# FUNWAVE-TVD WORKSHOP TUTORIAL

July 25-27, 2018 Embassy Suites, Newark DE







# Prerequisites for the FUNWAVE Workshop

- Your laptop is able to use Wi-Fi to access to the internet
- You can use SSH Secure Shell Client (like: Putty or Cygwin on Windows)
- If your laptop uses Windows OS, it is recommended that you download the latest version of cygwin (<u>http://www.cygwin.com</u>). Cygwin is a bash shell/unix emulation program and contains many of the tools such as tar, gzip/gunzip, and cpp, which will be useful for installation and compilation of FUNWAVE-TVD.
- Having a postprocessing toolbox on your machine (laptop). Both Matlab and Python post-processing script are provided with practice examples. Many participants already use Matlab, but if you do not, it is recommended that you install a Python package (information below).

# Downloading and Installing a Python Package (Anaconda)

The best and most comprehensive FREE package for the Python language, along with most tools and modules (e.g., NumPy, Matplotlib, etc.) is distributed by the Continuum Analytics under the Anaconda package. It is available for Linux, Mac OS X, and Windows machines. You do **NOT** need administrator privileges to install the Anaconda package, you can do so as a standard user on all three platforms listed above.

For the Anaconda package go to: <u>https://www.continuum.io/downloads</u>

Pick the <u>appropriate platform</u> (Linux, Mac OS X, Windows) by clicking the correct tab and get the Anaconda distribution that comes with <u>Python 3.6</u> (not 2.7). You can either download the <u>Graphical Installer</u> (recommended), of if you are comfortable with the terminal in the Linux/Mac OS X environment, you can also download it through the command line.

For the complete list of packages/modules included in the Anaconda Python distribution see: <u>https://docs.continuum.io/anaconda/packages/pkg-docs</u>

# Backup Plan (if UDel HPC has issues): Use Amazon AWS Cloud Computing

- Amazon AWS EC2 provides 12-month free tier, 760 hours/month
- If you don't have a HPC cluster, you can build your cluster in EC2
- A simple example can be found in **Appendix** in this tutorial

# Training Session # 1 (Wednesday, lead: Matt Malej)

# Topics

• FUNWAVE-TVD and Parallel Computing (MPI) - Documentation Wiki

Wiki ⇒ <u>https://fengyanshi.github.io/build/html/index.html</u>

• Where do I get the code? - Version Control (Github)

Full Repository ⇒ <u>https://github.com/fengyanshi/FUNWAVE-TVD</u>

Latest Code Release (July 2018) is version 3.3 ⇒ https://github.com/fengyanshi/FUNWAVE-TVD/releases/tag/Version 3.3

• Sandbox for USACE and DoD members with GUI [internal -- private on US Army side]

Link (need access) ⇒ <u>https://funwave.erdc.dren.mil</u>

- USACE/DoD HPC Portal Deployment of FUNWAVE [internal to DoD with ACL]
- How to build (compile/link) and install FUNWAVE-TVD on different machines for parallel computation?

https://fengyanshi.github.io/build/html/setup.html#compile-and-setup

# Practice

1) Log into ==> mills

```
> ssh your_user_id@mills.hpc.udel.edu
... input your password
> mkdir your_funwave_folder (optional, otherwise all will be in $HOME)
```

NOTE: \$HOME will be /home/funwave\_tvd\_workshop/tvdguest##

We suggest using **scp** on Mac/Linux (or FileZilla for USACE on ACE-IT laptop) to transfer data to/from *mills* 

> sftp your\_user\_id@mills.hpc.udel.edu

> scp your\_user\_id@mills.hpc.udel.edu:/home/your\_user\_id/test.txt ./
input your password

2) **Clone** FUNWAVE-TVD Package

> cd your\_funwave\_folder (if you created in step 1)

> git clone <u>https://github.com/fengyanshi/FUNWAVE-TVD.git</u>

- 3) Compile the source code (DIFFERENT EXECUTABLES)
  - > cd FUNWAVE-TVD/src
  - > emacs Makefile-Mills (if you want to modify the source file)

**NOTE:** Modify the Makefile if needed. Emacs/vi/gedit are text editors. You can use any other editor you are familiar with on the Unix/Linux system. To exit emacs editor press (Ctrl X then Ctrl C).

```
EXEC = funwave_surface_wave (for example)
FLAG_1 = -DDOUBLE_PRECISION
FLAG_3 = -DCARTESIAN
FLAG_2 = -DPARALLEL (if you want to run with parallel mode)
FC = mpif90 (on mills and amazon clooud)
```

The compiled/linked executable file will be funwave\_surface\_wave inside the src directory

- Compile the code for surface wave applications
  - > vpkg\_require openmpi (loads MPI libraries for parallel execution)
  - > make clean (or 'make clobber' if you want to remove the executable)
  - > make -f Makefile-Mills
- Compile the code for ship-wake applications [different executable]

Besides FLAGs used for surface wave applications, add/change

• Compile the code for sediment transport [different executable]

- > make -f Makefile-Mills-Sediment
- Compile the code for <u>spherical coordinates</u> (e.g., tsunami simulations)

Use FLAGs for surface wave applications, but **<u>remove</u>** 

FLAG\_3 = -DCARTESIAN

- > vpkg\_require openmpi (loads MPI libraries for parallel simulations)
- > make clean
- > make -f Makefile-Mills-Spherical

# Training Session # 2 (Wednesday, lead: Matt Malej)

# Topics

 How to run FUNWAVE-TVD? Navigating the basic sections within the INPUT file for different simulations (numerics, physics, input, output, etc.).

