

# NTHMP/MMS Workshop: Tsunami Currents Meeting Notes

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## Workshop Notes: Monday, Feb. 9<sup>th</sup>, 2015 <sup>1</sup>

In attendance: <http://nws.weather.gov/nthmp/2015annualmeeting/attendees.html>

**Introduction:** MMS co-chairs, Rick Wilson & Kara Gately

### **Purpose and Goals of Workshop [Wilson]** - [Presentation File](#)

**Purpose:** satisfy requirement for 2013-17 NTHMP strategic plan to evaluate numerical accuracy of tsunami currents.

#### **Goals:**

- Compare predictions
- Establish community standards
- Can benchmarks be improved

#### **Outcomes:**

- adequacy and accuracy of currents
- Group to write report to summarize the workshop, results, and process
- Follow-up on benchmark improvements

Q. If a model passes these tsunami benchmarks, are they valid for inundation too? A. No... MMS reminds modelers that they CAN do the benchmark problems individually and then contact MMS for pass/fail approval. MMS will be providing more information on this process.

### **Overview of Benchmark Problems [Lynett]** - [Presentation File](#)

Objectives: get a handle on accuracy and variability for decoupled velocity

1. **BM#1:** not the most geophysical but good to get a handle on model runup
  - a. Data to compare
    - i. Time series of velocity components in wake
    - ii. Can model get the magnitude and frequency of the vortex shedding?
  - b. 3 different configurations
    - i. Dissipation submodels included, 0.01 mannings value, HYDROLOGICALLY SMOOTH
    - ii. Optimized results – get your best fit.
    - iii. All dissipation submodels NOT included => no spinning or wave should be created... what is the equivalent numerical dissipation and how does it compare to the physical dissipation

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<sup>1</sup> These notes may have some inaccuracies and the reader should consult the forth-coming official MMS Workshop proceedings report for a full description of the workshop, modeling techniques, and definitive results.

2. **BM#2:** Hawaii ADCP from Pearl Harbor 2001
  - a. Boundary inputs were standardized as best as possible by putting in wave right above harbor
  - b. Low (6 min) sampling rate on the ADCP data
  - c. Questions to consider:
    - i. What level of precision can we expect with regards to resolution?
      1. 20 m
      2. 10 m
      3. 5 m
      4. Look both at local and spatial specifics
3. **BM#3:** New Zealand ADCP 2011 event
  - a. A good case for looking at how tides may play a role.
  - b. 3 cases:
    - i. Drive model with free surface elevation
    - ii. Tsunami only simulation
    - iii. Tsunami + tide simulation
4. **BM#4:** Flow through a built environment (model must be able to resolve buildings)
  - a. Requires moving shoreline
5. **BM#5:** Breaking solitary wave past conical obstacle

## Modeler Presentations

**Yalciner and Kanoglu (METU, Turkey)** - BM problems: 1,2,3,4,5 - [Yalciner Presentation File](#)

NAMI DANCE model - Solves NLSW, based on TSUANMI N2, TIME project of UNESCO

- **BM#1**
  - Dissipation submodels included - poor timeseries fit
  - Optimal - Vortex flow is there and reaches steady state
  - Dissipation submodels NOT included - vortex flow not there
- **BM#2**
  - Resolution comparison - all same
  - No difference between different mannings
  - Pretty good match with E-W/N-S ADCP timeseries (the 20m res almost looks better here)
  - Maximum speeds are adequate, but better inside the harbor than at entrance
  - (Pat) Did you look at the animations or speeds? A. haven't looked at them yet
- **BM#3 Tauranga**
  - Incident wave timeseries have good fit for surface elevation and ADCP
  - Tide gauge timeseries has large discrepancies after 20 hours
- **BM#4**

- Compare free surface velocity AND momentum flux information recorded through tank
- Modeled momentum flux is very low (B1)
- B6, B4, B9 have fair comparisons...
- BM#5
  - Free surface elevation measurements look good for Gauge 1,2... 4,5
  - Modeled data looks worse behind the island (gauge 3,6)
- BM#4 expanded... (using MOST and ComMIT) [Kanoglu Presentation File](#)
  - Loaded up grid for Seaside and buildings into ComMIT
  - Created boundary conditions
  - Some issues with arrival times, magnitudes adequate
  - There is some sort of scaling issue going on... with MOST, the results are very sensitive to how the problem is set up
  - (Pat) if time isn't scaled right then your velocity shouldn't be scaling correctly either
  - (Diego, Pat) try using different friction coefficients

