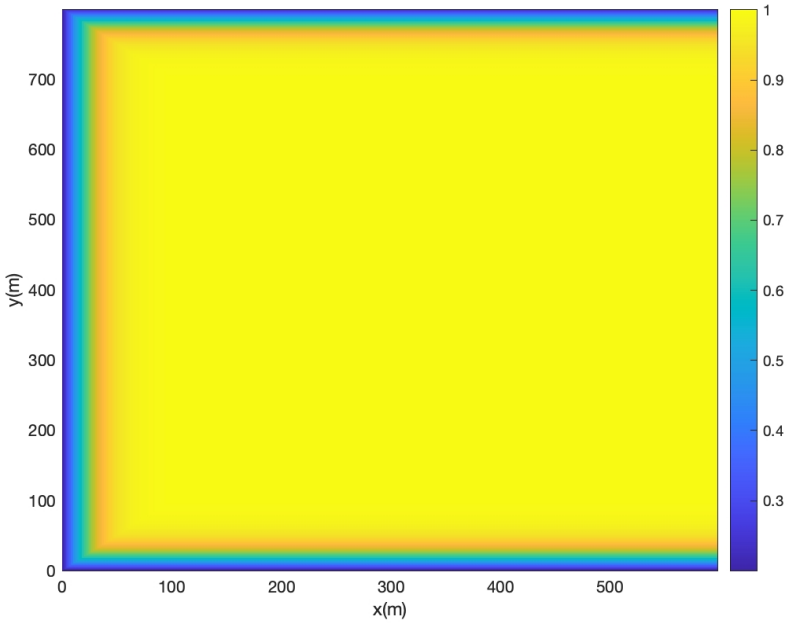

Figure 2: 2D sponge layers

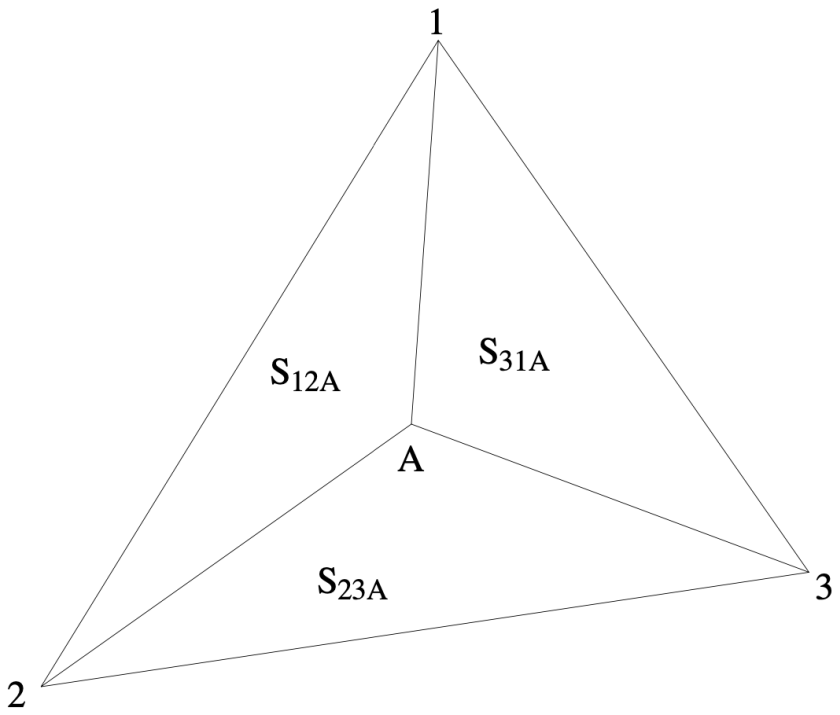

Figure 3: Interpolation triangle

3. The new module

The new module is called 'ABS_GEN_2D_MODULE' in mod_2d_abs_gen.F. To activate this module, you should specify

-DMAP2D_ABS_GEN

in Makefile when compiling the the code. In input.txt, the following parameters are needed, for example

