

Overview of the SMS (v13.0), Coastal Modeling System, and User Resources



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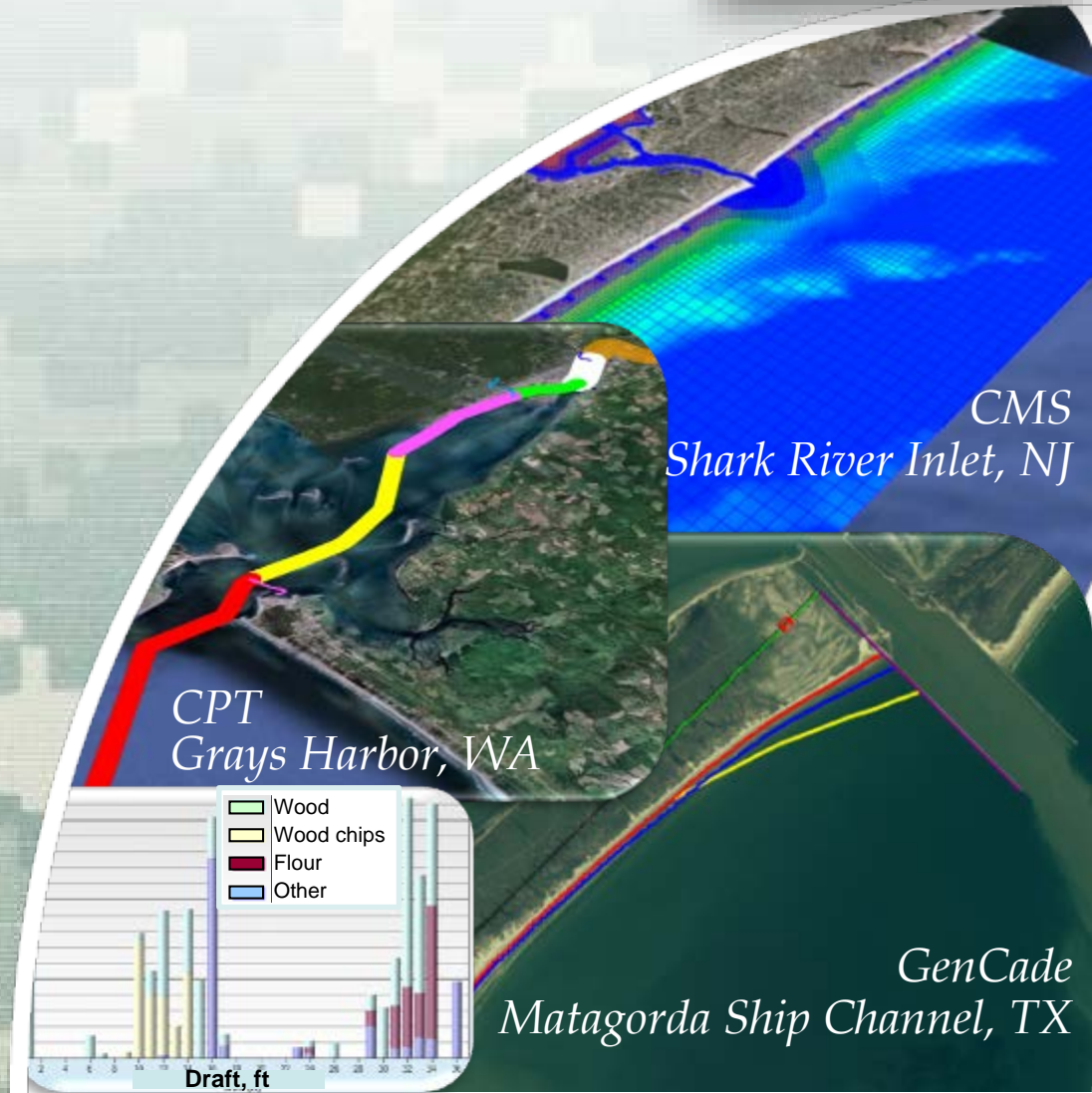
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US Army Corps of Engineers
BUILDING STRONG®





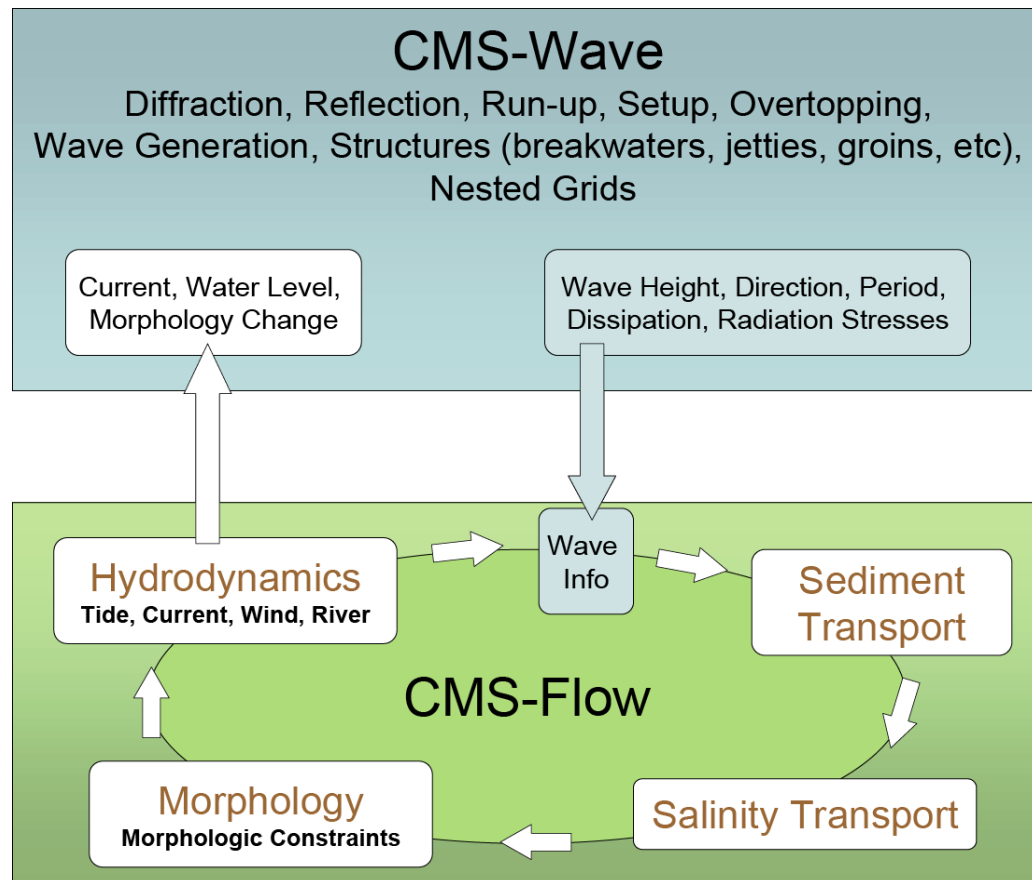
Overview of Presentation



- Introduction to the Surface-water Modeling System (SMS v.13.0)
 - What is it?
 - Tools, Modules, Data Tree, Images, etc.
 - CMS Models interface
- Introduction to the Coastal Modeling System (CMS)
 - CMS-Flow – Hydrodynamics, Sediment Transport, Morphology Change
 - CMS-Wave – Half-plane waves and Full-plane wind forcing.



CMS Overview



Since 1997...

- >70 workshops
- Districts can independently run the CMS!

Advantages...

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



What is the SMS?



- **A Pre-Processor**

- Organize and create input files for Corps of Engineers' numerical models

- **A Post-Processor (visualize results)**

- Create plots
- Create film loops
- Data calculator
- Dataset creation

- **Connect with outside tools**

- Import/export CAD data
- Import/export GIS data
- Import/export tabular ASCII data
- Import/export image data





Overview of SMS interface



The SMS interface is modular. Separate [modules](#) pertaining to each data type. As the user switches from one module to another, the [menus](#) and [tools](#) change. Inside the modules, the user associates a numerical model with a mesh or grid. When that grid is active, the tools and menus for the associated model are also enabled.

The SMS screen includes several [toolbars](#), [edit fields](#), and [menus](#). Some of these change as the user switches [modules](#) or [numerical models](#). The principal components include:

- [Menu Bar](#) - Menu to issue commands. These change as the module and model change.
- [Edit Window](#) - Fields directly below the menu bar showing the coordinates and function values for selected entities.
- [Graphics Window](#) - Display panel to show the data being manipulated.
- [Project Explorer \(Data Tree\)](#) - Tree representation of data currently referenced through SMS.
- [Time Step Window](#) – Appears if transient data are available.
- [Toolbars](#) - Several toolbars can be displayed. For more information on each toolbar, see the [Toolbars](#) article.
- [Help or Status Window](#)

The toolbars, project explorer, time steps window, and edit window are dockable windows. Dockable windows may be positioned by the user.

