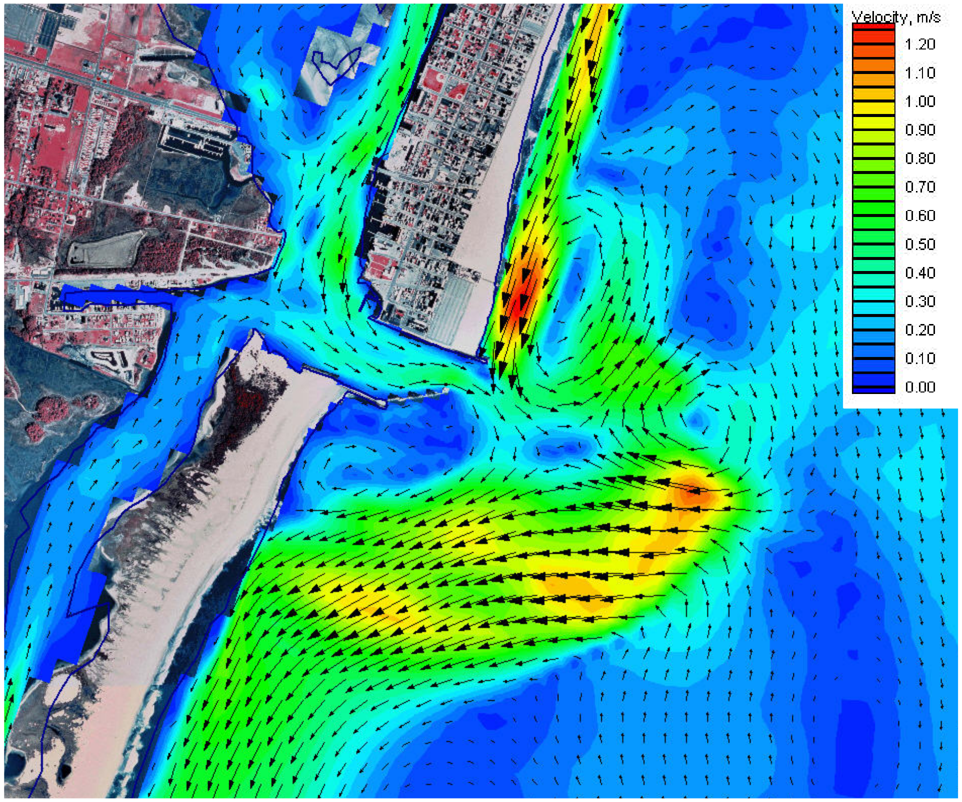
What's Next for the Coastal Modeling System?

Mitchell Brown, for the CMS Development Team

Tanya Beck, Mitch Brown, Nick Kraus, Honghai, Li, Lihwa Lin, Magnus Larson, Neil MacDonald, Chris Reed, Alex Sanchez, Ping Wang, Weiming Wu, Gary Zarillo, Alan Zundel,
and
Emeriti: Benoît Camenen, Adele Militello Buttolph, Ken Connell, Nobu Ono

Presentation Topics

1. Implicit solution.
2. Telescoping grid.
3. Sediment mixtures.
4. PTM.
5. Vegetation.
6. ShipSed.
7. Parallel processing.
8. Breaching.
9. Swash transport and shoreline change.
10. SMS/CMS Partnerships.



