Seamless Cross-scale Modeling with SCHISM: application to tsunami currents

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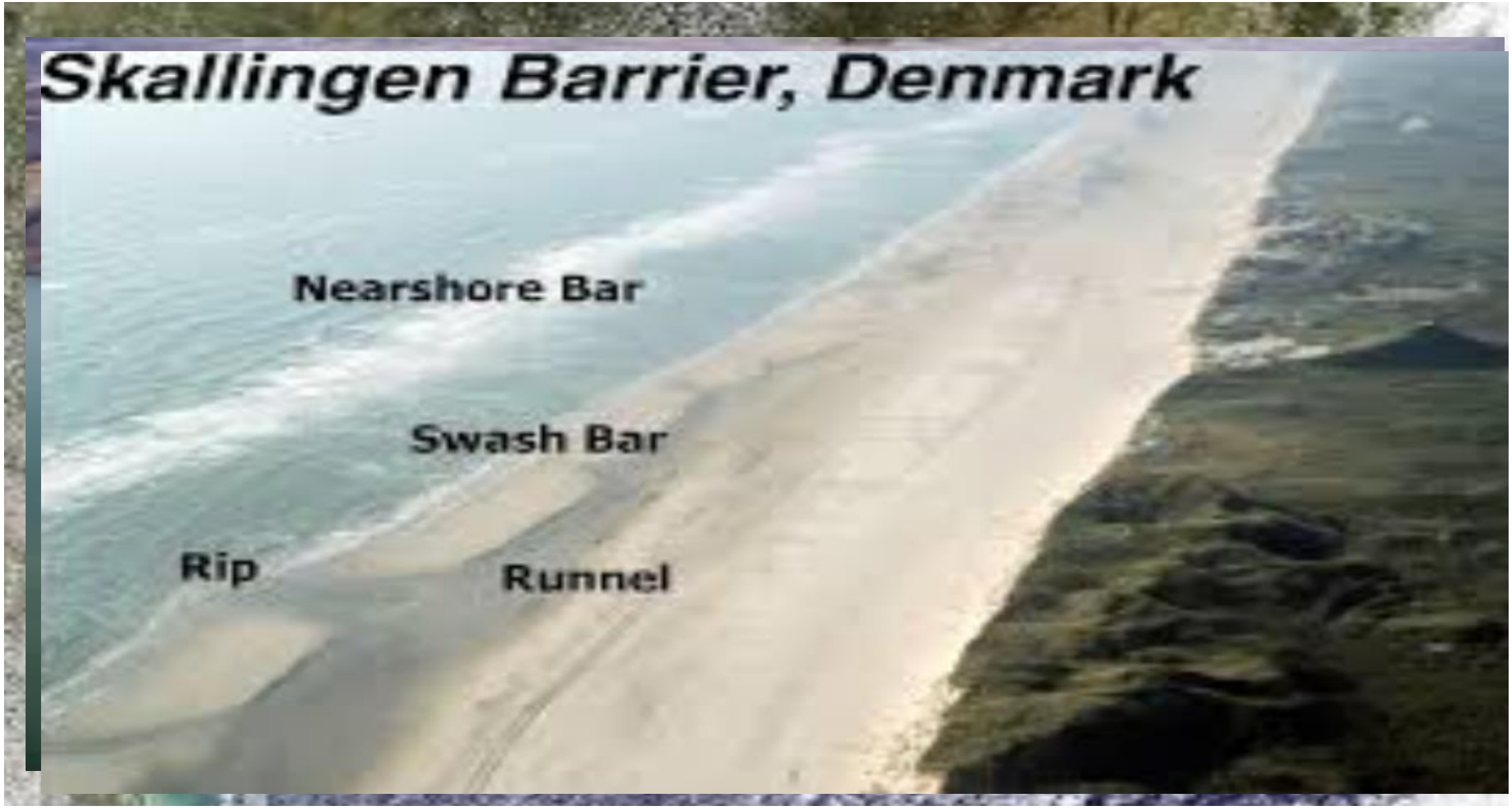
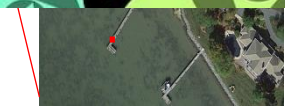
Virginia Institute of Marine Science
Center for Coastal Resource Management

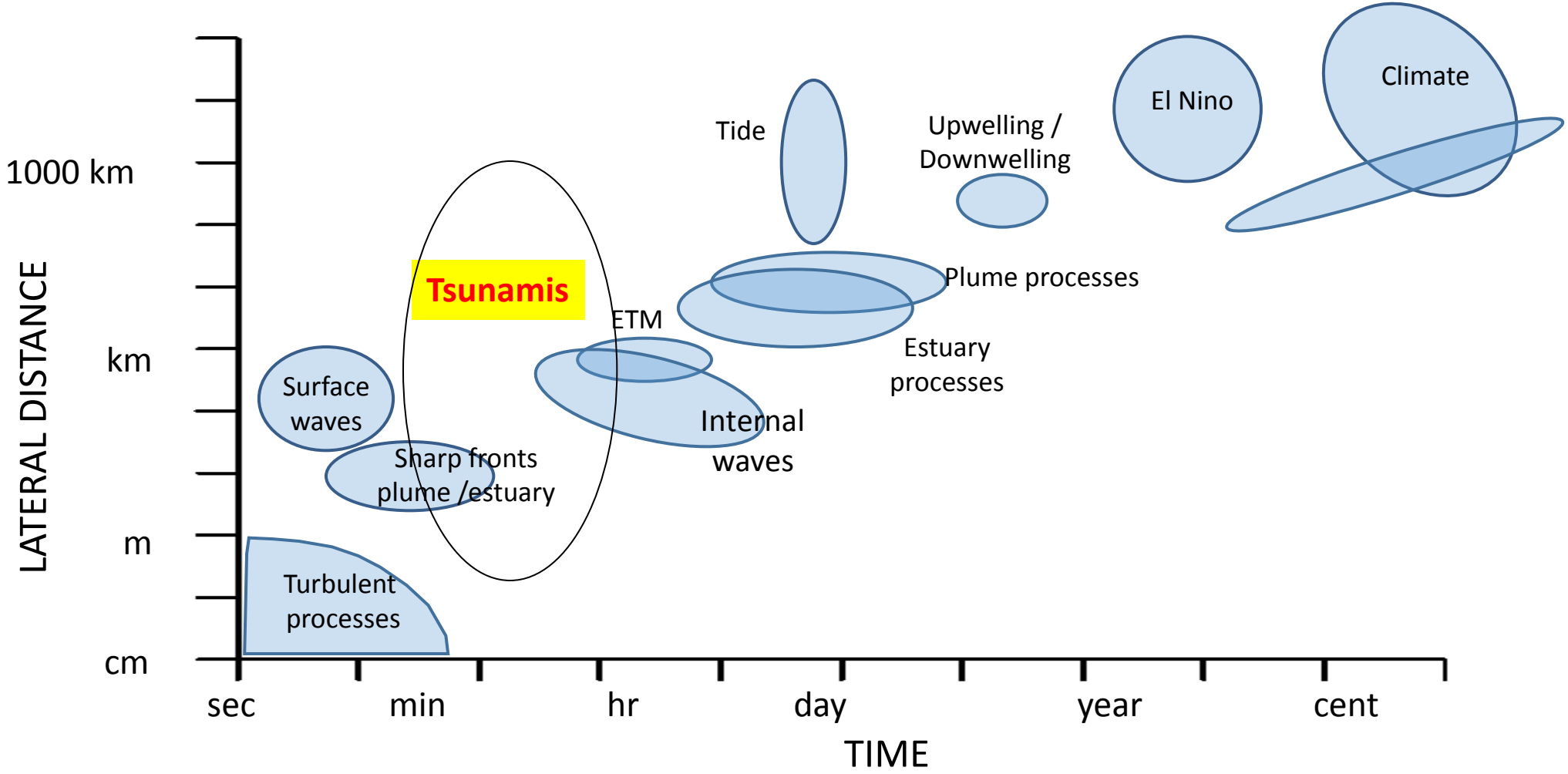
NOAA/NTHMP Mapping & Modeling Subcommittee Benchmarking Workshop: Tsunami Currents
February 9-10 Portland, Oregon


Skallingen Barrier, Denmark
Nearshore Bar
Swash Bar
Rip
Runnel

Resolution is king

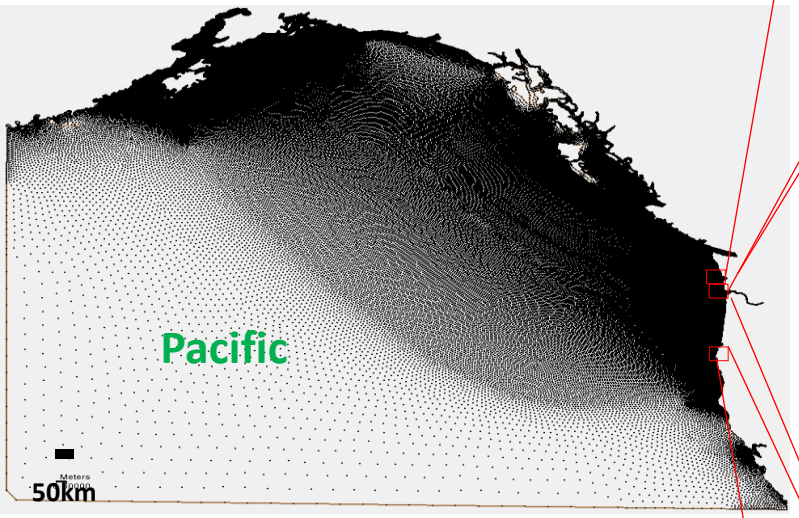


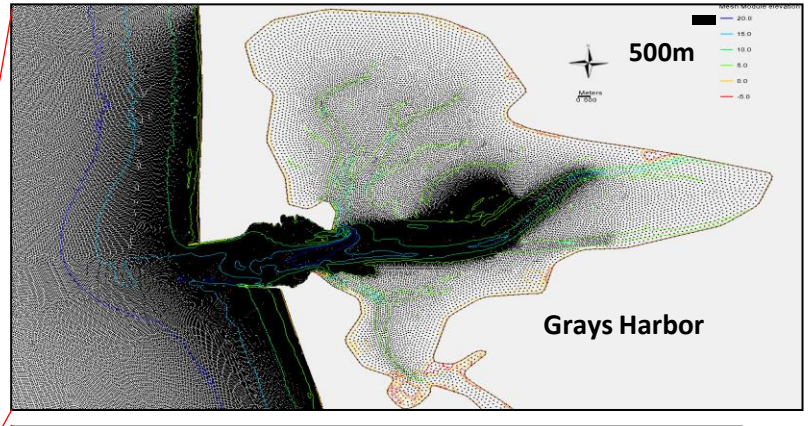
Cross-scale Seamless Modeling

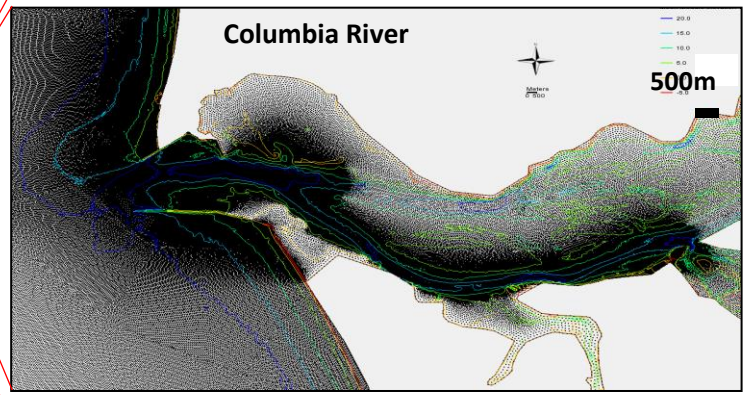


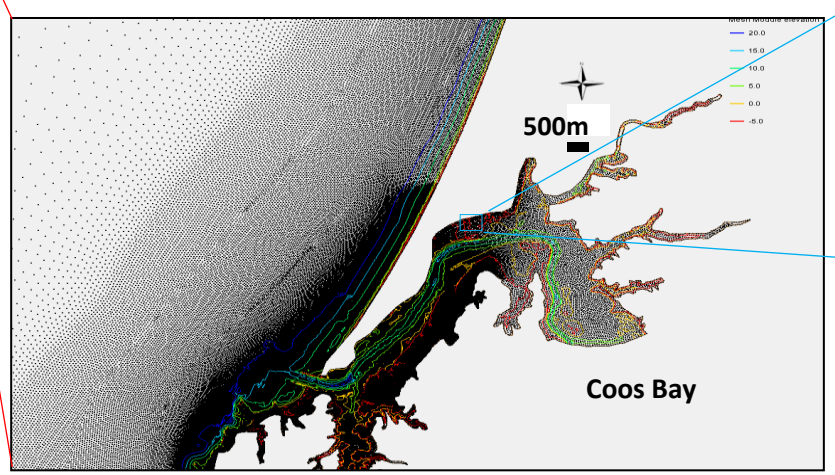
O(1m-1000km)
O(min – decade)