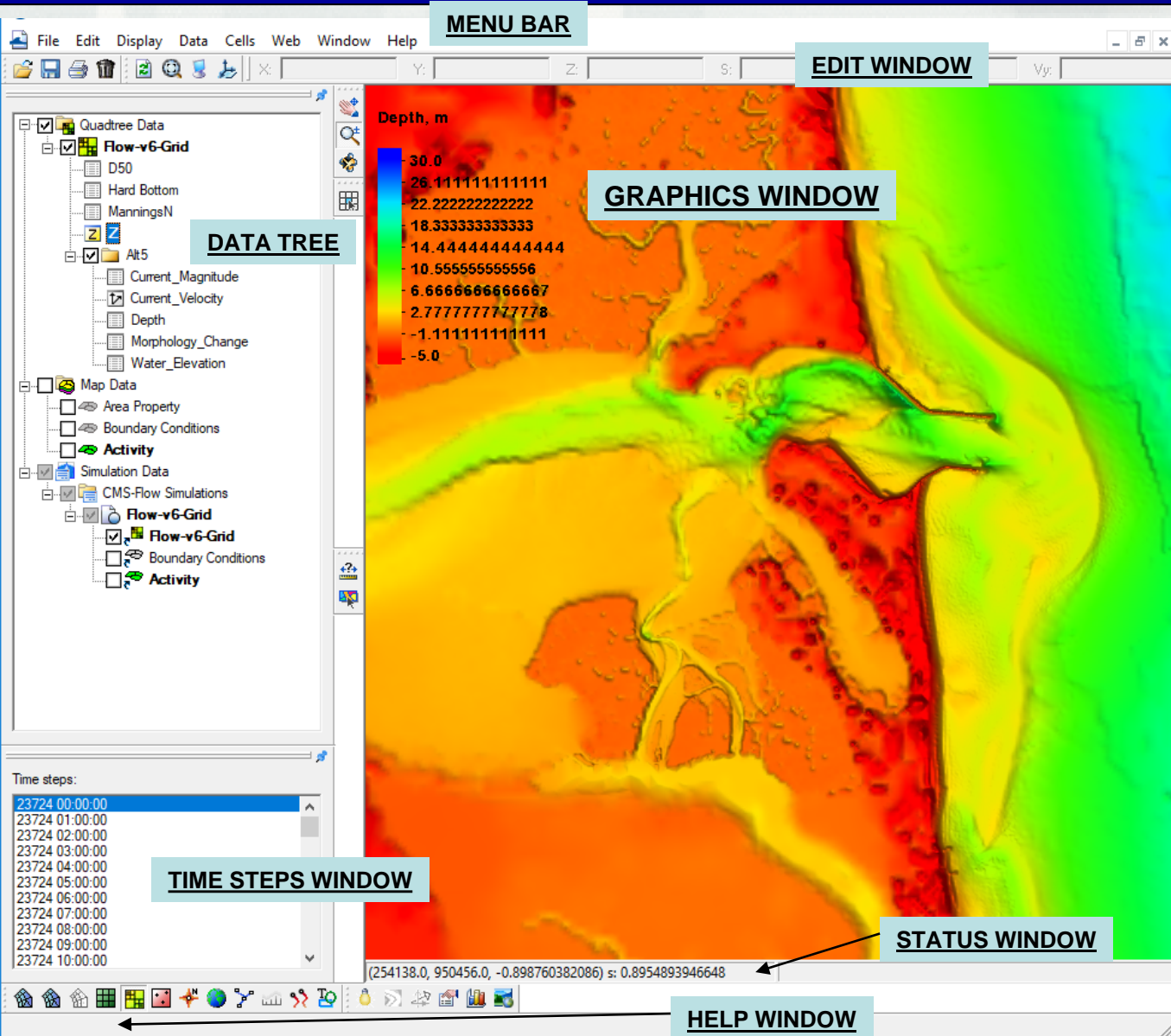


SMS Modeling Suite



The Data Tree (also referred to as the “Project Explorer”) is a dockable window that appears by default on the left side of the SMS screen.

This window displays a hierarchical tree structure representing all data currently being managed in an SMS simulation.





Toolbars

Toolbars

- Static Toolbar



- Dynamic Toolbar

- Grid

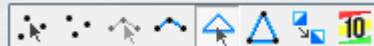
- CMS-Flow



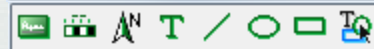
- CMS-Wave



- Scatter



- Annotation



- Data Toolbar



- Optional Toolbars

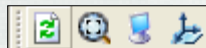
- Macro



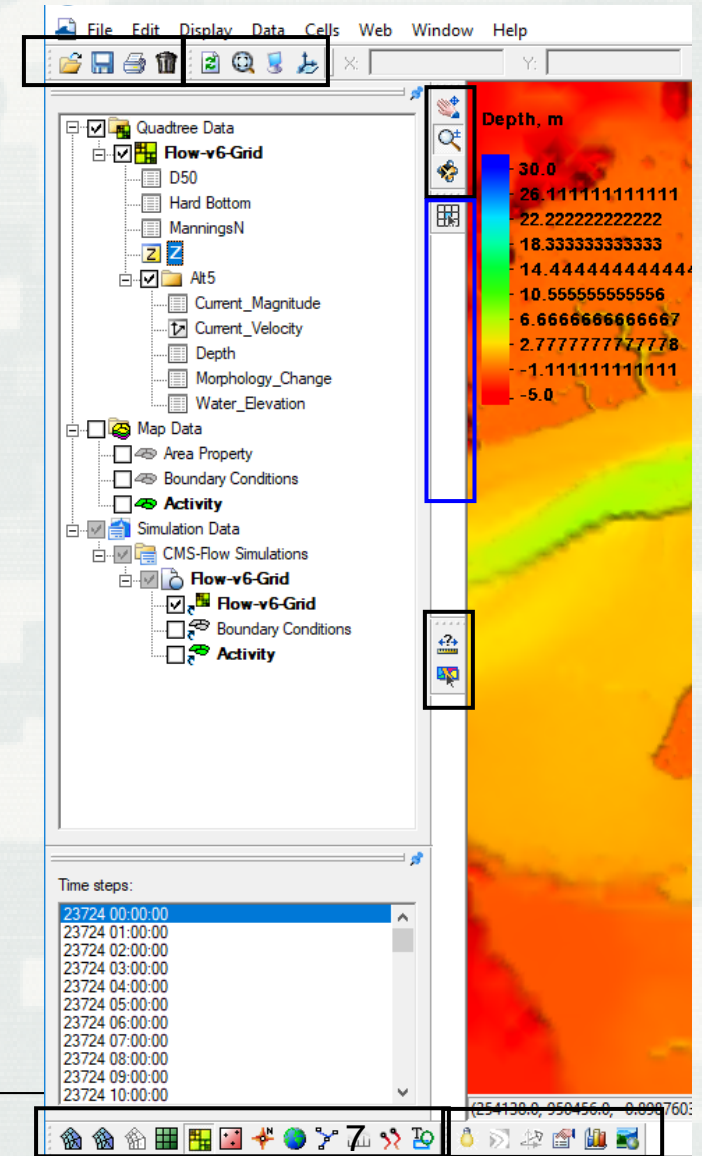
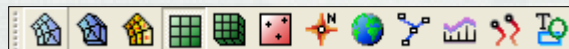
- File



- Display



- Module Toolbar








Tools









Individual Tools



- Static Toolbar

 Pan  Zoom  Rotate

- Module Toolbar

 Mesh  Cartesian Grid  Scatterpoint  Map  Particle  Annotations

- Data Toolbar

 Measurement Tool  Get Data Tool

- Optional Toolbars





- Macro

 Shading  Contours  Vectors  Info  Plot Wizard

- File

 Open  Save  Print  Delete

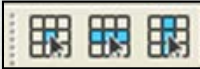
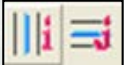
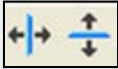



- Display

 Refresh  Frame  Display Options  Plan View







Dynamic Toolbar










Cartesian Grid / Quadtree tools

- Select Cell, Row, and Column 
- Split Column and Row 
- Move Column and Row Edges 
- Select and Create Cellstrings 
- Create Grid Frame 
- Apply Contour Labels 

Scatter Data tools

- Select and Create Point 
- Select and Create Breakline 
- Select and Create Triangle 
- Flip Triangle Edge 

Map Data Tools

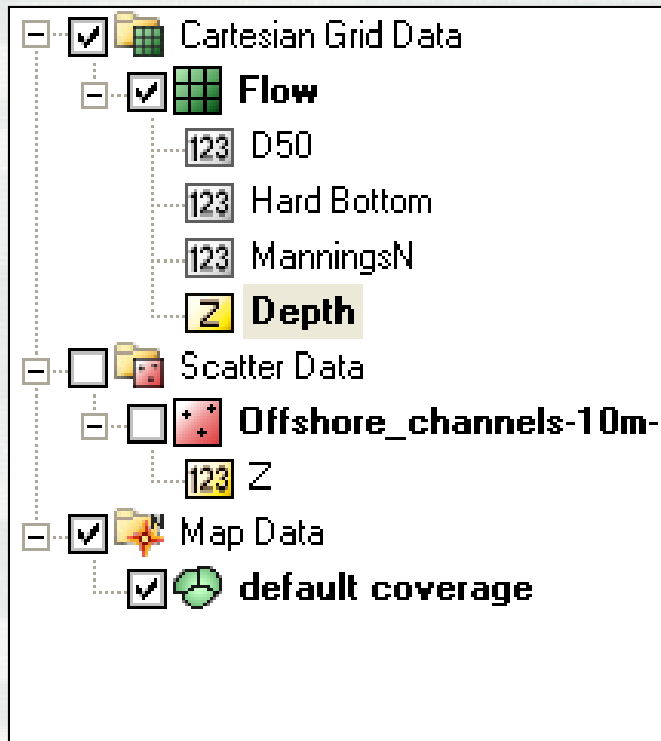
- Select Feature Node 
- Create Feature Node 
- Select Vertex 
- Add Vertex 
- Select Feature Arc 
- Create Feature Arc 
- Select Feature Polygon 
- Create 2-d Grid Frame 
- Select 2-d Grid Frame 

Selection tools usually have an arrow that points to the specific type of element.