Q. Are we asking too much to try and fit with just ONE manning coefficient?? A. Likely yes. (Diego A./Pat L.)

## **Horrillo and Knight (NTWC, AK) - BM problems: 1,2 - [Presentation File](#)**

ATFMv2 model

- BM#1
  - Problems:
    - NO vortex shedding was ever seen with the original upwind-downwind scheme
      - However, advection treated as in "VanLeer" Manner with U/V as piecewise linear functions across the mesh (to avoid loss of calculation of the velocity), DID produce good results
    - couldn't reach a steady state right away...
  - OPTIMIZED: M=0.015, and horizontal viscosity of  $5 \times 10^{-6} \text{ m}^2/\text{s}$  gave good results for both T1&T2. Max speed .24 m/s
  - Indication that bottom friction is not enough, need internal friction
  - INVISCID result: (no horizontal friction in model) keep manning = 0.01
  - From the modeler:
    - There is a need for higher order scheme
    - Extremely sensitive to small variations
- BM#2
  - Hilo TG amplitude was a little low, period pretty good. Control point looked good too.
    - Q. (Pat L.) what's going on in the first 30 minutes? A. Up/down dip... not sure, will follow-up with Bill Knight
  - reasonable ADCP fit
    - PROBLEM: unsure how to do the best match with 6 min averaged data

- Next time modeler hopes to try to match the amplitude at the tide gauge, not the control point, in hopes of being able to better achieve the V component at the gauge
- Resolution changes had no effect

## Arcas (NCTR) - BM problems: 1,2,3,4 - [Presentation File](#)

### MOST model

- BM#1:
  - was challenging to get it optimized, highly sensitive over the submerged island
  - Inviscid,  $n = 0$ : (no physical friction, but model has numerical friction) we get a wake with two standing vortices behind the island. It settles into a steady state
  - Prescribed,  $n=0.01$ : disorganized vortex shedding, U-vel is underestimated on gauge1
  - Optimized,  $n=0.025$ : nice vortex shedding that reaches steady state quite soon (U-vel for gauge behind island, still underestimated the horizontal velocity => wake behind the island is a little longer than it should be.
    - (Juan) including the horizontal velocity equation will shorten that
- BM#2:
  - ISSUE: Tide gauge tsunami arrival is before the max peak at the control point.
  - No difference in resolution changes. For wave amplitudes problem is very converged.
    - The overall magnitude of the currents is there, even though the peak to peak and timeseries waveform may not be exact
  - E-W and N-S current speeds show DO changes in resolution, but highest resolution is not always best. Low/high seem to have similar results, but the medium resolution has differences
    - (Pat) Late timeseries peaks may be from eddies.
    - $Cf=.01/.03$  results for tsunami currents are quite sensitive to the friction coefficient
- BM#3:
  - Tsunami Only:
    - good fit with sea elevation time series
    - tsunami currents: decent fit with ADCP data (U/V) but speed is underestimated by MOST
  - produce a solution with tidal velocities
- BM#4:
  - 0.025 friction coefficient to stabilize the code with use of buildings
  - Pretty good agreement with first three points, but not the last... have very small modelled values there, probably because of the high friction used
    - Model results have delayed arrival... To optimize, modeler would like to use a different friction coefficient from wet and dry points
- BM#5:
  - top the island, as in video

- Good comparison with amplitude and the overall features of the flow (looking at snapshots from experiment with model snapshots)
- Arrival time is good for points in front of the island, but as it travels around the island and comes back around the island, the arrival times become delayed
- Velocity is overestimated behind the island

Q. (Fai) Does the model make it to the top of the hill behind the island? A. No. I believe I'm using too much friction.

Comment on BM#4: (H. Yeh) The control point is VERY important, interested in the reflected wave as well. On BM#1: 2D model can't do without tweaking the parameters, flow become very 3D, same with #5. Using an unreasonably large value of N is necessary to promote mixing... Could be very unrealistic, but because of the nonsteady and non-uniform flow pattern, it works.