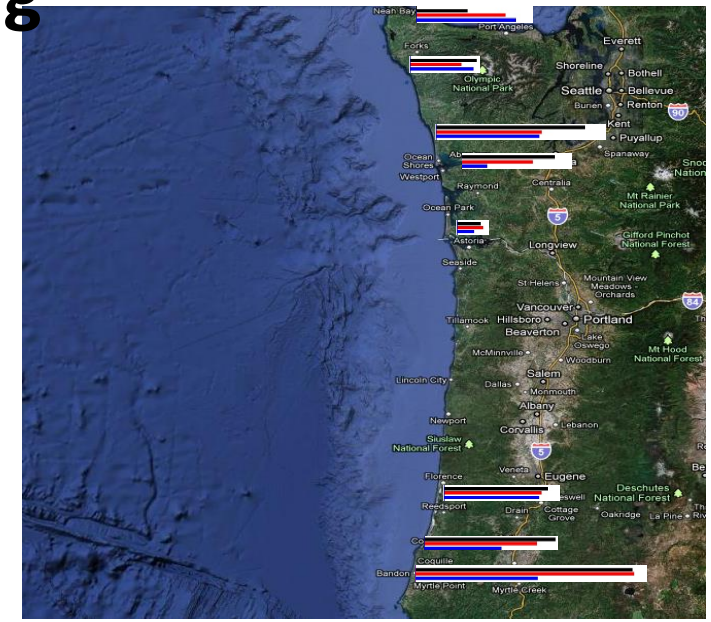
Cross-scale tsunami modeling

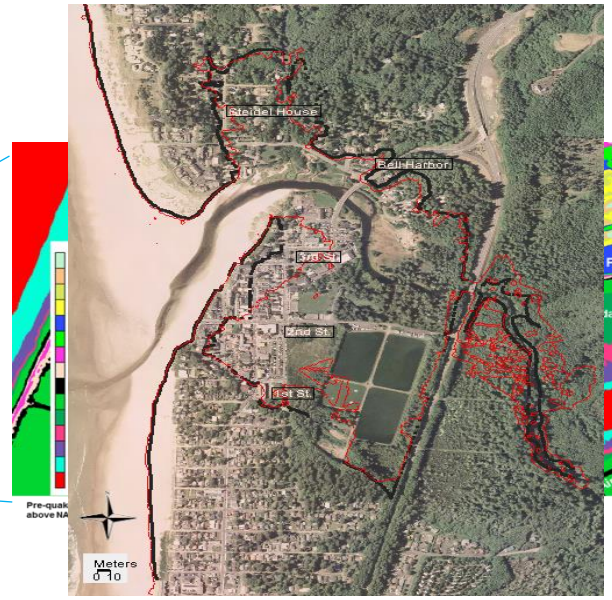




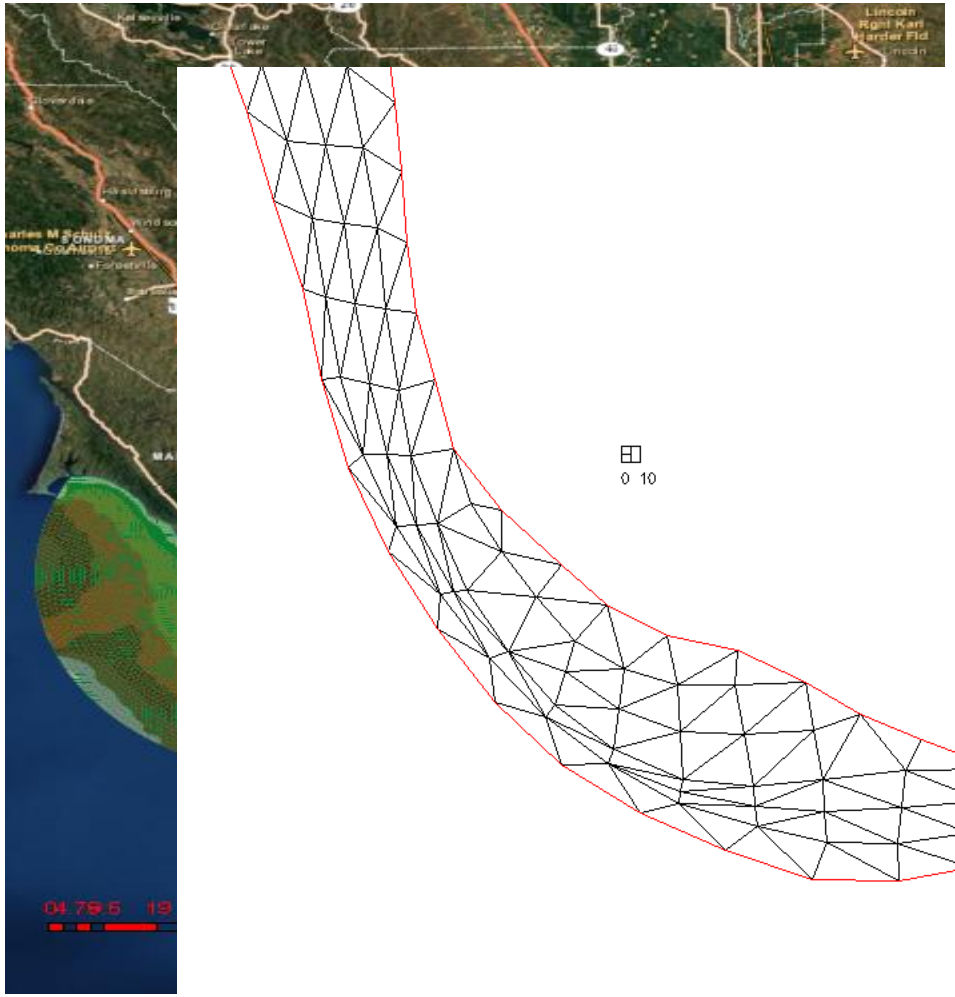


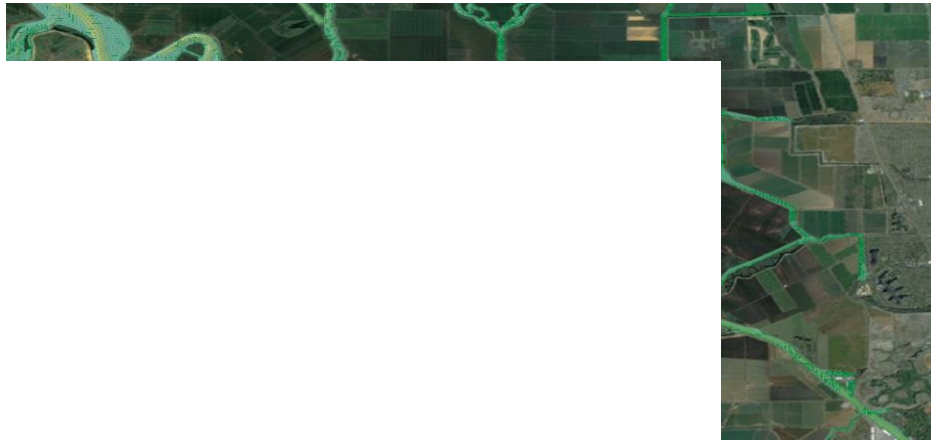






Cross-scale modeling





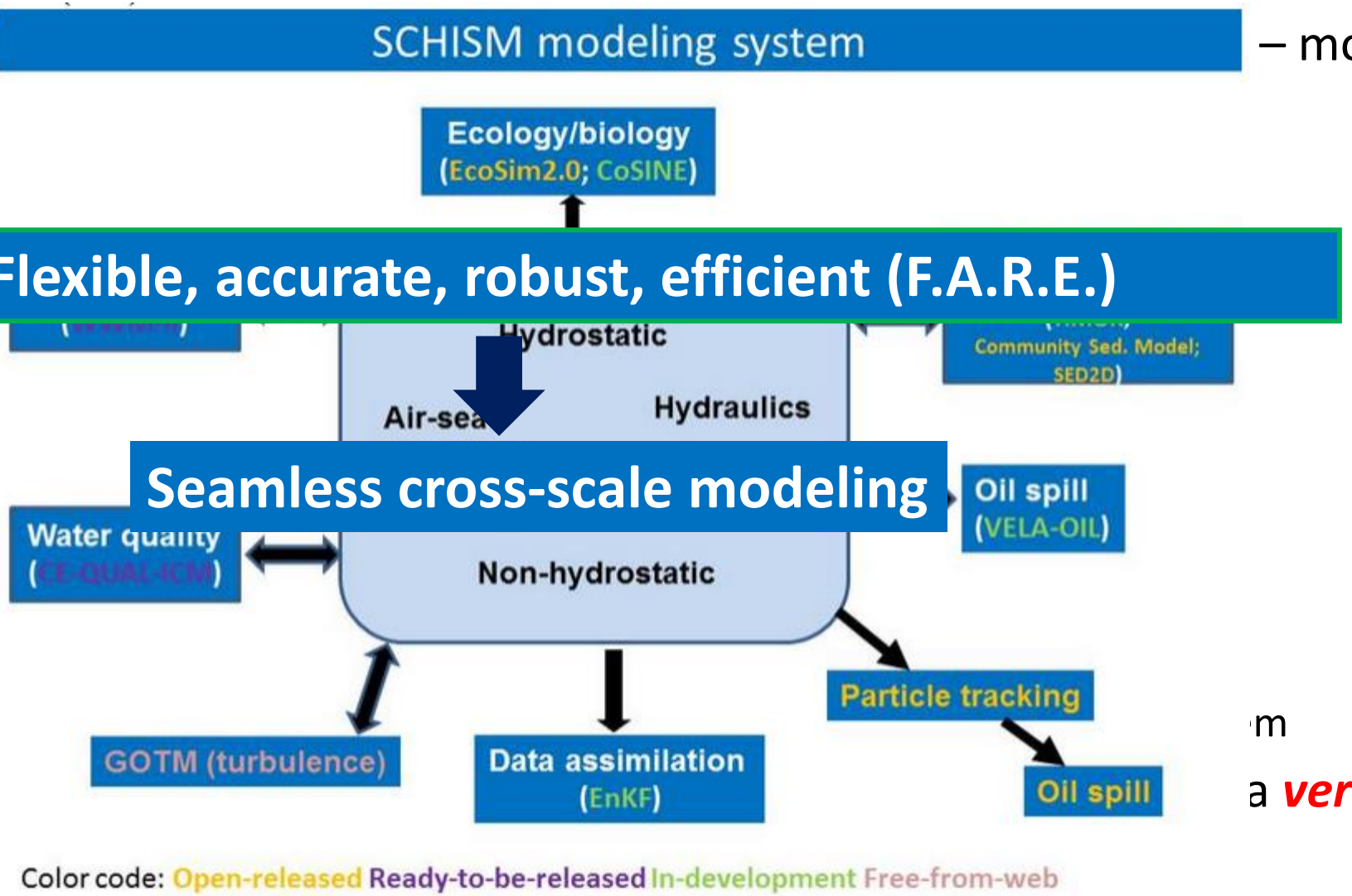
Non-orthogonal grid helps!

SCHISM: Semi-implicit Cross-scale Hydroscience Integrated System Model

- A derivative product of SELFE, distributed with Apache v2 license
- Galerkin finite-element and finite-volume approach: ***generic*** unstructured grids (mixed triangles and quadrangles)
  - ELCIRC (Zhang et al. 2005), UnTRIM (Casulli 1990; 2010), SUNTANS (Fringer 2006): finite-difference/volume approach →orthogonal grid
- **Semi-implicit** time stepping: no mode splitting → large time step and no splitting errors
- **Eulerian-Lagrangian** method (ELM) for advection → more efficiency & robustness
- All matrices are positive, definite, sparse and symmetric (robust solver)
- Hybrid *SZ* coordinates or **LSC^2** (Zhang et al. 2015) in the vertical: one grid with 1D/2D/3D capability
- Configurable
  - Cartesian or spherical coordinates
  - 2D or 3D
  - Hydrostatic or non-hydrostatic
- Mass conservative transport (upwind/TVD/…)

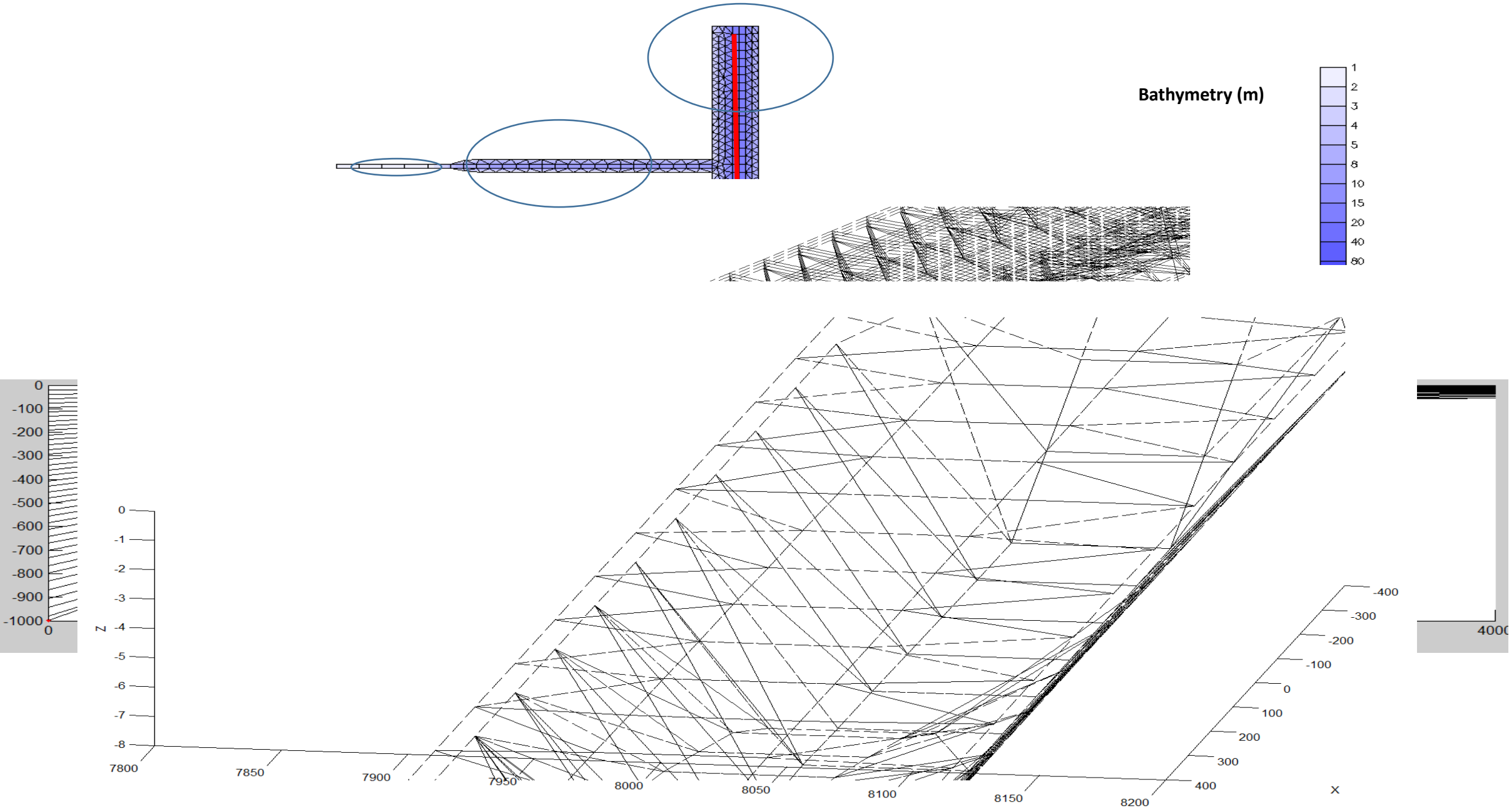
www.schism.wiki

- Includes higher – more forthcoming
- Fully parallelize
- Well
- Operationally t
- *Has evolved int*
- Software engin
  - svn server for a
  - Continuous soft
  - Unit & regressi
  - automatic test m
- Open source ar a ***verifiable*** and ***comprehensive*** n



Flexible, accurate, robust, efficient (F.A.R.E.)