Creation tools are identical to selection tools, only they do not have the arrow.



Data Tree Components



- The Data Tree makes selection of loaded datasets easy. Simply click on a dataset to make it active, and the graphics window updates accordingly.
- There are several “right-click” options available depending on the type of dataset activated, and within which module it is located. A few of these are:
 - Basic Dataset Information
 - Dataset-specific contour options
 - Export to file
 - Metadata Information
- The display of each asset in the Data Tree can be turned off by unchecking the display box next to the dataset name.

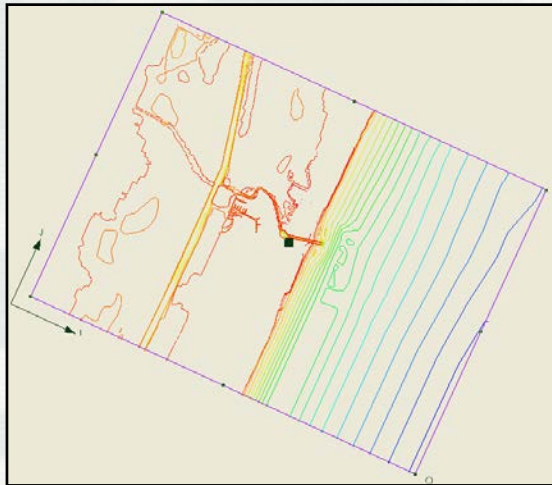
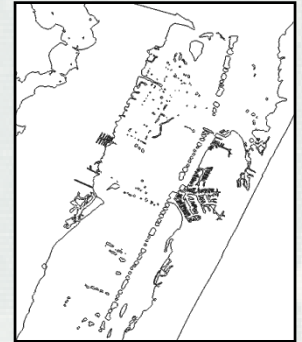
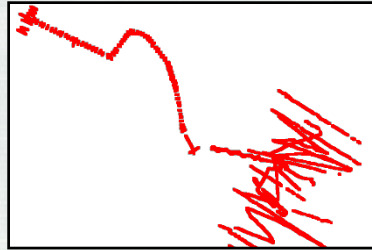


SMS – a complete modeling interface

Build a CMS model from start to finish – all within SMS

Import Background Data

- Topographic & bathymetric data – numerous formats supported
- Images – maps & aerial photos
- CAD, GIS & spreadsheet data

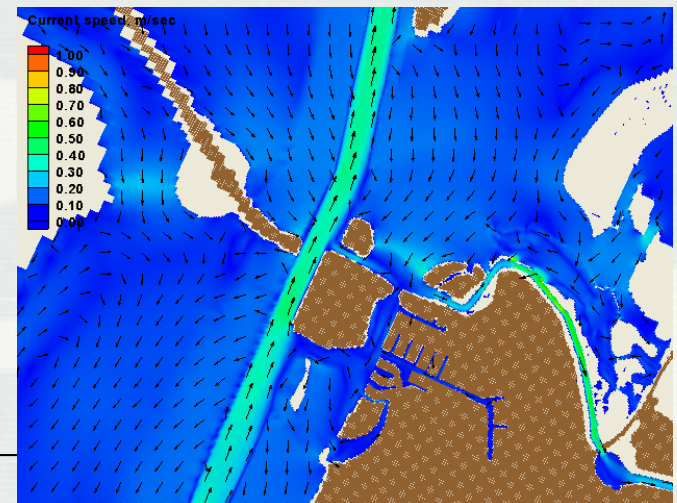


Create Conceptual Model

- Delineate CMS model domain
- Define areas of finer resolution

Generate & Run CMS Models

- Automatically generate grid
- Interpolate depths from background data
- Utilize built-in interfaces to define model-specific parameters and boundary conditions
- Run model and visualize results





SMS – Data Processing Import Wizard

File Import Wizard - Step 2 of 2

SMS data type:
Scatter Set

☐ No data flag -999.0

Name: Imported Data

Mapping options:
☒ Triangulate data ☐ Delete long triangles
Maximum edge length: 100000.0
Merge duplicate points within tolerance: 0.0000100

File preview

Type	X	Y	Z	Scalar data	Vector X	Vector Y
Header	XYZ	(2697	points)	WSE	Velocity	Velocity
	105.074	-286.841	50.750	53.318	1.260	-0.706
	104.575	-287.898	49.607	53.368	1.308	-0.412
	104.076	-288.955	48.464	53.418	1.577	-0.712
	103.612	-290.029	48.464	53.376	2.096	-0.604

First 20 lines displayed.

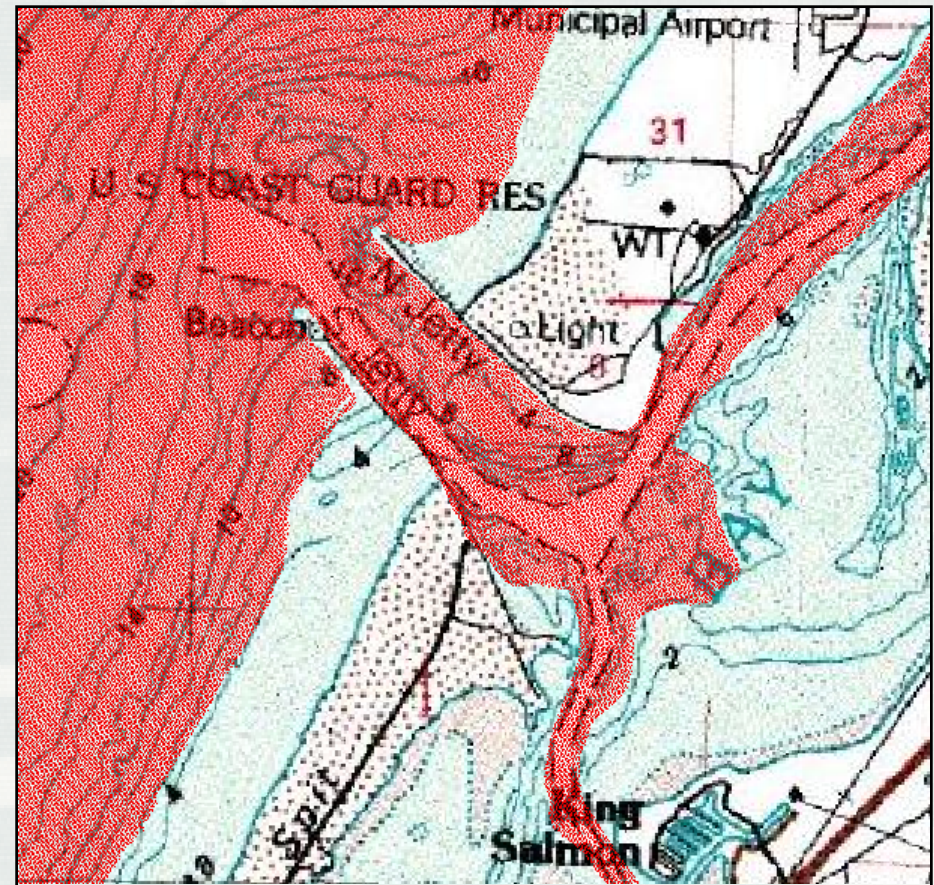
Help < Back Finish Cancel



Scattered Data (TINs)