### **Nicolisky (UA-F, AK) - BM problems: 1,2 - [Presentation File](#)**

Alaska Model

- BM#1:
  - $n=0.012$  (optimal), looks good with nice vortex shedding and easily reached steady state
  - Uvel underestimated for all Manning Coef's
- BM#2:
  - Control point: great fit (model result from NEOWAVE)
  - Tide Gauge: good initial fit on waveform, but model overestimates the amplitude and the fit decreases over time
  - Decent match with ADCP data, but again, hard to know with the 6min averaging
  - Max speed at 3 m/s
- BM#4: Good comparisons
  - Matches at control point
  - Nice fit for flow velocity and depth at all points but with late arrival on the last point

### **Tolkova (NWRA, WA) - BM problems:1,2,3,4,5 - [Presentation File](#)**

Cliffs model - (MOST with the wall in between wet and dry nodes)

- 2 possible difference schemes for  $Q(k,j)$  steady state equation
  - centered difference (Cliffs)
  - average between left and right cells (Cliffs2)
- BM#1:
  - $N=0$  vortex shedding
  - $N=0.01$
  - $N=0.015$  optimal

U1 is over-estimated by model for both  $n=0.01$  and optimal

Extra dissipation of reflected wave in MOST model, but Cliffs solves this (for example: MOST gave correct timeseries for 3 hours, Cliffs for 6... )

- BM#2:
  - Input a single pulse into the boundary to judge response at control point.
  - Control point is dead on, Hilo TG is adequate
    - Comment from the modeler on the need for better benchmarking using real observational data not simulated inputs
  - Good fits with e-w, n-s currents, only minor differences between the resolutions
  - Cliffs2 (using the second type of differencing scheme) showed better results than Cliffs
- BM#3:
  - Again sent in unit pulse
  - Good results for all cases
  - Huge spatial variability in the BM setup, there's a 3 x 3 area around the ADCP location
    - Modeling using the exact location of the ADCP shows some problems
- BM#4:
  - Input WG (5m) thru left boundary
  - Overall, good-to-decent fit through all points...Not quite matching overall amplitude and waveform for first few stations
  - A no houses comparison was made as well
    - Note that the gauges are down a clearing, not behind house. Explains some of the similarity in the with/without house model runs.
  - Used the same coefficient from the paper, for both.
    - Acknowledges that it would make sense to have a different friction coefficient.
  - Some concern and discussion about the BM#4 setup and the existence of a wall across the south side.
- BM#5:
  - Later arrival for points behind the island
  - Modeler feels that MOST cannot do this benchmark because it cannot handle this type of topography.

BM#3 extended: (Modeled by Dmitry N.) In ocean, you can't observe the whole wave front. You have DARTs. You can use impulse response to forward model, and you only need a single DART timeseries, with pre-computed responses that have nothing to do the source.

Pre-computed response control type modeling DOES rely on the problem being linear, and wave reflections do have a non-linearity but it wasn't an issue with these BMs.

**LeVeque (UW, WA)** - BM problems: 1,2,3,4,5 - [Presentation File](#)  
GeoClaw - no dissipation terms, adaptive refinement grid resolution



- BM#1:
  - $N=0.015$  (optimal)
  - Have to increase the velocity to get steady state shedding
  - No run with no friction, but 0.001 still has shedding, albeit more chaotic
  - Very sensitive to parameters in the numerical method (even time steps)
- BM#2:
  - Hilo using full propagation from Japan - pretty good fit on observations - TG location very sensitive to changes
  - Talk about the ADCP measurements in the vertical. Lots of 3D structure to flows that we can't hope to capture with 2D simulations
  - difficult to match with time history because of the transportation of eddies back and forth across the comparison points.
    - Discussion on this, and that in general, with the existence of eddies, trying to match timeseries exactly doesn't make a lot of sense
  - Slightly bigger areas of max velocity when the grid resolution is refined from 20 to 5, but same patterns
  - No difference in control points for varying resolution
  - Modeler Q. how well should the match at the control point predict the fit at the TG
    - Our model is not capturing what the EQ model that was used to create this benchmark got...
- BM#4:
  - Good amplitude match at gauges, but no reflected waves
    - Model guesses because model doesn't have dispersion?
  - Reasonable flow depth, last gauge poor
  - Reasonable velocity and momentum flux, but again last gauge poor

### **Yamazaki/Bai (UH, HI) - BM problems:1,2,5 - [Presentation File](#)**

NEOWAVE model - Hydrostatic hybrid scheme -> "breaking termination" non-hydrostatic, and flip back and forth.