Seamless cross-scale modeling


Bathymetry (m)
1
2
3
4
5
8
10
15
20
40
80
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
0
4000
Z
0
-1
-2
-3
-4
-5
-6
-7
-8
7800
7850
7900
7950
8000
8050
8100
8150
8200
-400
-300
-200
-100
0
100
200
300
400
X

Bay-Delta SCHISM

3D Hydrodynamics and Transport

Training

Next training opportunity:

CWEMF SELFE Workshop Series

We have developed a training course for SELFE that includes material on how to run SELFE, the major assumptions and tools for applying the model in the Bay-Delta as well visualization of results and introductory material on how to extend the model. The course is interwoven with material on tidal analysis, propagation, numerical modeling and estuary processes as necessary to understand the model inputs.

Support

Please send your questions to Eli.Ateljevich@water.ca.gov.

We'll field your questions and help you scope any SELFE-related efforts as best we can. Our hope is that we can help external institutions and modelers become qualified, SELFE-sufficient users.

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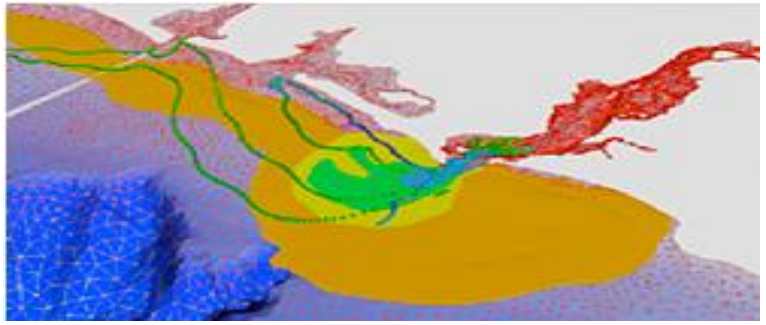
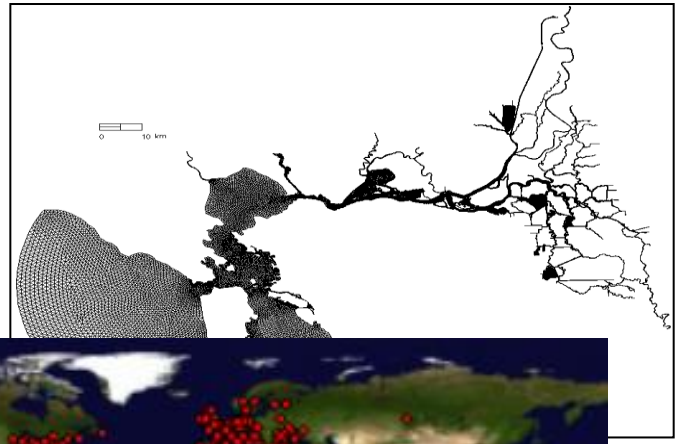
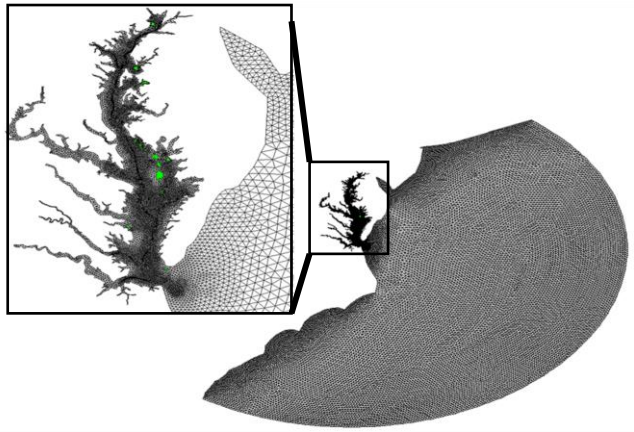
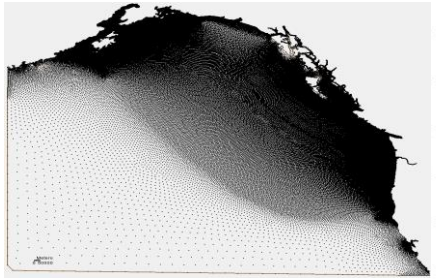
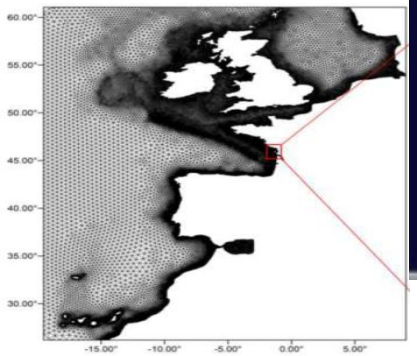
c/o: SCHISM users

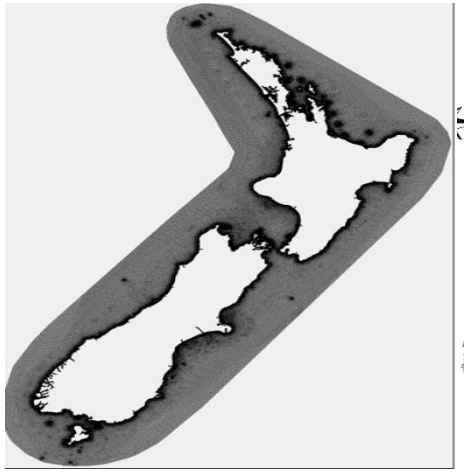


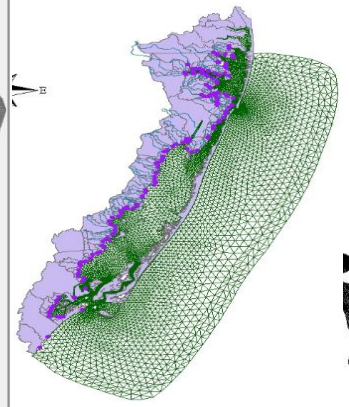


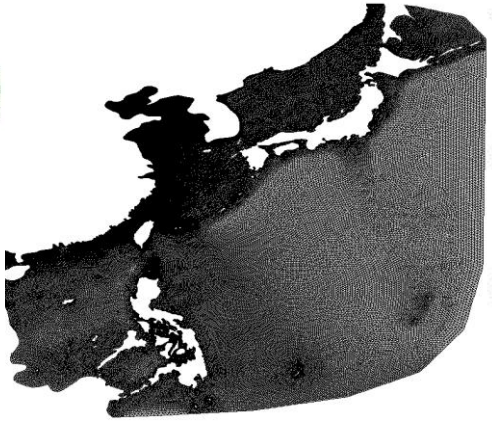


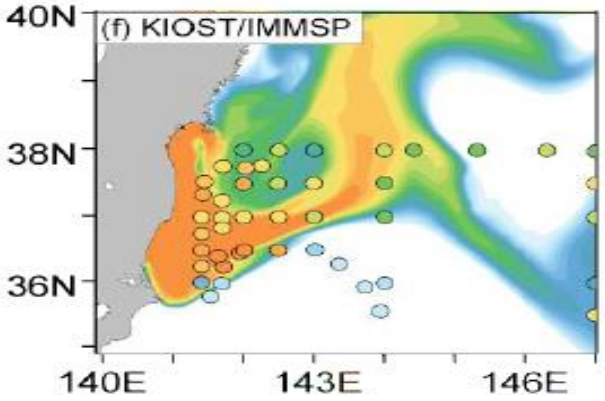


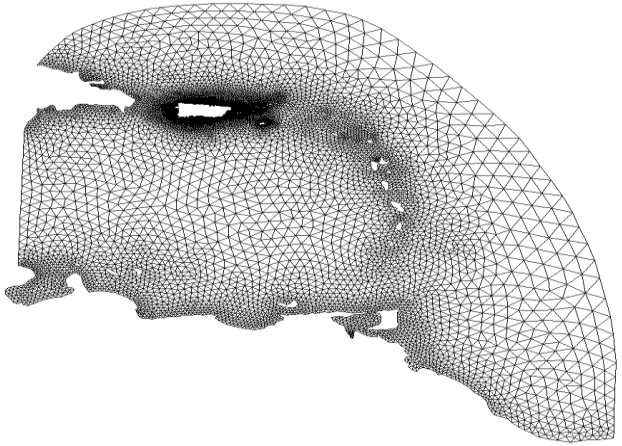












tidesandcurrents.noaa.gov/ofs/creof

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CREOFS SUBDOMAINS

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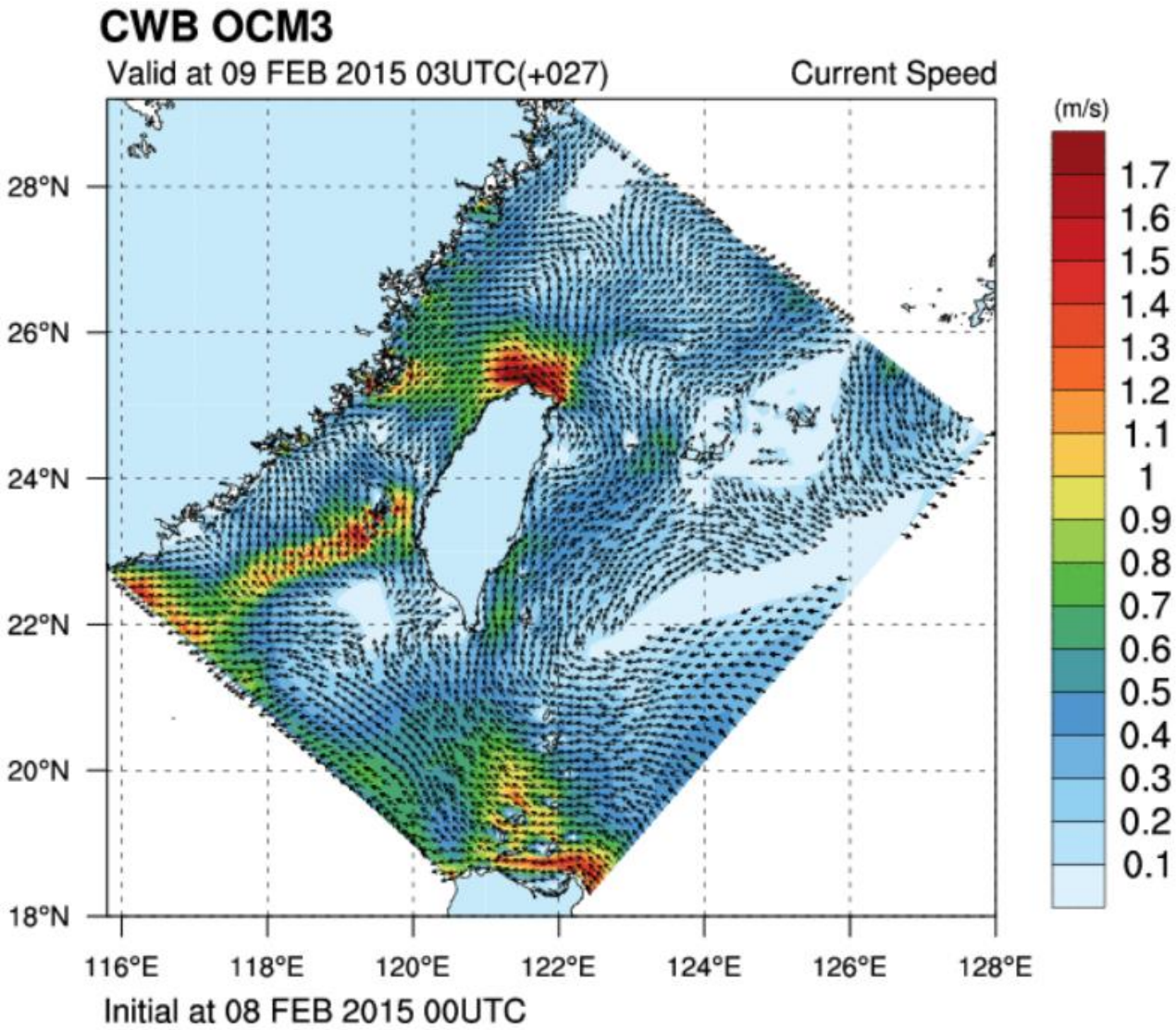
PORTS®

- Lower Columbia River PORTS®

cwb.gov.tw/V7e/forecast/nwp/wave_display_full.htm

First Previous Pause Play Next Last

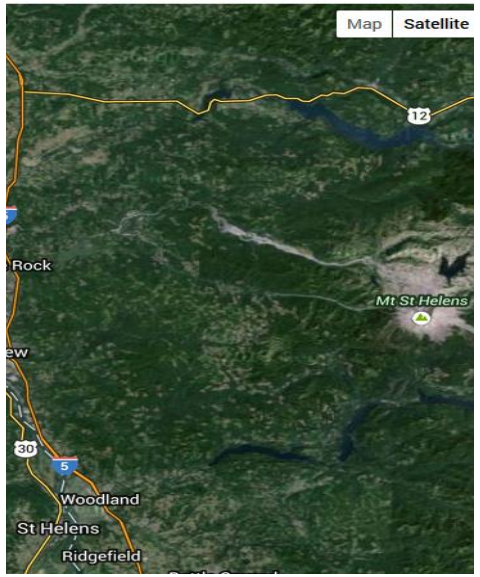


satellite photo

onnect Centra...