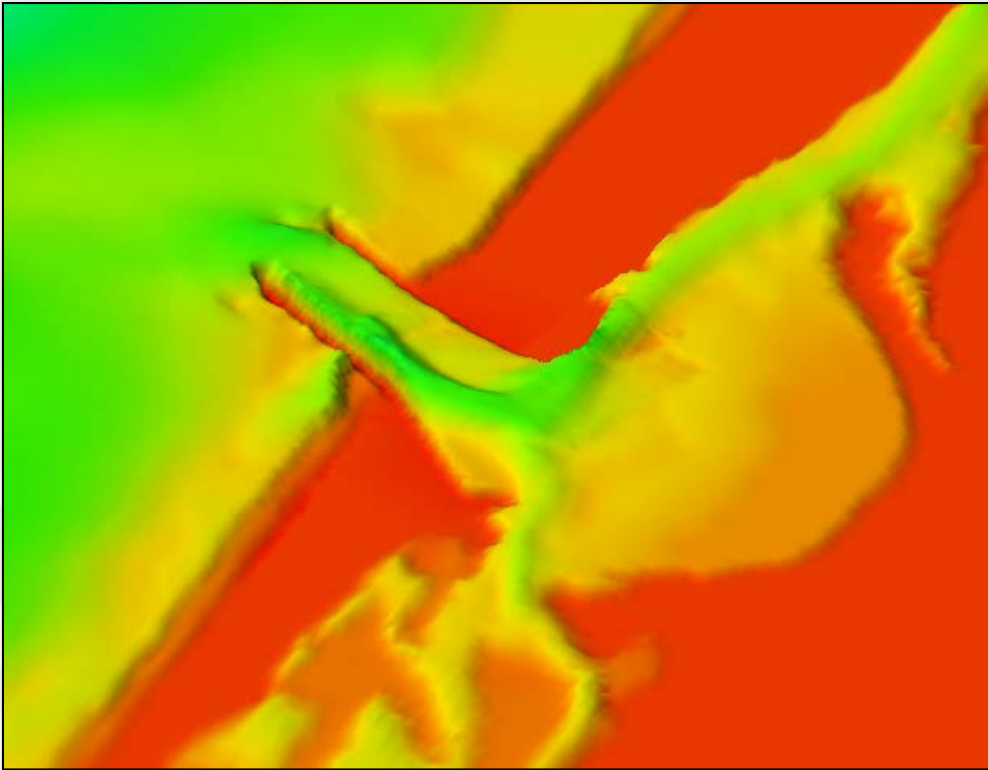
- **Stores spatially varied data**

- ▶ Bathymetric data most common
- ▶ Interpolates from one grid/mesh to another
- ▶ Allows combination of data sources
- ▶ Facilitates data thinning or filtering





Visualization of Scattered Data



Humboldt Bay, CA
Oblique view
Z-magnification 5x

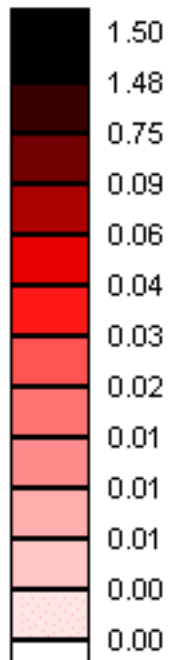
■ Options

- Magnify in Z direction
- Oblique or plan views
- Fill with contours options
- Shading



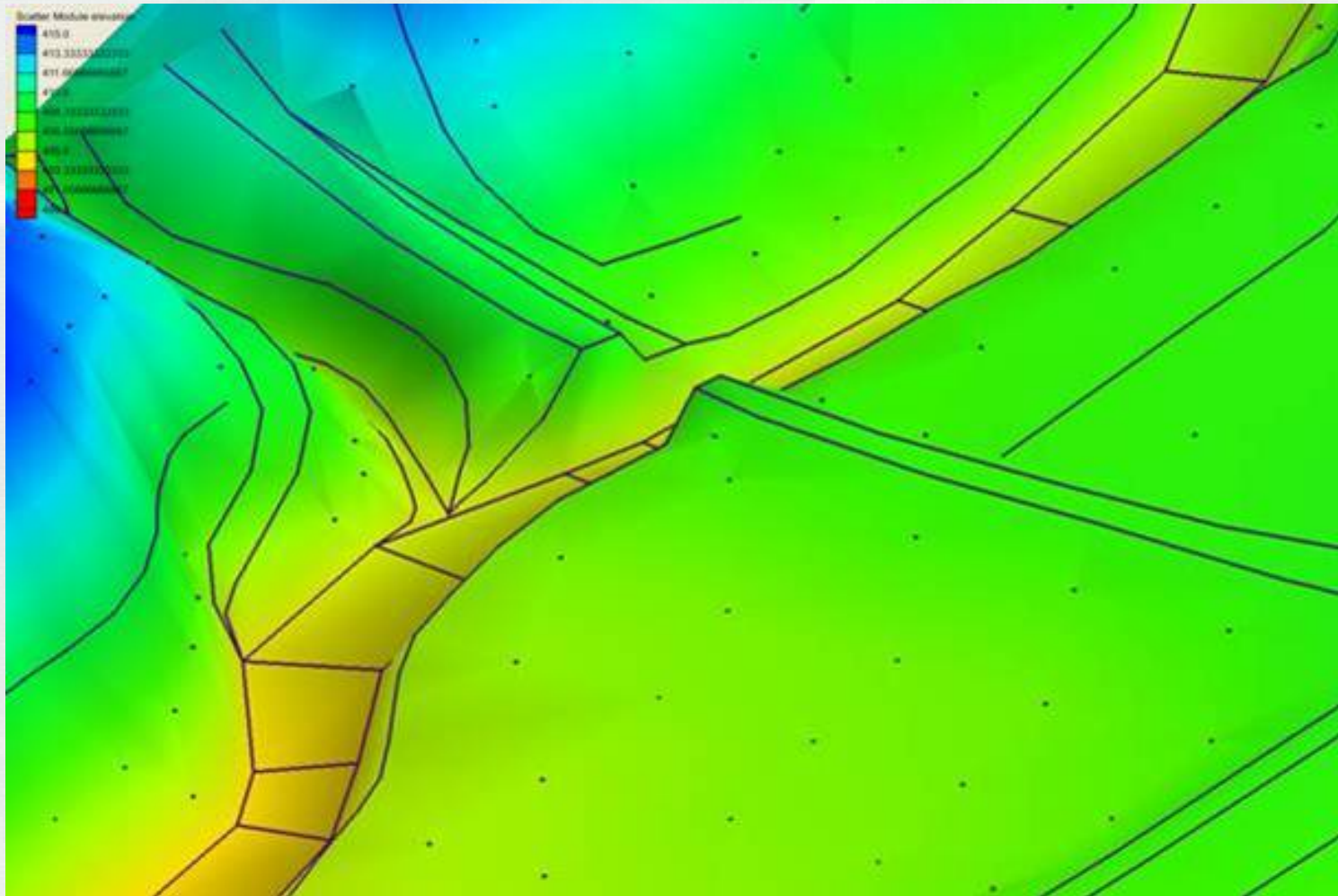
Lidar Survey

Gradient





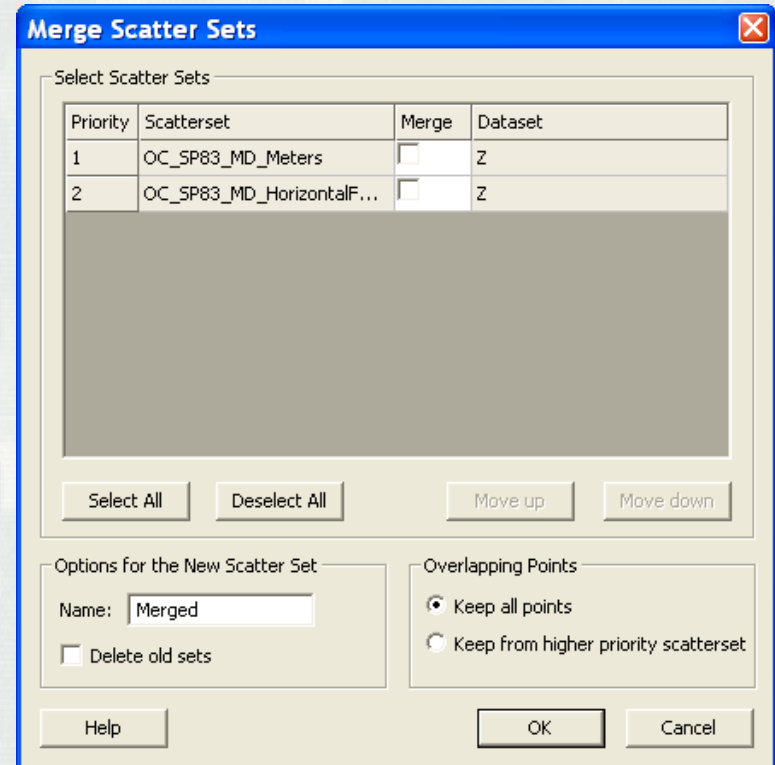
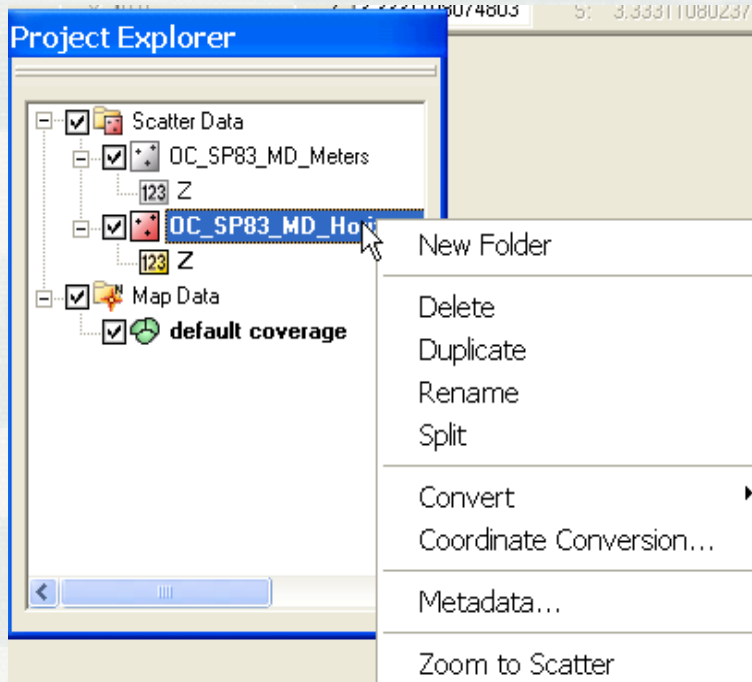
Breaklines