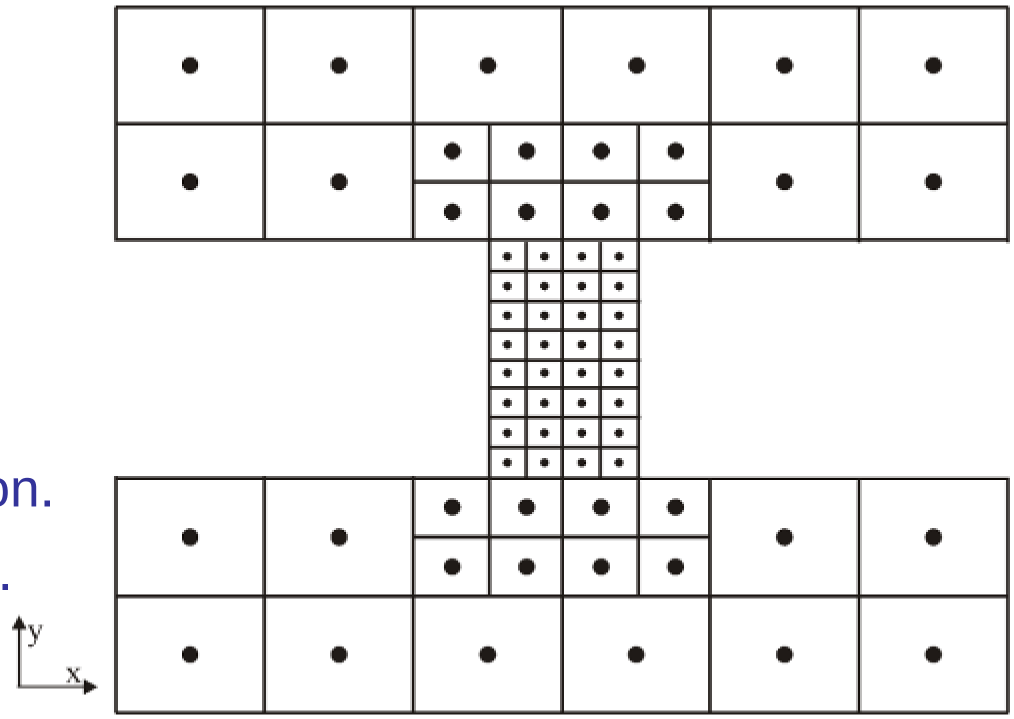
Ocean City Inlet, MD

1. Implicit Solution Models: Flow & Transport

- Time step of 10-30+ min possible ☞ very short run times.
- Both hydrodynamics and sediment/salinity transport.
- Long-term simulations will be possible – years, in reasonable execution time.
- All features presently available to be incorporated – boundary conditions, NET, avalanching, salinity, etc., included.

2. Telescoping (non-conforming) Grids

- Intuitive rectangular grid.
- Grid refinement by splitting one cell into fine cells.
- Unstructured grid indexing.
- Advantages:
  - Can exclude inactive cells.
  - Reduce number of cells.
  - Increase local resolution.
  - More flexibility in grid generation.
  - Efficient in overall computation.
  - Maintain mass-conservation inherent in finite-volume calculations, while gaining efficiency of unstructured grids.



Telescoping (non-conforming) Grids

High-aspect cells far from targeted areas of interest

Unnecessary fine area yielding inefficient use of computational resources for rectangular grids

unnecessary high resolution occurs

Telescoping grids provide more flexibility in grid generation – eliminate inefficiencies, decrease run time (beat Courant)