Some prior model validation through 2011 Tohoku tsunami (Honolulu coast and Penguin Bank)

- Can reproduce tsunami induced current as observed on HDFR near Penguin Bank
- BM#1: (note: resolution does affect the shape of the conical island)
  - 2 cm resolution (tried, 1,2 ,3) gives best results
  - No viscosity incorporated yet
  - As resolution increases, so does the strength of the vorticity as well as the oscillation frequency of the vortices
  - With  $n=0$ , modeled vortex results are still the same
- BM#2:
  - Had to fill in the grid boundary edge to keep model stable.

- Model results do not depend on resolution
- Pretty good fit for amplitude and velocity time series
- Strength in vorticity increases with increased resolution, but the general characteristics stay the same
- BM#5:  $n=0.012$ 
  - Resolution does not change results
  - Vortices are generated in wake and around the island
  - The initial wave profile is not well resolved, although amplitudes are fine
  - Vortex strength is weaker than in higher resolution, but general pattern is the same
  - The run-up process involves vortices as well

Conclusions:

Can reproduce the mean flow (tsunami induced current) which is less sensitive to resolution

Numerically generated vortex field depends on:

- Spatial and temporal resolution
- Bottom friction
- Numerical scheme
- Generation mechanism

## Lynett (USC, CA) - BM problems:1,2- [Presentation File](#)

COULWAVE model

Backscatter model is important for perturbations (interface mixing) - though it increases the computational time by a factor of two, so only used when needed to show a difference

- BM#1:
  - Optimal (1cm resolution) and using backscatter model
  - Roughness height = 0.015 hydraulically smooth
  - All dissipation models off (when no limiters used, simulations crash from instability)
    - no steady state pattern achieved
  - Prescribed bottom friction: resolution of 0.015m
  - Friction factor formulation is very important
- BM#2:
  - Control Pt.
    - Changing the resolution has no impact
    - Input wave looks fine, 20 m resolution output off by 20 cm.. or so
    - Numerically converging at 20m resolution
    - Time series differences better done by subtracting the wave envelope
  - 5 & 20 m resolutions match, but the 10 meter had an eddy at HA25...
    - ...something worth considering
  - HA26 eddies the whole time
    - Eddy variability and error are quite similar

- Variation amongst resolutions is only where the eddies are => 20 meters likely ok in areas where you don't have eddies

Modeler's leaving thought: In areas where tsunami currents are controlled by eddies, what value does a deterministic solution have?

### Zhang (VIMS, VA) - BM problems: 1,2 - [Presentation File](#)

SCHISM: Semi-Implicit Cross-scale Hydroscience Integrated System Model (3D model)

- BM#1:
  - phase is very sensitive to model inputs,  $\Delta t$  and  $C_d$
  - 2D
    - With dissipation,  $n=0.01$
    - Without dissipation,  $n=0$  => no flow (for 3D as well)
  - 3D with dissipation and 10 vertical layers
  - Large differences between 2D/3D models (3D performs best)
- BM#2: jetty resolved by splitting triangles by 4 for grid resolutions, took isobaths line as the upper boundary for Hilo harbor entrance (only did 2D modeling on this)
  - No change with resolution (it seems this model did not have the troublesome eddy off jetty that others did which caused the 10m resolution to be different.
    - (Pat) looks like the main eddy is larger in your model than the others
  - Pretty good fit overall at ADCP and tide gauge

### Macias (Univ of Malaga, Spain) - BM problems:1,2,3,4,5 - [Presentation File](#)

HySea model – composed of several different numerical schemes depending upon the problem.

