Overview of the SMS (v11.0), Coastal Modeling System, and User Resources

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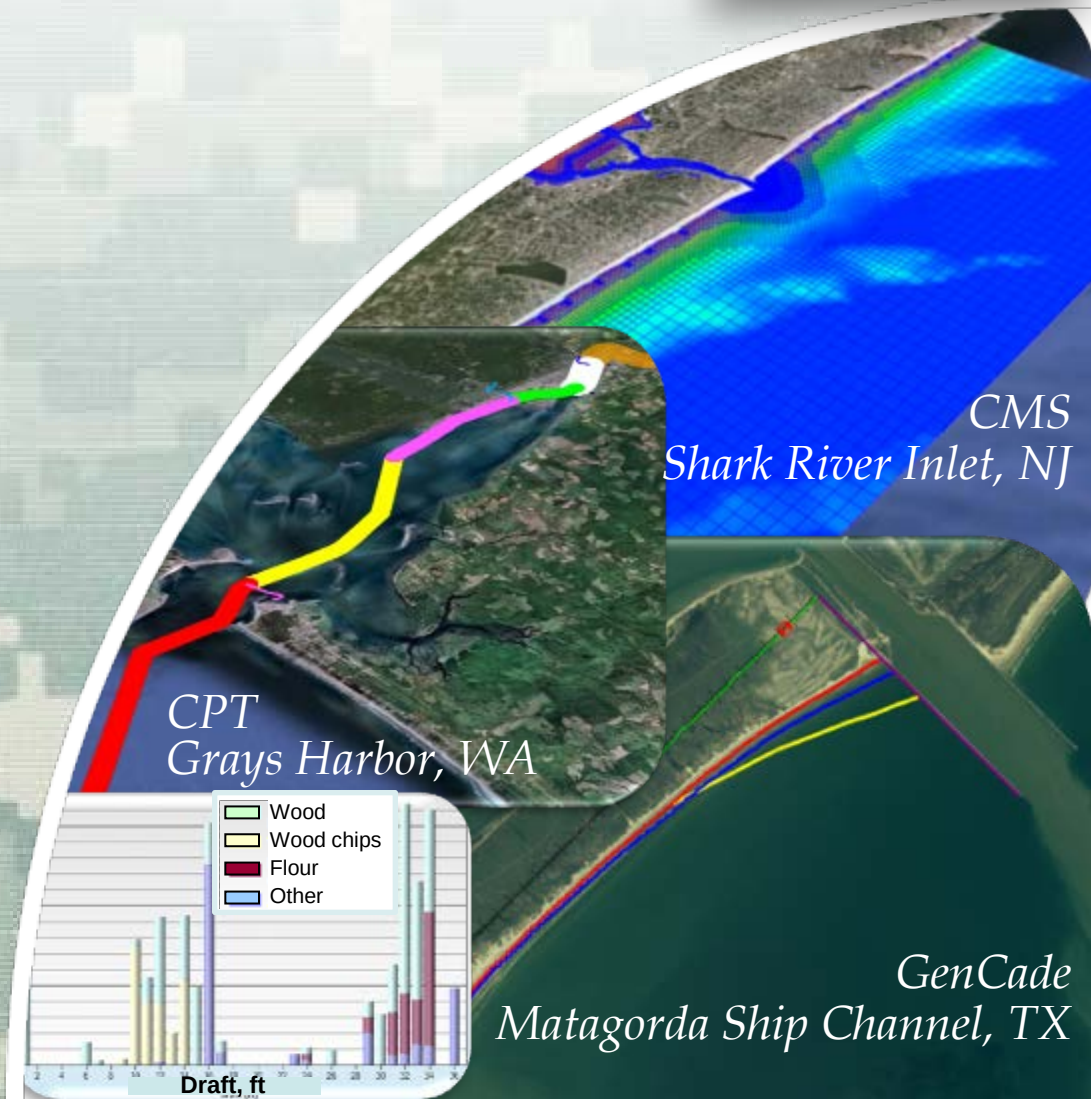

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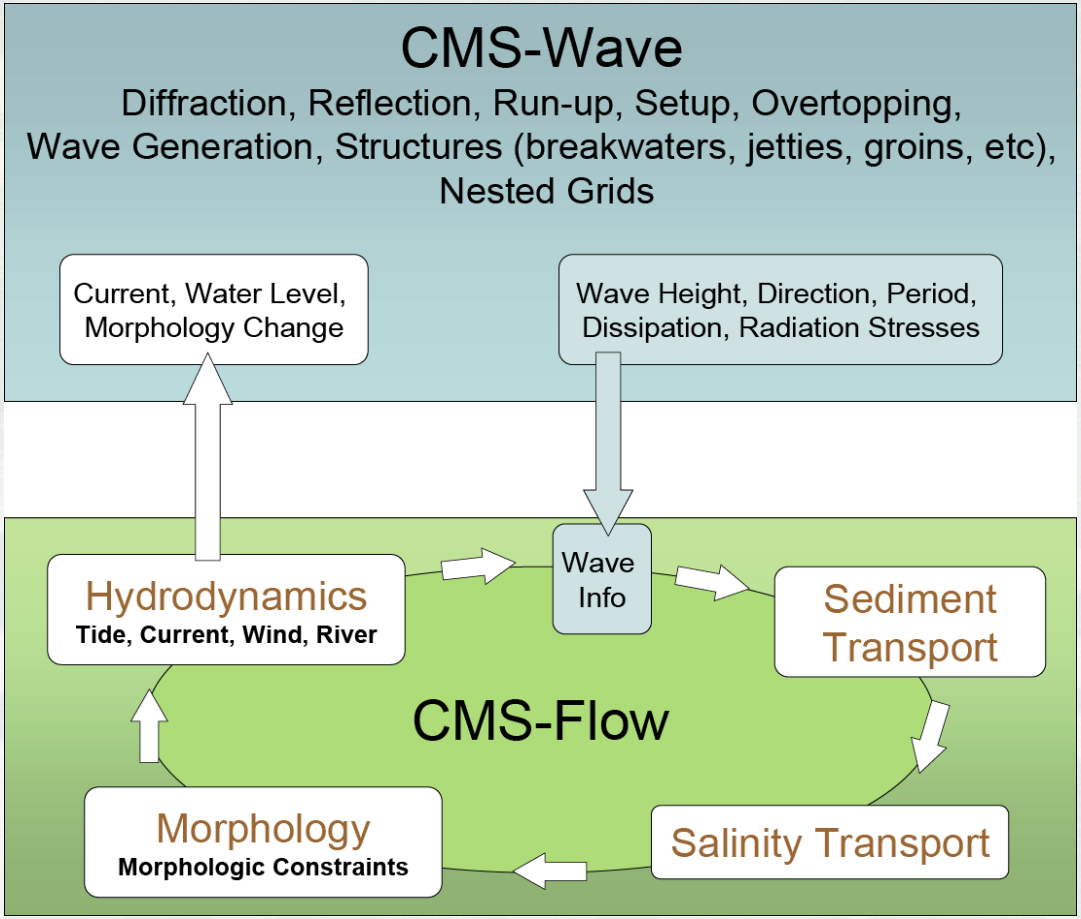
Overview of Presentation

- Introduction to the Coastal Modeling System (CMS)
  - CMS-Flow – Hydrodynamics, Sediment Transport, Morphology Change
  - CMS-Wave – Half-plane waves and Full-plane wind forcing.

Objective

- **Deliver** to engineers' desktops **integrated** advanced models that can be used as **practical** engineering tools for **coastal** inlet and adjacent beach studies.
  - Integrated: All relevant processes, models efficiently coupled together
  - Practical: PC-based, user-friendly interface, fast, robust and accurate
  - Deliver: Manuals, tech reports, journal papers, Wiki, workshops, phone help, etc.

