NTHMP Tsunami Currents Mapping and Modeling Subcommittee Benchmarking Workshop

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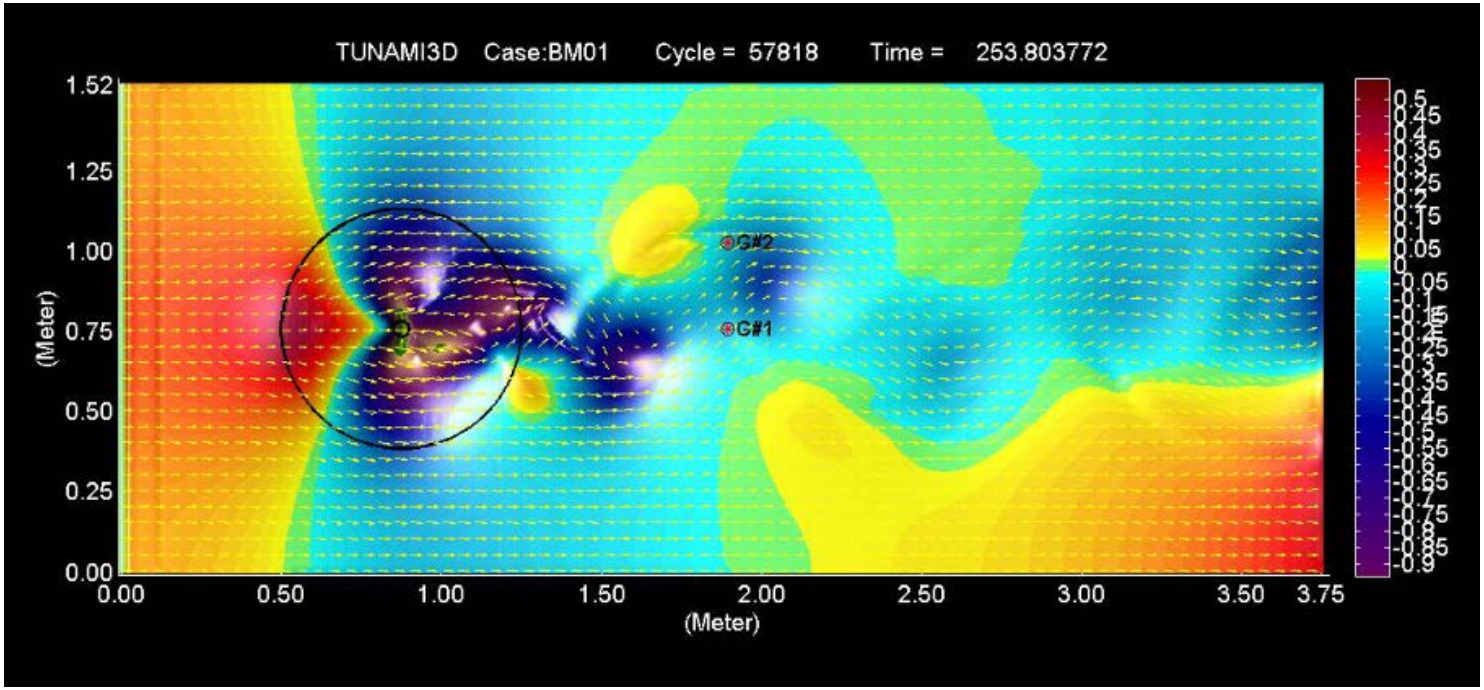
Model Description

- 3D Navier-Stokes equations for Newtonian, incompressible fluid
- Nonhydrostatic → mode on
- Structured grid
- Finite difference scheme
- Simplified VOF method for free surface tracking
- Basic upwind-downwind formulation for nonlinear terms

Movies BM#1

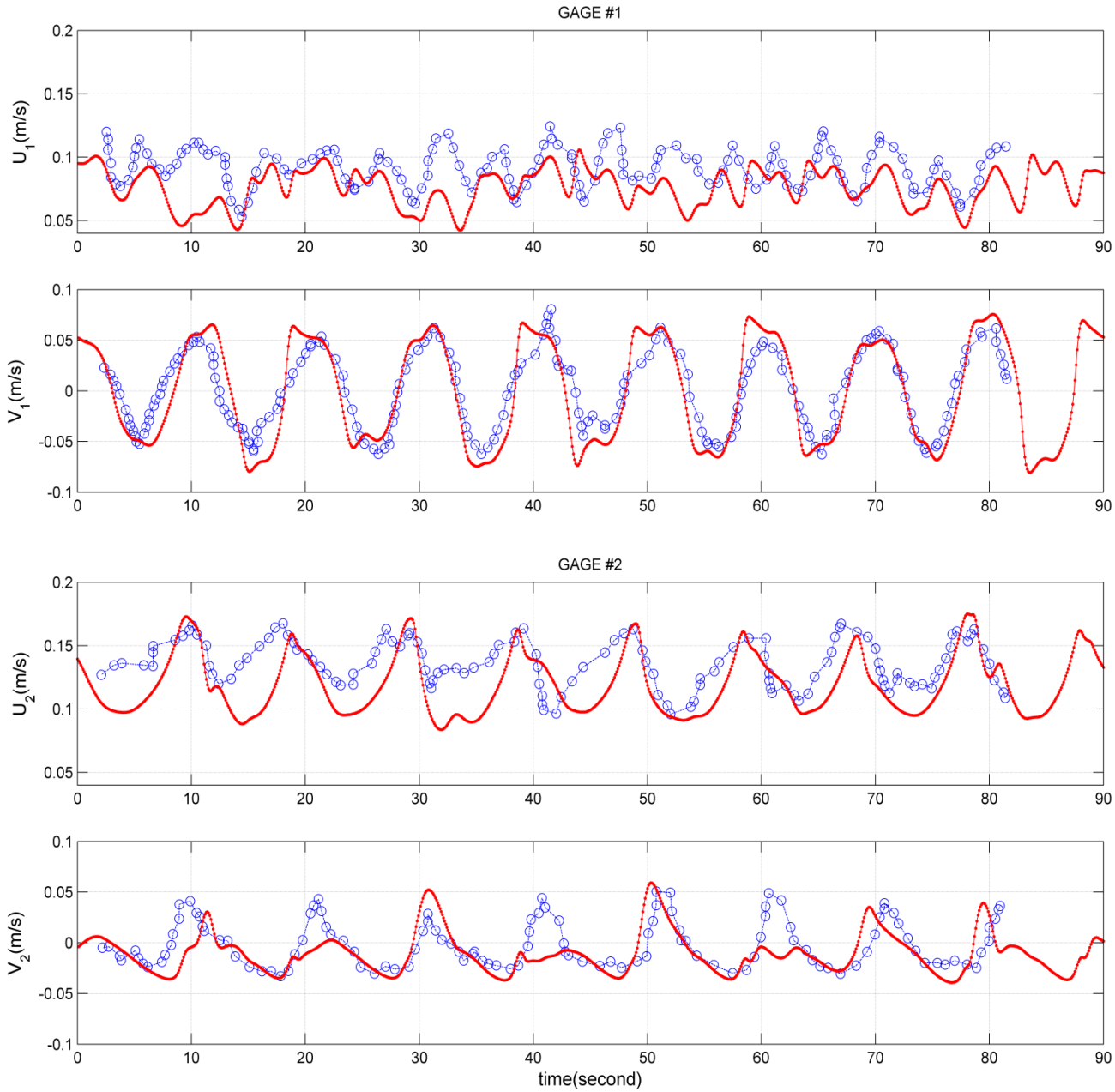

TUNAMI3D Case:BM01 Cycle = 57818 Time = 253.803772
1.52
1.25
1.00
0.75
0.50
0.25
0.00
(Meter)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
3.75
(Meter)
G#2
G#1

Benchmark #1

- 3.75m x 1.52m x 0.054m computational domain
- 0.01m x 0.01m x 0.0027m cell size
- 154 x 377 x 28 = 1,625,624 cells total
- ~16 hours CPU time for 100 sec, 8 CPUs, Cray CX1
- Inflow condition: $U = 0.115\text{m/s}$ applied at the left boundary, 1.52m x 0.054m
- Outflow condition: $U = \eta\sqrt{\frac{g}{H+\eta}} + 0.115$