- BM#1: was most difficult for the modeler of all the problems
  - 112 numerical experiments - Problem extremely sensitive to changes, wanted to know more
    - 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> order methods
    - Friction law,
    - changes in friction coefficient
    - changes in boundary conditions
    - Problem extremely sensitive to changes, wanted to know more
  - Changing the Manning coefficient actually ended up having the most positive effect
  - Optimal choice was difficult
    - Amplitude and velocity had different best configurations
    - Friction:
      - Higher sensitivity for low values
      - Lower sensitivity for higher values
    - Boundary Condition (BC)
      - Implementation is crucial

- If perturbations do not leave, they become problematic
  - Order:
    - Don't even bother with 1<sup>st</sup> order
    - 3<sup>rd</sup> not necessarily better
    - Higher the order the better the BC must be
- BM#2:
  - good match at control point
  - good velocity and amplitude comparisons at the ADCP
    - sensitivity to friction
  - Hilo TG fit is pretty good
  - Very little sensitivity to resolution
    - Although modeler notes resolution outside the harbor is important
- BM#3:
  - Tsunami only – good fit
  - Tide only – good fit
  - Tsunami+Tide – good fit
- BM#4: good fit, but again, no reflected waves
  - Didn't quite get initial flow depth data, but the rest fit well.
    - This part of the talk was covered very fast due to time restraints
- BM#5: non-dispersive versus dispersive (for the first time)
  - Dispersion is mandatory for this problem
  - Friction has more of an effect for locations behind the obstacle

Model run times on GPUs are fast. A 50x speedup on 1 GPU. 10 GPUs gives a 277x speedup – a full Tohoku run in ~ 7 min.

### **Pampell (TAMU-G, TX) - BM problems: 1,2 - [Presentation File](#)**

TSUNAMI3D model – optimized for submarine landslide cases (3D)

- BM#1: was most difficult problem for this group
  - Optimal solution
    - Vortex shedding with steady pattern
    - Captures velocity, amplitude, and period – gave gauge1 a little lower than obs
    - is inviscid
      - has artificial viscosity ( $10^{-4}$ ) same as the effective viscosity for this flow
    - free slip BC
  - $N=0.01$  (experimental friction factor)
    - No slip BC – “logarithmic law of the wall”
- BM#2: Reasonable fits... good at control point, not quite as good farther in. Smoothing helped when comparing results to the ADCP data (difficulty comparing with the 6 min data again)

(Pat) Numerically fine, but not really geophysically correct – model does not show eddies like the others do.

## **Discussion:**

Q. How best to compare among models using two point sources which have eddies going back and forth?

Q. Can the models be used for our maritime hazard purposes? Maximum velocity is important for NTHMP.

We need more observational data.

- Q. What is most important to model correctly? Eddies off shore, near shore currents, etc? A. It depends upon the need... calm areas, boat entrance to harbor, etc.
- Discussions about accuracy already... Q. but are we addressing the ADEQUACY of this tomorrow?
- For the engineering community, height of crest to prevent inundation, maximum depth for scour, forces applied to a ship (max vel.), time of arrival - what the engineering community needs is a clear report or documentation of these assumptions
- From the Emergency Management perspective, real observational scenarios are best and it was surprising how well each of the models did on BM#2. Encouraging... or we're all doing it wrong.
- Q. Could we talk about modelling tides tomorrow (Zhang)
- BM problems forced by timeseries, engineering uses a ground movement for source

The following request from MMS was announced and sent out via email: Please provide 1-3 things which you feel would improve the tsunami current benchmark problems, setup procedures, and/or presentation of model results.

## Workshop Notes: Feb. 10<sup>th</sup> 2015 <sup>2</sup>

### The Potential of Near-Field HF Radar Tsunami Velocity Observations for Alerts and Heights Based on Modeling [Barrick] - [Presentation File](#)

An overview on tsunami detection from CODAR HF Radar sensors:

- How HF radar “sees” the tsunami
- The development of a tsunami detection algorithm for use in early warning
- HF radar observations of tsunami currents can be used to infer the wave height near the coast, when used in conjunction with good tsunami models

Questions:

1. Elena Suleimani: What is Q-factor: Non-linear empirical trigger unrelated to velocity.
2. Elena S. follow-up: How are tsunami velocities distinguished from others: Spatial scales
3. Diego A.: what you are measuring in wave elevation? No, we measure the velocity: two velocities: orbital and phase (the big velocity)
4. Diego A. follow-up: Which velocity is measured: Answer: orbital measured  
Compared with data? No, with ADCP velocity data only

## Modeler Presentations

### Kirby (UD, DE) - BM problems: 1,2,3,4,5 - [Presentation File](#)

Questions:

Chip Guard: On #3, how wide is channel?

Kirby defers to Grilli who says to count the grid cells: each are 40-meters. 15 cells x 40 == 600m wide.