CMS Overview



Since 1997…

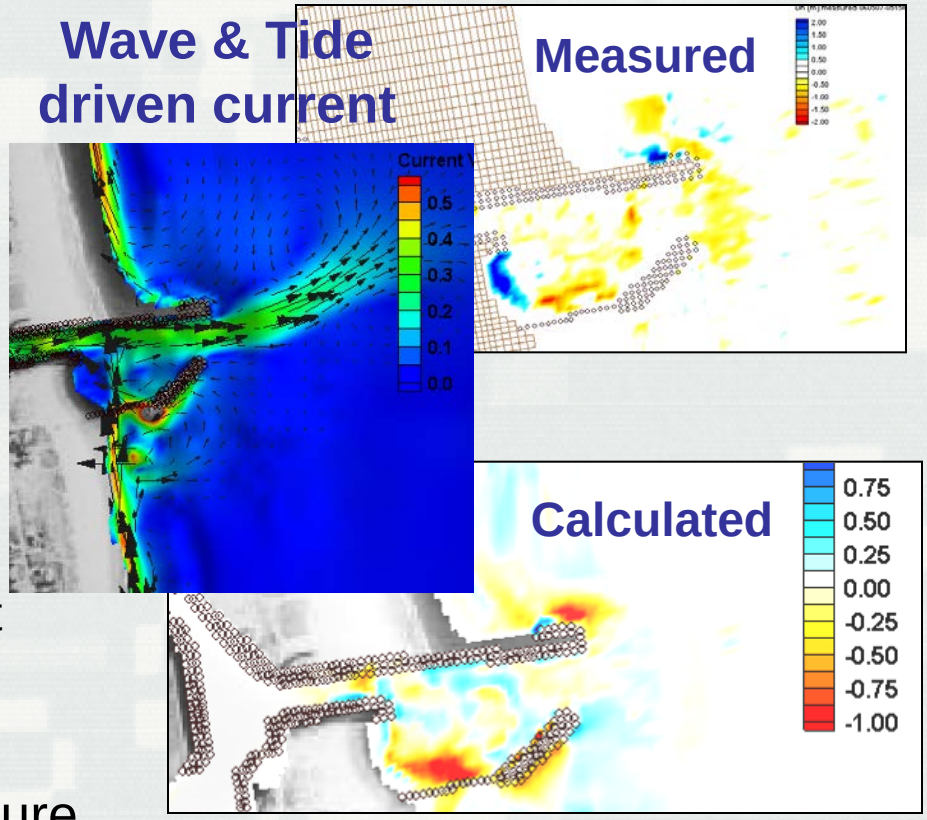
- 2 webinars
- 38 workshops
- Districts can independently run the CMS!

Advantages…

- Robust
- Physics-based
- Integrated SYSTEM
- In SMS
- User-friendly

CMS-Flow Key Features

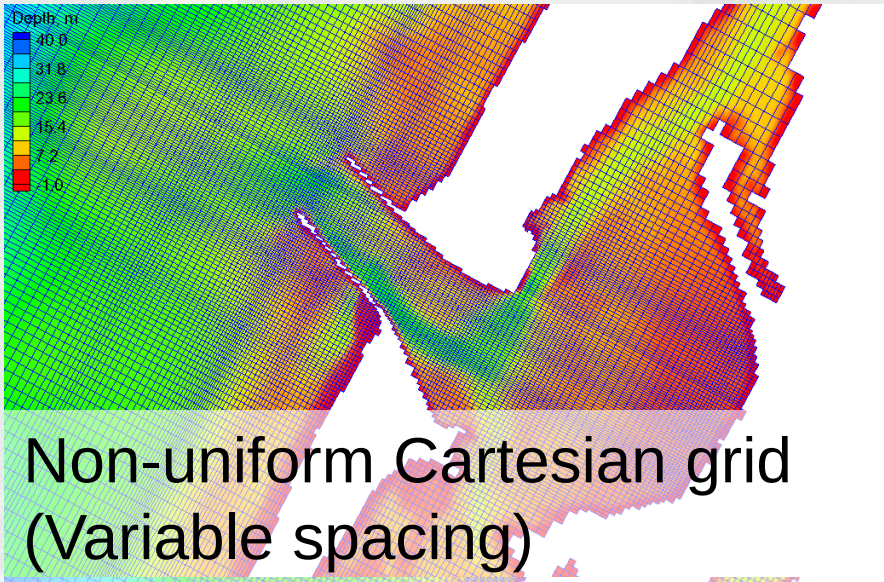
- Finite Volume Method
  - Conserves mass
  - Stable
  - Accessible
- Coupled with spectral wave model (CMS-Wave)
  - Wave-current interactions
- Inline sediment transport and morphology change
  - Non-equilibrium sediment Transport model (NET)
- Nesting capability
- WSE, river, wind/atmospheric pressure forcing
- Tidal constituent forcing (NEW)



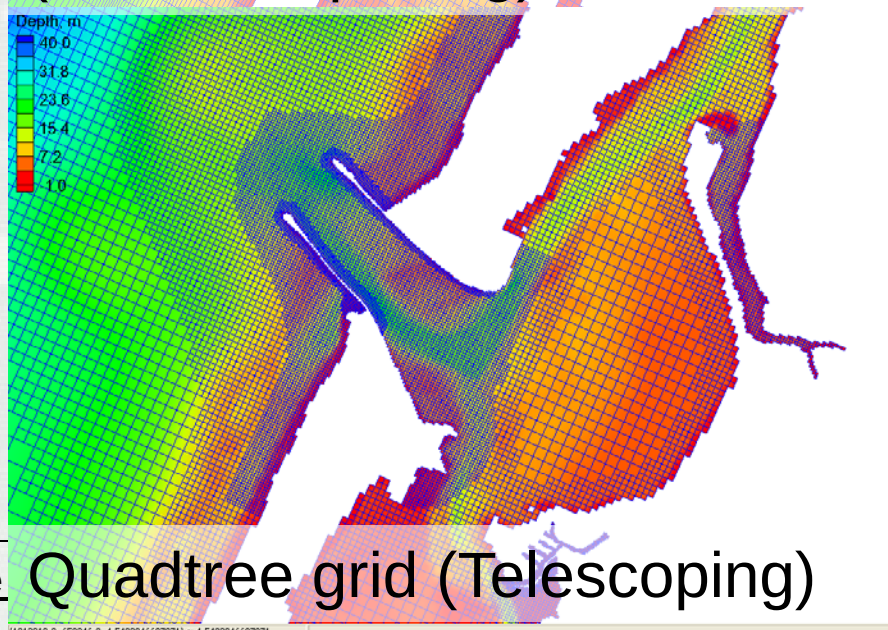
CMS-Flow Key Features

- Grid options
  - Non-uniform Cartesian grid: Easy to setup
  - Quadtree (telescoping) grid: Efficient, flexible (presently, only available for Implicit model)
- Solver options
  - Implicit: Tidal flow, long-term morphology change, parallel processing.

    ~5 - 30 minute time step
  - Explicit: Flooding, breaching, super-critical flow. ~1 second time step, parallel processing



Non-uniform Cartesian grid (Variable spacing)



Quadtree grid (Telescoping)

Hydrodynamics

Included terms for the depth-averaged shallow water equations in Cartesian coordinates