EOFS)

CREOFS will use a general-purpose map
vember 12th.



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Center for Coastal Resources Management

VIMS | William & Mary

Virginia Institute of Marine Science

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Main Page

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SCHISM WIKI

1. The information on this wiki site under 'User contribution' is contributed by users and developers alike, and therefore the developers cannot guarantee all info is correct and up to date, although they are committed to patrolling the site regularly. Verify if necessary by sending a message to the SCHISM mailing-list: schism_list@vims.edu
2. Some info may be version sensitive, and so consult the files in your source code bundle for up-to-date info
3. Please consider contributing to any topic and suggest new topics of your interest. You first need to have an account created for you (we do not allow people to create accounts themselves to prevent spams). If you would like to contribute to the page please send an e-mail to Joseph Zhang, with some basic info: your *real* name and email address.
4. The links below that have content are in blue.

The map below indicates the location of visitors to this site.
Click on the map to see a larger view

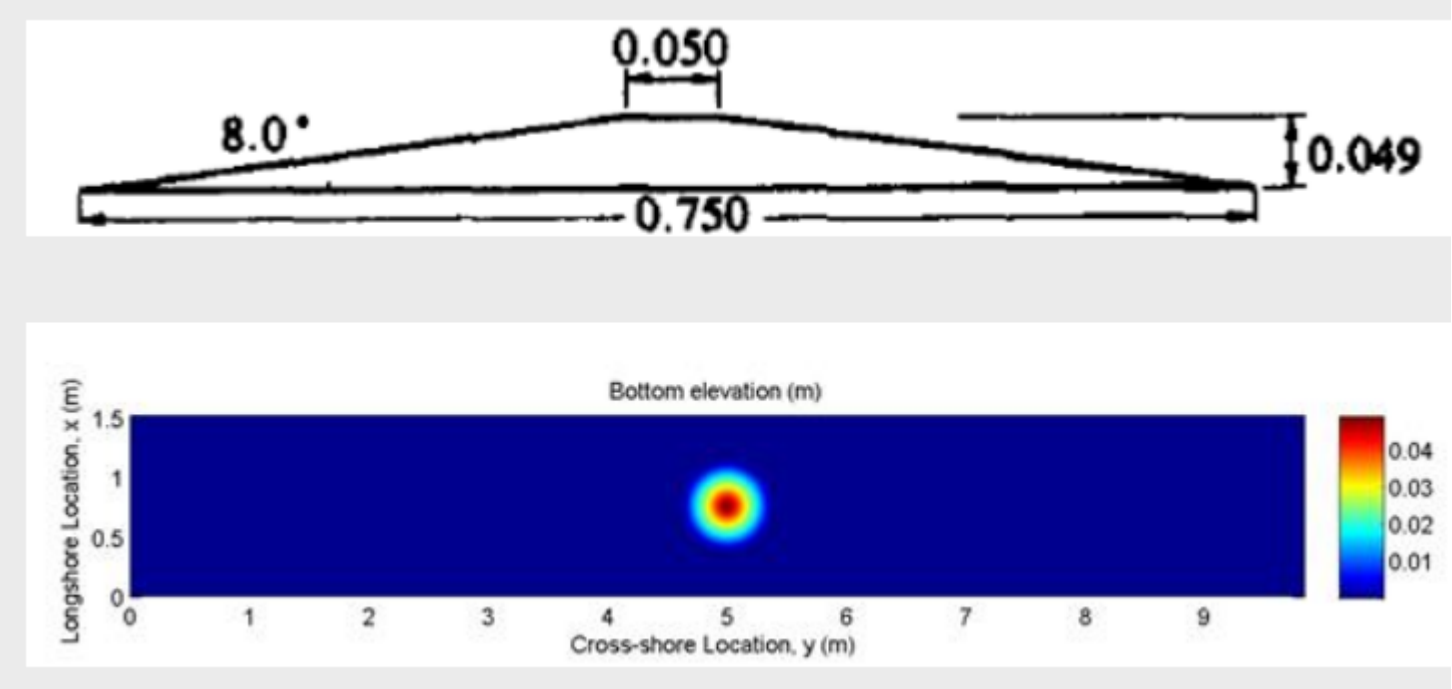
SCHISM web

Part I: Formal documentation pages

- About SCHISM
- SCHISM news and announcements

www.schism.wiki/?title=Main_Page

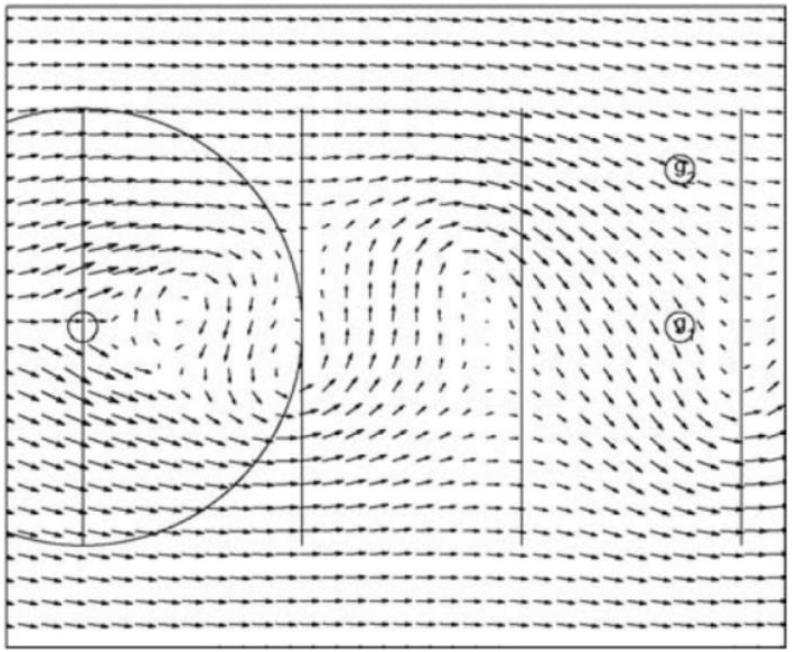
BM1: Submerged island

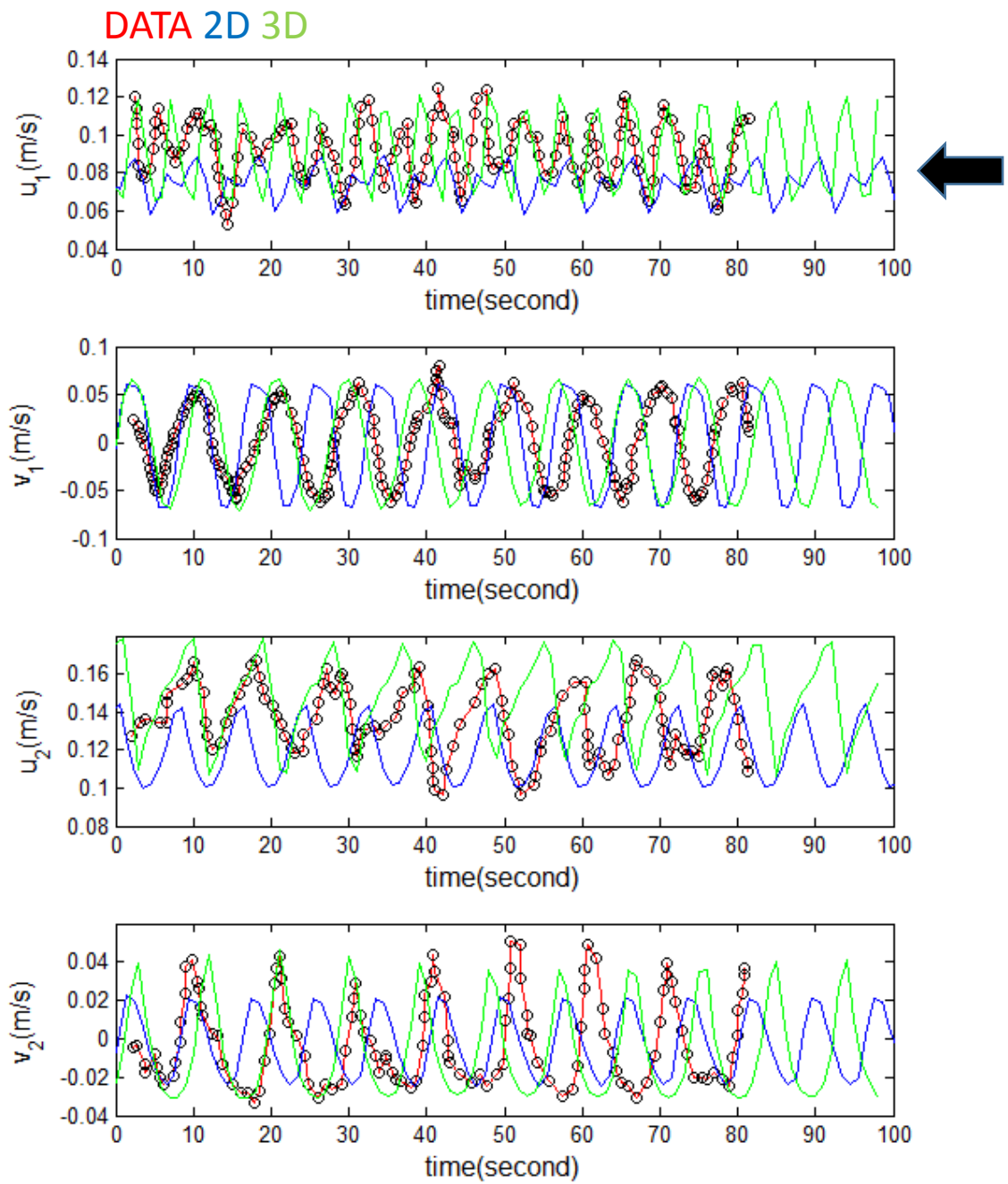


SCHISM set-up

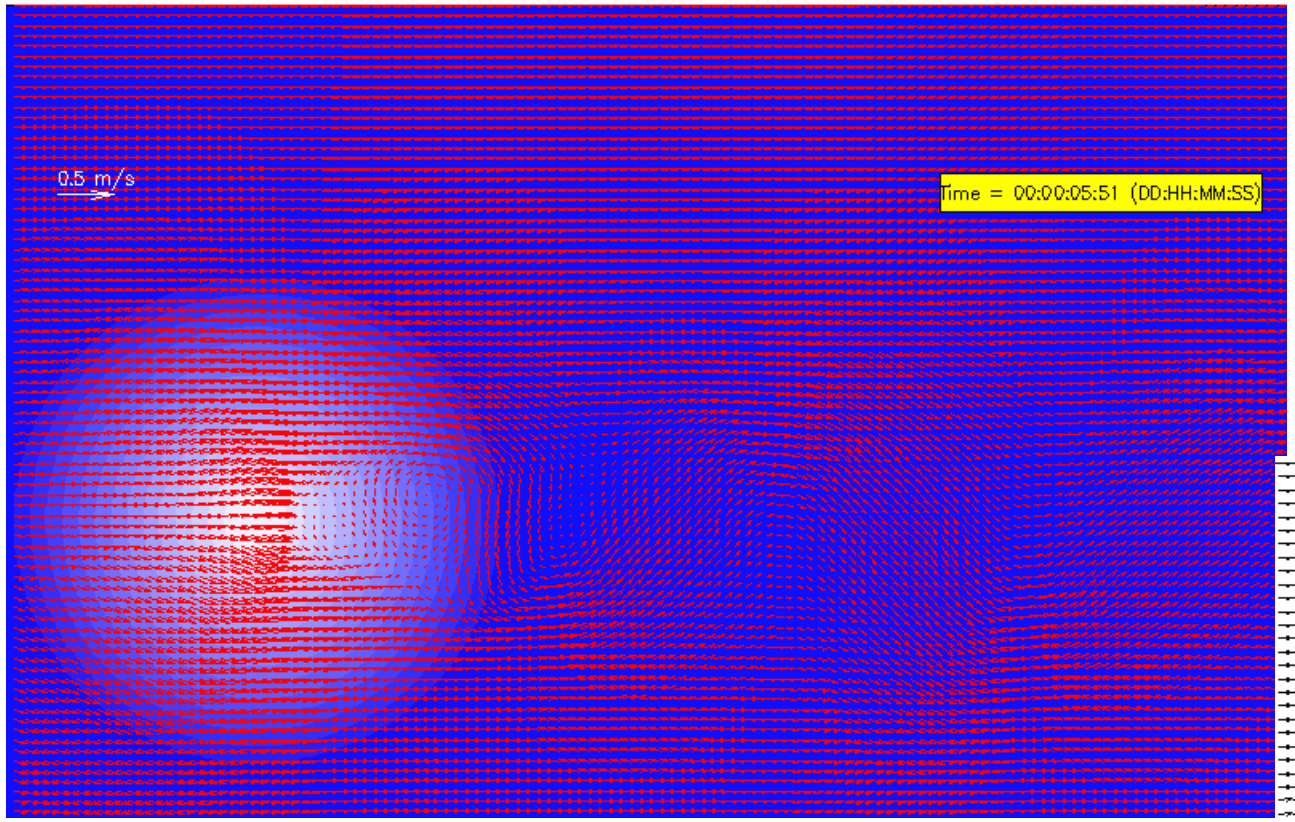
- 400 sec simulation; initially did not tune friction
- 2D: with and without dissipation
  - Δx=Δy=1.52cm, Δt=0.05s, Manning n=0.01 (as in Lloyd and Standby)
  - Without dissipation: Manning n=0
- 3D: with dissipation
  - Same grid and time step
  - 10 σ layers in the vertical
  - C_D=0.006 (as in Lloyd and Standby)
  - Turbulence closure: k-ε