Operating With Scatter Sets

■ Merge

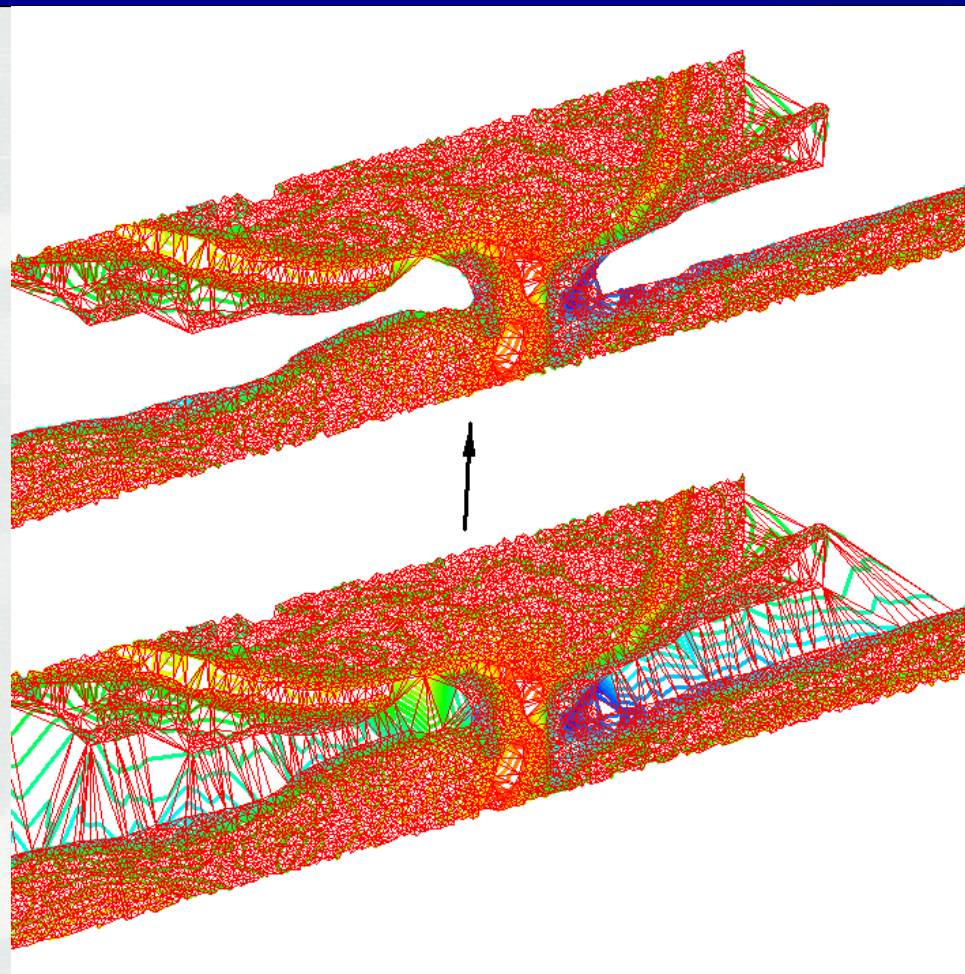




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Points and Triangles

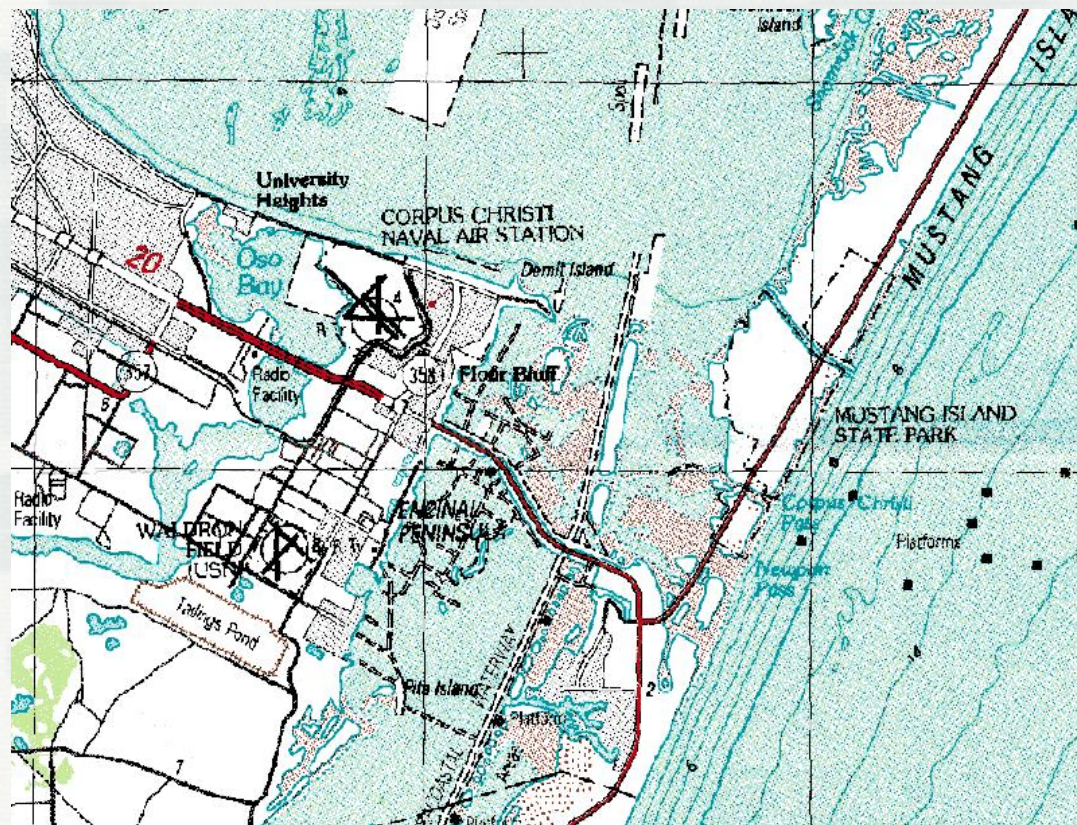
- User can delete points or triangles to change extents of a set.
- User can swap edges to alter shape of surface
 - Used in linear interpolation





Images

Topo Maps



Aerial Photos



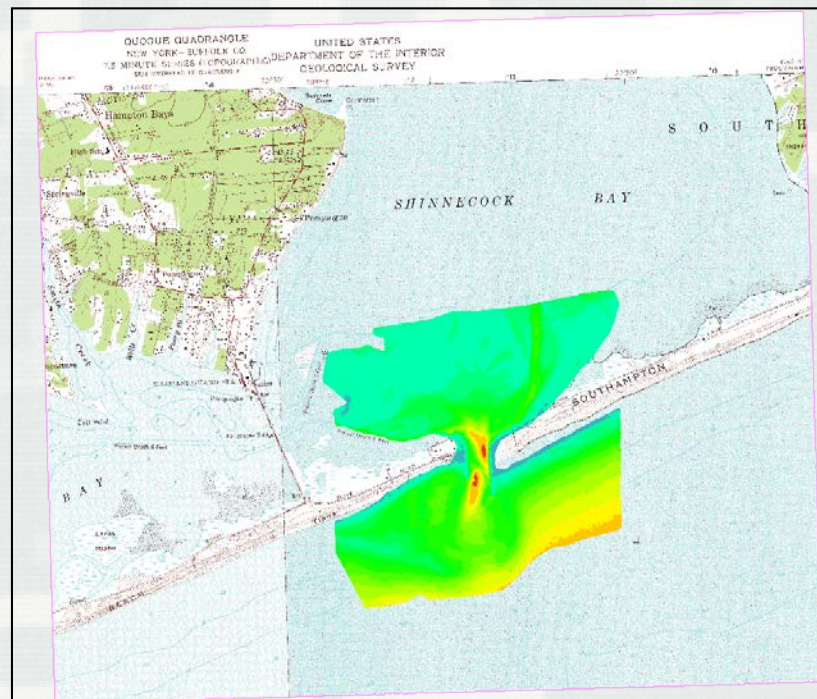
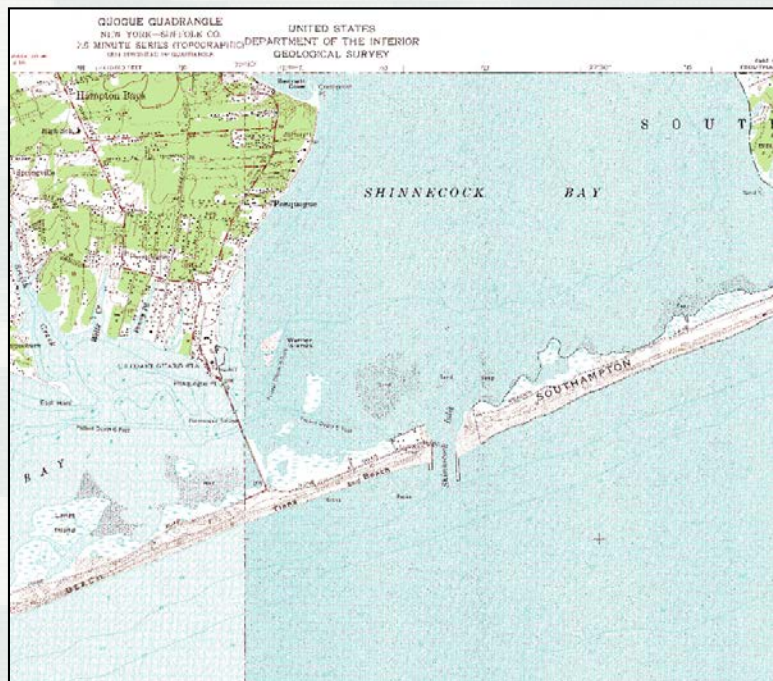