Depth - averaged current velocity

Total water depth

Still water depth

Water surface elevation

Gravity

Atmospheric Pressure

Precipitation / Evaporation

Coriolis

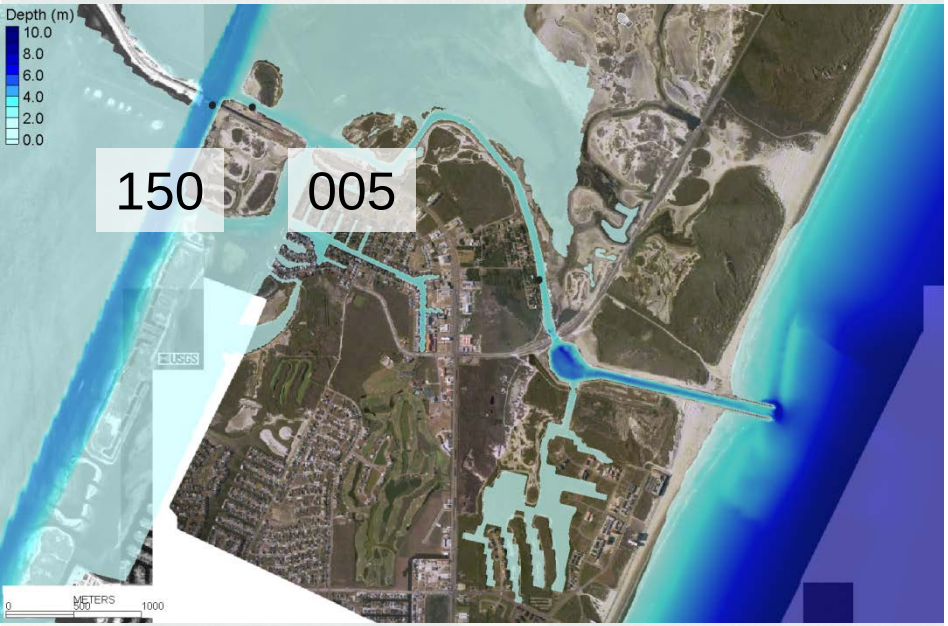
Turbulent eddy viscosity

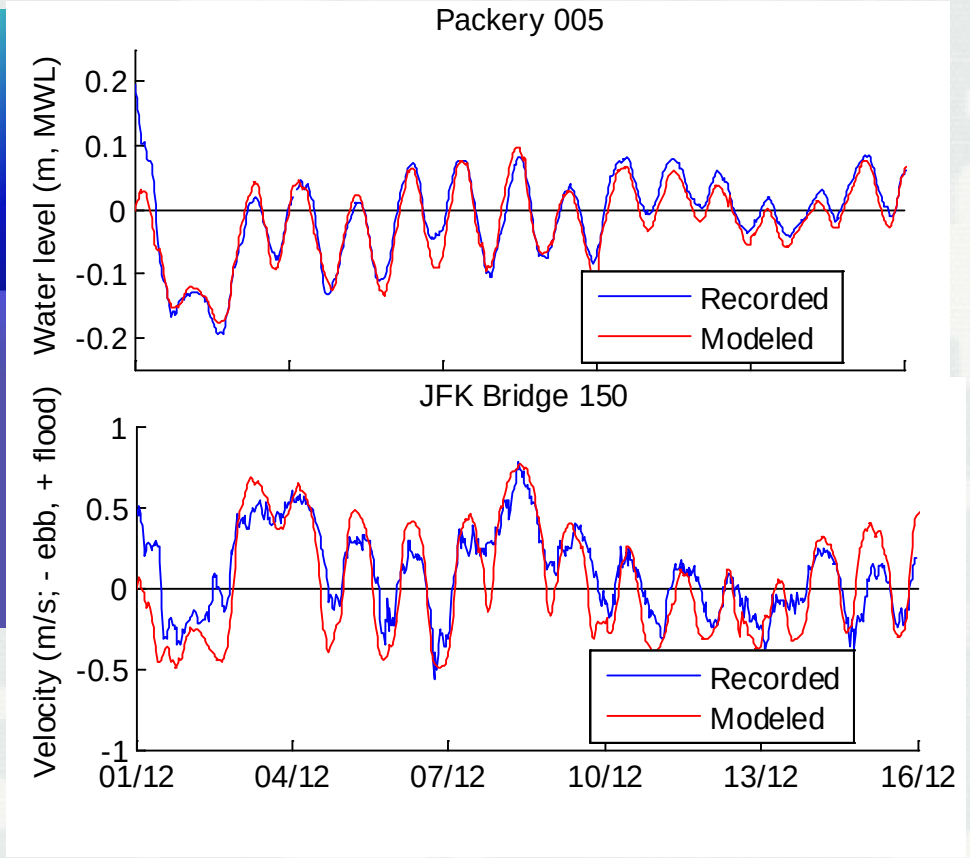
Bottom stress (including waves)

Wave stress (forcing)