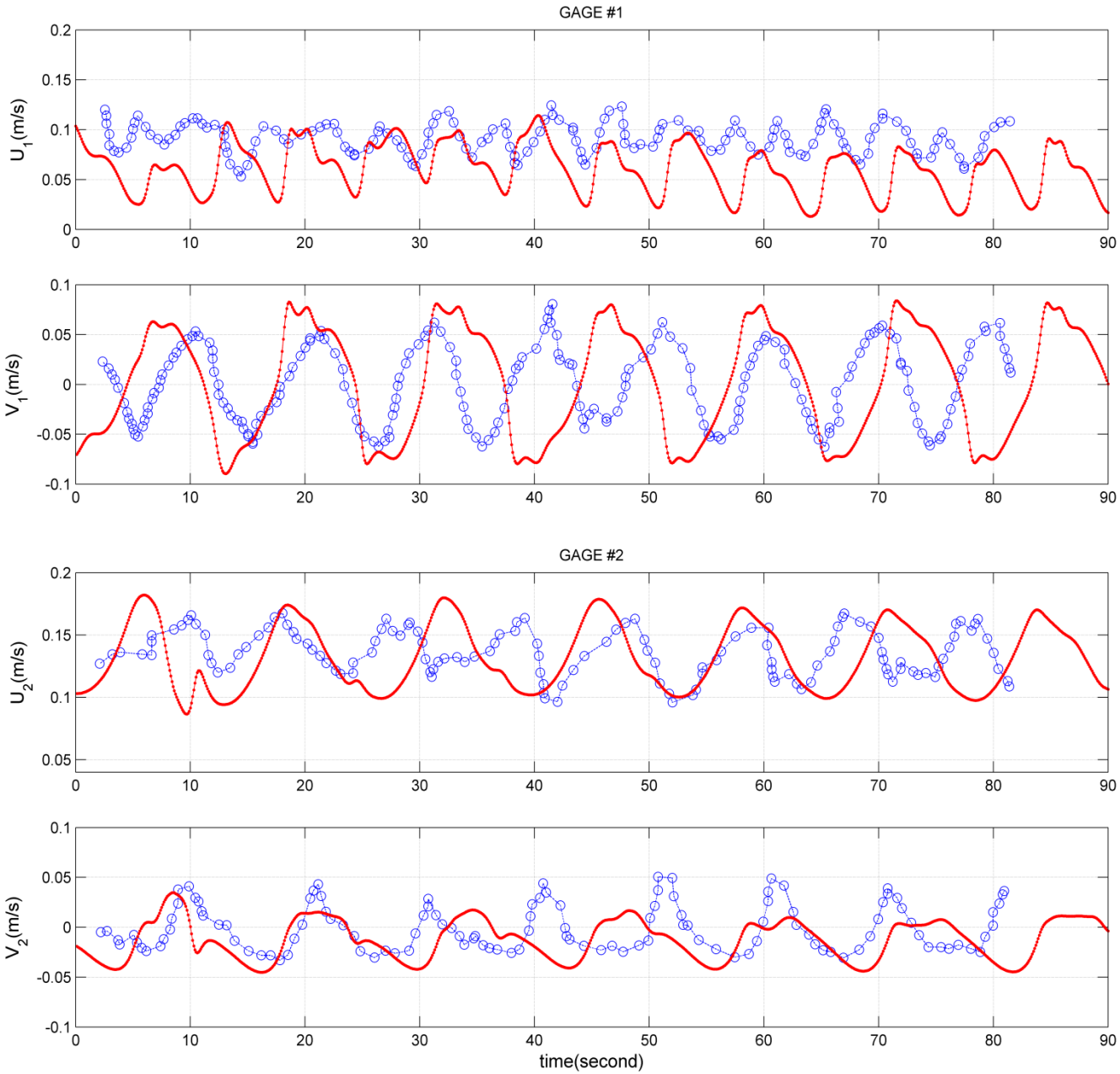
Optimized Solution

- Free-slip boundary conditions
- Invicit as the artificial viscosity from truncation error of upwind-downwind scheme is of the same order, $O(10^{-4})$, as the effective viscosity for this flow .
- Good match to data in amplitude and period