BM1: Comparison of velocity at S1, S2

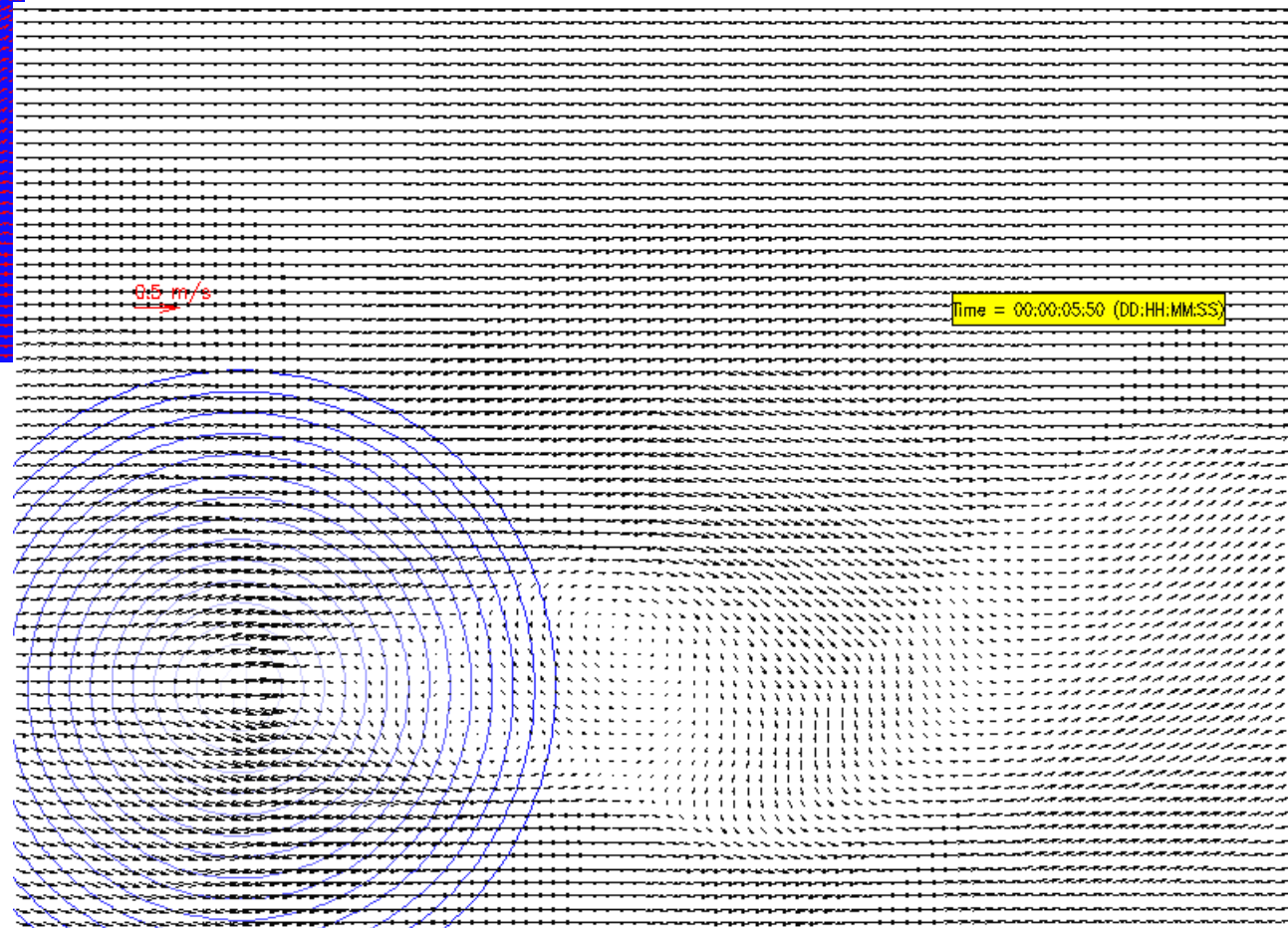




2D vs 3D

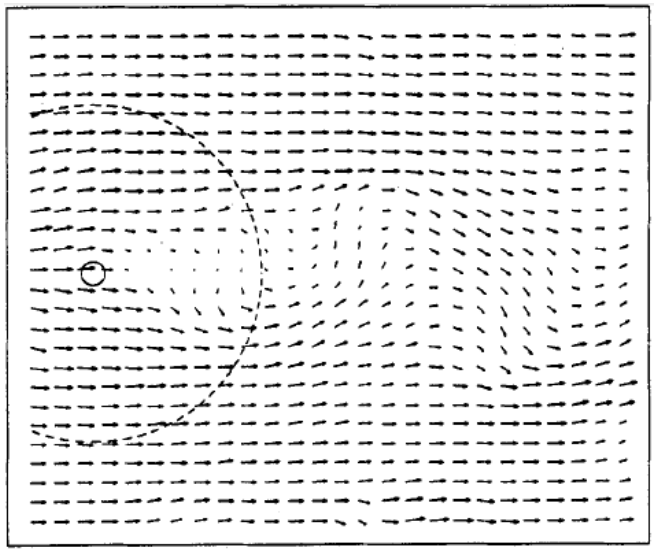


2D

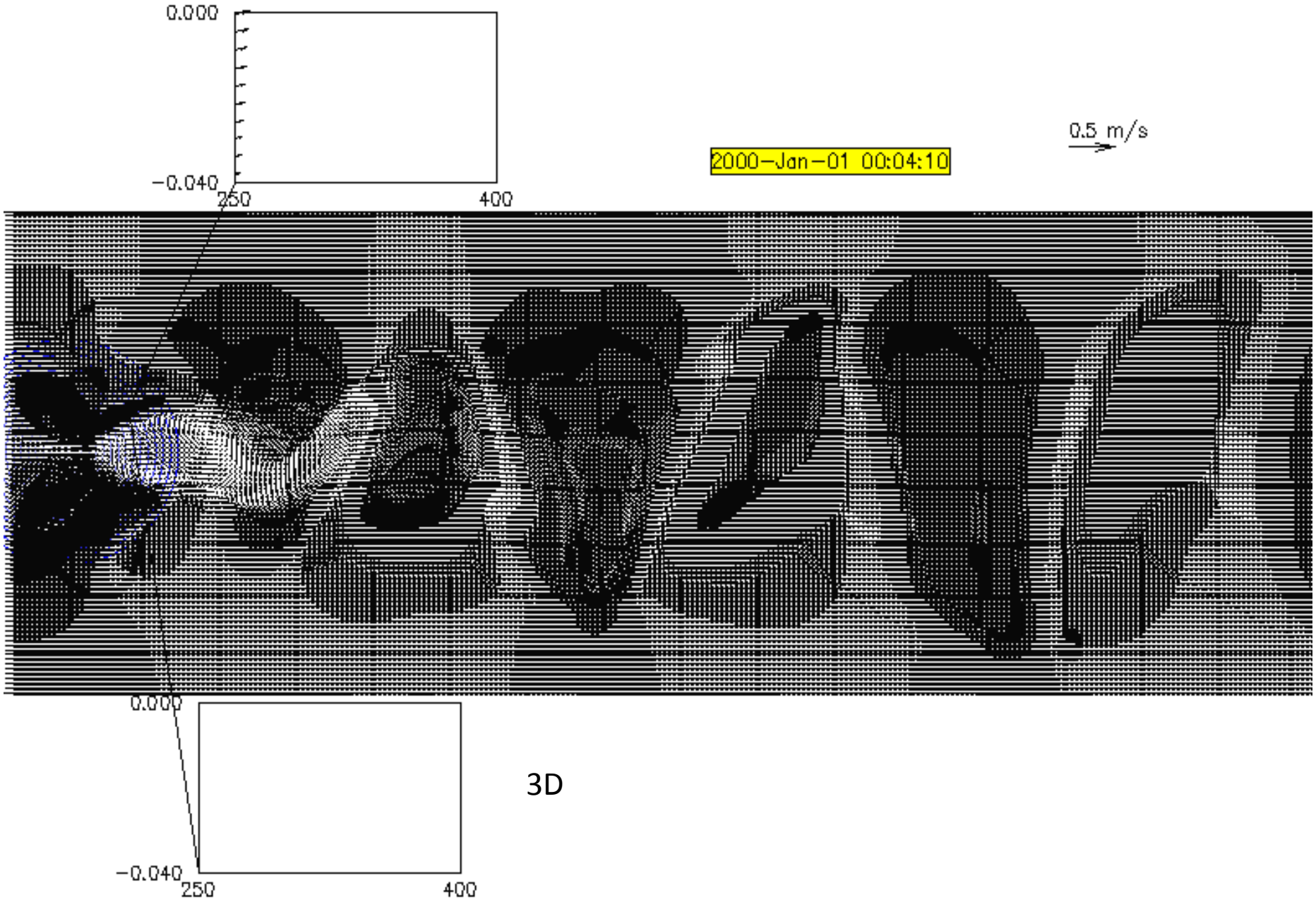


3D

Lab
(Lloyd and Standby)