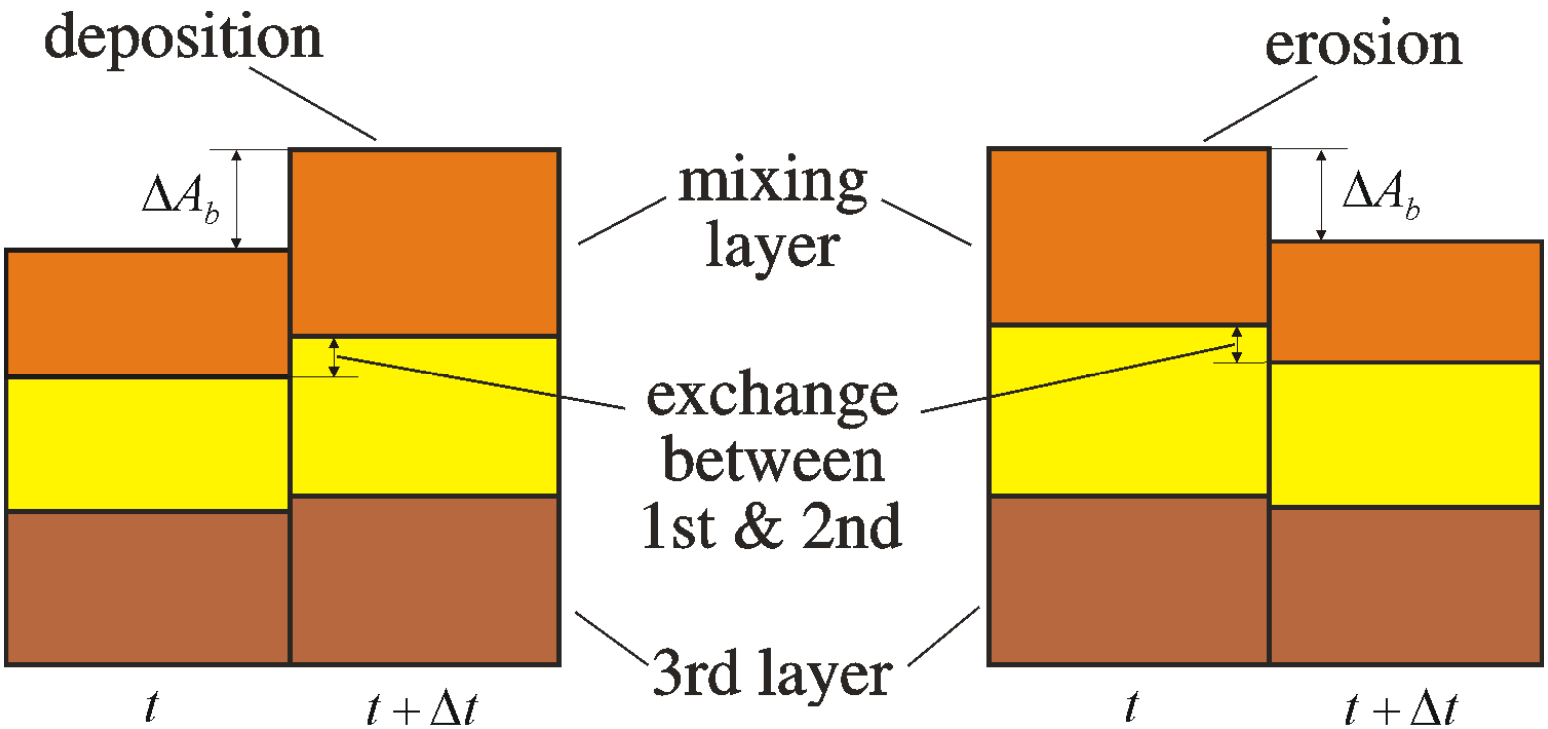
larger cells offshore

high resolution confined to required areas

3. Non-uniform Sediment Transport

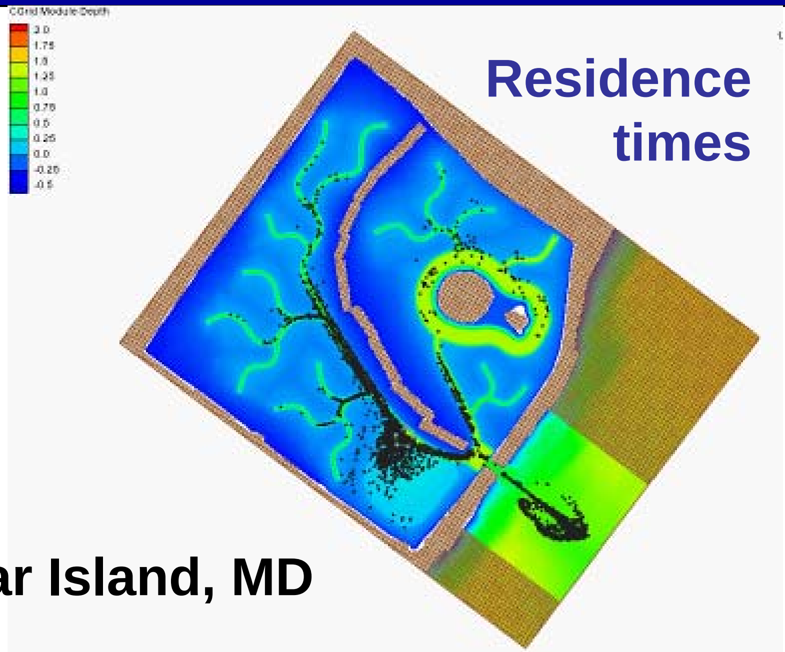
- Non-uniform sediment mixtures typical.
- Divide sediment mixture into a suitable number of size classes (e.g., 2-4 sizes).
- Compute each size class as uniform sediment.
- Represent hiding and exposure among different size classes of bed material.
- Represent bed material sorting (fine particles are easy to move) and armoring.
- Result -- more realistic and accurate simulation of natural sediment transport processes.