Solution with Experimental Friction Factor

- No-slip boundary condition using the "Logarithmic Law of the Wall" for n=0.01

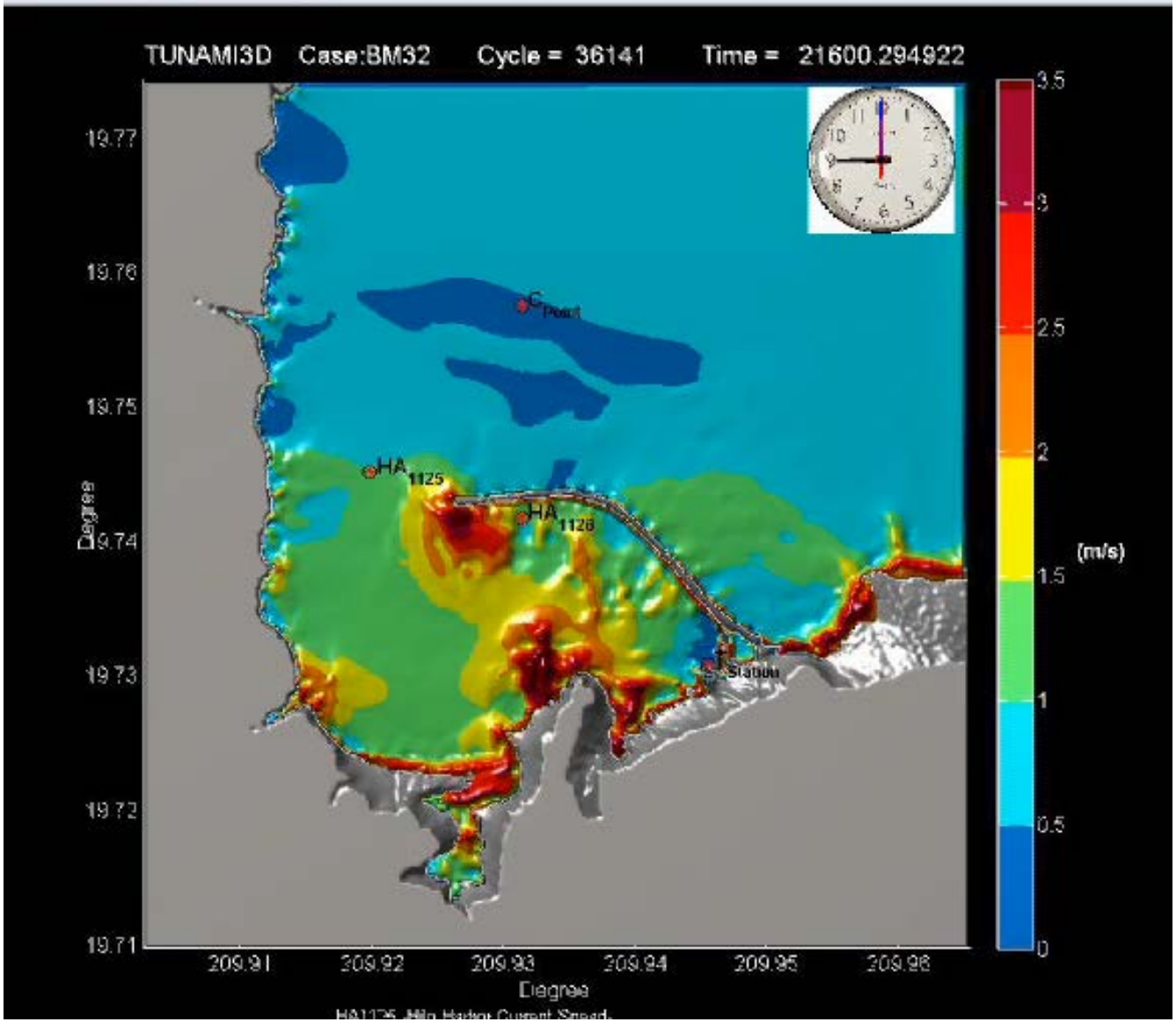


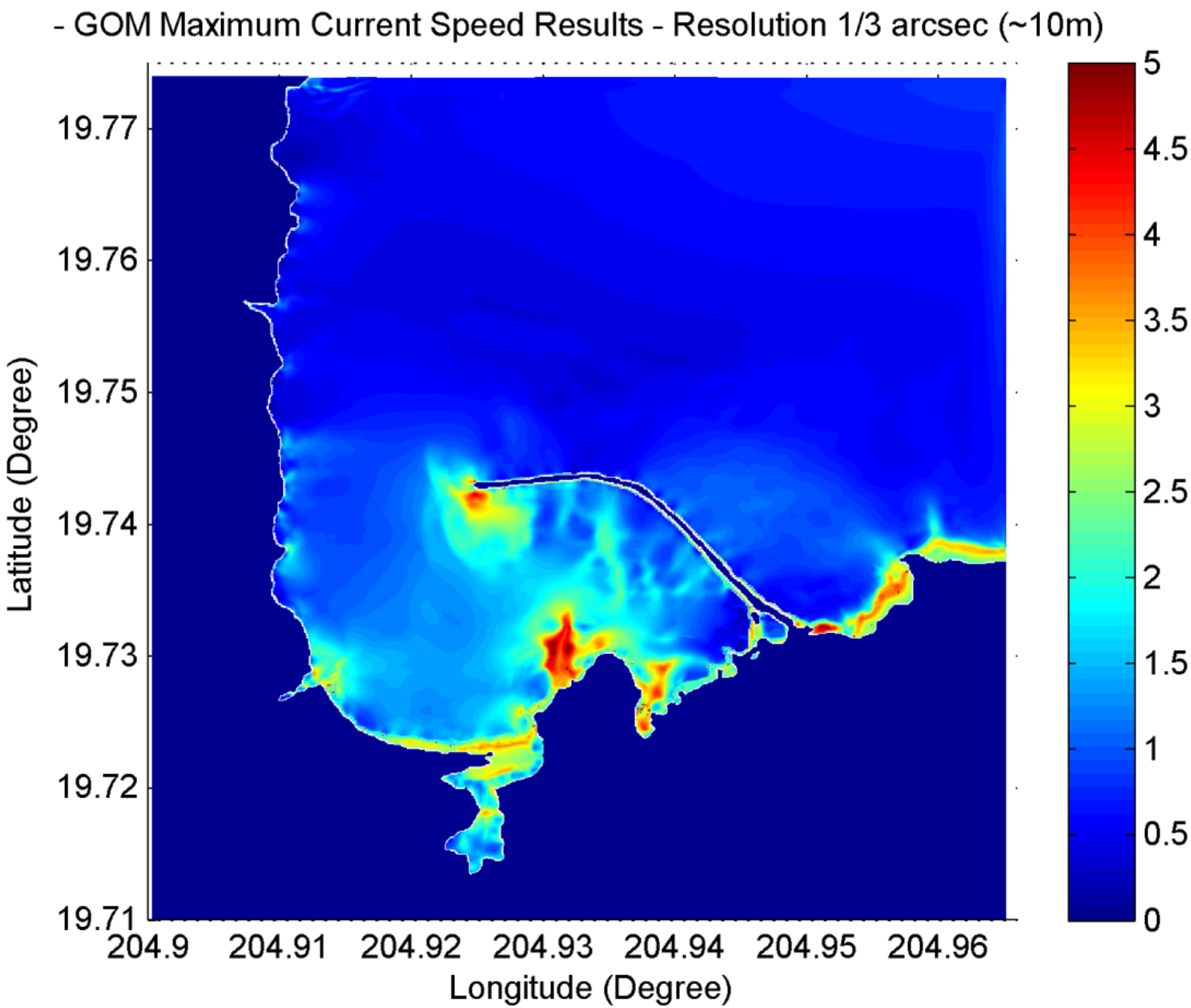
Benchmark #2

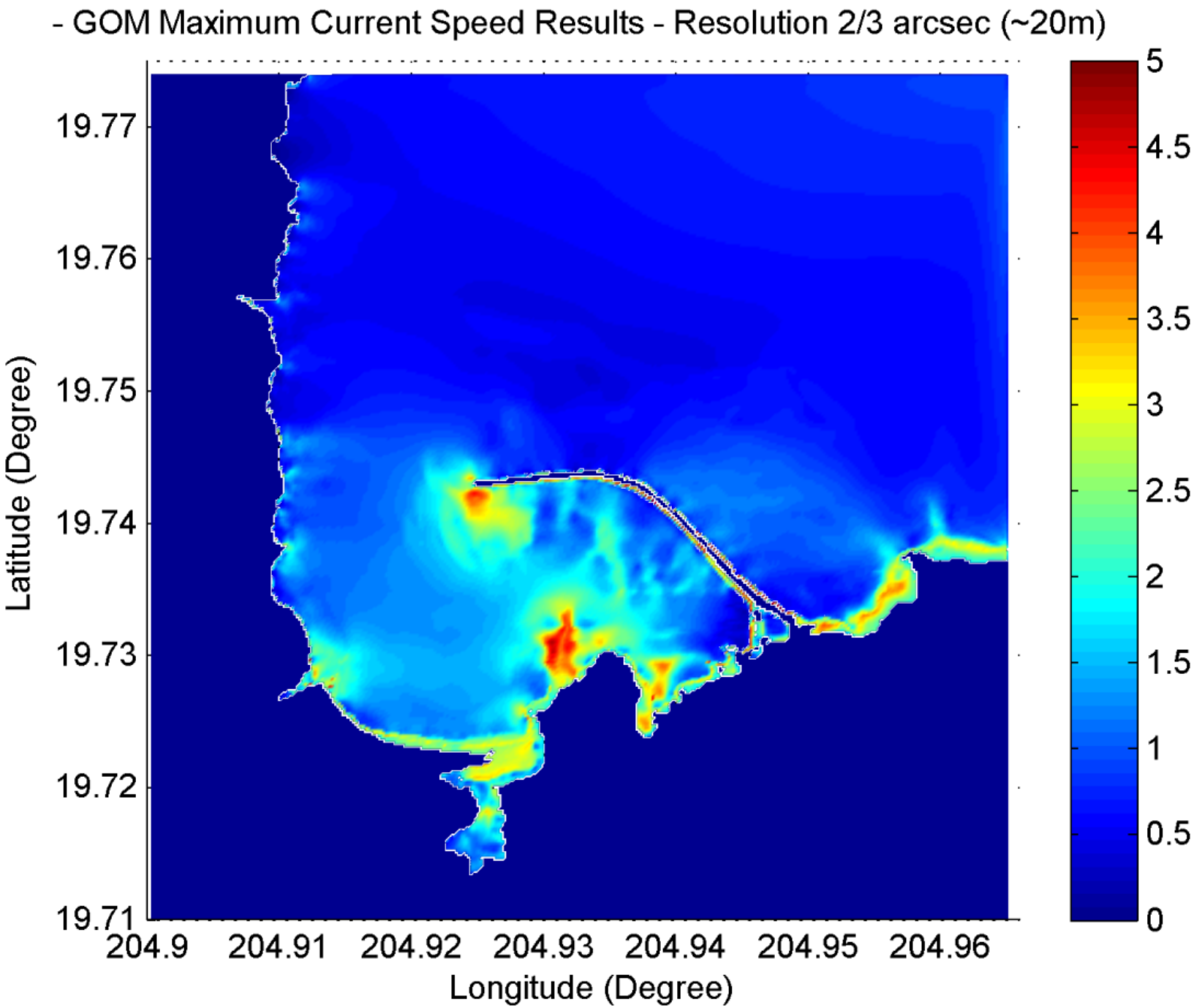
Benchmark #2

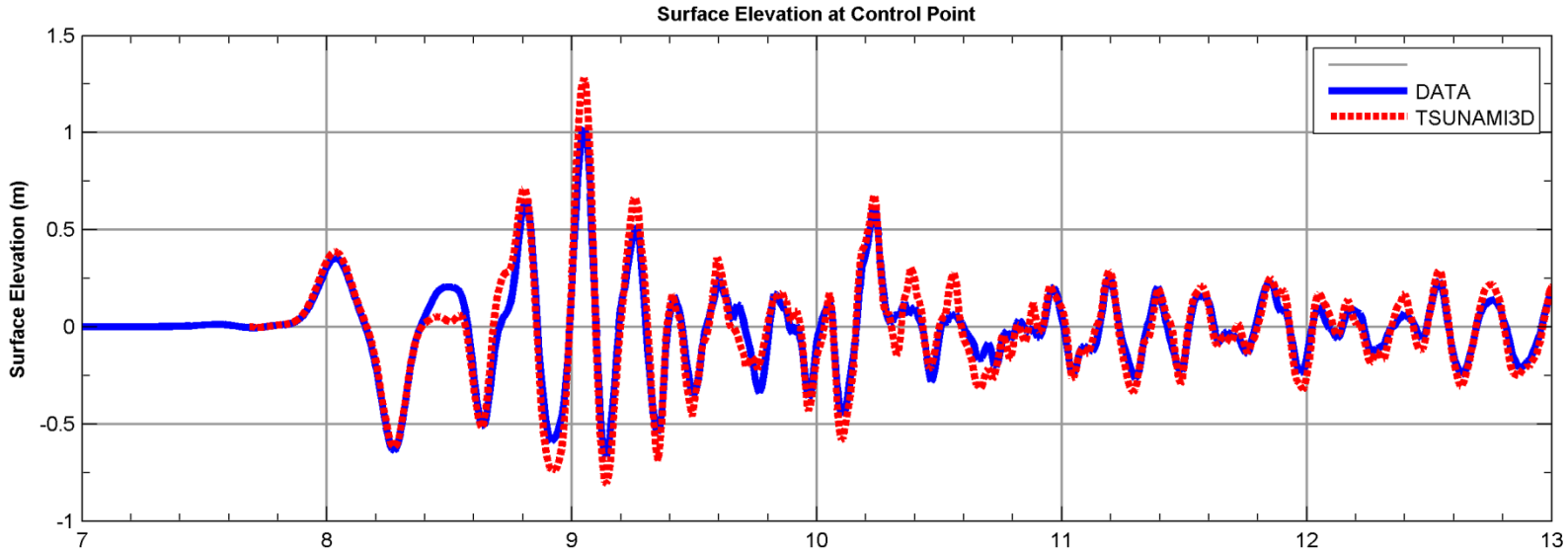
- ~10m x ~10m x 0.2-1m cell size
- Total # Cells 22’831,848
- ~5-6 days CPU time, 32 CPUs
- No-slip condition for bottom boundary
- Inviscid
- Inflow condition: Vel. at northern boundary imposed using summation of Fourier harmonics of incoming signal and radiating out the out-coming signal