Wiki Direct Link ⇒ <u>https://fengyanshi.github.io/build/html/definition.html</u>

• Setting up (Linux/Mac OS X and HPC machines with PBS scheduler), running, and post-processing your first FUNWAVE-TVD simulation (1D beach runup or levee overtopping with shoaling and wetting/drying).

# Practice



# 1) Surface Waves on 1D Sloped Beach

Grid Dimensions: 1024X3. Grid sizes: DX=DY=2m. Depth at flat bottom: 10 m, Beach slope: 1/20.

- Go to the directory of the 1D case
  - > cd FUNWAVE-TVD/simple\_cases/surface\_wave\_1d
- Create a work directory

> mkdir work

Copy and rename one of input the files into a work folder (regular wave as an example)

```
> cd work
> cp .. / input_files/input_reg.txt input.txt
```

Copy compiled executable into the work directory

> cp ../../src/funwave\_mills ./

• Check and Modify input.txt

The following statements are necessary in the input.txt

```
Parallel (if applicable)
  PX = \dot{4}
  PY = 1
Depth
  DEPTH_TYPE = SLOPE
  DEPTH_FLAT = 10.0
  SLP = 0.05
  Xslp = 800.0
Dimensions
  Mglob = 1024
  Nglob = 3
Time
  TOTAL_TIME = 200.0
  PLOT INTV = 10.0
  SCREEN_INTV = 10.0
Grid sizes
  DX = 1.0
  DY = 1.0
Add wavemaker
  WAVEMAKER = WK REG
  DEP_WK = 10.0
  Xc_WK = 250.0
  Yc WK = 0.0
  Tperiod = 8.0
  AMP_WK = 0.5
  Delta WK = 3.0 ! the default is 0.5, set a larger number for long waves
Add sponge layer
  FRICTION_SPONGE = T
  DIRECT_SPONGE = T
  Sponge west width = 180.0
  Sponge_east_width = 0.0
  Sponge_south_width = 0.0
  Sponge_north_width = 0.0
Breaking scheme (default: SWE breaker)
  VISCOSITY_BREAKING = T
  Cbrk1 = 0.65
  Cbrk2 = 0.35
Wetting and Drying
MinDepth=0.01
Output
  RESULT FOLDER = output/
  ETA = T
```

MASK = T

#### • Run the Model

```
> cp ~/FUNWAVE-TVD/simple_cases/YourNamePBS.qs ./run_script.qs
```

open the run\_script.qs and examine/change desired content

> qsub run\_script.qs

**NOTE:** make sure run\_script.qs is in the current work directory. Computational time: 100 sec across a total of 4 cores.

## Post-Process Your Results

Download your results to your laptop (eta\_#####, mask\_#####, dep.out) and use the provided Matlab or Python scripts (using either sftp or scp).

```
> cd directory_where_you_want_to_download_your_results
> scp -r
your_user_id@mills.hpc.udel.edu:/home/your_user_id/FUNWAVE-TVD/simple
_cases/surface_wave_1d/work ./
```

...enter your password

**NOTE:** You will need to modify the output folder name in Matlab/Python scripts to load your results.



Figure: an example plot using Matlab plot\_wave.m

## 2) Waves on 2D plane beach



Model Configuration: Grid dimensions: 250X500. Grid sizes: DX=DY=2m. Depth at flat bottom: 8 m, Beach slope: 1/20.

- Go to directory FUNWAVE-TVD/simple\_cases/beach\_2d
- Create a work directory
  - > mkdir work
- Copy and rename one of input files into the work directory (regular wave as an example)
  - > cd work
  - > cp ../input\_files/input\_reg.txt input.txt
- Check and Modify input.txt

The following statements are necessary in input.txt

```
Slope bed
DEPTH_TYPE = SLOPE
DEPTH_FLAT = 8.0
SLP = 0.05
Xslp = 300.0
```

Output folder RESULT\_FOLDER = output/

Dimensions Mglob = 250 Nglob = 500 **Grid sizes** DX = 2.0 DY = 2.0

#### Add wavemaker

WAVEMAKER = WK\_REG DEP\_WK = 8.0 Xc\_WK = 150.0 Yc\_WK = 0.0 Tperiod = 8.0 AMP\_WK = 0.5 Theta\_WK = 30.0 Delta\_WK = 3.0

#### Add periodic boundary condition PERIODIC = T

#### Sponge layer

DIFFUSION\_SPONGE = F FRICTION\_SPONGE = T DIRECT\_SPONGE = T Csp = 0.0 CDsponge = 1.0 Sponge\_west\_width = 100.0 Sponge\_east\_width = 0.0 Sponge\_south\_width = 0.0 Sponge\_north\_width = 0.0

#### Wave breaking

VISCOSITY\_BREAKING = T Cbrk1 = 0.65 Cbrk2 = 0.35

#### Wave average property

T\_INTV\_mean = 100.0 STEADY\_TIME=100.0

#### Output

ETA = T Umean = T Vmean = T ETAmean = T MASK = T WaveHeight = T

NOTE: the required model computational time will be set to TOTAL\_TIME=950 sec, and ran on 8 cores

- Use the same procedures as in the previous sessions to run the model and post-process results
- Try different wavemakers, sponge layers, wave breaking scheme, non periodic boundary condition, etc.