Non-uniform Sediment Transport

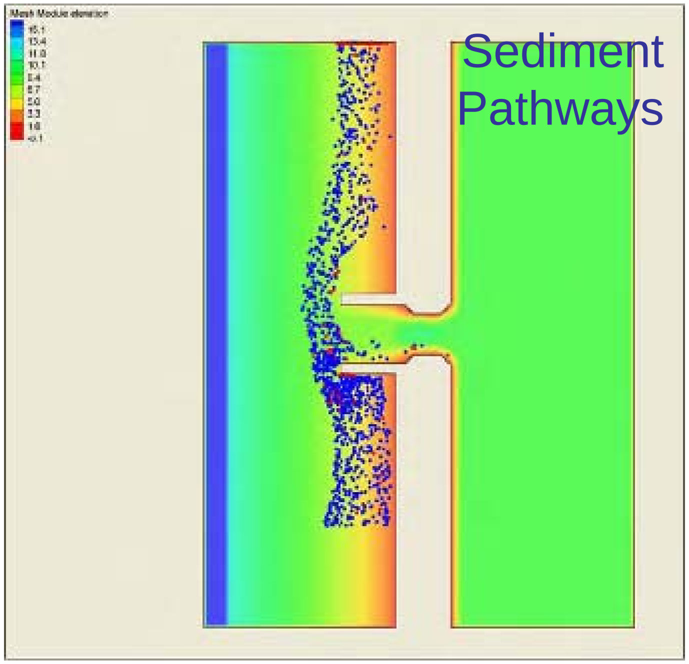


4. Particle Tracking Model (CMS-PTM)

- Lagrangian approach to simulate transport, dispersion, entrainment and settlement of particles under both currents and waves.
- 2D **and 3D** calculation.
- Driven by CMS (flow and waves).



Poplar Island, MD



Idealized Inlet

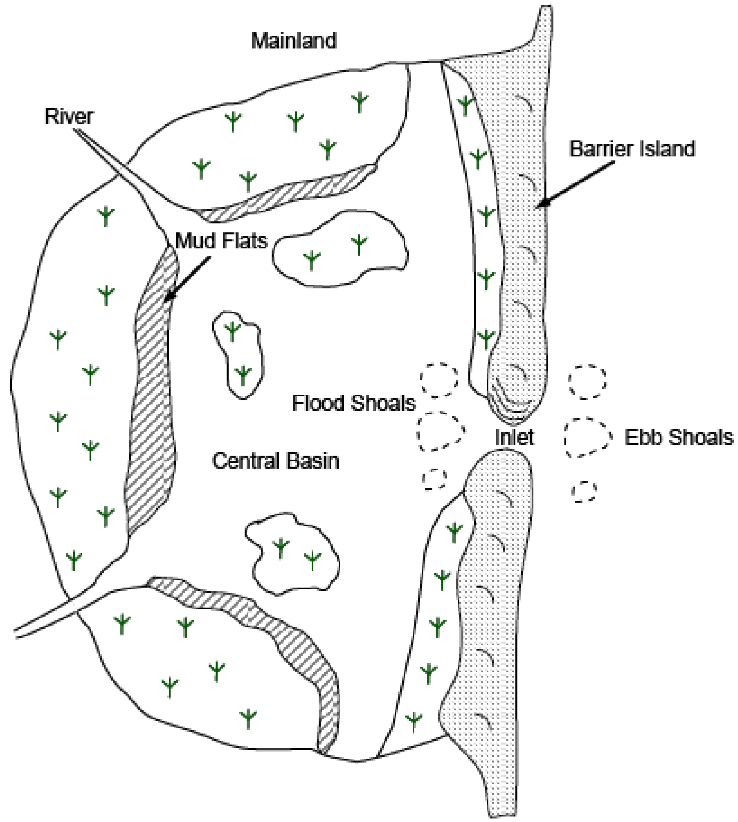
- Large variety and flexibility in specifying sources and sinks.
- **Improved visualization for communication of transport to sponsors.**
- Calculated spatial maps of sediment mobility, bedforms, sediment pathways, etc.