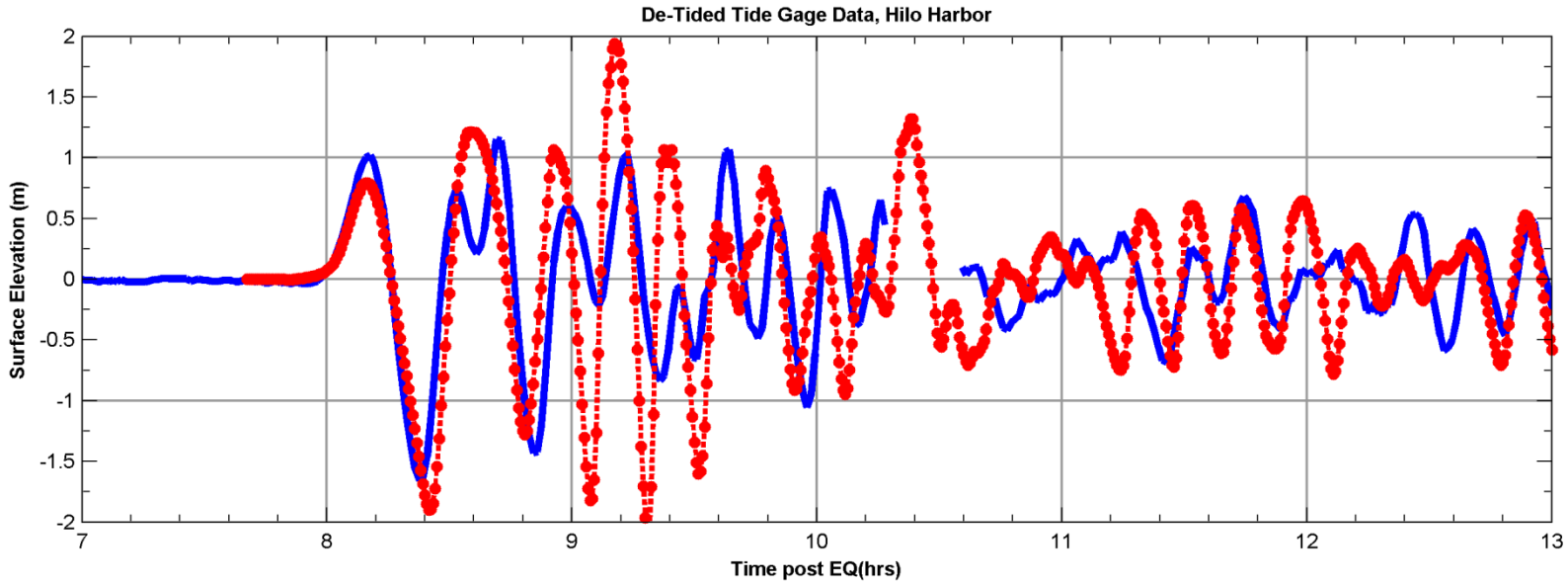
Movies BM2

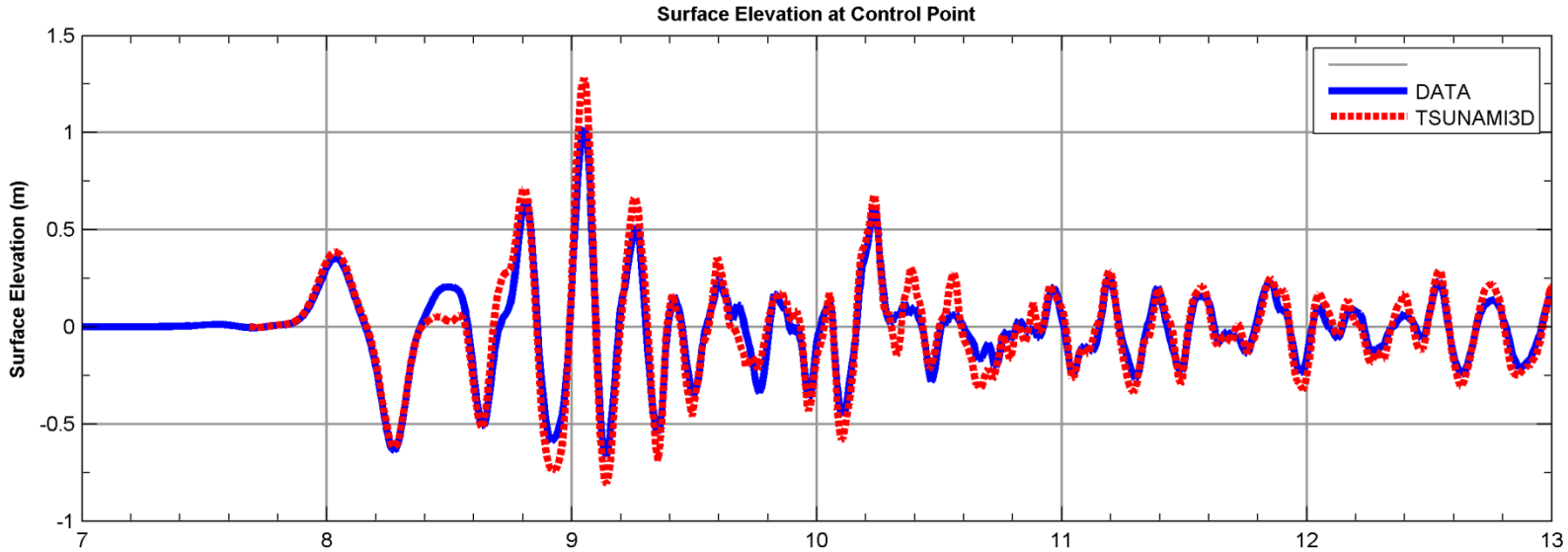

TUNAMI3D Case:BM32 Cycle = 36141 Time = 21600.294922
19.77
19.76
19.75
19.74
19.73
19.72
19.71
Degree
C Port1
HA 1125
HA 1126
Station
209.91
209.92
209.93
209.94
209.95
209.96
Degree
3.5
3
2.5
2
1.5
1
0.5
0
(m/s)