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Image Data

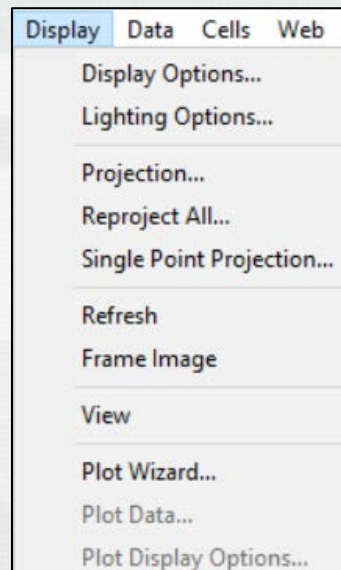
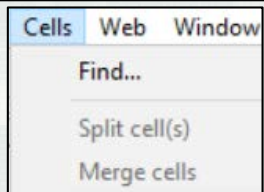
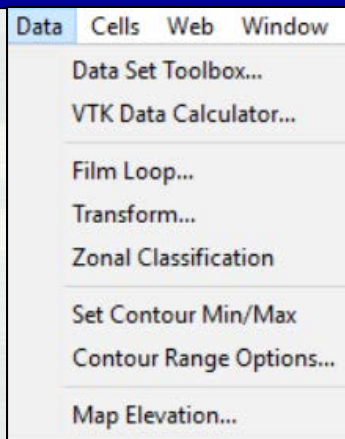


Overlay data over images





CMS-Flow Interface: Pull-down menus



The Data pull-down menu contains many items – here are a few:

- Dataset Toolbox – Dataset-based operations (includes Calculator)
- Vector/Contour Options – Change appearance of data within the Graphics Window
- Film Loop – Generate animations based on loaded data/solutions
- Transform – manually changes geometry properties
- Map Elevation – Define a dataset to be the “Z” (Depth) dataset for a grid

The Cells pull-down menu contains options for finding specific cells and manipulating one or many selected cells.

The Display pull-down menu contains commands to manipulate what and how data is viewed inside the interface.

- Display Options – Affect visibility of various options
- Lighting Options – Enable and modify an “external light source”
- Projection – Set the default display projection for items loaded into SMS
- View – get information on various selections for later reproducibility.
- Plot Wizard – View loaded data in various graphical charts and plots.



CMS-Flow Model Control

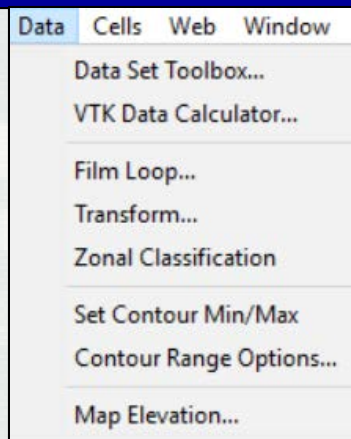
Parameter Specification and File I/O

- Time Control
- Auxiliary Files
- Parameters
 - Wet/Dry depth
 - Flags
- Process sections to Include
 - Flow
 - Sediment Transport
 - Wind
 - Waves
 - Salinity
 - Output options

The screenshot shows the 'Model Control' dialog box with the 'General' tab selected. The 'Start date/time' is set to '12/15/2014 12:00:00 am'. The 'Simulation duration' is '4392' hours. The 'Ramp duration' is '0.5' days. The 'Second order skewness correction' checkbox is checked. Under 'Hot start', the 'Initial conditions file' checkbox is unchecked, and the 'Write Hot Start output file' checkbox is checked. The 'Time to write out' is '48' hours. The 'Automatic recurring Hot Start file' checkbox is checked, and the 'Interval' is '0.34' hours. The 'Solution scheme' is set to 'Implicit', and the 'Matrix solver' is 'GMRES'. The 'Threads' section is partially visible at the bottom. The dialog has 'Help...', 'OK', and 'Cancel' buttons at the bottom.

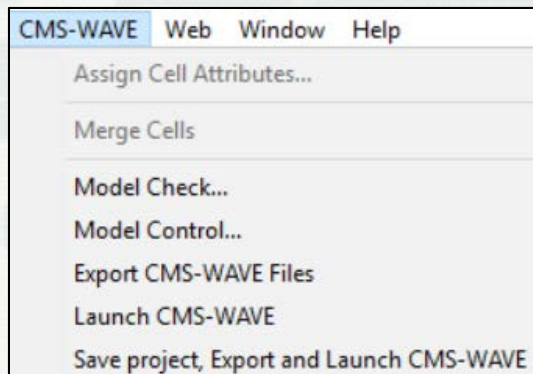


CMS-Wave Interface: Pull-down Menus



The Data pull-down menu uses most of the items as for CMS-Flow:

- Dataset Toolbox – Dataset-based operations (includes Calculator)
- Vector/Contour Options – Change appearance of data within the Graphics Window
- Film Loop – Generate animations based on loaded data/solutions
- Transform – manually changes geometry properties
- Map Elevation – Define a dataset to be the “Z” (Depth) dataset for a grid



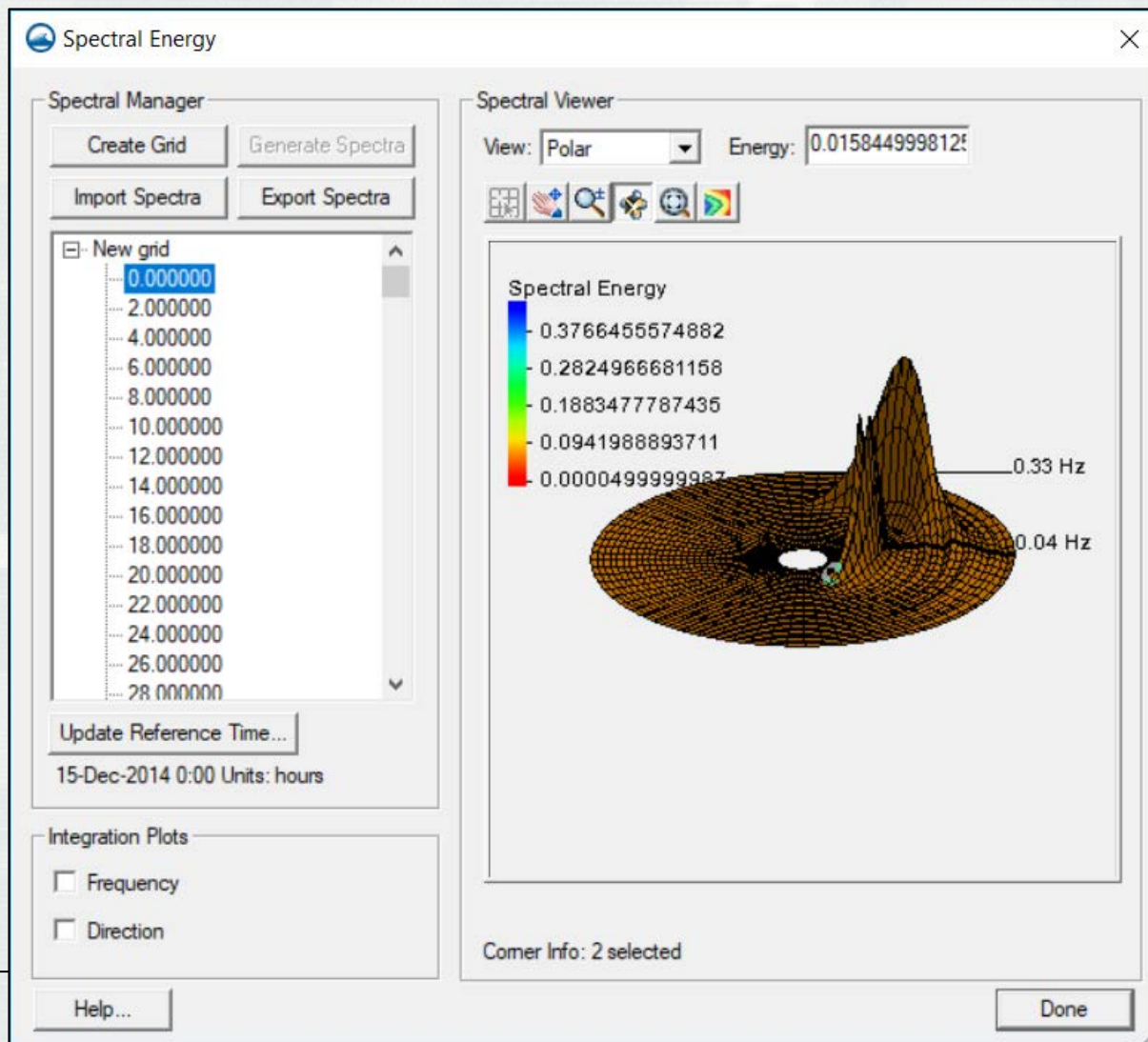
The CMS-Wave menu contains commands to operate the model.