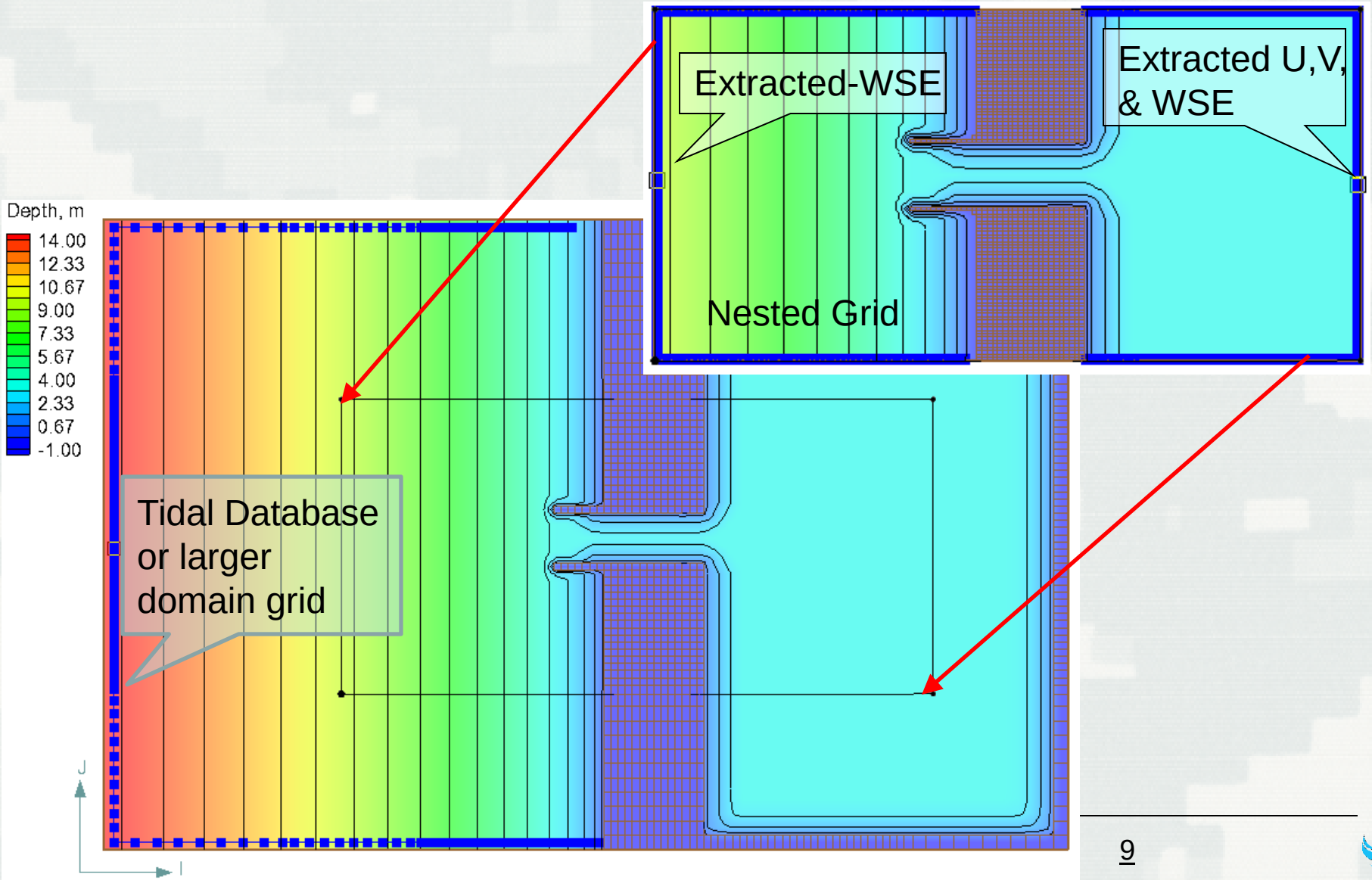
Wind stress

Packery Channel, TX



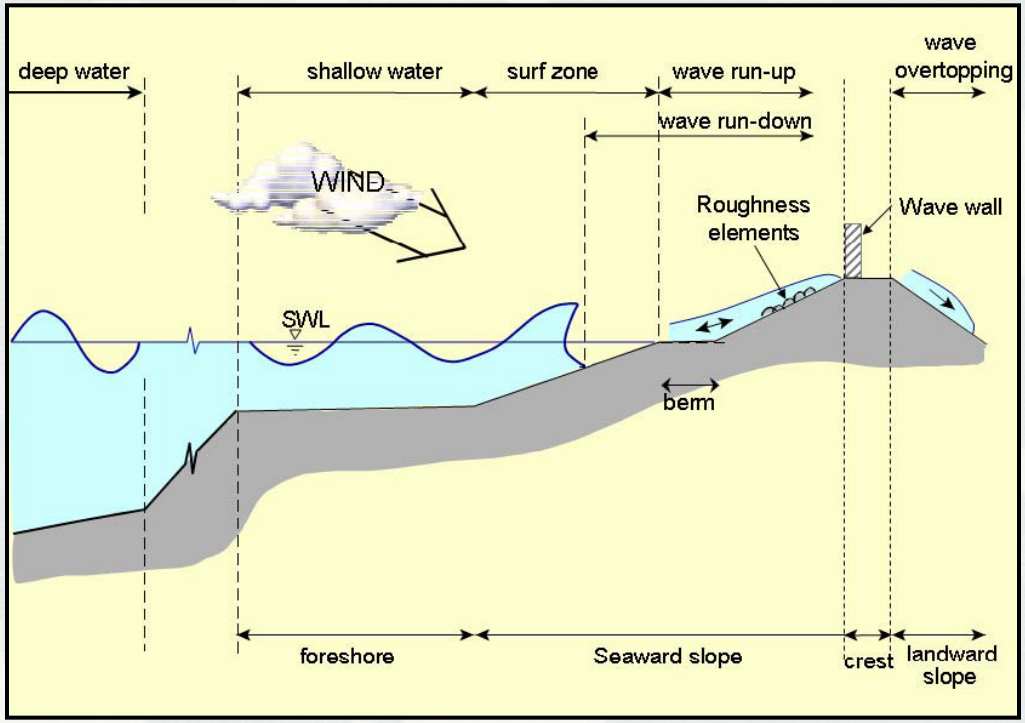


Nested Grid Capability

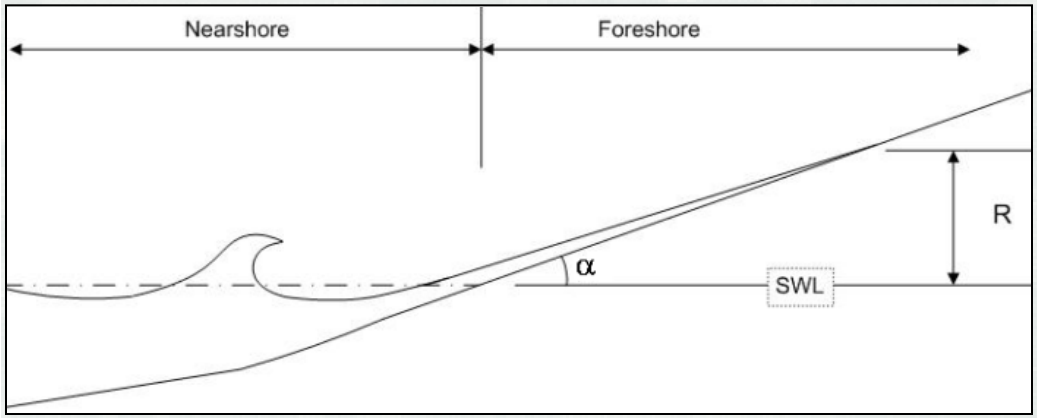


CMS-Wave: Key Features

- Shoaling, refraction, diffraction, reflection
- Bottom friction
- White capping
- Wave breaking (4 options)
- Wind generation
- Wave-current, and wave-wave interactions
- Transmission, runup and overtopping
- Muddy bottom
- Automatic grid rotation
- Non-uniform Cartesian grid with nesting capability
- “Fast Mode”



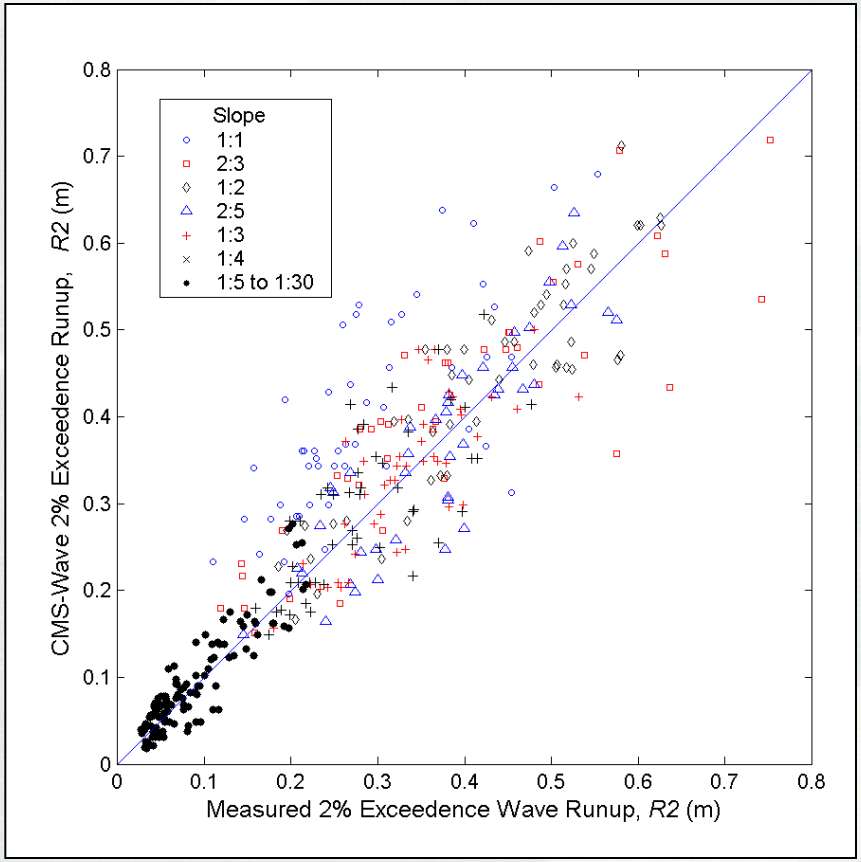
Wave Run-up



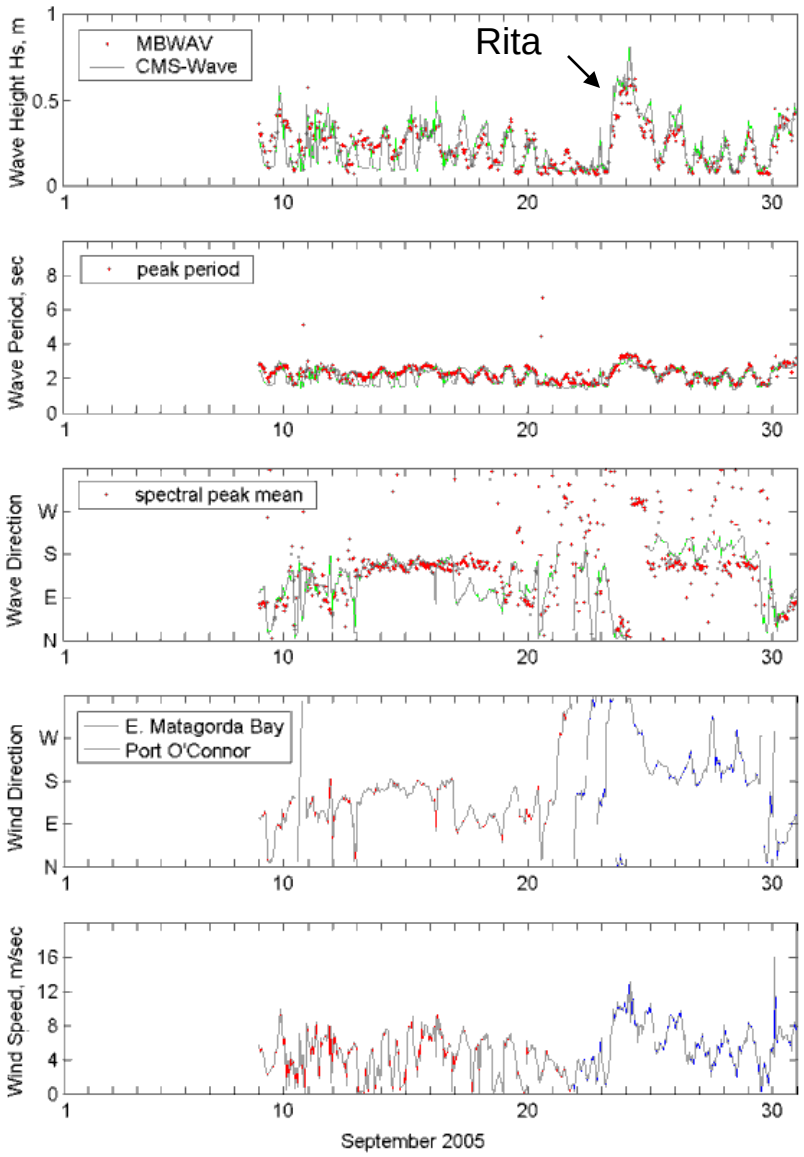
Wave run-up: rush of waves up a slope or structure