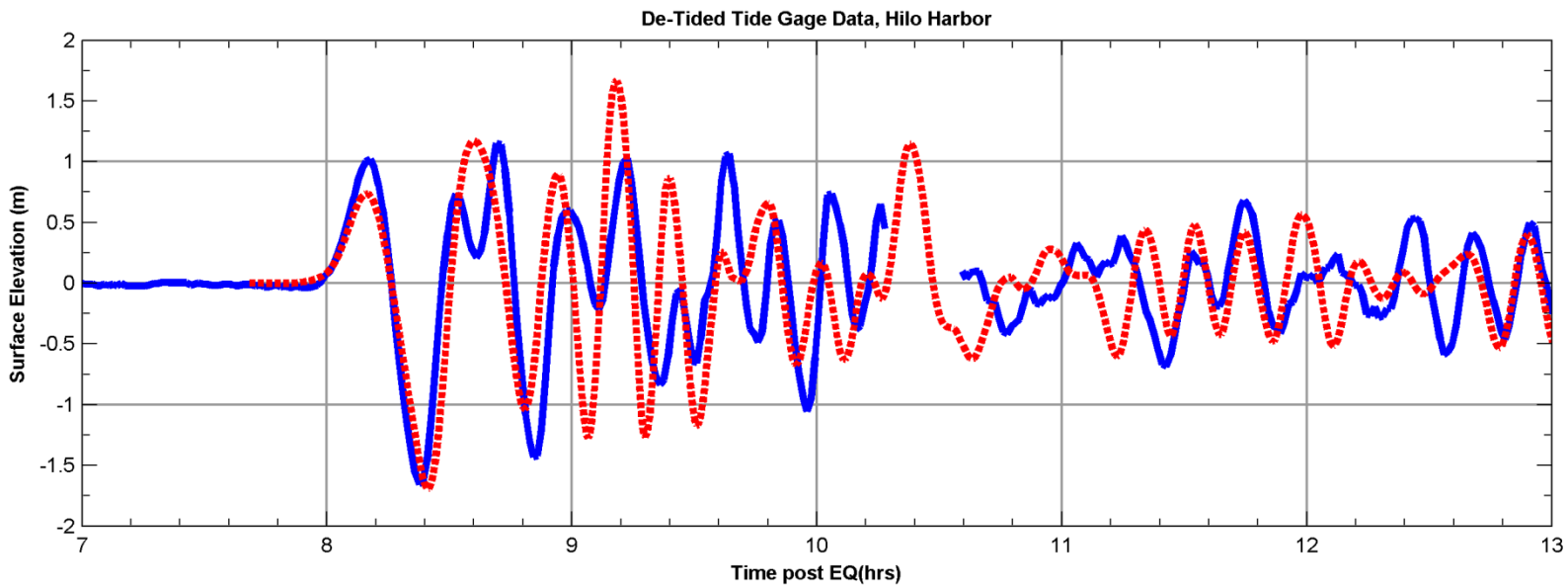

- GOM Maximum Current Speed Results - Resolution 1/3 arcsec (~10m)
Latitude (Degree)
19.77
19.76
19.75
19.74
19.73
19.72
19.71
204.9
204.91
204.92
204.93
204.94
204.95
204.96
Longitude (Degree)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

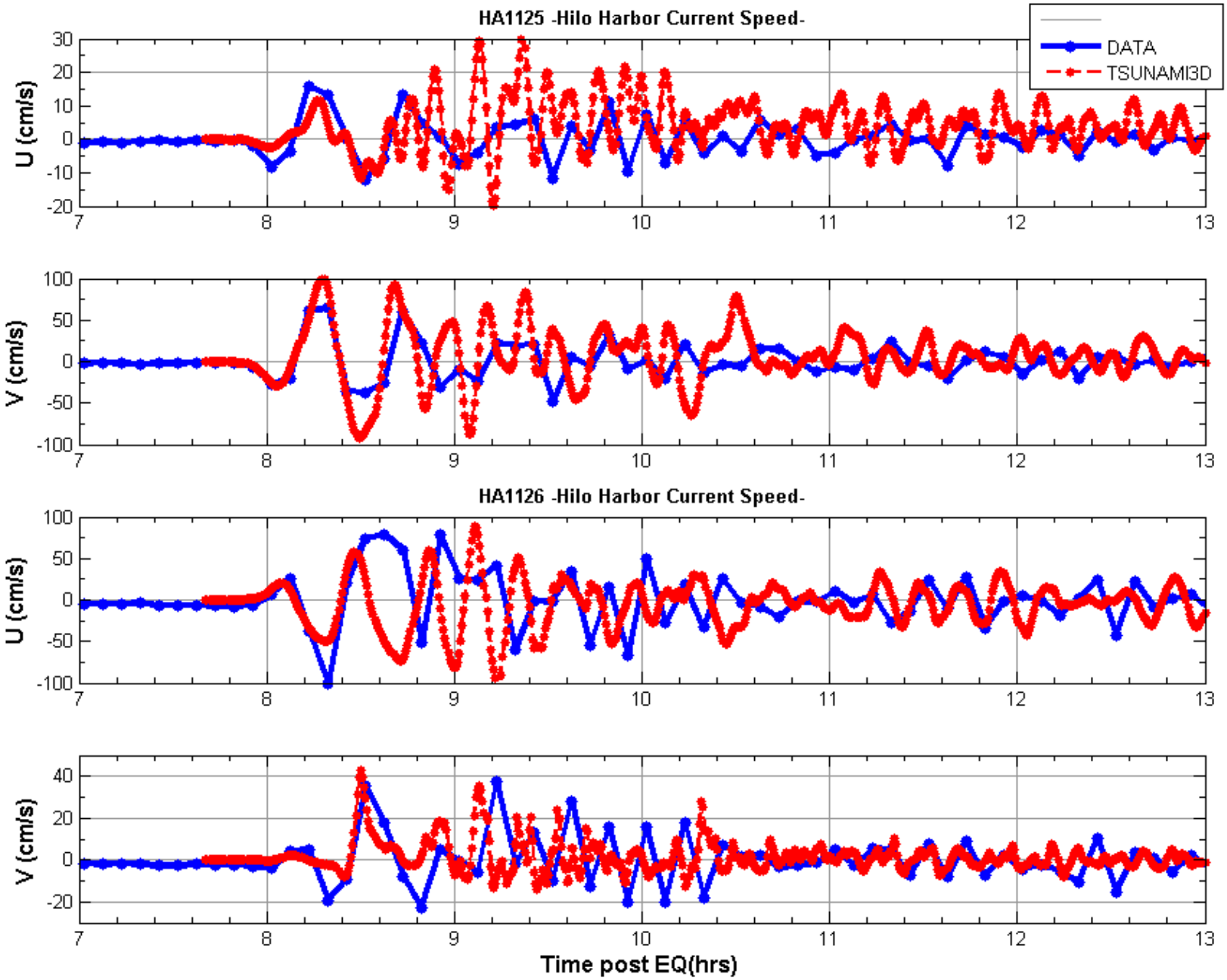

- GOM Maximum Current Speed Results - Resolution 2/3 arcsec (~20m)
Latitude (Degree)
19.77
19.76
19.75
19.74
19.73
19.72
19.71
204.9
204.91
204.92
204.93
204.94
204.95
204.96
Longitude (Degree)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