Zhang: If you turn off all friction and dissipation you get vortices. Says that he represents the only group who couldn't get vortices.

Juan Horillo: Provided his thoughts on 3D model. Results between 3D and 2D do not make sense to him.

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Kirby: Thought it would be worth pursuing, particularly with 3D models, 2-D models over-predict eddy energy. 3D tend to under-predict

Grilli: Surface elevation varies very slightly within the ADCP. Not a lot of variation in surface elevation but there is great velocity field variation

Lynett: Points out that feature seen in plot isn't eddies

Diego: Comment - Areas in where there are differences is where there are eddies; Velocity at 20-m resolution looks more like 5-m resolution than 10-m resolution.

Kirby: Don't have vorticity field to look at here with me.

Diego: Comment - He did plot the vorticity and sees an effect of eddies

Diego: Comment - Only problem for which all models are getting the same result for a real-life case.

John: Flow depths were dropping substantially: Requests comment on changes taking place; is reflection taking place between measured areas?

Kirby: cannot comment at this time

Dmitry: Comment – possible reason for grey band in plots

Dmitry: Hilo harbor: models produce different results.

Grilli & Kirby speculate movement by the current string.

NOS person? Nope; upward looking ADCP

## **Roeber (Tohoku University, Japan)** - BM problems: 1,2,5 - [Presentation File](#)

- As shown in all presentations, u-component is underestimated by model. Off by a factor of two so 'wonders' if there is something wrong with the data.
- Used full domain; has seen others clip the domain but he used the full domain.
- He did modify bathymetry

Questions:

Zhang: #1 results – 1<sup>st</sup> gauge, the gauge is located at the end of the circulation zone so you might be pulling data out from the wrong location. Zhang had good results with 3D model.

Lynett: Clarification – Zhang didn't move the gauge – don't move the gauge

## **Li (AECOM, CA)** - BM problems: 1,2,5

Presented by Hong Kie Thio

Clawpack-based code (inundation) GeoClaw, FUNWAVE

- Essentially uses GeoClaw except for a modification to use fixed telescoping grids. They find it to be faster and provides better performance.
- Ran old benchmarks too – looks ‘pretty good’ but there are some issues in run-up.
- Runs through current benchmarks (#’s 1, 2, 4, 5)

Questions:

1. Elena Tolkova: Code is based on GeoClaw?  
Thio: yes
2. Tolkova: Please explain why there is no inundation in bottom panel of #4.  
Randy: Depends on Manning Coefficient and Grid resolution.  
Diego and others: found the same low inundation results  
Hong Kie does not know what parameters were used – will check

### **Arikawa (PARI, Japan)** - BM problems: 1,2,4 - [Presentation File](#)

STOC (2D) & CADMAS-SURF (3D) models

- Quasi-3D model
- STOC: Storm surge & tsunami simulator
- BM 1 – STOC-ML (2D) results == bad; 3D results == good
- BM 2 – STOC-ML == good results
- BM 4 – STOC-ML

Questions:

1. Lynett: What is numerical dissipation – what are advection terms (how are you handling advection terms) – Leap frogging in time and space so have fairly large numerical errors
2. How do you choose eddy viscosity?  $Ve$
3. So far lab scale,  $Ve$  is probably very very large
4. Zhang: Finest grid is for 3D model usually people do opposite;  
Lynett: Wondering why you made grid choice; Why is 3D model used in inner most nest; closest to shore

Presenter: Calculation time maybe

Lynett: answer - Want to resolve flow around structures; something that 2D doesn’t do as well.

5. Rick: Harbor areas  
Port/Harbor areas we use STOC model  
Are models publically available? Yes  
Are data publically available – probably ok for research purposes

### **Sampath (Centriod Pic, CA / Idaho National Labs)** - BM problems: 1,2,5 - [Presentation](#)

[File](#)



## SPH model

- Designed for astrological problems – relaxed Jacobi solver
- Used for compressible fluids
- (<http://www.naadir.tk/phd-thesis>)
- BM 1: he was able to set up vortices by changing the problem (island size and parameter tweaking)
- BM 2: problems with runs
- Overall – looking for collaboration with and advice from other modelers.
- Has done movie graphics so generated a mega wave

### Questions:

1. Juan Horrillo: can create particles so maybe create and throw away particles instead of recycling them back.

Particles are inherently known by neighbors so creation of new ones might create instabilities so went with recycling