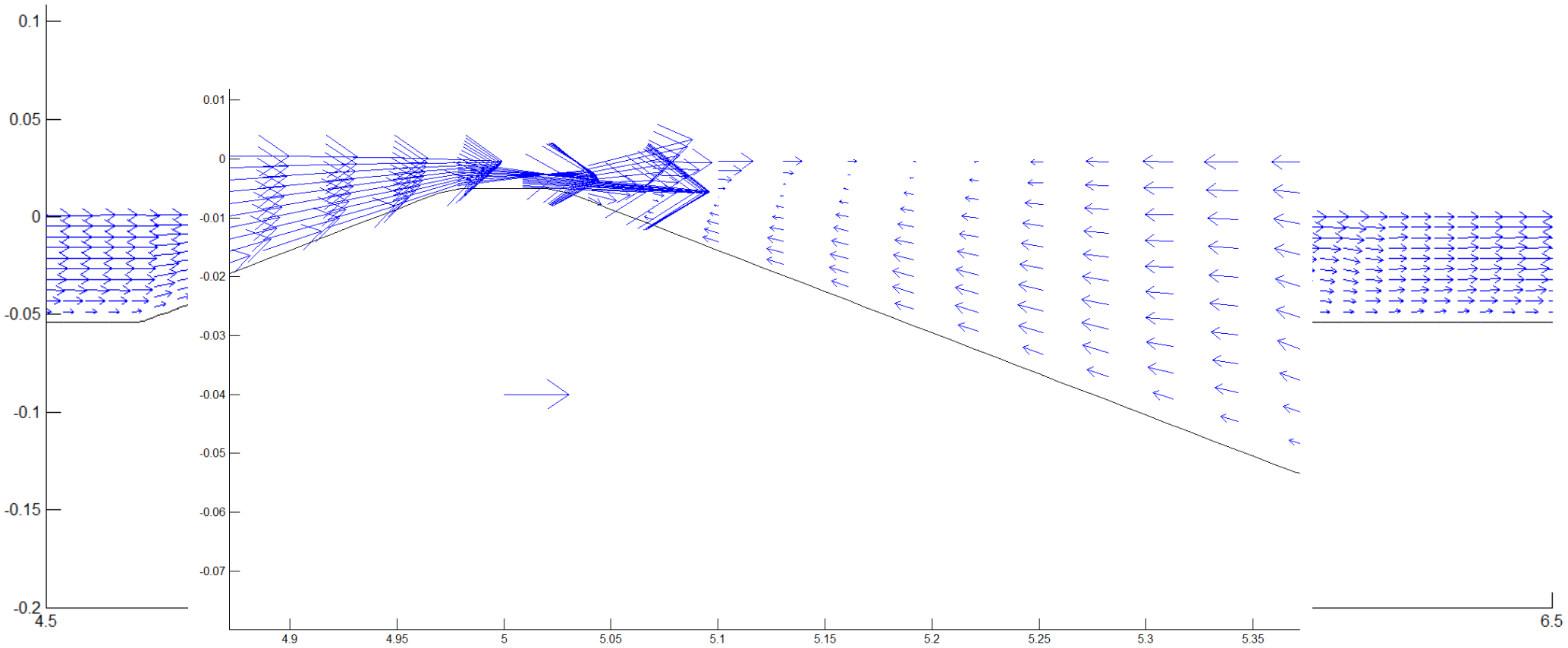


3D vertical profile



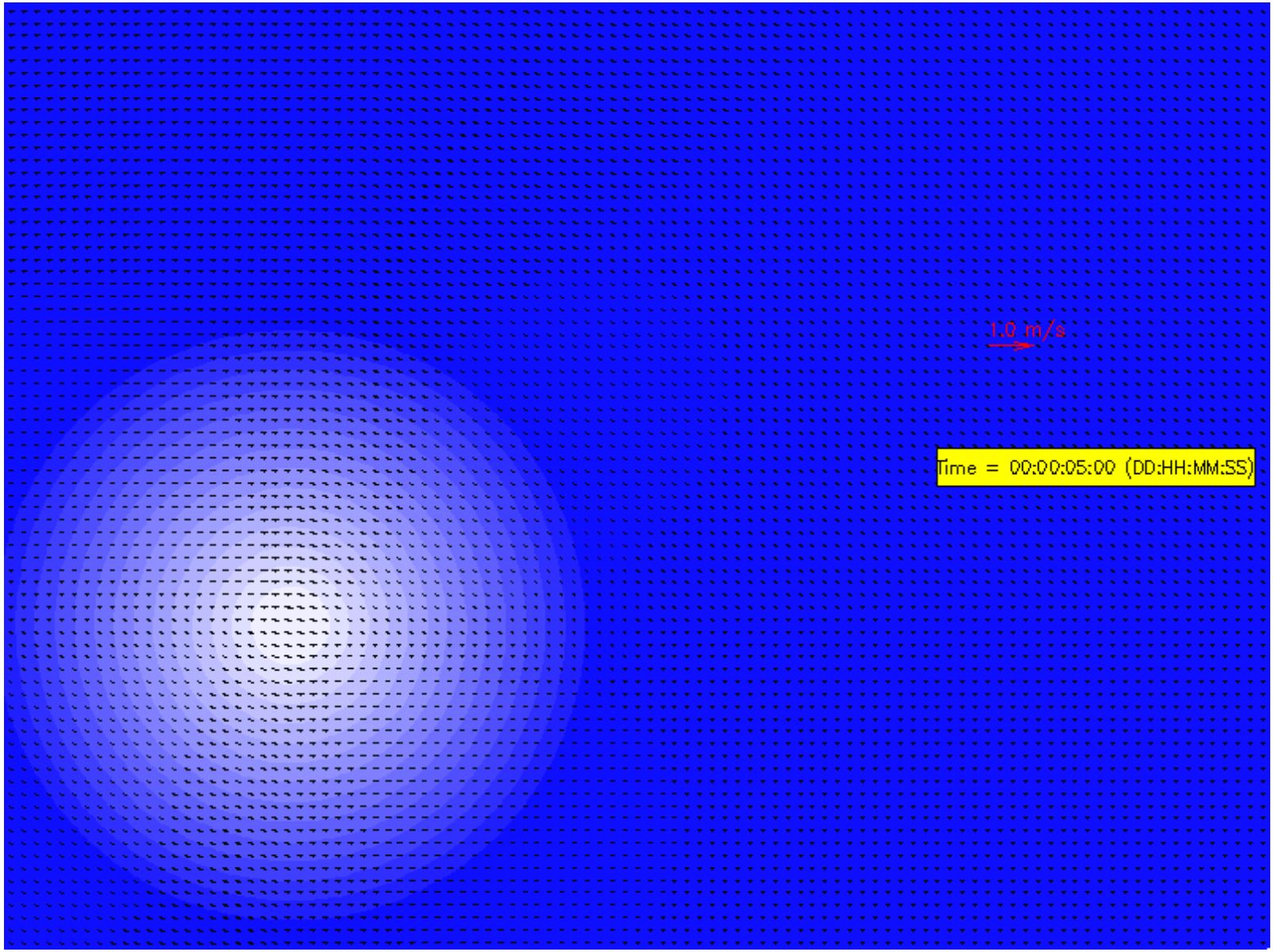
3D

Vertical transect: recirculation zone



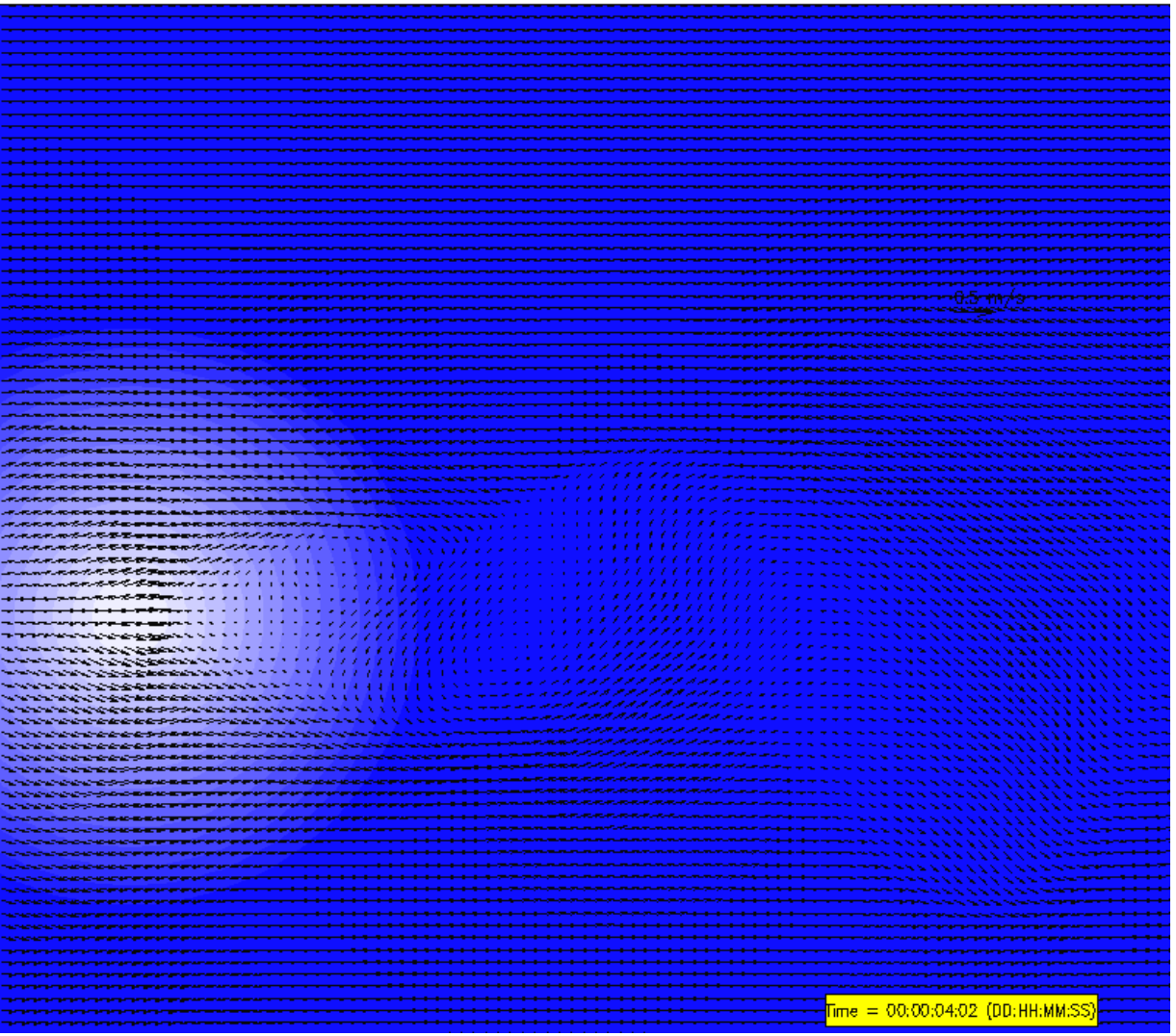
Not as wide as in L&S!

Without dissipation

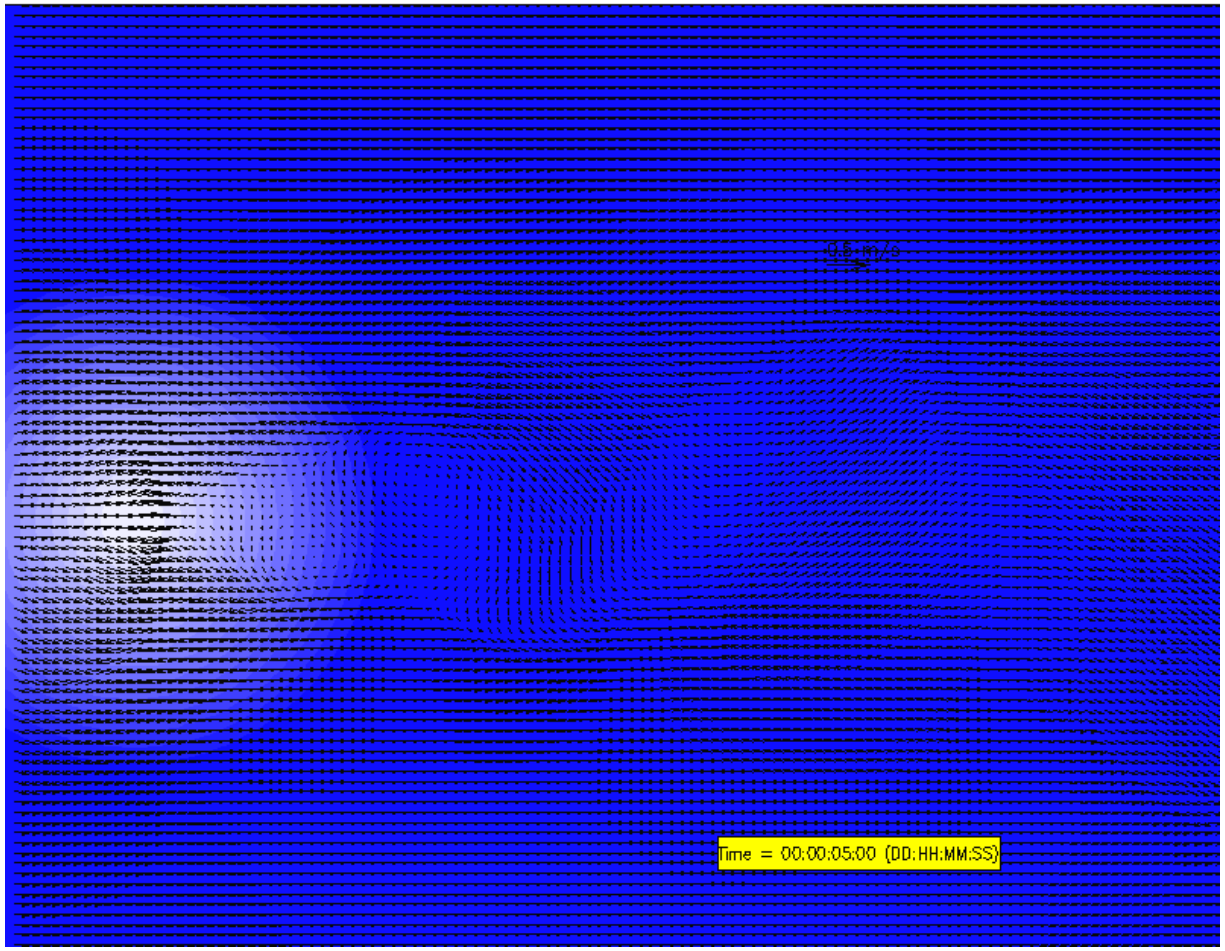


Sensitivity

Δt=0.06s



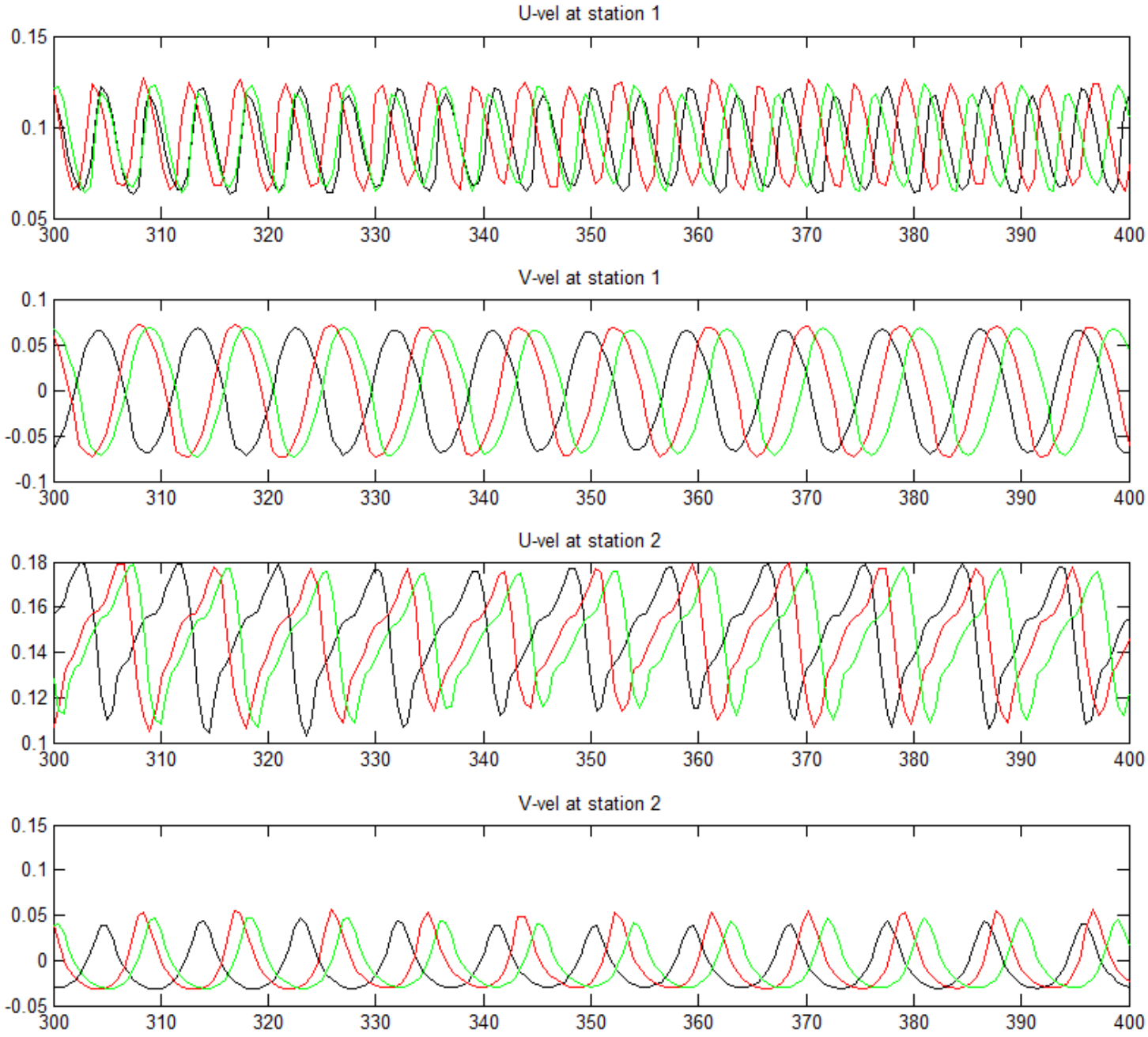
C_D=0.005



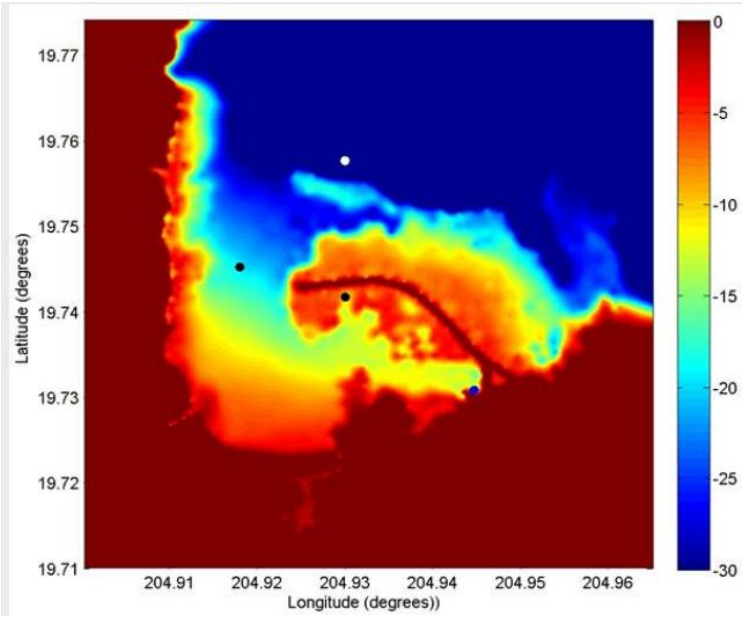
Base (Δt=0.05s, C_D=0.006)