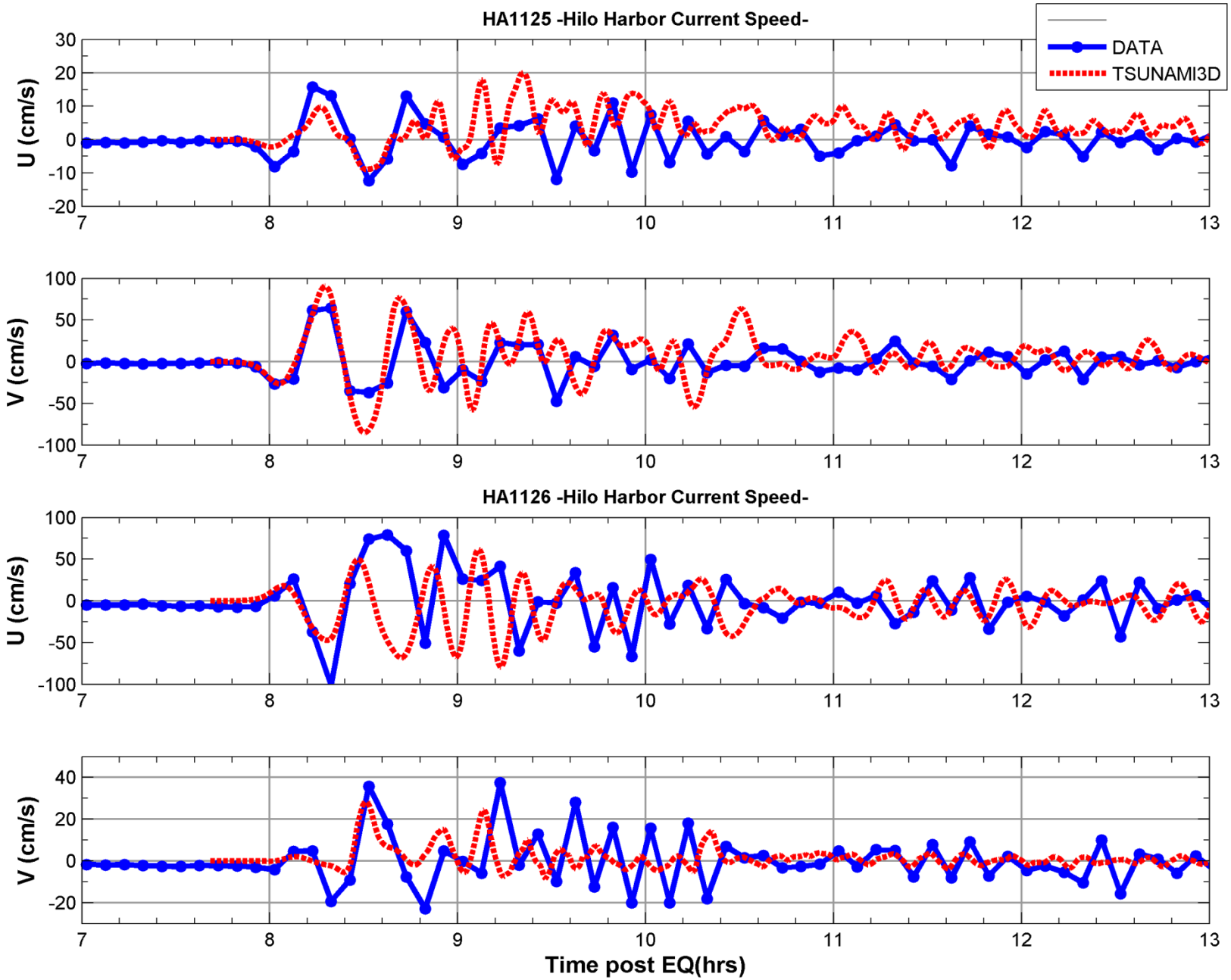

Surface Elevation at Control Point
Surface Elevation (m)
DATA
TSUNAMI3D
1.5
1
0.5
0
-0.5
-1
7
8
9
10
11
12
13

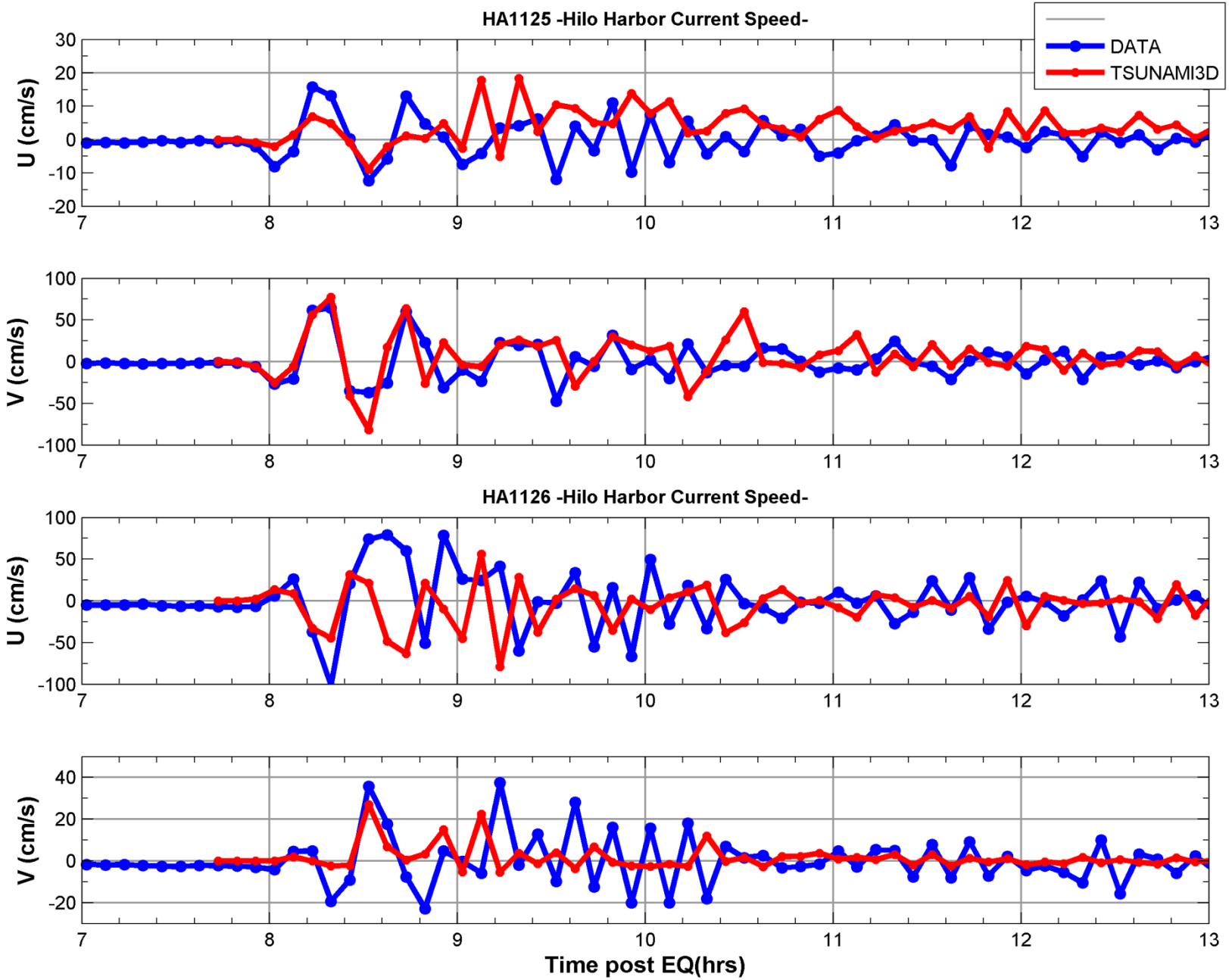

De-Tided Tide Gage Data, Hilo Harbor
Surface Elevation (m)
Time post EQ(hrs)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
7
8
9
10
11
12
13

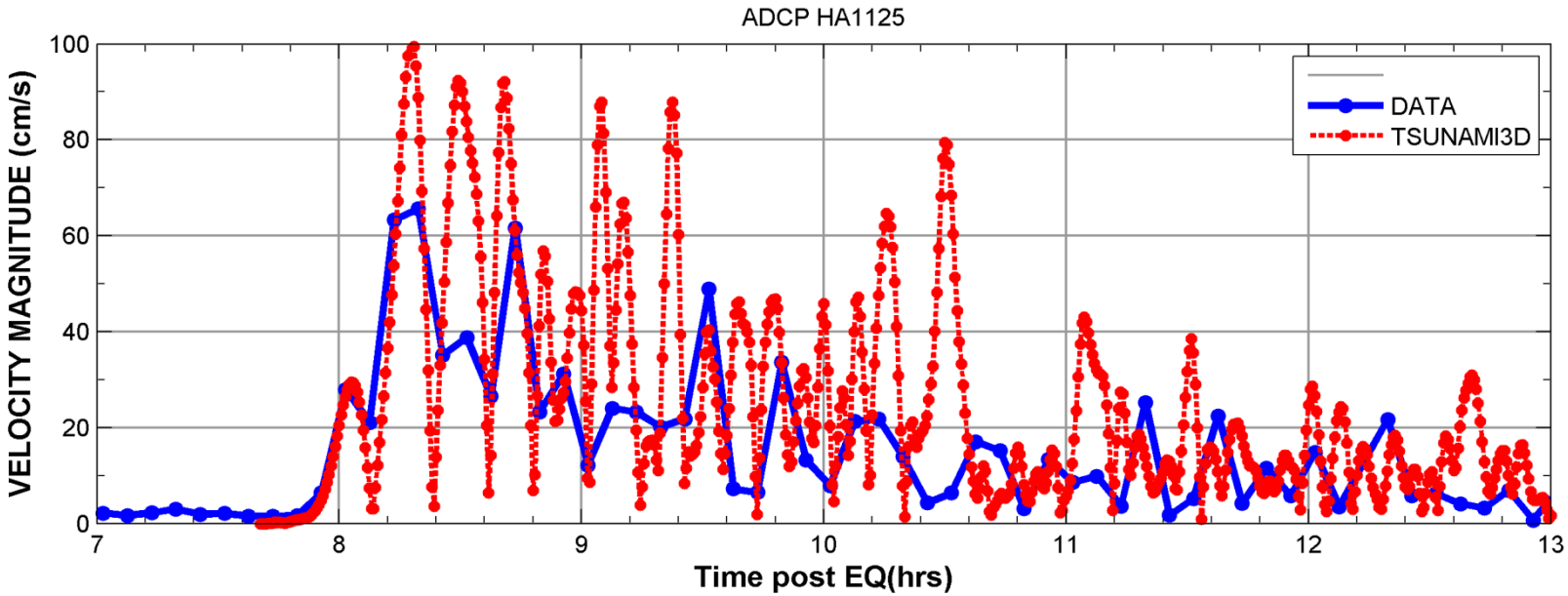

Surface Elevation at Control Point
Surface Elevation (m)
DATA
TSUNAMI3D
1.5
1
0.5
0
-0.5
-1
7
8
9
10
11
12
13