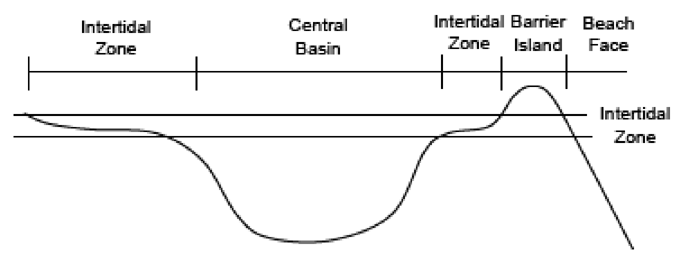
CMS-PTM

- Coupling with new telescoping CMS-Flow (explicit and implicit).
- Improved user interface and visualization within the SMS.
- Improved post-processing routines.
- Coupling with CMS-3D.

5. Vegetation

- Hydromorphic parameters
  - Bay and inlet dimensions (length, width, depth, etc.)
  - Ratio of volume of intertidal wetland to volume of bay
  - Ratio of area of wetlands to area of bay
  - Ratio tidal amplitude to bay depth (friction)
  - Area-height relationship
- Vegetation capability already operational within the CMS
  - More testing needed
- Full SMS implementation in FY10.



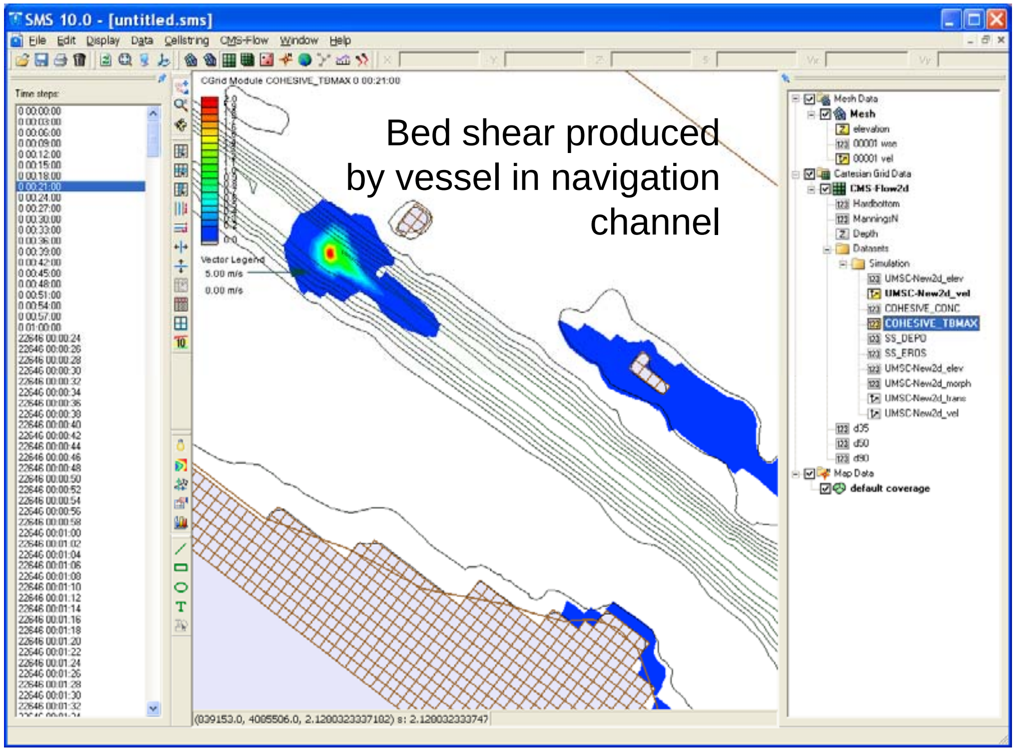


6. ShipSed

- ShipSed quasi-operational with the CMS; has been low priority.
- Predicts flows and sediment transport due to ship passages:
  - Drawdown
  - Wake
  - Prop-wash
  - Return flow
- Simplified approach for long-term simulations.

ShipSed

- Coupled with CMS-Flow2D
  - Driven by waves and flow
  - Solution computed on a separate unstructured mesh.
  - Sediment transport calculations with CIRP-Lund formulas.



- ShipSed SMS interface will help user to specify ship info -- size, propulsion, route, speed, draft, sailing time.

7. CMS-Flow – Parallel Processing (SMS moving to parallel processing, too)

Time comparison from one interval of steering wave-flow steering

- Flow grid ~42,000 cells
- Hydro Timestep – 0.5 sec
- Transport Timestep – 10 s
- Morphology update – 0.5 hours

	Serial 1 Processor	**Parallel** 1 Processor (2 Threads)	**Parallel** 2 Processors (4 Threads)	**Parallel** 3 Processors (6 Threads)	**Parallel** 4 Processor (8 Threads)
Hydro + Waves only	12 m 52 s	8 m 23 s ~1.5x faste6	4 m 29 s **~2.8x faster**	6 m 6 s ~2.1x faster	5 m 4 s ~2.5x faster
Hydro + Waves + ST : Total Load – Lund CIRP	15 m 46 s	8 m 37 s ~1.8x faster	5 m 10 s **~3.0x faster**	6 m 37 sec ~2.4x faster	6 m 34 s ~2.4x faster
Hydro + Waves + ST : NET – Lund-CIRP capacity	17 m 28 s	11 m 15 s ~1.5x faster	7 m 17 s **~2.4x faster**	7 m 50 s ~2.2x faster	7 m 15 s ~2.4x faster