Lynett: Methods to include turbulence -- will discuss together later

## Summary and discussion of model results intercomparisons [Lynett] - [Presentation File](#)

- **What do we NEED from our models.**
- **What can we realistically expect from our models.**

## Notes from Discussion (one perspective):

B#1:

- (Marie) split models into groups, don't compare optimized with other results...
- (Pat) BM#1 is a canonical problem, it's something really simple that you can test your model against... but there is an argument that this IS not geophysically accurate and maybe another problem should be used. The CHALLENGE is the friction... it's super smooth. Way less than geophysical.
- (Zhang) don't compare 2D with 3D
- Suggestion to use frequency for result summation
- Look at goodness of fit for the last 60 seconds of timeservers, and also look at frequency (structural engineers are concerned with period)
- We need to decide what is an allowedable standard deviation....

- Metric looked at should be something that looks at the mean or the median
- (George) From a hazard standpoint looking at the max is possibly better
- Analysis should only include models that converged after reached a quasi-steady state
- Suggestion for a second dataset from the lab to confirm truth
- Keep B#1? If we can't create a wake with a simple model, how do we model anything overland?
- (grili) a 3D model is needed for eddies...
- (Elena S.) WC modelling needs to take into account source location and directionality
- Since we are mostly 2D modelers, don't think frequency is something we can look at (if 3D then yes... )
- Look at integrated energy over an average cycle, includes both the frequency effect and the amplitude effect. If you have energy correct, then you have a decent production of frequency...
- (Grili) B#1 – dispersion important  
B#2 – dispersion not important.... Separate out models that use dispersion
- Modelers provide CONVERGENT result for OPTIMUM configuration. Use a metric of integral of energy in a period.
  - Not sure what acceptable deviations are for this yet...

B#2:

- Envelope timeseries ... because of phase differences it's not easy to compare timeseries
- Good agreement, all models within 20 cm, and between 10-20 cm/s
- Why use the 10m resolution versus others... why not use all?
- Does the model data need to be de-sampled?? Or find out what the original averaging method for the ADCP data was...?
- The ensemble mean average is better than all results.

Possibly moving forward, do we want to...

- Duration of currents greater than 1.5 knots... this is more variable and not sure we currently have to observations necessary for it, but could get them. Can't expect accuracy greater than 1-2 hours.
- Models differ where eddies are generated... You can't just blindly use a single model result because the variation is high.
- As a group, for model velocities, we have converged... but this doesn't show up for individual models  
Ensemble means are converging much faster

- You have to use standard deviation to have knowledge of your confidence
- “Thresh-holding” maritime hazard maps into greater than 1.5 m/s banding, (or > 2m/s, or 3-6 knots, etc.) seems to work pretty well for maritime hazard. We need to find the preferred threshold limits, or sweet-spots. “One example is from Pat Lynett and others (2014) paper addressing the relationship between current velocity and damage severity. These current threshold bins are from 0-3 knots for no damage, 3-6 knots for minor to moderate damage to occur, 6-9 knots for moderate to major damage to occur, and above 9 knots for major to complete damage to occur. The current thresholds might be less (2-5-8 knots) if harbor facilities are older or not maintained.
- Experienced modelers could identify these areas of vorticity based on bathymetry and structural elements which may produce vortices. These areas can be identified on current hazard maps.
- How is this different than maximum vorticity?
- How do you propose to judge models as a combined B#1/2 pass?
- To improve the benchmark for HILO: Model from the source rather than control point? Benchmark it as the model would be used in practice. If you want to use your own source, use the DART as a control point. Metric is the TG and 1 ADCP.

## Notes from Discussion (another perspective):

Grilli: Asks for identification of models in results

1. Ask ourselves: what are we doing? Remind ourselves of what we are modeling
2. Question: What should we get from a model? Pat decided look first at range. He is trying to come up with statistics to show that models are appropriate to use.
3. BM 1 All results submitted are summarized (some model results are best (after tweaking parameters, aka friction...) while other model results are strictly following benchmark results)
  - Range consideration means offset is ignored
  - Single spike will skew results
  - Focus is on evaluation metric and what to expect from model performance
  - Tim Walsh asks: does this include results from models that didn’t converge. Pat: Not all results here converged so we would need to require that models converge.
  - Gary Chock: RMS of all peaks – measure of maximum deviation of peaks. Bestows engineering perspective on what would be useful. Not only magnitude but also characterization of results in statistical way is needed.
  - Diego: Need to know what the metrics will be so appropriate results are submitted for evaluation.
  - Pat: Is BM 1 appropriate as a metric
  - Grilli: Suggests having two groups re-run BM1 and conduct testing