Figure: an example of plot using plot\_wave.m, irregular obliquely incident waves.

# 3) EXTRA CHALLENGE - PROGRESSION

For those participants who were able to to complete the above task and want an additional challenge, try to set up the following (in simple\_cases/levee\_1d)

- a) Modify the **input.txt** to force the wavemakers with a **Solitary Wave** as input (**Hint:** WAVEMAKER=INIT\_SOL), of **0.16 meter** amplitude.
- b) Use the supplied bathymetry (**depth\_levee.txt**) as the **'DATA'** depth type with dimensions of [500 x 3] points.
- c) The depth at the wavemaker is **0.4** meters and it is located **4.0** meters from the left boundary.
- d) Set the **TOTAL\_TIME** to **30.0** seconds with a **PLOT\_INTERVAL** of **0.1** seconds.
- e) Activate the sponges (**DIRECT\_SPONGE** only) on the **west** (2.0m) and **east** (1.0m) side.
- f) Set the spatial discretization to dx=dy=0.08 meters, wetting/drying to 1 millimeter (MinDepth=0.001), FroudeCap=2.0, and CFL condition to 0.1.
- g) Output the depth, surface elevation (eta), and mask.



# Training Session # 3 (Thursday, lead: Fengyan Shi)

## Topics

- 1) Waves and wave-induced circulation
- 2) Sediment transport

## Practice

# 1) Rip channels



**Model Configuration:** The figure shows bathymetry (/simple\_cases/sediment\_rip/bathy/depth\_a15.txt). Waves generated at x = 280 m on flat bottom: 8 m. Grid dimensions: 312X100. Grid sizes: DX=1.0m, DY=2.0m. Depth file is in /simple\_cases/sediment\_rip/bathy/depth\_z15.txt.

- Compile the code with -DSEDIMENT flag on
- Go to directory FUNWAVE-TVD/simple\_cases/sediment\_rip

```
> cd work
```

- > cp ../../src/funwave\_wave\_sed ./
- Check and modify input.txt

The following statements are necessary in input.txt

```
Bathymetry
DEPTH_TYPE = DATA
DEPTH_FILE= ../bathy/depth_a15.txt
```

#### Output folder

RESULT\_FOLDER = output/

#### Dimensions

Mglob = 312 Nglob = 100

#### Grid sizes

DX = 1.0 DY = 2.0

#### Time

TOTAL\_TIME = 1000 PLOT\_INTV = 100.0 PLOT\_INTV\_STATION = 0.5 SCREEN\_INTV = 100.0

#### Add wavemaker

WAVEMAKER = WK\_REG DEP\_WK = 8.0

Xc\_WK = 280.0 Tperiod = 8.0 AMP\_WK = 0.5 Theta\_WK = 0.0 Delta\_WK = 3.0

#### Add periodic boundary condition PERIODIC = T

#### Sponge layer

DIFFUSION\_SPONGE = F FRICTION\_SPONGE = T DIRECT\_SPONGE = T Csp = 0.0 CDsponge = 1.0 Sponge\_west\_width = 0.0 Sponge\_east\_width = 60.0 Sponge\_south\_width = 0.0

#### Wetting and drying

MinDepth = 0.01

#### Wave breaking

VISCOSITY\_BREAKING = F

#### Wave average property

T\_INTV\_mean = 50.0 STEADY\_TIME=100.0

#### Sediment parameters

Bed\_Change = T BedLoad = T

D50 = 0.0005 Sdensity = 2.68 n\_porosity = 0.47 WS = 0.0125 Shields\_cr = 0.055 Shields\_cr\_bedload = 0.047 Tan\_phi = 0.7 Kappa1 = 0.3333 Kappa2 = 1.0 MinDepthPickup = 0.1





*Figure:* Case of sediment transport in rip channels. (left) surface elevation, (middle) sediment concentration, (right) morphological change

## 2) EXTRA CHALLENGE - PROGRESSION:

- analysis of wave-averaged properties such as the significant wave height (Hsig) and wave-induced currents.
- rip current case in /simple\_cases/rip\_2d/



Figure: rip current case. (Left) surface elevation, (middle) vorticity field, (right) nearshore circulation.