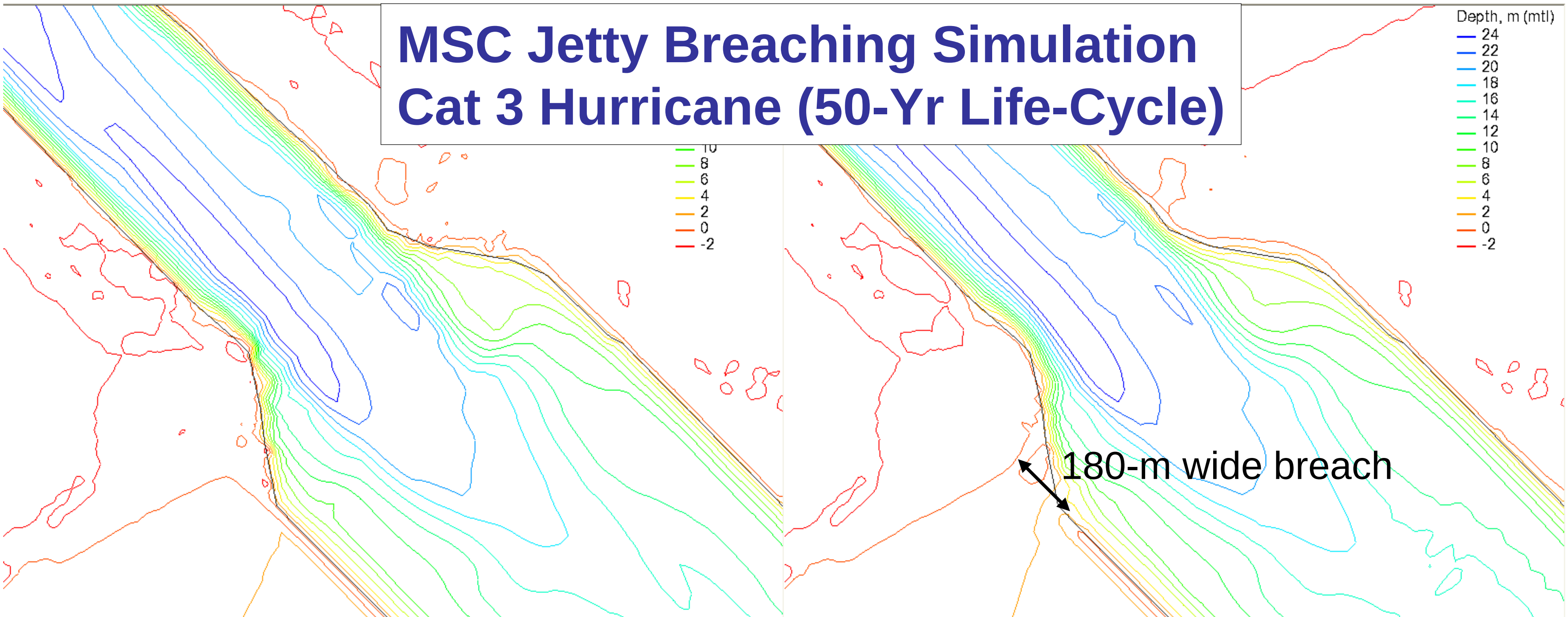
Bottom line: Start purchasing quad, dual-quad PCs.

8. Breaching

Initial bathymetry

After 12-hr simulation

MSC Jetty Breaching Simulation
Cat 3 Hurricane (50-Yr Life-Cycle)