- Elena S.: Harbor characteristics are important
- Pat: How to move forward: 2D models just cannot adequately model eddies...
- Spaniard 1: Use maximum velocity as metric
- Pat: integrated energy as a metric should be correct – this will take offset into account.
- Trying to come up with the optimum result.
- Kirby: Careful about defining an averaging period...
- Volker: Suggest more runs with other specifications
- Vasily: provide results and parameters that were used.

Criteria: Modelers provide:

1. A convergent result
  2. Period, kinetic energy ( $u^2 + v^2$ ), 3D Models == vertical integration of ( $u^2 + v^2$ )
4. BM 2
- Results of all 12 models (10-meter resolution) show very tight and consistent performance.
  - As a group, models are consistently 10-20 cm/sec error.
  - Average error across entire time series
  - Model max speed across entire time series. (max model velocity subtracted from max data)
  - Duration of currents greater than 1.5 knots – unstable statistic
  - Eddies are problems – do a better job
  - Thresh holding: gives areas of confidence → gives some support to looking at bins of velocity.
5. How would you propose to judge models using BM1 and BM2?
  6. Benchmark for Hilo: Should be used as a real problem.
  7. Randy: Agree that there is value at having a signal control point. Specify more than 1 single control point.

## Plan for writing summary report:

- Create a proceedings report –
  - Keep it non-NOAA, just technical proceedings report
  - in it limit the amount of pages (2, 5? written pages per benchmark), total max of pages (15?). These will be determined.
  - have standardized graphics (created by Pat)
  - have standardized document sections
    - for full disclosure and easy comparison, make sure headings and subsections are detailed and cover things like modifications made to the benchmark.

- Have a results section that is written by Pat solely or some other outside source
- Also create a scholarly journal article submission with summarized outcomes.
  - Pat to write and then send out for review and approval.
- Also set up a data repository for all the benchmark results
  - Hosted by USC, along with the benchmark problems
  - Would provide access to the data for future reference,
  - Possibly handy for engineers who need to look at things not summarized in the NTHMP proceedings, like flow depth, maximum velocity, momentum flux, etc.

★ **A Microsoft Word Template Document with Table of Contents, Headings, Subsections, and Figure listings, will be created and circulated to the modelers for use in their individual reports.**

## **Workshop Summary and the Path Forward [Wilson, Gately] - [Gately Presentation File](#)**

### **Summary:**

Workshop attendance and participation was wonderful. The modelers were very prepared and the presentations led the way for valuable and interactive group discussions.

BM#1: Several modelers had difficulties with this one. The parameters needed to reach an “optimal” solution varied greatly. Some people had trouble getting the model to even shed vortices much less reach a steady state.

BM#2: Overall, most people did well on this one. The various resolutions all performed similarly, with the only obvious difference being in the spawning, location, and size of the eddies. Overall, modeled velocities had a 1-2 m/s error and the modeled amplitudes were within 20 centimeters of each other at the Hilo tide gauge.

BM#3-5: Were done as a whole or in part by several modelers as well, and the results were encouraging.

### **Path Forward:**

The MMS co-chairs will be working closely with Pat Lynett to summarize the results of the workshop in a statistical and graphical manner that best highlights the model results. As there is very little observational data for tsunami currents, it is difficult to benchmark a single model in a manner which fully validates it for all possible scenarios. Hence, three paths forward were discussed:

- Individual state modeling – use the results of the workshop to identify the error or confidence you have in your model, and go forward with it, in a manner that represents that error to the public.
- Hazard Binning of Results – by grouping the velocities into separate bins related to the hazard and damage potential, you can increase your confidence in an individual model results and

provide a usable product for harbor response planners; areas where vortices are developed and move to can be identified by experienced modelers on the hazard/damage potential maps

- NTHMP ensemble modeling – work with NTHMP partners and states to perform ensemble modeling, perhaps through a shared platform, to ensure results are more consistent and possibly more conservative in capturing areas of strong currents