- Model Control – Set up the parameters and running options for a CMS-Wave simulation
- Model Check – Analyze present wave grid and modeling parameters for errors before run commences.
- Export CMS-Wave files – Writes all the CMS-Wave information out to the correctly formatted files.
- Launch CMS-Wave – Runs CMS-Wave with assigned options
- Save project, Export, and Launch – Saves the project and then both exports the files and launches the model, all in one step.



Spectral Energy menu

Example of Imported Spectra from Wave Gauge





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Generate Spectra from Bulk Criteria

Generate Spectra

Parameter Settings

Generation Method:

TMA (Shallow Water)

TMA (Shallow Water)
JONSWAP
Bretschneider (ITTC)
Pierson-Moskowitz
Ochi-Hubble Double Peak

☒ Replace Old Spectra

Directional Spreading Distribution:

☐ Wrapped Normal

☒ Cosine Power

Seaward boundary depth:

☒ Specify once for all spectra

☐ Specify for each spectrum

30.0

m

Angle Settings

Projection:

Shore Normal

Spectral Parameters

	Time Offset (hrs)/Index	Angle (deg)	Hs (m)	Tp (s)	Gamma	nn
1	1.0	30.0	2.0	10.0	3.3	4
2						

Import

Import from GenCade

Export

Spectral Defaults >>

Help...

Generate

Cancel



CMS-Wave Model Control



- Turn on Wetting & Drying of Cells
- Turn on Reflection (FWD, BWD)
- Choose Bed Friction type
- Set parameters
- Choose Output Datasets
- Choose Wave Source

CMS-WAVE Model Control

Input Forcing

Currents:

Water level:

Spectra

Source:

Plane type:

Interpolation type:

Date Format:

Wind

Source:

Settings

Bed Friction

Cf = Darcy-Weisbach friction coefficient
n = Manning friction coefficient

Forward reflection:

Backward reflection:

Muddy bed:

Wave breaking formula:

Matrix Solver

Number of threads:

☒ Allow wetting and drying

☒ Non-linear wave effect

☒ Infragravity wave effect

☐ Run up

☒ Diffraction intensity:

☒ Fast-mode run

Output

☐ Radiation stresses

Format:

☐ Sea/swell

☒ Wave breaking

☒ Indices

☐ Energy dissipation

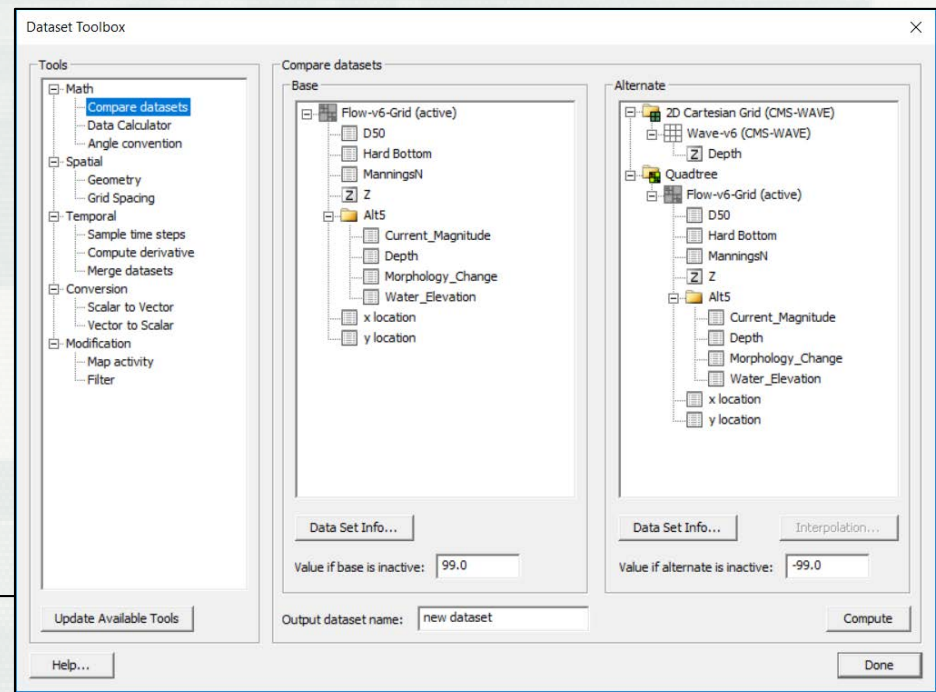
Input Datasets

Format:



Dataset Toolbox

- Temporal Operations
 - Sample times
 - Temporal derivatives
- Mathematical Operations
 - Comparisons
 - Data Calculator
- Spatial Operations
 - Spacing
 - Gradients/Derivatives
 - Smoothing
- Conversions
 - ▶ Vector <-> Scalars
- Coastal Functions
 - ▶ Wavelength/Celerity
 - ▶ Courant number
- Activity Mapping
 - ▶ Map activity
 - ▶ Value filtering





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Dataset Calculator

Dataset Toolbox

Tools

Math

Compare datasets

Data Calculator

Angle convention

Spatial

Geometry

Grid Spacing

Temporal

Sample time steps

Compute derivative

Merge datasets

Conversion

Scalar to Vector

Vector to Scalar

Modification

Map activity

Filter

Update Available Tools

Help...

Data Calculator

Data Sets

Flow-v6-Grid

d1. D50

d2. Hard Bottom

d3. ManningsN

d4. Z

Alt5

d5. Current_Magnitude

d7. Depth

d8. Morphology_Change

d9. Water_Elevation

d10. x location

d11. y location

Add to Expression

Data Set Info...

Time Steps

1 0 00:00:00

☐ Use all time steps

Calculator

/

*

-

+

(

ln

log

1/x

)

x^y

sqrt

abs

min

max

ceil

floor

Output dataset name: new dataset

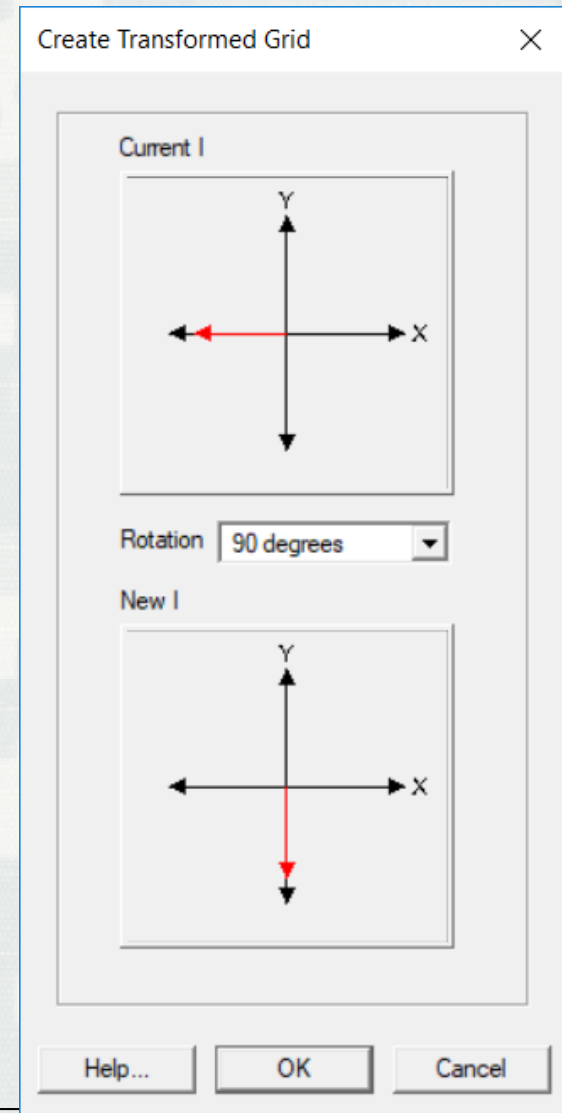
Compute

Done



Duplicate/Rotate Grid (Cartesian Grids)