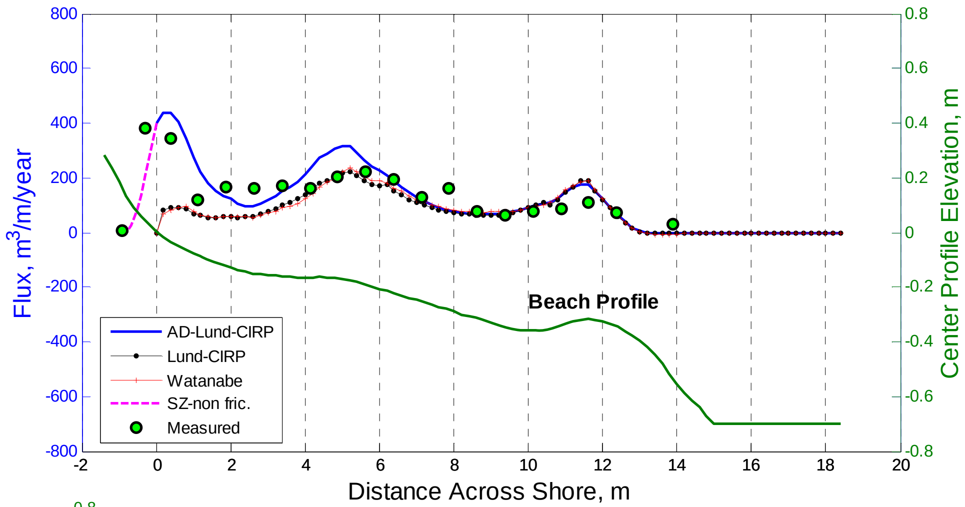


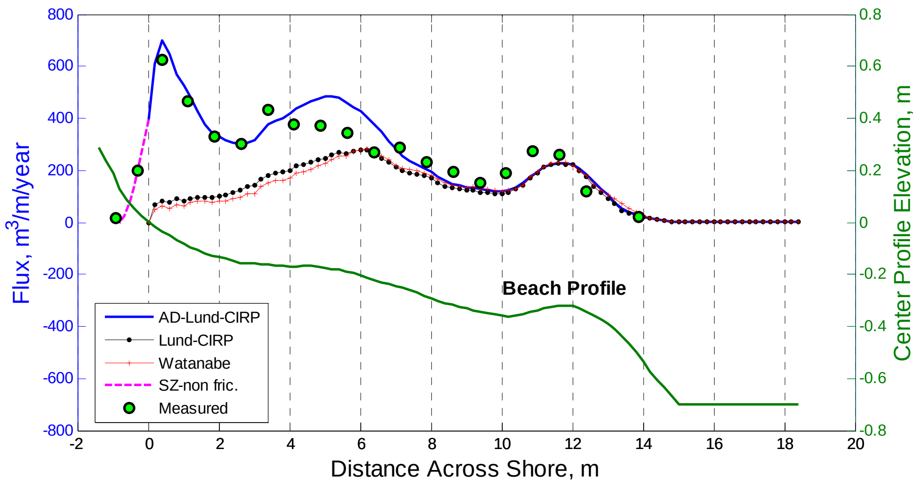
- Peak storm surge level reaches 3.5 m between Hrs 4 and 8
- Incident offshore wave is 7.6 m, 14.3 sec, from southwest
- Calculated breaching width is 180 m, and maximum depth is 3.4 m

9. Swash-zone Calculations

New Sand Transport Algorithm: Comparison with LSTF Data

Computed and measured longshore sediment flux for LSTF Case BC-1

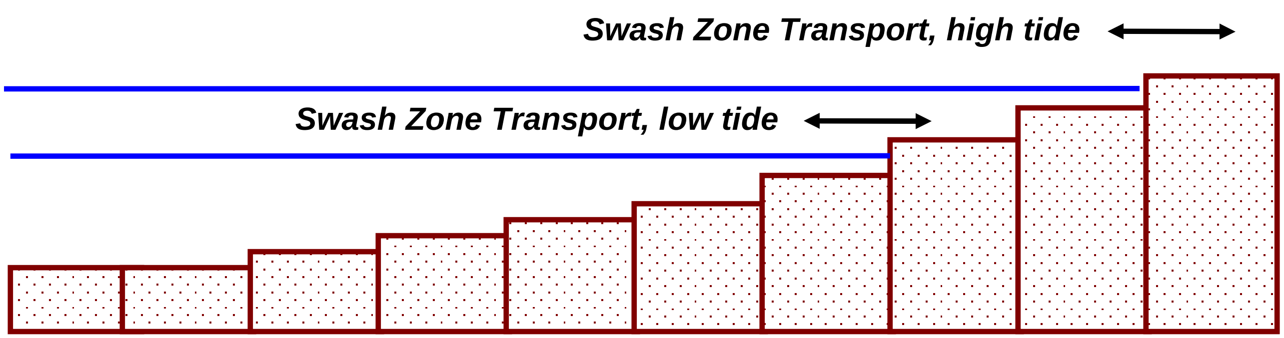




Computed and measured longshore sediment flux for LSTF Case BC-2

Swash-zone Calculations

Swash zone module simulates sediment transport between grid cells below MWL and above MWL. Swash zone exchange varies across the grid as cells wet and dry with the tide, run-up, and setup.



Cross-Shore View of CMS Grid – Swash Zone at Low & High Tide

10. SMS/CMS Partnerships

- Coastal Modeling System – funded by the Navigation Program at HQ, Corps of Engineers, through the Coastal Inlets Research Program.
- CMS is free, but needs an interface – the SMS essential for model running and pre- and post-processing.
- SMS also supported by the CIRP/Corps via NMSP program.
- CMS & SMS available to academia and private industry. Fee charged for SMS license and CMS only in-so-far as need to support non-Corps users.
- **CMS & SMS development teams are interested in your applications. Let's join together in continuing to advance this powerful and inexpensive system!**