# Training Session # 4 (Thursday, lead: Fengyan Shi)

# Topics

- Wave simulation on 2D random bathymetry with complex shoreline geometries
  - 1) Inlet Problem (to include post-processing analysis of Harbor Resonance)
  - 2) Obstacles and Breakwaters (partially absorbing and reflecting inner boundaries)

# Practice

1) Inlet Problem



**Model Configuration:** Grid dimensions: 512X1024. Grid sizes: DX=DY=2m. The bathymetry / topography include flat bottom, barrier beaches, shoal, inlet and shallow basin.

- Go to FUNWAVE-TVD/simple\_cases/inlet\_shoal
- Create a work directory

> mkdir work

Copy and rename one of input files into the work directory (regular wave as an example)

> cd work

- > cp ../input\_files/input\_reg.txt input.txt
- Check and Modify input.txt

## The following statements are necessary in input.txt

Parallel (if applicable) ... running here on 16 CPU's (or cores/ranks) PX = 4 PY = 4Depth DEPTH TYPE = DATA DEPTH\_FILE = ../bathy/dep\_shoal\_inlet.txt **Output folder** RESULT FOLDER = output/ Dimensions Mglob = 512 Nglob = 1024 Time TOTAL\_TIME = 1200.0 PLOT INTV = 30.0 PLOT\_INTV\_STATION = 0.5 SCREEN\_INTV = 30.0 Grid sizes DX = 2.0 DY = 2.0 Wavemaker WAVEMAKER = WK REG DEP\_WK = 10.0 Xc\_WK = 250.0 Yc WK = 0.0 Tperiod = 12.0  $AMP_WK = 1.0$ Theta\_WK = 0.0 Sponge layer FRICTION\_SPONGE = T DIRECT SPONGE = T Csp = 0.0CDsponge = 1.0 Sponge\_west\_width = 180.0 Sponge\_east\_width = 0.0 Sponge\_south\_width = 0.0 Sponge\_north\_width = 0.0 Add periodic boundary condition: PERIODIC = T Wetting and drying MinDepth=0.01 Breaking scheme VISCOSITY\_BREAKING = T Cbrk1 = 0.65 Cbrk2 = 0.35 Wave averaging property T\_INTV\_mean = 240.0 STEADY\_TIME=480.0 Output ETA = T MASK = T WaveHeight = T

Use the same procedures as in the previous sessions to run the model and post-process results

## **EXTRA CHALLENGE - PROGRESSION:**

Try different options, for example, with **periodic boundary condition** for **obliquely incident waves**, **different wavemaker** and wave parameters.

# 2) Obstacles and Breakwaters (partially absorbing and reflecting inner boundaries)

For obstacles: Add an OBSTACLE FILE

OBSTACLE\_FILE = ../bathy/obs\_shoal\_inlet.txt

For breakwaters with full reflection: Add a breakwater structure in the bathymetry file

DEPTH\_FILE = ../bathy/dep\_shoal\_inlet\_brk.txt

For breakwaters with partially absorbing and reflecting inner boundary conditions: In addition to the bathymetry with the breakwater structure, add BREAKWATER FILE for partial reflection



Case: monochromatic, normal incidence



Case: irregular, normal incidence



Case: breakwater using obstacle option



Case: monochromatic, oblique incidence



Case: irregular, oblique incidence



Case: breakwater by modifying depth file



Case: partially reflecting/absorbing breakwater

## **EXTRA CHALLENGE - PROGRESSION:**

- 1) Analysis of harbor resonance.
- 2) Set up your own surface wave case

# Training Session # 5 (Friday, lead: Matt Malej)

## Topics

- Ship-wakes
  - 1) Setup with multiple vessels (paths, size, velocities)
  - 2) Ship wake-induced sediment transport
  - 3) A vessel moving on random bathymetry

## Practice

1) Setup with Multiple Vessels



**Model Configuration:** Grid dimensions 500x100. Grid sizes DX=DY=1.0m. Vessel 1, length=10m, width=5m, draft=2.0m, speed=10m/s, starts from x=50m. Vessel 2, length=20m, width=8m, draft=3m, speed=5m/s, starts from 450m toward -x direction.

- Compile the code with -DVESSEL flag in the Makefile
- Go to FUNWAVE-TVD/simple\_cases/vessel\_flat\_bottom
- Copy the executable to the current working directory
- Check and Modify input.txt

The following statements are necessary in input.txt

```
Parallel Info (if use parallel)

PX = 4

PY = 1

Depth

DEPTH_TYPE = FLAT
```

DEPTH\_FLAT = 10.0

Dimensions

Mglob = 500 Nglob = 100

#### Grid sizes

DX = 1.0 DY = 1.0

DT - 1.

#### Set time

TOTAL\_TIME = 50.0 PLOT\_INTV = 1.0 PLOT\_INTV\_STATION = 50000.0 SCREEN\_INTV = 1.0

#### Add vessels

VESSEL\_FOLDER = ./ NumVessel = 2

NOTE: You will need two vessel files: vessel\_00001 and vessel\_00002 in the current folder.