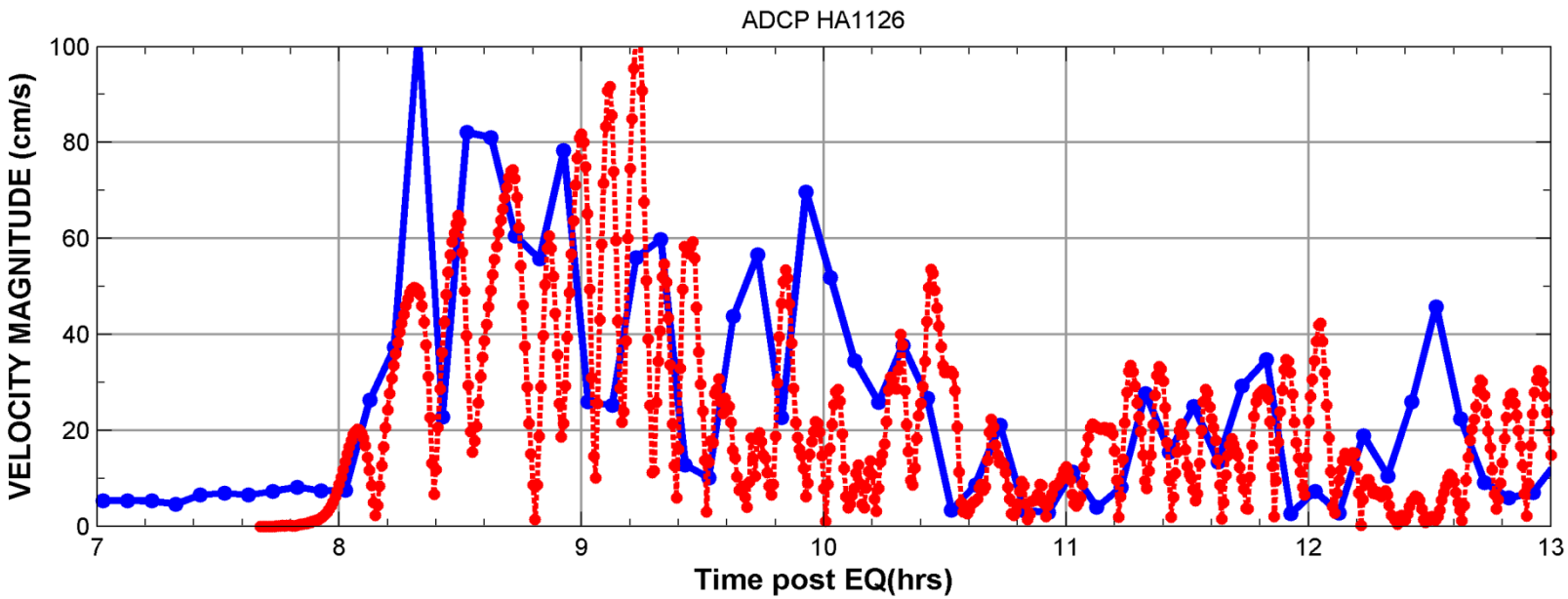

De-Tided Tide Gage Data, Hilo Harbor
Surface Elevation (m)
Time post EQ(hrs)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
7
8
9
10
11
12
13


HA1125 -Hilo Harbor Current Speed-
DATA
TSUNAMI3D
U (cm/s)
V (cm/s)
HA1126 -Hilo Harbor Current Speed-
U (cm/s)
V (cm/s)
Time post EQ(hrs)


HA1125 -Hilo Harbor Current Speed-
DATA
TSUNAMI3D
U (cm/s)
V (cm/s)
HA1126 -Hilo Harbor Current Speed-
U (cm/s)
V (cm/s)
Time post EQ(hrs)


HA1125 -Hilo Harbor Current Speed-
DATA
TSUNAMI3D
U (cm/s)
V (cm/s)
HA1126 -Hilo Harbor Current Speed-
U (cm/s)
V (cm/s)
Time post EQ(hrs)


ADCP HA1125
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
DATA
TSUNAMI3D
0
20
40
60
80
100
7
8
9
10
11
12
13


ADCP HA1126
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
0
20
40
60
80
100
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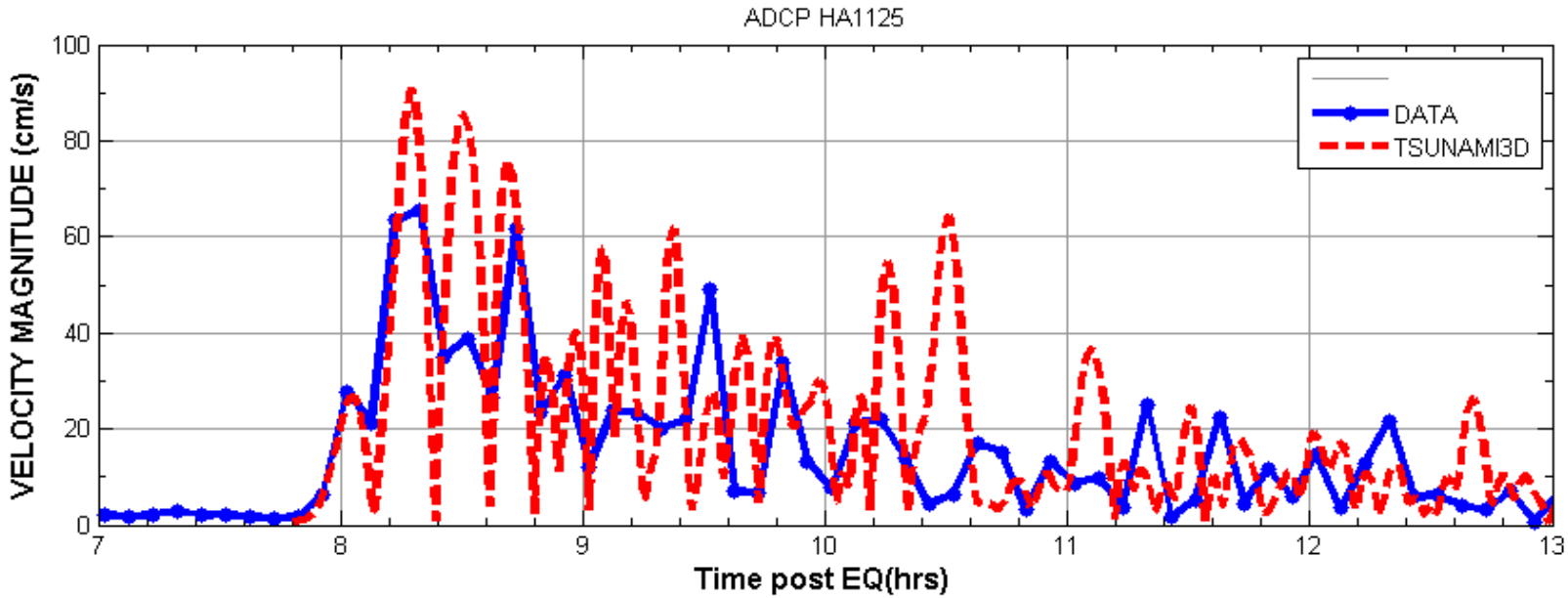
12
13