Δt=0.06s

C_D=0.005

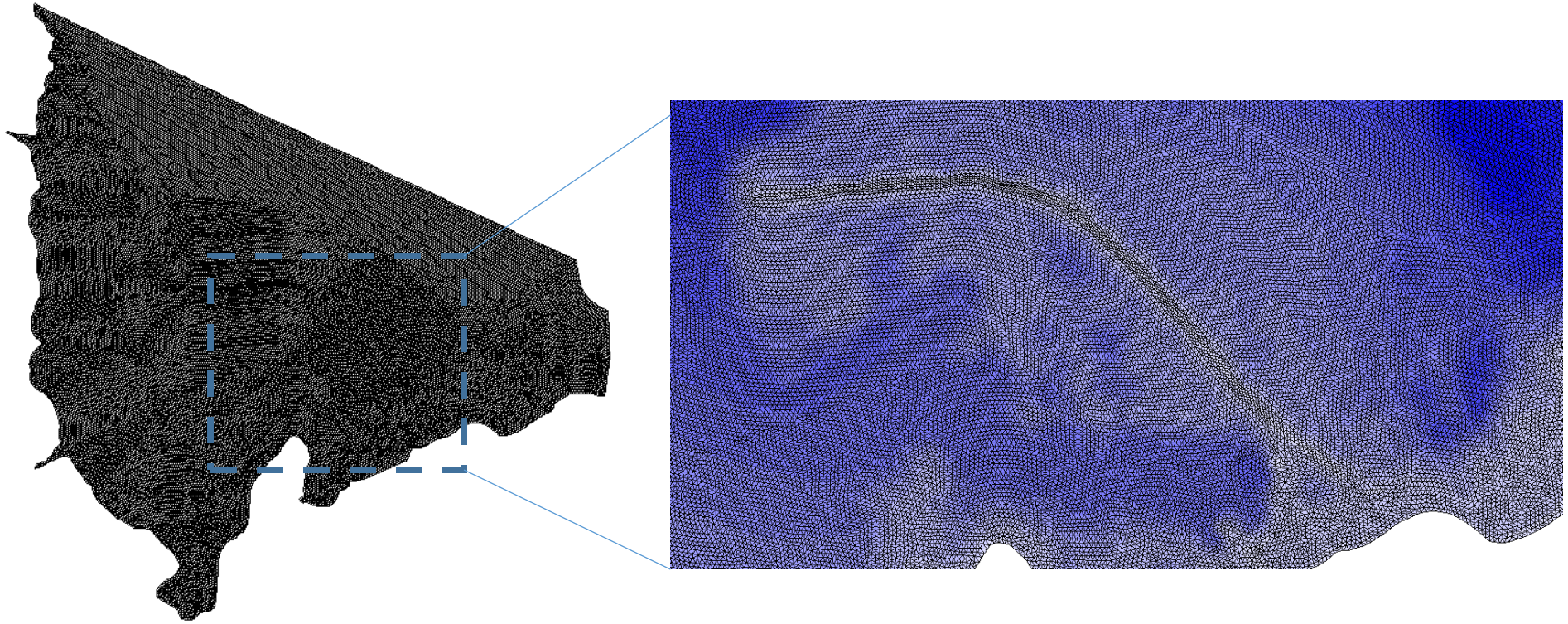


BM2: Tohoku @ Hilo

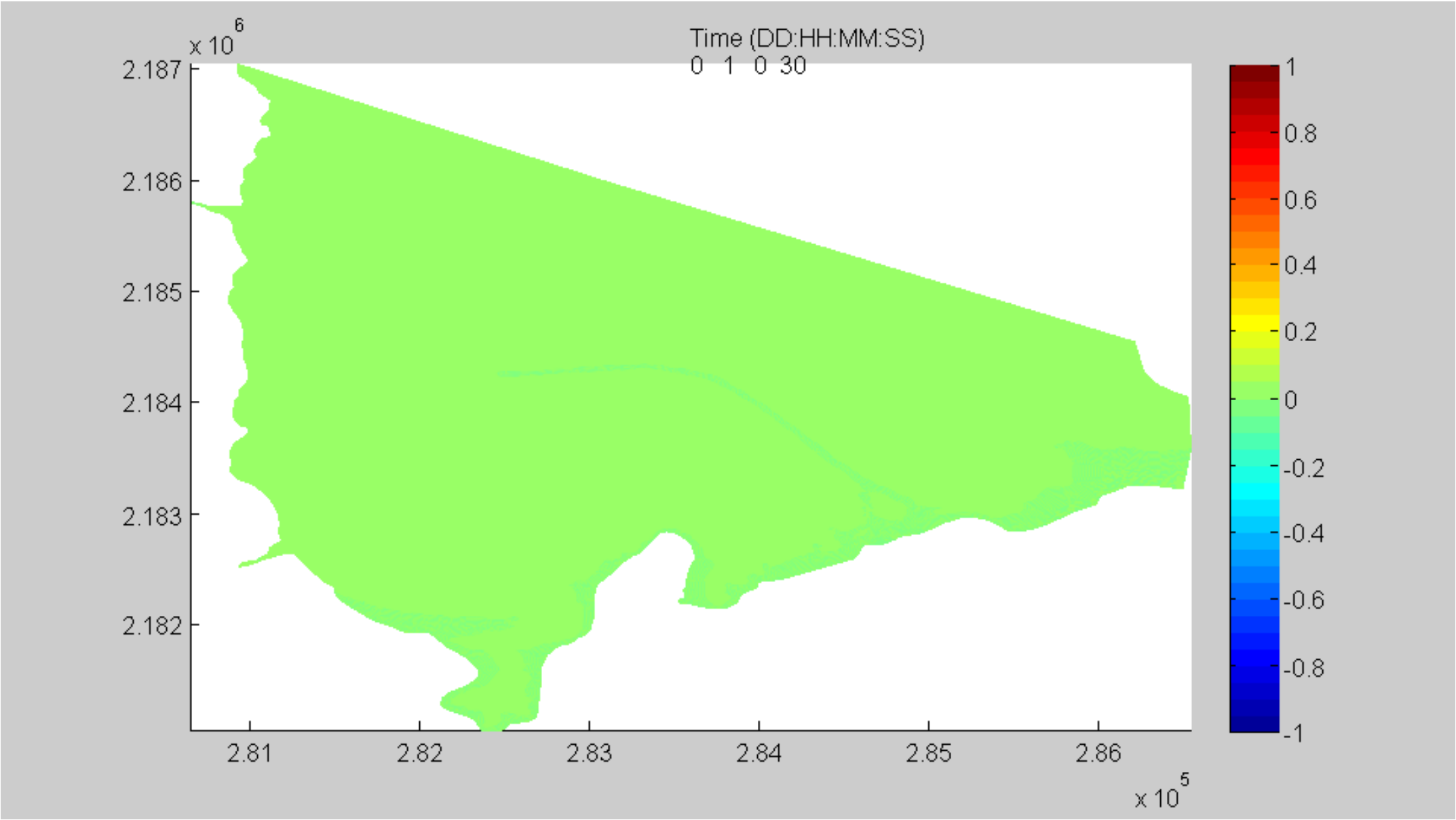


SCHISM set-up

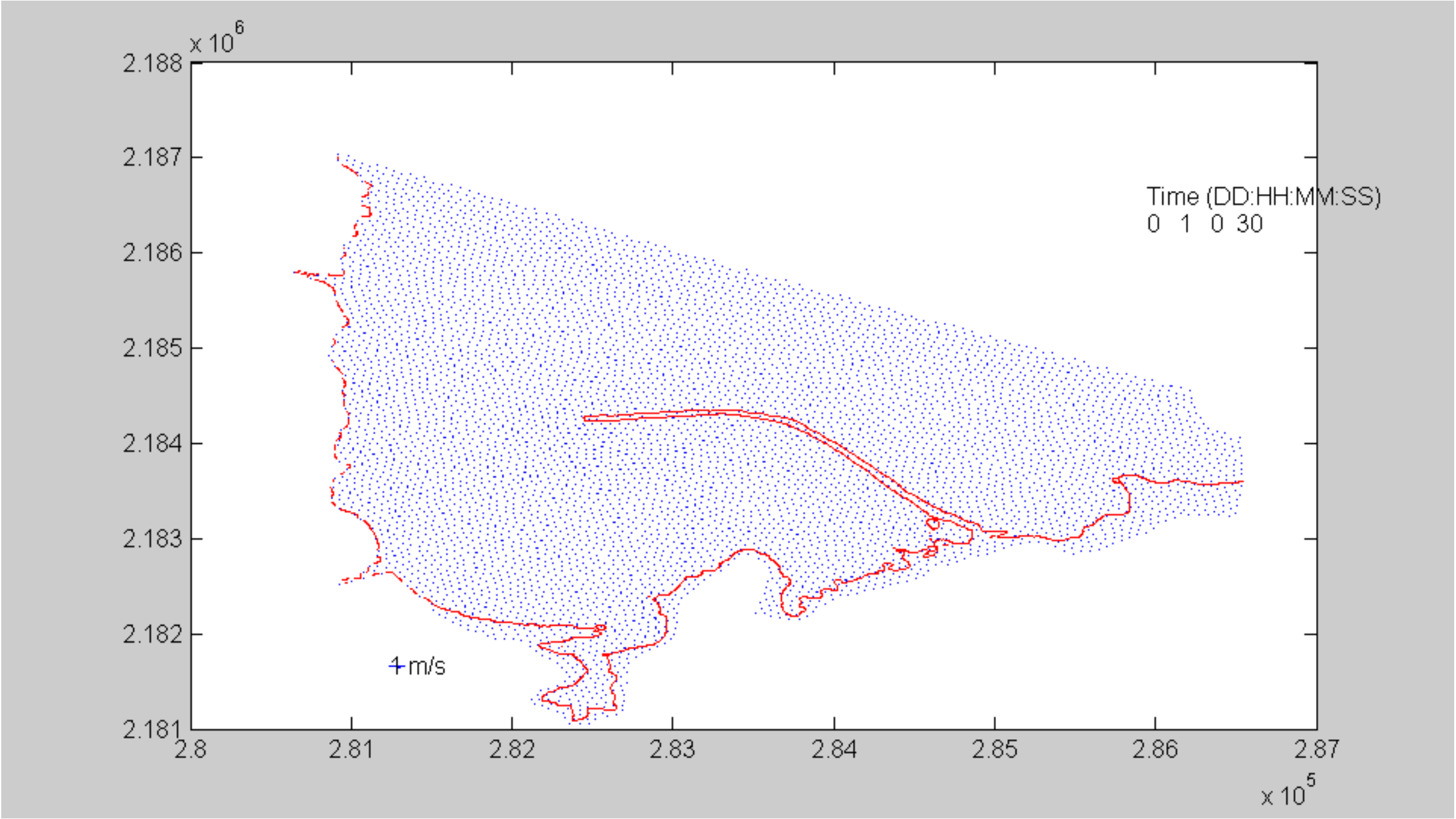
- 6-hour simulation, starting from 7 hours after EQ
- 3 (nominal) resolutions: 5m, 10m, 20m (via splitting triangles by 4)
  - Jetty resolved
- Δt=1.5s, Manning n=0.025



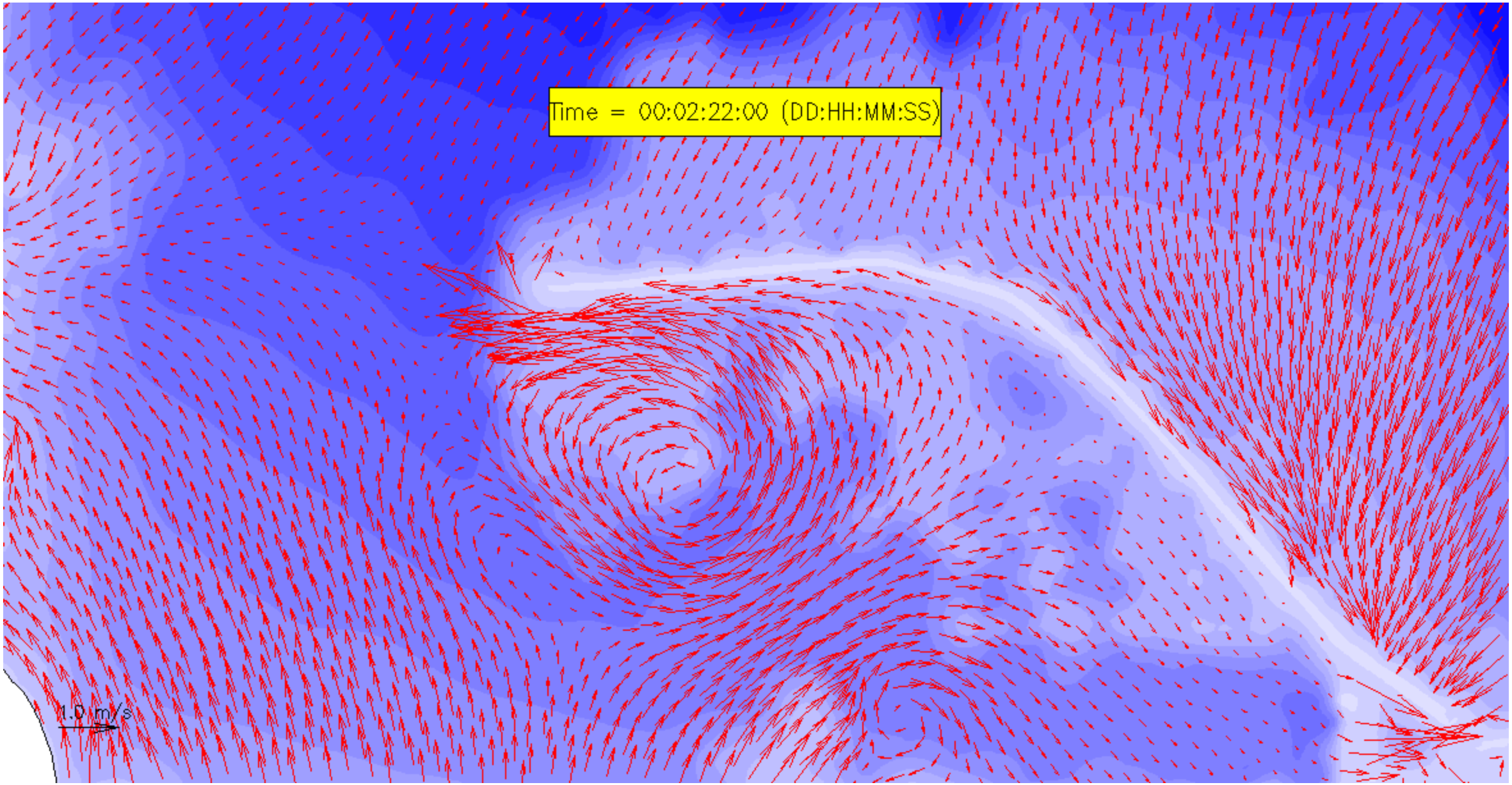
Waves


Time (DD:HH:MM:SS)
0 1 0 30
x 10^6
2.187
2.186
2.185
2.184
2.183
2.182
2.81
2.82
2.83
2.84
2.85
2.86
x 10^5
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