#### In vessel\_00001, specify:

Title: Vessel # 1 Blue\_Star\_I

Length(m), Width(m), Alpha(0.5), Beta(0.5), P(draft,m) 10.0 5.0, 0.5, 0.5, 2.0

Time, X(m), Y(m) (relative to the origin of the coordinates) 0.0 50.0 40.0 100.0 1050.0 40.0

#### In vessel\_00002, specify:

Title: Vessel # 2 Blue\_Star\_II

Length(m), Width(m), Alpha(0.5), Beta(0.5), P(draft,m) 20.0 8.0, 0.5, 0.5, 3.0

Time, X(m), Y(m) (relative to the origin of the coordinates) 0.0 450.0 60.0 100.0 -50.0 60.0

#### Output

RESULT\_FOLDER = output/ ETA = T

 Use the same procedures as in the previous sessions to run the model and post-process results



Figure: an example of plot using matlab code plot\_wave\_vessel.m

2) Ship wake-induced sediment transport



*Figure:* Simulation is performed in a half domain y=0-60m. Grid dimensions 400x60. Grid sizes DX=DY=1.0m. Vessel is specified in vessel\_00001. Vessel length=20m, width=10.0, draft=2m.

**NOTE:** SIMULATION WILL BE PERFORMED IN A HALF DOMAIN.

## Parallel Info (if use parallel) PX = 4 PY = 1 Depth DEPTH\_TYPE = DATA DEPTH\_FILE = ../bathy/depth.txt Dimensions Mglob = 400 Nglob = 60

#### Grid sizes

DX = 1.0 DY = 1.0

#### Set time

```
TOTAL_TIME = 60.0
PLOT_INTV = 2.0
PLOT_INTV_STATION = 0.1
SCREEN_INTV = 2.0
```

#### Sediment parameters

```
Bed_Change = T
BedLoad = T
D50 = 0.0005
Sdensity = 2.68
n_porosity = 0.47
WS = 0.0125
Shields_cr = 0.055
Shields_cr_bedload = 0.047
Tan_phi = 0.7
Kappa1 = 0.3333
Kappa2 = 1.0
MinDepthPickup = 0.1
```

#### Add vessels

VESSEL\_FOLDER = ./ NumVessel = 1

#### Output

RESULT\_FOLDER = output/ ETA = T

NOTE: You will need a vessel file: vessel\_00001 in the current folder.

In vessel\_00001, specify:

Length(m), Width(m), Alpha(0.5), Beta(0.5), P(draft,m) 20.0 10.0, 0.5, 0.5, 2.0

Time, X(m), Y(m) (relative to the origin of the coordinates) 0.0 40.0 60.0 25523.0 180040 60.0

NOTE: this is based on Froude number = 1.3 == U\_vessel / Cp = 7.05 / sqrt(9.81\*3.0) = 1.3



**Figure:** (top) surface elevation, (middle) sediment concentration, (bottom) bed change. Use /simple\_examples/vessel\_short\_channel/postprocessing/plot\_vessel\_morpho.m

# 3) A vessel moving in a random bathymetry



**Model Configuration:** Grid dimensions 500x500. Grid sizes DX=DY=2.0m. Vessel is specified in vessel\_00001. Vessel length=20m, width=10.0, draft=1m.

- Go to FUNWAVE-TVD/simple\_cases/vessel\_island\_beach
- Check and Modify input.txt

The following statements are necessary in input.txt

```
Parallel info (if use parallel) ... 16 CPU's used for computation here
        PX = 4
        PY = 4
Depth
        DEPTH_TYPE = DATA
        DEPTH_FILE = depth.txt
Set up dimensions
        Mglob = 500
        Nglob = 500
Discretization
        DX = 2.0
        DY = 2.0
Time
        TOTAL_TIME = 300.0
        PLOT_INTV = 1.0
        SCREEN_INTV = 1.0
Add a vessel
        VESSEL_FOLDER = ./
        NumVessel = 1
Output
        RESULT_FOLDER = output/
        ETA = T
 In vessel_00001, specify:
 Title: Vessel # 1
```

```
Blue_Star_I
Length(m), Width(m), Alpha(m), Beta(m), P(unit)
20.0 10.0, 0.5, 0.5, 1.0
0.0000000e+00, 5.6000000e+02, 5.0000000e+02
1.0000000e+00, 5.6374897e+02, 5.0255132e+02 ..... etc.
```



Figure: example of plot using Matlab code plot\_wave\_vessel\_island.m

## **EXTRA CHALLENGE - PROGRESSION:**

Design vessel paths in the inlet-shoal domain. Consider the interaction between wind waves and ship-waves.

- Compile the code with -DVESSEL
- Go back to one of the inlet-shoal cases, for example, input\_irr\_30deg\_ship.txt (rename it to input.txt when running the case) is in the folder /simple\_cases/inlet\_shoal/input\_files/
- Modify input.txt

```
VESSEL_FOLDER = ./
NumVessel = 1
```

Create a vessel file: vessel\_00001

In vessel\_00001, specify:

```
Title: Vessel # 1
Blue_Star_I
Length(m), Width(m), Alpha(m), Beta(m), P(unit)
10.0 5.0, 0.5, 0.5, 2.0
Time, X(m), Y(m) (relative to the origin of the coordinates)
0.0 900.0 0.0
150.0 900.0 0.0
250.0 900.0 1000.0
1000.0 -6600 1000.0
```



An example of vessel path in the inlet-shoal domain.