Two-percent run-up, *R2* : the vertical up-rush level exceeded by 2-percent of the larger run-up height

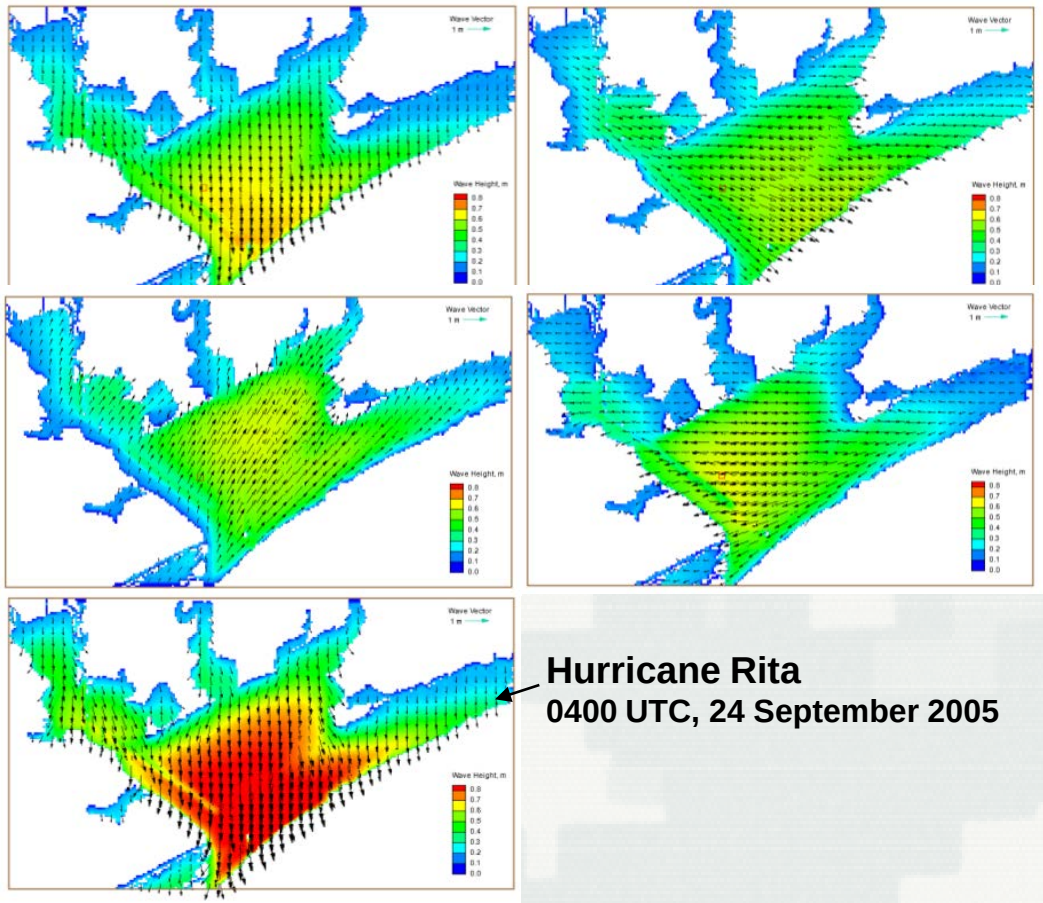
Ahrens & Titus (1981), Mase & Iwagaki (1984) ~ 400 laboratory experiments