MAP2D_GEN_ABS = T
BC_WEST_NEST = T
BC_EAST_NEST = F
BC_SOUTH_NEST = T
BC_NORTH_NEST = T
MappingDataFileName = large_model_data.txt

In the application, BC_EAST_NEST = F is applied, meaning no sponge and large-scale model results are needed. The nesting boundary conditions will be applied on WEST, SOUTN, and NORTH boundaries.

large_model_data.txt contains the large-scale model results in time. The following is an example of the data format:

eta, u, v data from a large-scale model (void line)
2 2 ! M_DATA N_DATA (the data grid is 2x2)
! 2d x-coordinate (void line)
0 1000 (x-coordinates)
0 1000 (x-coordinates)
! 2d y-coordinate (void line)
0 0 (y-coordinates)
1200 1200 (y-coordinates)
0.0 -time (in second)
0.0 0.0 - eta
0.0 0.0
0.0 0.0 - u
0.0 0.0
0.0 0.0 - v
0.0 0.0
500.0 -time
0.5 0.1 - eta
0.0 0.0
0.0 0.0 - u
0.0 0.0
0.0 0.0 - v
0.0 0.0

4. Example

The example can be found in /nest_large_model/. Procedures:

1) compile and code in the example folder

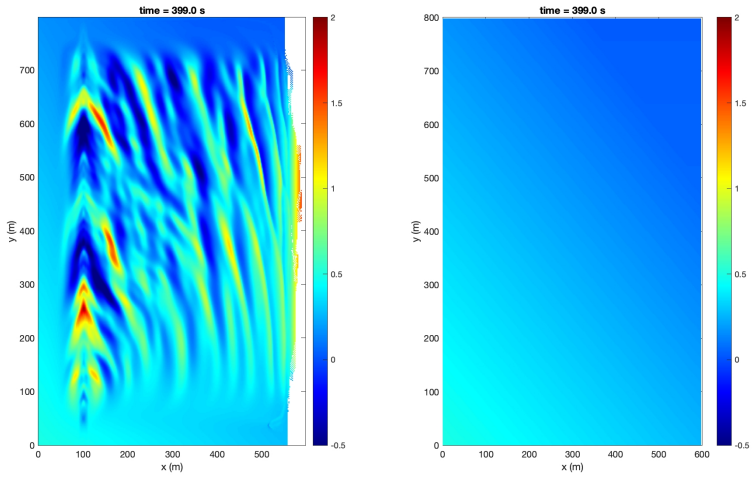

Figure 4: Left: surface elevation from FUNWAVE; right: surface elevation interpolated from the large-scale model

2) check input.txt
3) run the model
4) matlab scripts can be found in /postprocessing/
The following are two plots from the example.

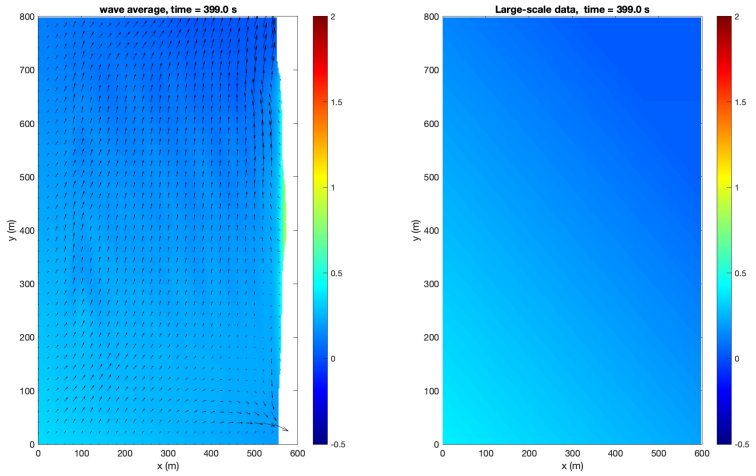

Figure 5: Left: mean surface and mean velocity from FUNWAVE; right: surface elevation interpolated from the large-scale model