# Training Session # 6 (Thursday, lead: Fengyan Shi)

Topic: Tsunami sources and tsunami simulation using the spherical coordinates

## Practice

1) Tohoku Tsunami



**Model configuration:** Computational domain covers a region of the Pacific Ocean from 60°S to 60°N in the south-north direction, and from 132°E to 68°W in the west-east direction. The example is a 30min x 30min resolution case. Grid dimensions: 320x240, Grid sizes Dphi=Dtheta=0.5 deg.

- Recompile the source code <u>without</u> the flag -DCARTESIAN in the Makefile-Mills
- Go to FUNWAVE-TVD/simple\_cases/tohoku\_tsunami
- Copy the new executable into the current working directory
- Check and Modify input.txt

The following statements are necessary in input.txt

```
Parallel (if applicable)

PX = 2

PY = 2

Specify bathymetry

DEPTH_TYPE = DATA

DEPTH_FILE = ../external_files/depth_30min.txt

Dimensions

Mglob = 320

Nglob = 240

Grid

Lon_West = 132.0

Lat_South = -60.0

Dphi = 0.5

Dtheta = 0.5
```

```
Time
        TOTAL_TIME = 86400.0
        PLOT_INTV = 3600.0
        PLOT_INTV_STATION = 1.0
        SCREEN_INTV = 3600.0
Add initial conditions
        INI UVZ = T
        ETA FILE = ../external files/ETA 30min.txt
        U_FILE = ../external_files/U_30min.txt
        V_FILE = ../external_files/V_30min.txt
Add Sponge layers
        DIRECT_SPONGE = T
        FRICTION_SPONGE = T
        Sponge_west_width = 100000.0
        Sponge_east_width = 100000.0
        Sponge_south_width = 100000.0
        Sponge_north_width = 100000.0
Add friction
        Cd = 0.001
Avoid inundation in the basin scale (specify a large minimum depth)
        MinDepth= 10.0
Stations/Wave Gauges
        NumberStations = 78
        STATIONS_FILE = stations-pacific.txt
Output
        RESULT_FOLDER = output/
        ETA = T
        Hmax = T
```



Figure: an example of plot using Matlab code plot\_surface.m

# APPENDIX: Amazon AWS Cloud Computing (EC2)

Amazon AWS provides 12-month free tier https://aws.amazon.com/free/

1. Sign in AWS or 'Register now' if you don't have an account



# 2. Click EC2 to choose EC2 service



# 3. Create instance (build a machine for you)



4. Select a machine (I usually choose Linux AMI 2018)



# 5. Select instance type (any free one)

a a	WS Services	s v Resour	ce Groups 👻	*		🗘 fyshi	i ≁ Ohio ≁ Supj	port 👻
1. Choo	se AMI 2. Choose Ins	stance Type 3.	Configure Instance	4. Add Storag	e 5. Add Tags	6. Configure Security Gro	oup 7. Review	
Step 2: Choose an Instance Type Amazon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. Larger more about instance types and how they can meet your computing needs. Filter by: All instance types  Current generation  Show/Hide Columns								
Curre	ntly selected: t2.micro	(Variable ECUs, 1	vCPUs, 2.5 GH	z, Intel Xeon Fan	nily, 1 GiB memory, E	BS only)		
	Family ~	Туре –	vCPUs (i) -	Memory (GiB)	Instance Storage (GB) (i)	EBS-Optimized Available (i)	Network Performance (i)	IPv6 Support *
	General purpose	t2.nano	1	0.5	EBS only	-	Low to Moderate	Yes
	General purpose	t2.micro Free tier eligible	1	1	EBS only	-	Low to Moderate	Yes
	General purpose	t2.small	1	2	EBS only		Low to Moderate	Yes
	o .							
				Cancel	Previous Revi	ew and Launch	lext: Configure Instan	ce Details

# 6. Click Launch

	aws	ervices v	Resour	ce Groups 👻	*		4	fyshi 👻	Ohio 👻	Support 👻
1. Cho	oose AMI 2. Cl	hoose Instance	Type 3. C	Configure Instance	4. Add Storage	5. Add Tags	6. Configure Secur	ity Group	7. Review	_
Step Please the lau	Step 7: Review Instance Launch Please review your instance launch details. You can go back to edit changes for each section. Click Launch to assign a key pair to your instance and complete the launch process.									
▼ A!	VI Details									Edit AMI
▼ In:	eligible Ruby, F Root Dev stance Type	erl, and Java. rice Type: ebs	The repositor	ries include Docker, f	PHP, MySQL, Pos	tgreSQL, and ot	ther packages.		Edi	t instance type
	Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Sto	rage (GB)	EBS-Optimized A	vailable	Network	Performance
	t2.micro	Variable	1	1	EBS only		-		Low to M	oderate
✓ Security Groups Edit security groups										
								Canc	Previo	bus Launch
<b>₹</b> F	eedback 🥝	English (US)		© 2008 ·	- 2018, Amazon We	b Services, Inc. o	or its affiliates. All rights	reserved.	Privacy Policy	y Terms of Use