Wave Generation

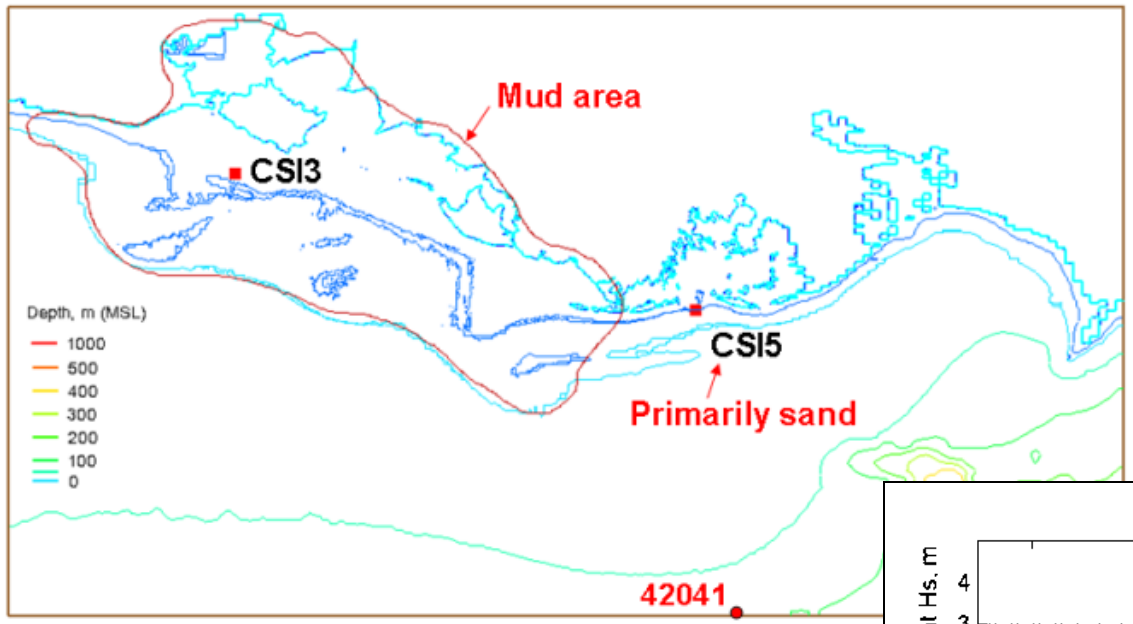


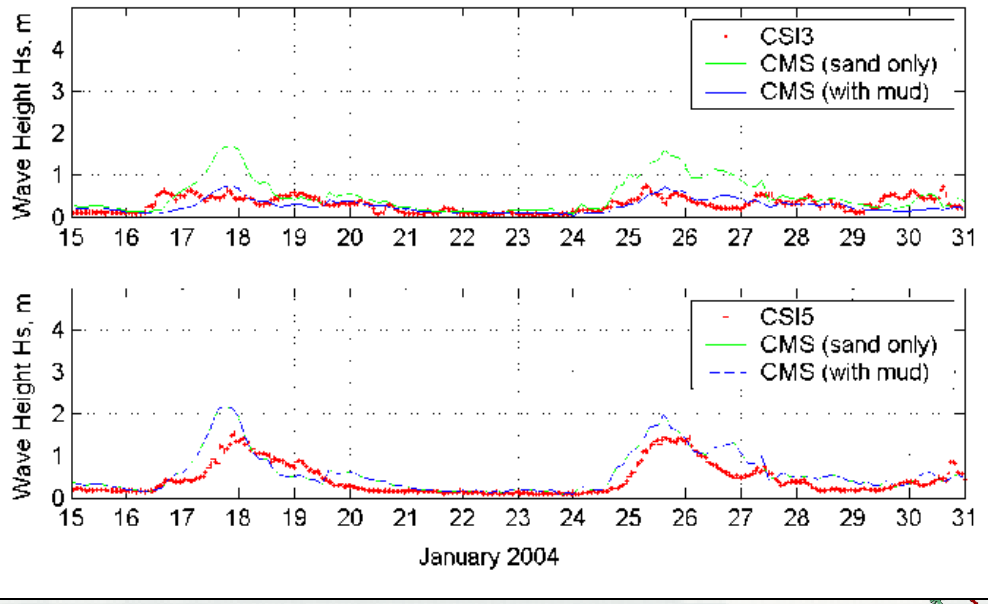
Matagorda Bay, TX



Hurricane Rita
0400 UTC, 24 September 2005

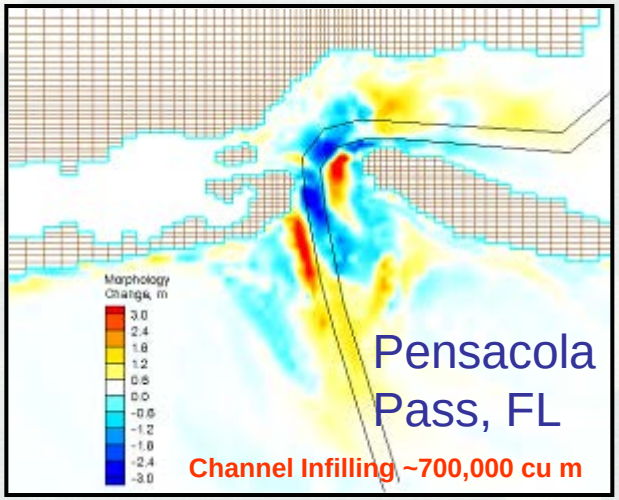
Wave Dissipation over Muddy Coast

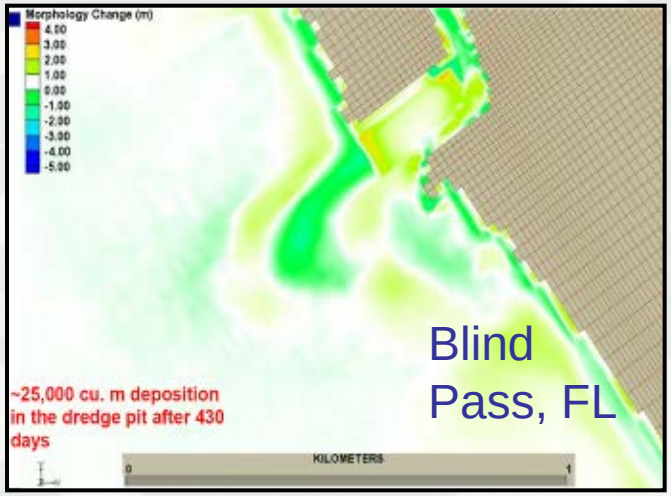




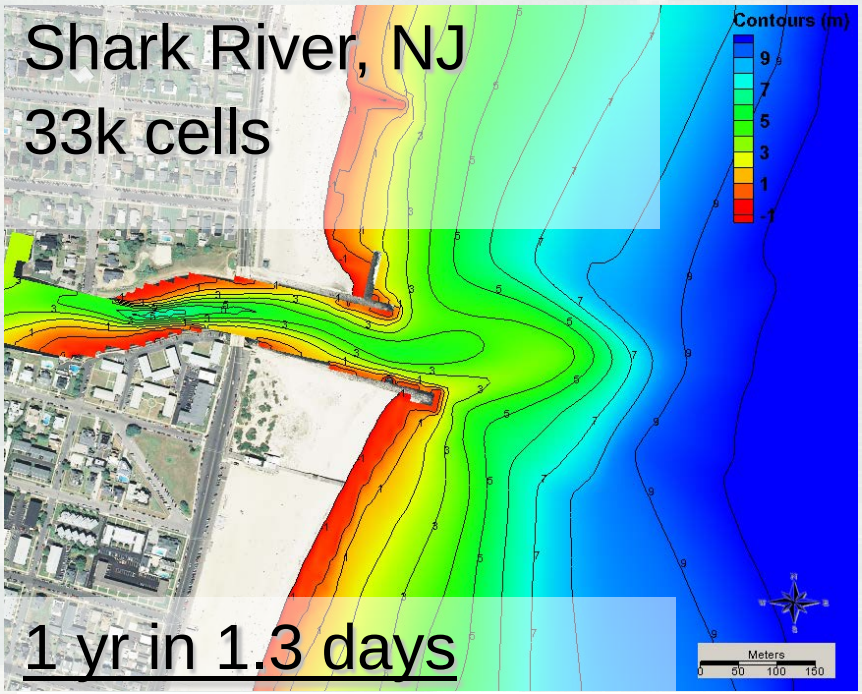
Sediment Transport: Key features

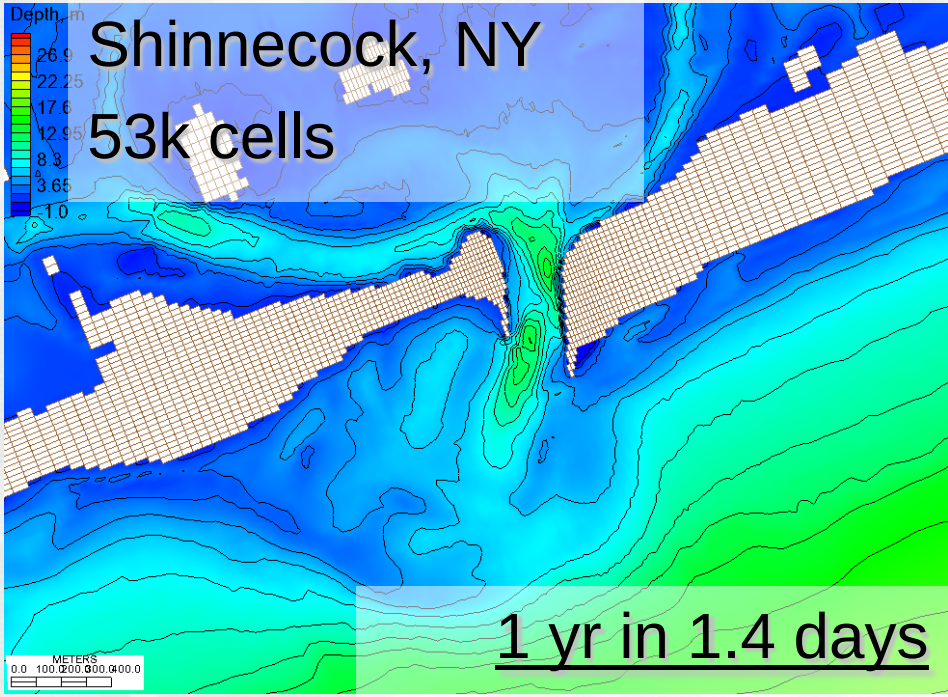
- Sediment transport models
  - Equilibrium Total Load (Exner equation)
  - Eq. Bed Load + Advection-Diffusion (AD) Suspended Load
  - Non-Eq. (AD Total Load)
- Sediment transport formulas
  - Lund-CIRP
  - Van Rijn
  - Watanabe
  - Soulsby
- Hard-bottom
- Avalanching
- Bed slope influence on bed load
- Multiple-sized sed. transport (NEW)

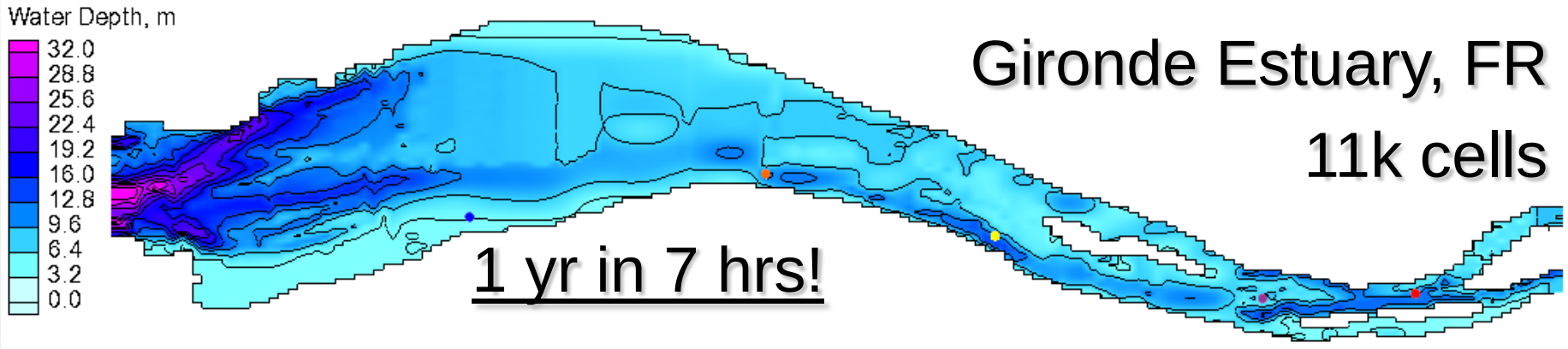




Computational Speed (Implicit)