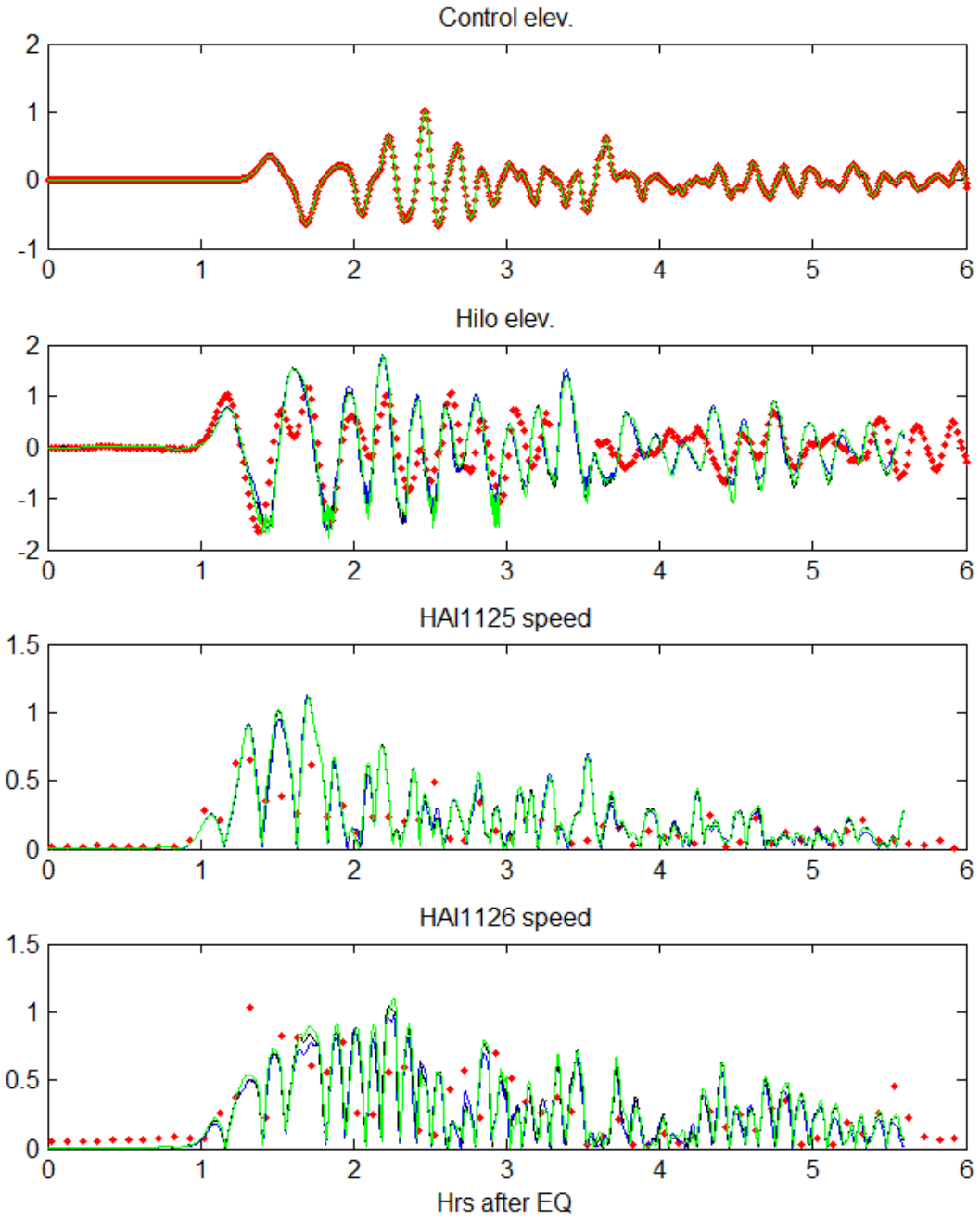
Currents


x 10^6
2.188
2.187
2.186
2.185
2.184
2.183
2.182
2.181
2.8
2.81
2.82
2.83
2.84
2.85
2.86
2.87
x 10^5
Time (DD:HH:MM:SS)
0 1 0 30
4 m/s

Shear

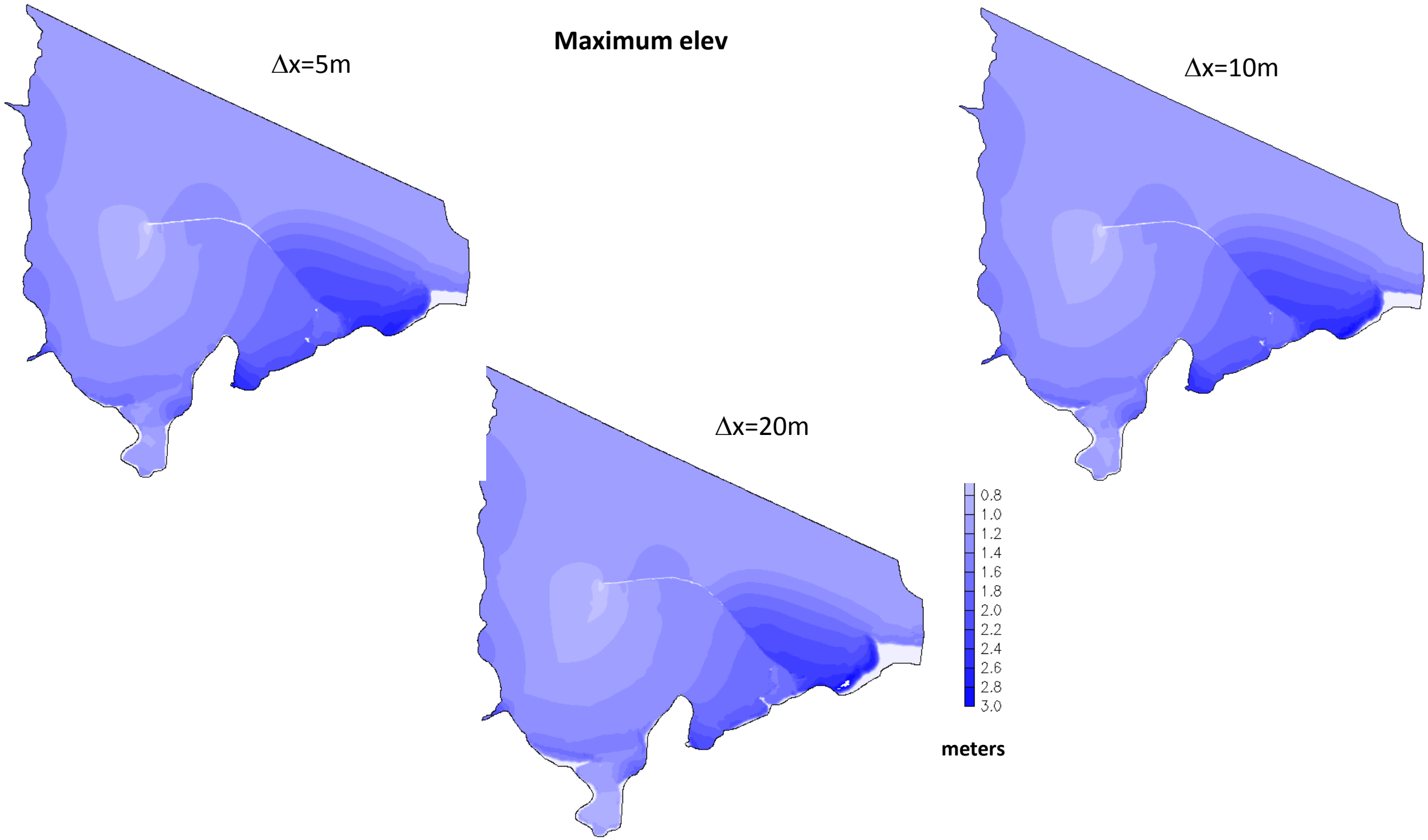


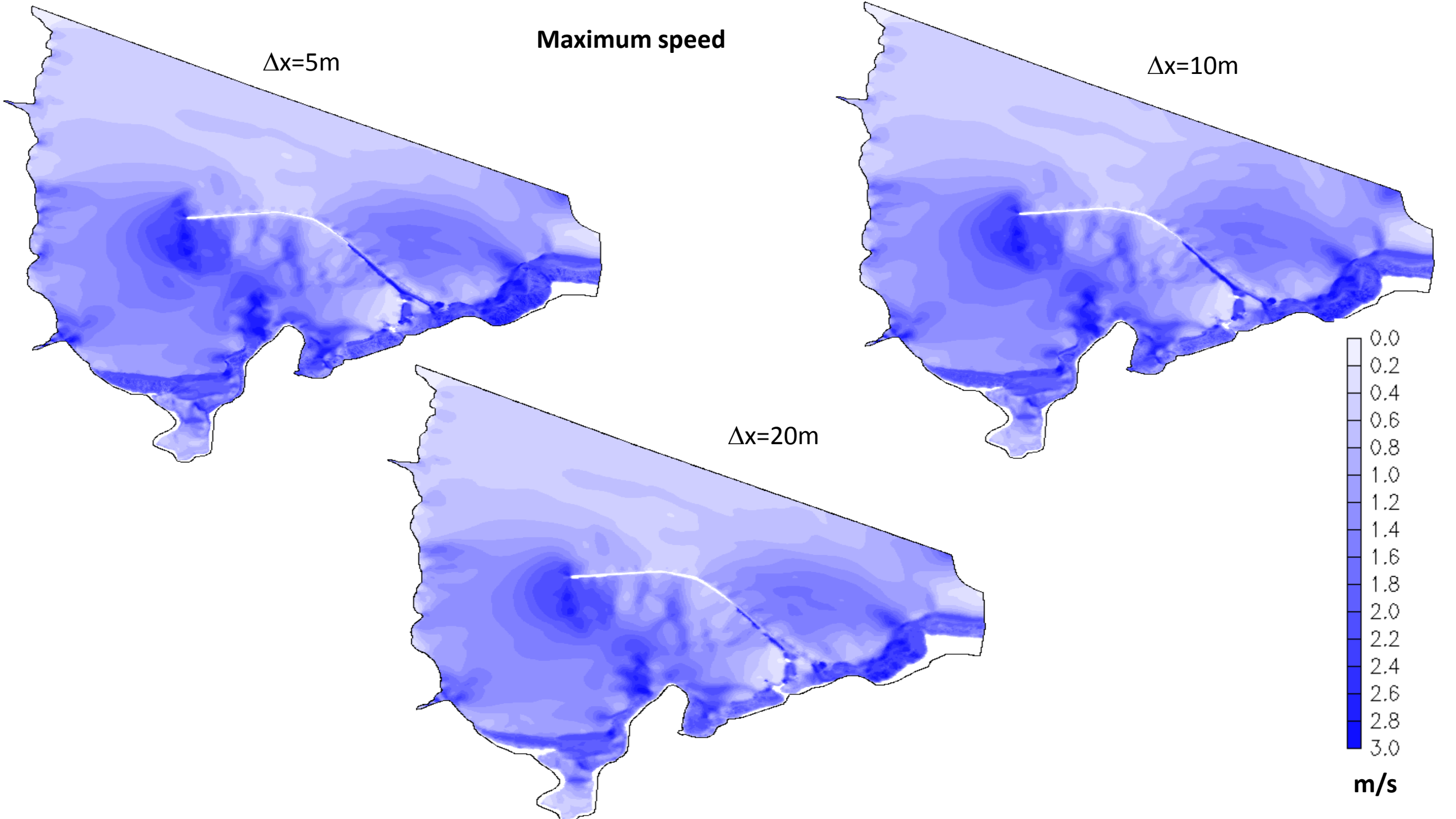
BM2: comparisons



DATA 20m 10m 5m

Maximum elev




Maximum speed
Δx=5m
Δx=10m
Δx=20m
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
m/s

BM5

- Results already submitted to Pat at ISEC workshop in July 2009

Conclusions

- The seamless cross-scale capability of SCHISM is well suited for tsunami-related applications
  - Resolution is king with unstructured grid technology
  - Flexible vertical grid
  - Minimize the use of grid nesting
- Model has been extensively validated and applied to many real-world systems
  - Ability to simulate tsunami heights
  - Validated for tsunami currents with BM1,2,5
- The 1D/2D/3D capability of SCHISM modeling system has potential applications for
  - Tide-tsunami interaction (Zhang et al. 2011)
  - Sediment transport during tsunami events