ADCP HA1125
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
DATA
TSUNAMI3D
0
20
40
60
80
100
7
8
9
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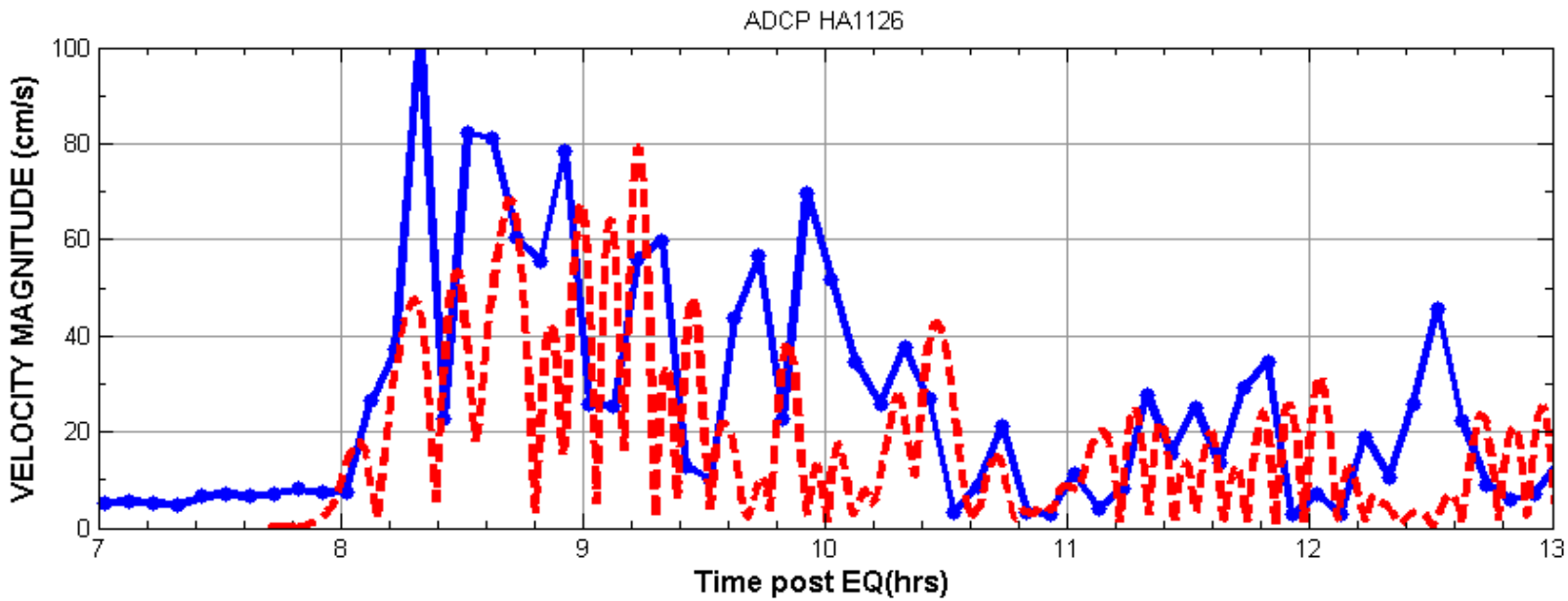
12
13


ADCP HA1126
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
0
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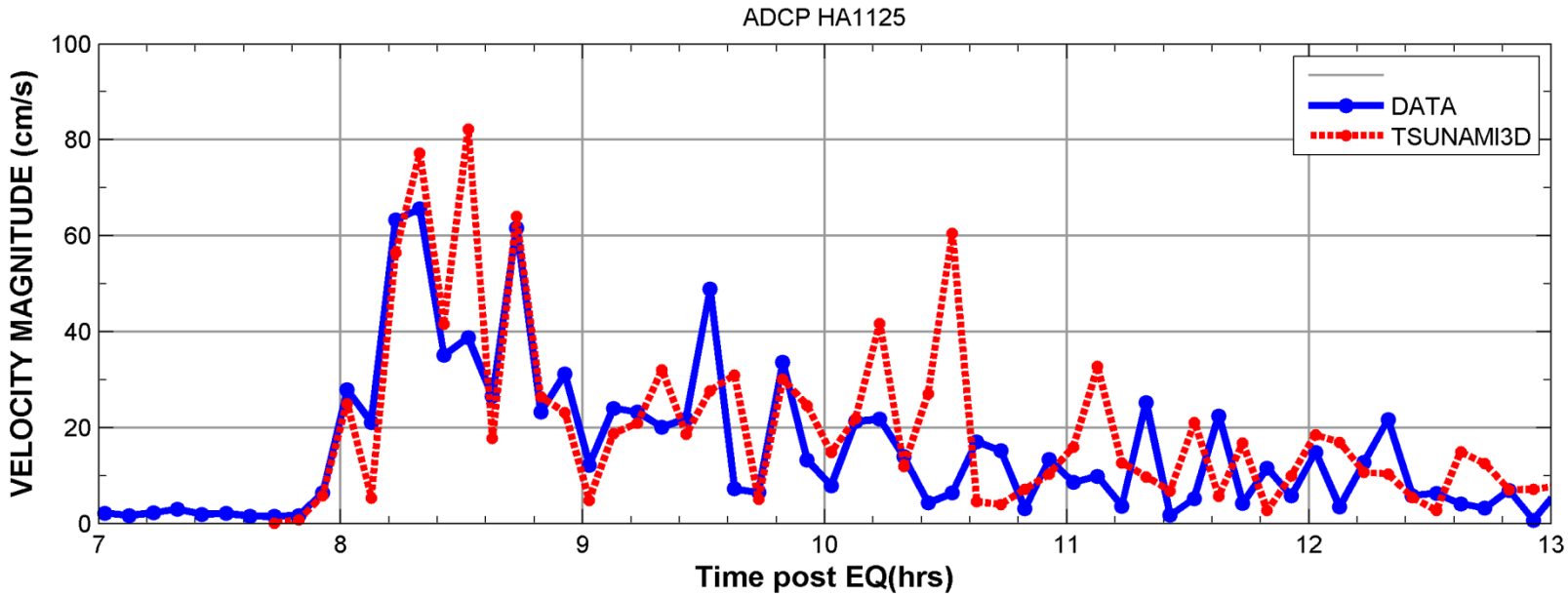
ADCP HA1125
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
DATA
TSUNAMI3D
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100
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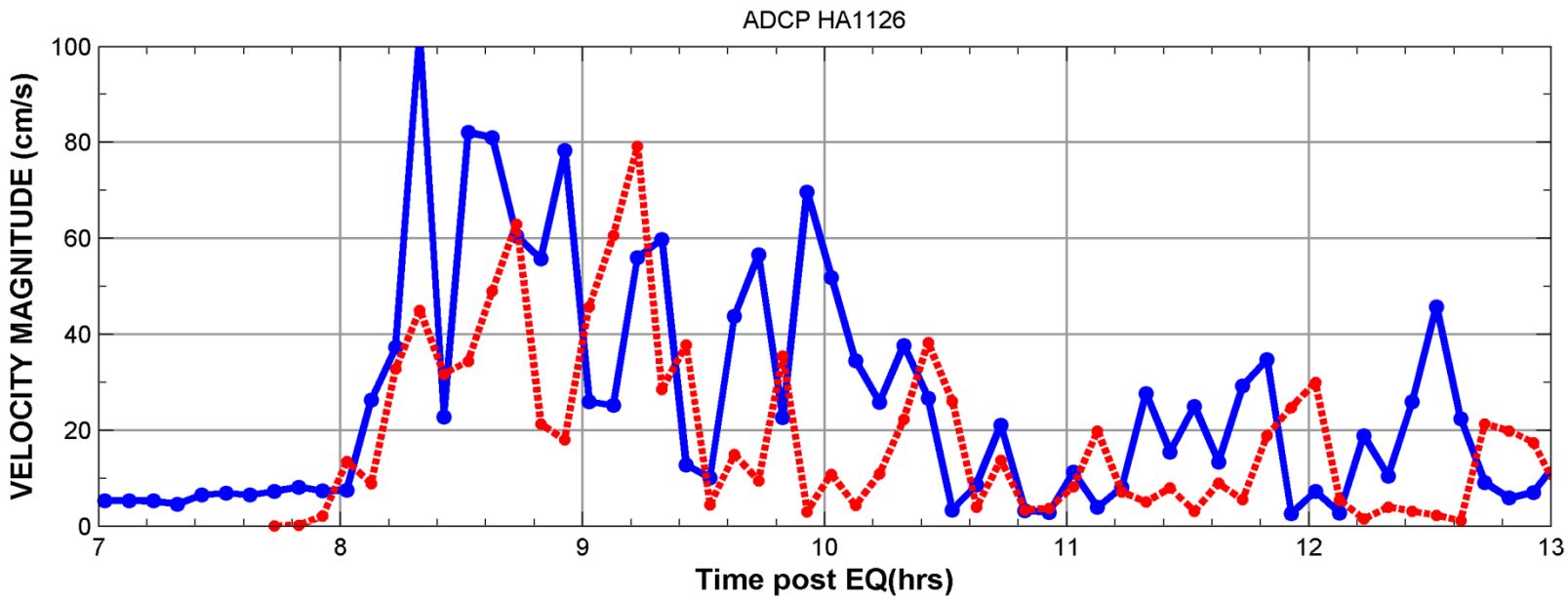
ADCP HA1126
VELOCITY MAGNITUDE (cm/s)
Time post EQ(hrs)
0
20
40
60
80
100
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12
13

Conclusion

- BM1 experiment develops a dominate flow pattern, consisting of an average flow and an eddy structures containing the majority of the kinetic energy of the flow.
- Thus, the dissipation mechanisms inherent in the numerical methods may alone be sufficient to produce reasonable results as the truncation error of the Upwind scheme is similar and same order of the friction term.
- Still is not clear how the “artificial” bottom friction works having a free slip condition (contribution of the blocked cells to conform the bathy?)
- It is possible to supply additional dissipation with a simple turbulence model such as a constant eddy viscosity or a mixing length assumption. (still going on work)