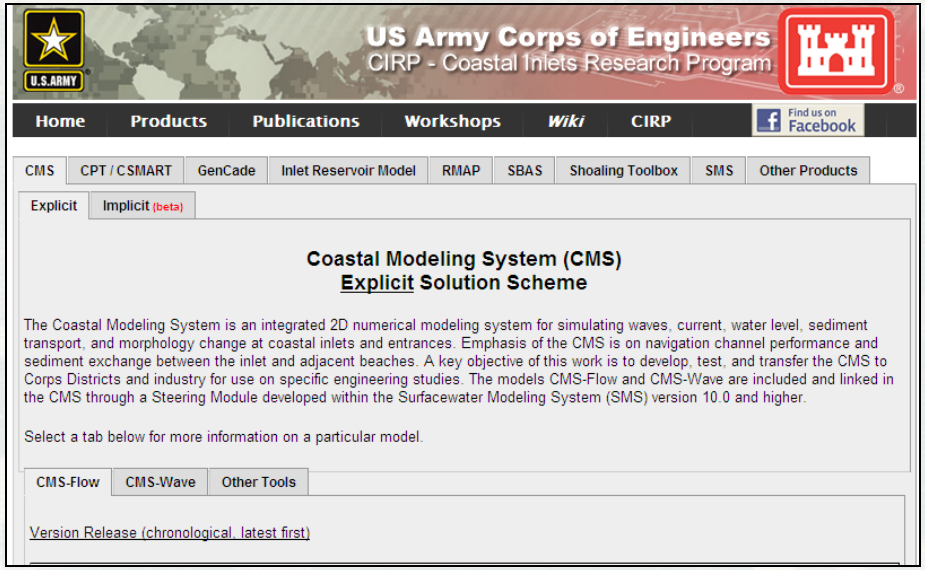






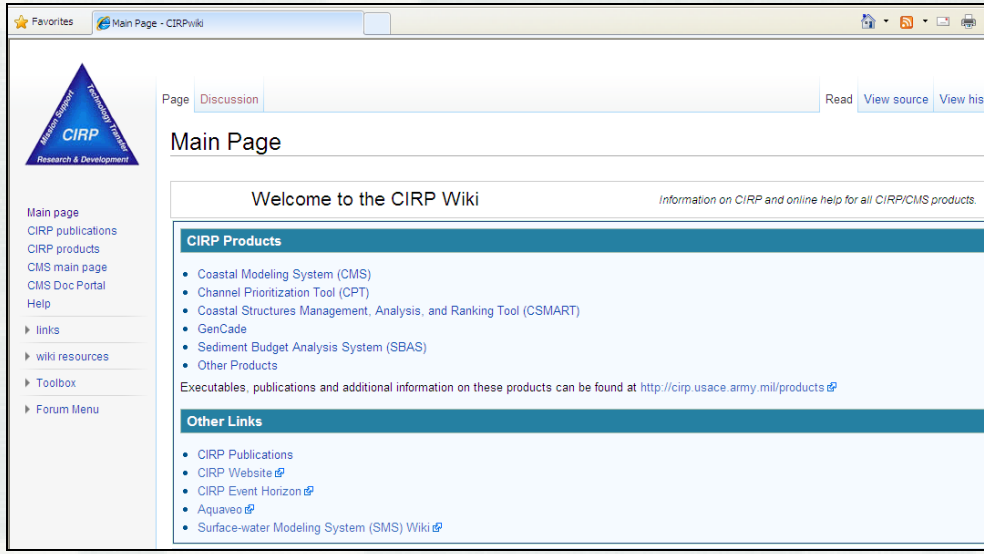
Documentation

- CIRP website



http://cirp.usace.army.mil/

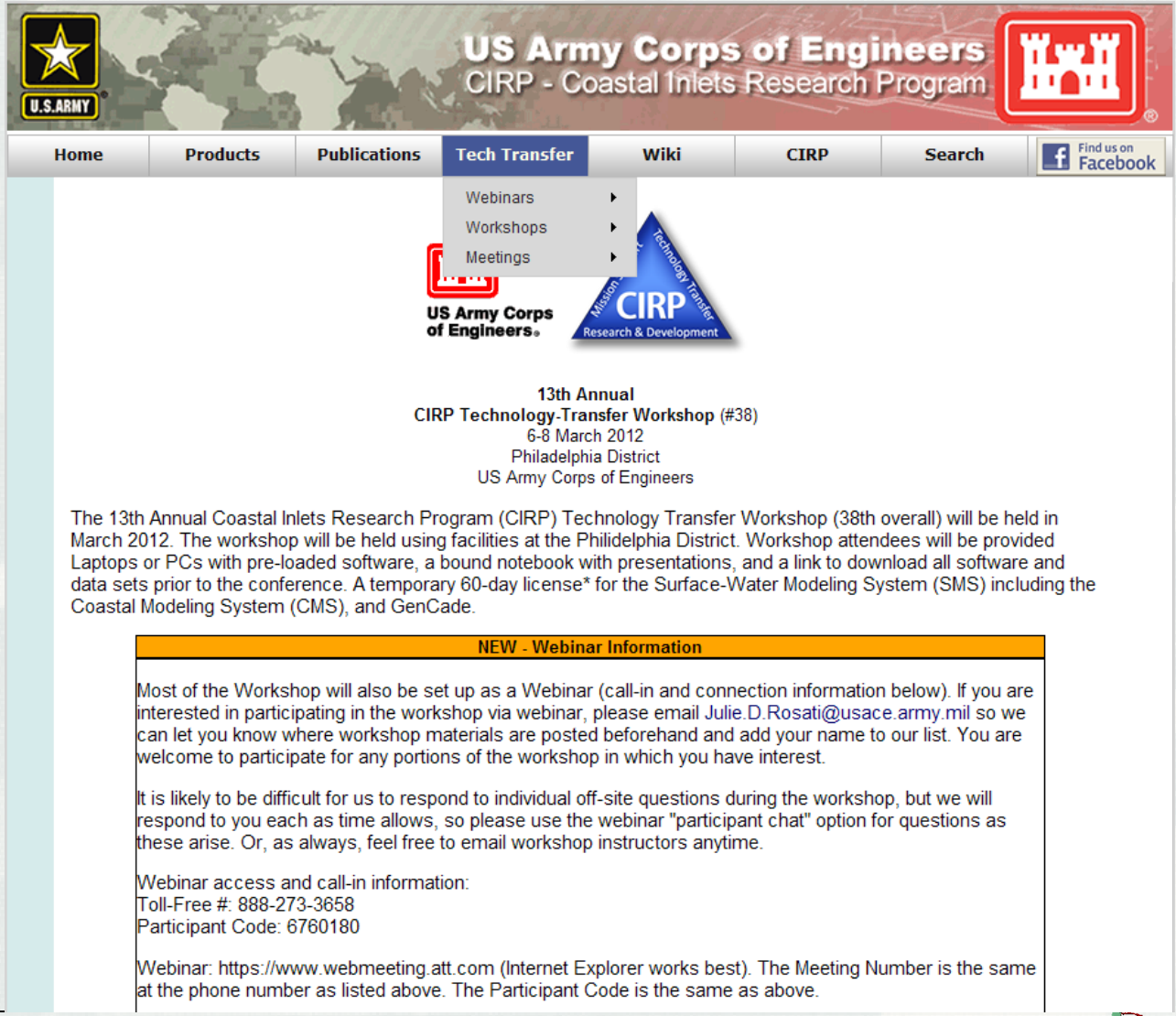
- CIRP Wiki



http://cirp.usace.army.mil/wiki/

Documentation
Website

- Products
  - CMS
  - GenCade
  - Others
- Publications
  - Technical Reports
  - CHETNS
  - Journal Articles
  - Others
- Tech Transfer
  - Upcoming
  - Recent



Documentation
Wiki

- CMS
  - Documentation Portal
  - Tutorials
  - Technical Info (Equations)
  - Validation Cases
- Gencade
  - Information
  - User Guide
- CPT/CSMART
  - Information and Guidance

Channel Portfolio Tool (CPT)

POC: Dr. Kenneth Ned Mitchell
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601-634-2022
US Army Engineer Research and Development Center (ERDC)
Coastal and Hydraulics Lab (CHL)

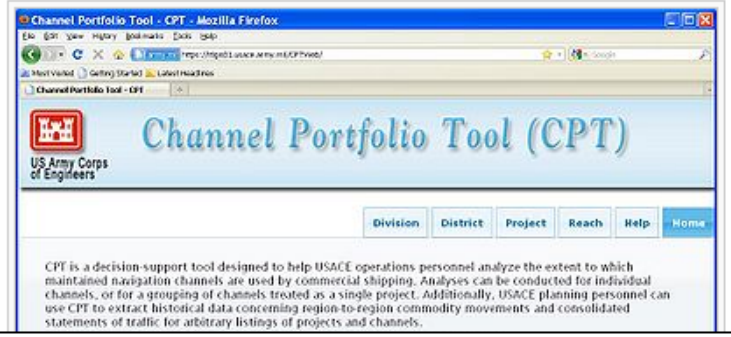
Active URL (Corps machines only): https://itlgis01.usace.army.mil/CPTWeb/

CPT is developmental software that is updated frequently.