7. If you don't have a key pair, create a new one

- Choose 'create a new key pair'
- Name it in the second line (here I type fyshi\_new\_key)
- Download Key Pair
- Store the downloaded file (fyshi\_new\_key.pem) into a directory you can find later
- Go to the directory, in command line, type: chmod 400 fyshi\_new\_key.pem
- You can re-use the **Key Pair** in AWS (next page)

aws	Se	rvices v	Resource	Groups v	*			4	fyshi ~	Ohio +	Support -	
1. Choose AMI	2. Cho	ose Instance Typ	e 3. Conf	igure Instance	4. Add Storage	5. Add Tags	6. Configure Sec	urity Group	7. Review			
Step 7: R	eview	/ Instanc	e Laun	ch							_	
Instance	Туре	ECUs	vCPUs	Select	an existing	key pair	or create a	new key j	pair		× nce	
t2.micro		Variable	1	A key pair (	consists of a pub	lic key that AW	S stores, and a pri	ivate key file t	hat you store	. Together.		
▼ Security	Groups	5		they allow y to obtain th securely SS	you to connect to e password used SH into your insta	your instance i I to log into you nce.	securely. For Wind ir instance. For Lin	ows AMIs, the ux AMIs, the p	private key f rivate key file	le is required allows you	i y grouj	ps
Security gr Description	roup nam n	ne la la	unch-wizarc unch-wizarc	Note: The t about remo	elected key pair wing existing key	will be added to pairs from a po	o the set of keys av ublic AMI.	uthorized for th	iis instance. I	.earn more		
Туре 🕕			Protocol	Creat Key pa	e a new key pair ir name					0		
				fyshi_r	ew_key					_		
<ul> <li>Instance</li> <li>Storage</li> <li>Tags</li> </ul>	Details	1		•	You have to dov it in a secure an again after it's o	micad the priva nd accessible i reated.	ate key file (".pem location. You will r	file) before you	Download a can continu download the	Key Pair te. Store file	e deta : stora; Edit ta	uils Ige Igs
								Cance	Launch	Instances	Launo	a
Peedback	. <b>9</b> E	nglish (US)			0 2008 - 2	2018, Amazon We	b Services, Inc. or its	affiliates. All right	ts reserved.	Privacy Policy	Terms of Us	

7-A. You can re-use the Key Pair if you already had one

aws service	ces v Resource Groups v		.ᢕ fyshi ∽	
1. Choose AMI 2. Choose	Instance Type 3. Configure Instance	4. Add Storage 5. Add Tag	s 6. Configure Security Group	7. Review
Step 7: Revier	Select an existing key	pair or create a new	key pair	× instance and complete
AMI Details     Amaze     Free tier     The Am     Bithy P	A key pair consists of a <b>public key</b> they allow you to connect to your in to obtain the password used to log i securely SSH into your instance.	hat AWS stores, and a private Is stance securely. For Windows A into your instance. For Linux AM	cey file that you store. Together, Mis, the private key file is required is, the private key file allows you f and for this instance. Learn more	e Edit AMI
Root Dev	about removing existing key pairs fr Choose an existing key pair Select a key pair	om a public AMI.		Edit instance type
Instance Type	fyshi@udel.edu	cess to the selected private key	\$) file (fyshi@udel.edu.pem), and	work Performance
<ul> <li>t2.micro</li> <li>Security Group</li> </ul>	that without this file, I won't be a	ible to log into my instance.	Cancel Launch Instances	Edit security groups
			Cane	cel Previous Launch
🔍 🗨 Feedback 🛛 🥥 Engl	lish (US) © 20	008 - 2018, Amazon Web Services, In	c. or its affiliates. All rights reserved.	Privacy Policy Terms of Use

8. After successful launch, you will see the following page



9. Click Instances on left panel, you will see instances (here I launched two) running Choose one (blue square) you want to access by a terminal, Click Connect

	a + Hesource Groups +	<b>*</b>		÷ ,	
EC2 Dashboard Events	Launch Instance 👻 Conne	ct Actions ~		∆ ⊙ ♦	
Tags	Q, Filter by tags and attributes or r	earch by keyword			Ν
Reports	Name - Instance I	D - Instance Type - Availability Zone -	Instance State - Status Check	s v Alarm Status Public DNS (IPv4) v	IPv
Cirina	i-0da54c29	6c001a3e3 t2.micro us-east-2b	🥥 running 🛛 🚊 Initializing	g None 🍃 ec2-18-219-134-5.us-e	18.
<ul> <li>INSTANCES</li> </ul>	i-Oeec3bf6	198a38ecb t2.micro us-east-2b	running Ø 2/2 checks	None 🍃 ec2-18-222-128-106.us	18.
Launch Templates Spot Requests	Instance: i-0da54c296c001a3e	3 Public DNS: ec2-18-219-134-5.us-east-2.com	npute.amazonaws.com	88	
Reserved Instances	Description Status Checks	Monitoring Tags			
Dedicated Hosts	Instance ID	i-0da54c296c001a3e3	Public DNS (IPv4)	ec2-18-219-134-5.us-east- 2.compute.amazonaws.com	
IMAGES	Instance state	running	IPv4 Public IP	18.219.134.5	
AMIs	Instance type	t2.micro	IPv6 IPs		
Bundle Tasks	Elastic IPs		Private DNS	ip-172-31-25-27.us-east-2.compute.internal	
ELASTIC BLOCK STORE	Availability zone	us-east-2b	Private IPs	172.31.25.27	
Volumes	Security groups	launch-wizard-3, view inbound rules, view	Secondary private IPs		
Snapshots	Scheduled events	No scheduled events	VPC ID	vpc-b55e7fdd	
NETWORK & SECURITY     Security Groups	AMI ID	amzn-ami-hvm-2018.03.0.20180622-x86_64- gp2 (ami-40142d25)	Subnet ID	subnet-21b4375b	
Flastic IPs	Platform		Network interfaces	eth0	
Discourse Comme	LAM role		Source/dest. check	True	

10. Copy the line highlighted (paste in the terminal later)



# 11. Access to the virtual machine using ssh

A. Go to the directory you stored your Key pair file fyshiudeledu.pem:

# \$ cd directory\_you\_store\_key\_pair

# B. ssh (or sftp), paste the ssh link you did in step 10:

\$ ssh -i "fyshiudeledu.pem"
ec2-user@ec2-18-219-134-5.us-east-2.compute.amazonaws.com

The authenticity of host 'ec2-18-219-134-5.us-east-2.compute.amazonaws.com (18.219.134.5)' can't be established.

RSA key fingerprint is 72:49:9d:11:cd:4c:70:79:8c:06:3e:6c:66:aa:59:6c.

Are you sure you want to continue connecting (yes/no)? yes

Warning: Permanently added

'ec2-18-219-134-5.us-east-2.compute.amazonaws.com,18.219.134.5' (RSA) to the list of known hosts.

\_\_| \_\_|\_ ) \_| ( / Amazon Linux AMI \_\_\_|\\_\_\_|

https://aws.amazon.com/amazon-linux-ami/2018.03-release-notes/ 2 package(s) needed for security, out of 2 available Run "sudo yum update" to apply all updates.

# 12. Start to use the virtual machine

# 13. After using it, you should stop your instances.

The "bill" will be based on the time used by instances after the free period

- To stop or terminate your instances, click Actions ->Instance state-> stop or terminate
- If you terminate your instance, everything associated with this instance will be removed, including software you installed.

aws services	i 🗸 Resource Groups 🤟 🛠	۵ •	yshi + Ohio + Support +
EC2 Dashboard	Launch Instance - Connect Actions A		∆ -0 <b>0</b>
Tags	Q, Filter by tags and attributes or search Get Windows Password		
Reports	Name - Instance ID Launch More Like This Availability	v Zone - Instance State - Status Checks - Alarm Status	Public DNS (IPv4) - IPv4
Limits	I-0da54c298c00 Instance State     Start     Instance State     Start     Start	running Ø 2/2 checks None	🍃 ec2-18-219-134-5.us-e 18.21
Instances	■ i-0eec3b/6498a5 Image      Reboot	running Ø 2/2 checks None	🍃 ec2-18-222-128-106.us 18.22
Launch Templates	Instances: I-0da54c296c001a3e3, CloudWatch Monitoring >	to	880
Spot Requests Reserved Instances	Description Status Checks Monitoring Tags		
Dedicated Hosts	i-Oda54c296c001a3e3: ec2-18-219-134-5.us-east-2.compute.amazonaws. i-Deec3b/6498a38ecb: ec2-18-222-128-106.us-east-2.compute.amazonaw	com is.com	
IMAGES     AMIs		490 (99411)	
Bundle Tasks			
<ul> <li>ELASTIC BLOCK STORE</li> <li>Volumes</li> </ul>			
Snapshots			
NETWORK & SECURITY     Security Groups     Elastic IPs			
Feedback Q English	03	© 2008 - 2018, Amazon Web Services, Inc. or its affiliates, All rights res	arved. Privacy Policy Terms of Use

# 13. Install Git, gfortran, MPICH, and FUNWAVE-TVD

Using the terminal that you created in step 11, go and

A) Install Git by

\$ sudo yum install git

- B) Install gfortran
  - \$ sudo yum install gcc-gfortran
- C) Install MPICH by
- download MPICH at http://www.mpich.org/downloads/
- use sftp to put the downloaded file mpich-3.2.1.tar.gz into the virtual machine
- \$ tar -xzf mpich-3.2.1.tar.gz
- \$ cd mpich-3.2.1/
- \$ ./configure --disable-cxx
- \$ make
- \$ sudo make install
- D) Get FUNWAVE-TVD

\$ git clone <u>https://github.com/fengyanshi/FUNWAVE-TVD.git</u>

E) Compile the code and test it! And ..... Voila!