CPT general layout

Setting the level of analysis (Reach, Project, District, Division)

CPT is designed to enable analysis of commercial utilization of the Corps-maintained waterway infrastructure at a variety of coverage levels. At the most detailed level, individual channel sub-reaches may be chosen for analysis and compared to other sub-reaches in the USACE portfolio of navigation projects. However, in order to provide decision support to personnel at all levels of Corps management, CPT can also be used to analyze and compare commercial usage figures at the Project, District, and Division levels. For example, a District program manager might want to see which navigation project under his or her control handles the most exports of a particular commodity. CPT pulls from a large database that is maintained by the Corps' Waterborne Commerce Statistics Center (WCSC). Setting the desired level of analysis is done through the CPT Home screen: https://itlgis01.usace.army.mil/CPTWeb/ . Figure 1 shows the four levels of analysis provided by CPT; the desired level is chosen by simply clicking on the respective link.



Reports and Tech Notes

- Demirbilek, Z., K. J. Connell, N. J. MacDonald, and A. K. Zundel. 2008. **Particle Tracking Model in the SMS 10: IV. Link to Coastal Modeling System,**. Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IV-71. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Brown, M. E., and N. C. Kraus. 2007. **Tips for developing bathymetry grids for Coastal Modeling System Applications,** Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL CHETN-IV-69. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Buttolph, A. M., Reed, C. W., Kraus, N. C., Ono, N., Larson, M., Camenen, B., Hanson, H., Wamsley, T., and Zundel, A. K. 2006. **Two-Dimensional Depth-Averaged Circulation Model CMS-M2D: Version 3.0, Report 2, Sediment Transport and Morphology Change,** Technical Report ERDC/CHL-TR-06-7, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Lin, L., Z. Demirbilek, H. Mase, J. Zheng., and F. Yamada. 2008. **CMS-Wave: A Nearshore Spectral Wave Processes Model for Coastal Inlets and Navigation Projects**. ERDC/CHL TR-08-13.
- Lin, L., H. Mase, F. Yamada, and Z. Demirbilek. 2006. **Wave-Action Balance Equation Diffraction (WABED) Model: Tests of Wave Diffraction and Reflection at Inlets**. ERDC/CHL CHETN-III-73.

Publications: Sediment Transport

- Sánchez, A., and Wu, W. 2011. **"A Non-equilibrium Sediment Transport Model for Coastal Inlet Applications".** *Journal of Coastal Research*, in press.
- Camenen, B., and Larson, M., 2008. **"Equivalent Roughness Height for Plane Bed Oscillatory Flow,"***Estuarine, Coastal, and Shelf Science*, Vol 81, pp 409-422.
- Camenen, B., and Larson, M., 2008. **"A General Formula for Non-Cohesive Suspended Sediment Transport,"** *Journal of Coastal Research*, Vol 24, No. 3, pp 615-627.
- Camenen, B., and Larson, M. 2007. **"A Unified Sediment Transport Formulation for Coastal Inlet Application,"** Contract Report ERDC/CHL-CR-07-1, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Camenen, B., and Larson, M. 2007. **"A Total Load Formula for the Nearshore,"** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 56-67.
- Hanson, H., and Camenen, B. 2007. **"Closed Form Solution for Threshold Velocity for Initiation of Sediment Motion Under Waves,"** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 15-27.
- Camenen, B. and Larson, M., 2006. **"Phase Lag Effects in Sheet Flow Transport,"** *Coastal Engineering*,Vol 53, pp 531-542.
- Camenen, B., Bayram, A., and Larson, M., 2006. **"Equivalent Roughness Height for Plane Bed Under Steady Flow,"** *Journal of Hydraulic Engineering*, Vol 132, No. 11, pp 1146-1158.
- Gravens, M. B., and Wang, P. 2007. **"Data Report: Laboratory Testing of Longshore Sand Transport by Waves and Currents; Morphology Change Behind Headland Structures,"** Technical Report ERDC/CHL-TR-07-8, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.

Publications: Applications/Projects

- Beck, T.M., and Wang, P. 2009. **Influences of channel dredging on flow and sedimentation patterns at microtidal inlets, West-central Florida, USA.** Proceedings Coastal Dynamics 2009.
- Li, H., Brown, M. E., Smith, T. D., Podoski, J. H., 2009 (draft). **Evaluation of Proposed Channel on Circulation and Morphology Change at Kawaihae Harbor and Pelekane Bay, Island of Hawaii, HI**, Technical Report ERDC/CHL-TR-XX-XX, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.
- Seabergh, W.C., Smith, E.R., and Rosati, J.D. 2009 (draft). **Sabine-Neches Waterway, Sabine Pass Jetty System: Past and Future Performance,** ERDC/CHL-TR-09-X, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS
- Demirbilek, Z., Lin, L., and Nwogu, O. G. 2008. **Wave Modeling for Jetty Rehabilitation at the Mouth of the Columbia River, Washington/Oregon, USA,** ERDC/CHL-TR-08-3, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Barcak, R. G., Kraus, N. C., Lin, L., Smith, E. R., Heilman, D. J., and Thomas, R. C. 2007 **Navigation Improvement, Mouth of the Colorado River, Texas,** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1502-1514.
- Wang, P., Tidwell, D. K., Beck, T. M., and Kraus, N. C. 2007. **Sedimentation Patterns in a Stabilized Migratory Inlet, Blind Pass**, FL. *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1377-1390.
- Zarillo, G. A., and Brehin, F. G. A. (2007). **Hydrodynamic and Morphologic Modeling at Sebastian Inlet, FL,** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1297-1310.
- Wamsley, T. V., Cialone, M. A., Connell, K. J., and Kraus, N. C. 2006. **Breach History and Susceptibility Study, South Jetty and Navigation Project, Grays Harbor, Washington,** ERDC/CHL-TR-06-22, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.
- Hughes, S. A., and Cohen, J. 2006. **Half Moon Bay, Grays Harbor, Washington: Movable-Bed Physical Model Study,** Technical Report ERDC/CHL-TR-06-15, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Publications: Various

- Nam, P.T., and Larson, M. 2010. **Model of nearshore waves and wave-induced currents around a detached breakwater,** Journal of Waterway, Port, Coastal, and Ocean Engineering, 136(3),156-176.
- Wu, W., Sánchez, A., and Mingliang, Z., 2011. **An Implicit 2-D Shallow Water Flow Model on an Unstructured Quadtree Rectangular Grid**, *Journal of Coastal Research*, in press.
- Nam, P.T., Larson, M., Hanson, H., and Hoan, L.X. 2009. **A numerical model of nearshore waves, currents, and sediment transport,** Coastal Engineering, 56, 1084-1096.
- Demirbilek, Z., Lin, L., Seabergh, W.C., Mase, H., and Zheng, J.I. 2009. **Laboratory and Numerical Studies of Hydrodynamics Near Jetties,** *Coastal Engineering Journal* Vol. 51, No. 2, 143-175.
- Sánchez, A. 2008. ***Interactions between wetlands and tidal inlets,*** Coastal and Hydraulics Engineering Technical Note. ERDC/CHL CHETN-IV-72. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Seabergh, W. C., Demirbilek, Z., and Lin, L. (2008). **Guidelines Based on Physical and Numerical Modeling Studies for Jetty Spur Design at Coastal Inlets,** *International Journal of Ecology & Development (IJED)*, Vol. 11, No. F08, pp 4-19.
- Zheng, J., H. Mase, Z. Demirbilek, and L. Lin. 2008. **Implementation and evaluation of alternative wave breaking formulas in a coastal spectral wave mode**. *Ocean Engineering*. Vol. 35., pp.1090-1101.
- MacDonald, N. J., Davies, M. H., Zundel, A. K., Howlett, J. D., Demirbilek, Z., Gailani, J. Z., Lackey, T. C., and Smith, J. (2006). **PTM: Particle Tracking Model; Report 1: Model Theory, Implementation, and Example Applications,** Technical Report ERDC/CHL-TR-06-20, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.

Questions?

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