- Accessed by Right Click on Grid in Project Explorer
 - Duplicate Flow grid for Wave model or vice-versa
 - Rotate Wave grid to appropriate orientation





Coordinate Projections

- All major datums
- Project
 - Point
 - Object
 - Entire project
- Support for projection files
- Automatic detection of projections
 - Images
 - CAD
 - GIS

Display Projection

Horizontal

☐ No projection Units:

☒ Global projection

Projection name:
NAD83_New_Jersey

WKT:
PROJCS["NAD83_New_Jersey",GEOGCS
["GCS_North_American_1983",DATUM
["D_NORTH_AMERICAN_1983",SPHEROID
["GRS_1980",6378137,298.257222101]],PRIMEM["Greenwich",0],UNIT
["Degree",0.017453292519943295]],PROJECTION
["Transverse_Mercator"],PARAMETER["scale_factor",0.9999],PARAMETER

Vertical

Datum: Units:



SMS – Post Processing



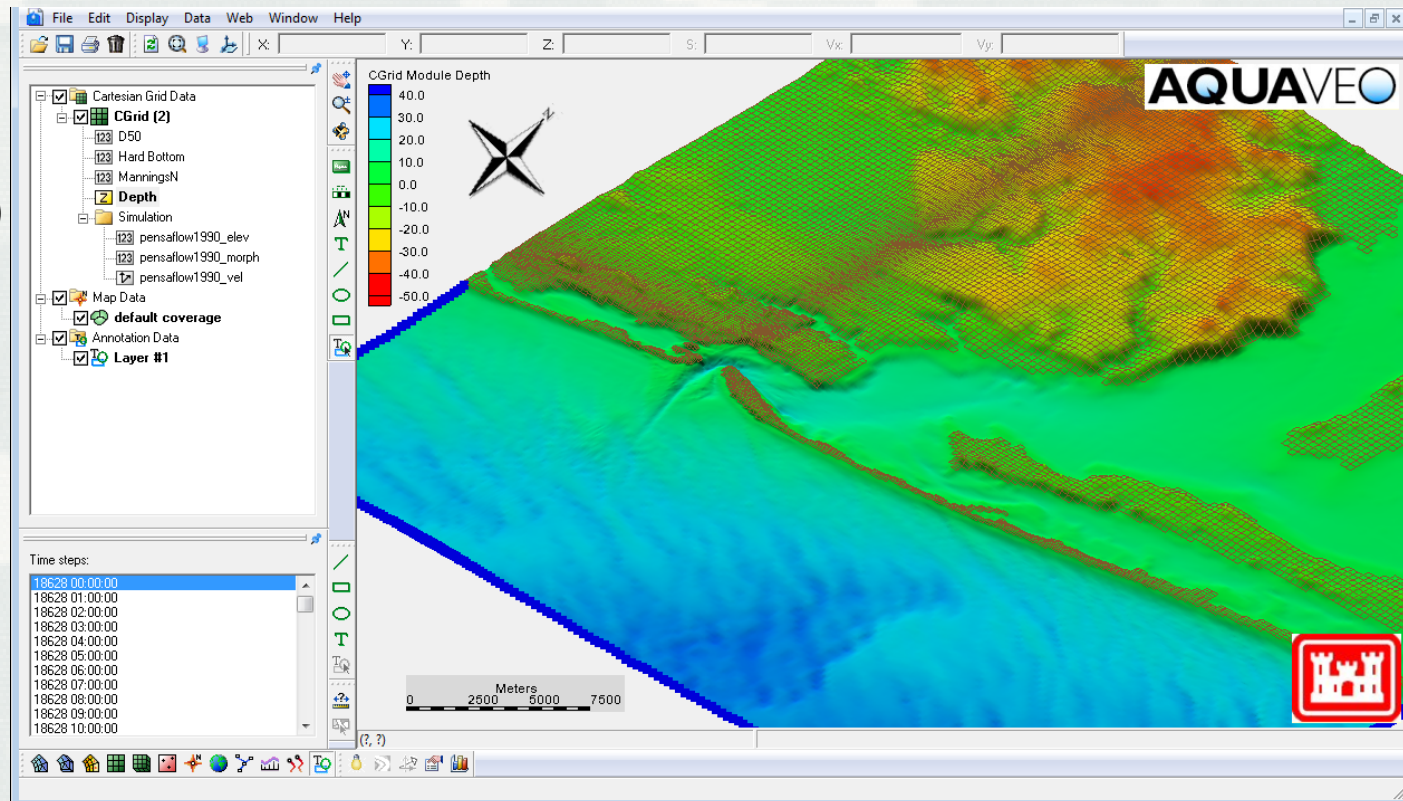
- Annotations
- Graphic images
- Animations
 - AVI filmloops
 - kmz – Google Earth Exports
- 2D Plots
 - Time series
 - Profiles and Cross sections – both steady state and transient



Annotation Layers



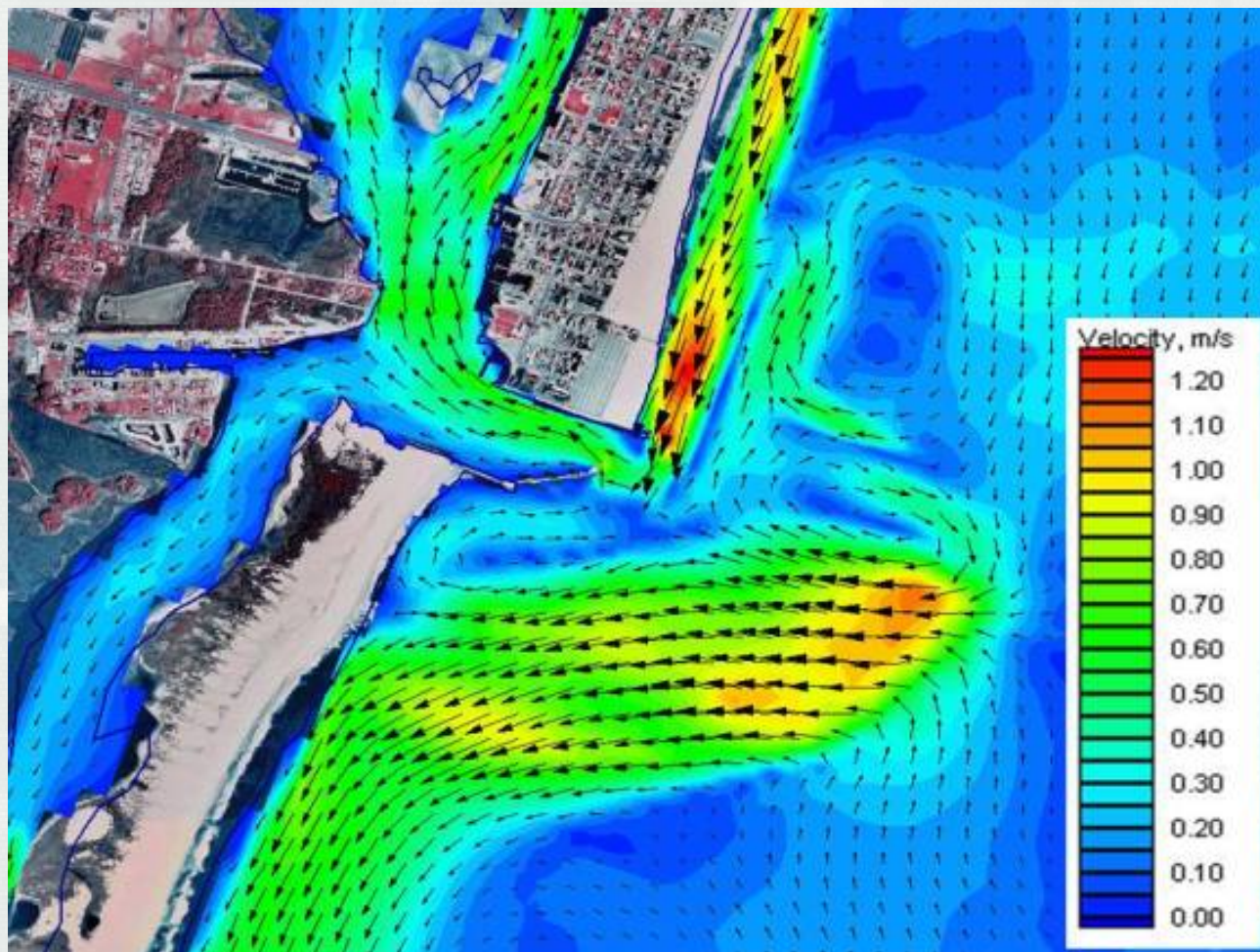
- Replaces Drawing Objects
- New Objects
 - Screen space images (logos)
 - Scale bars
 - North Arrows
- Organizes entities into layers
- Anchored in either world or screen





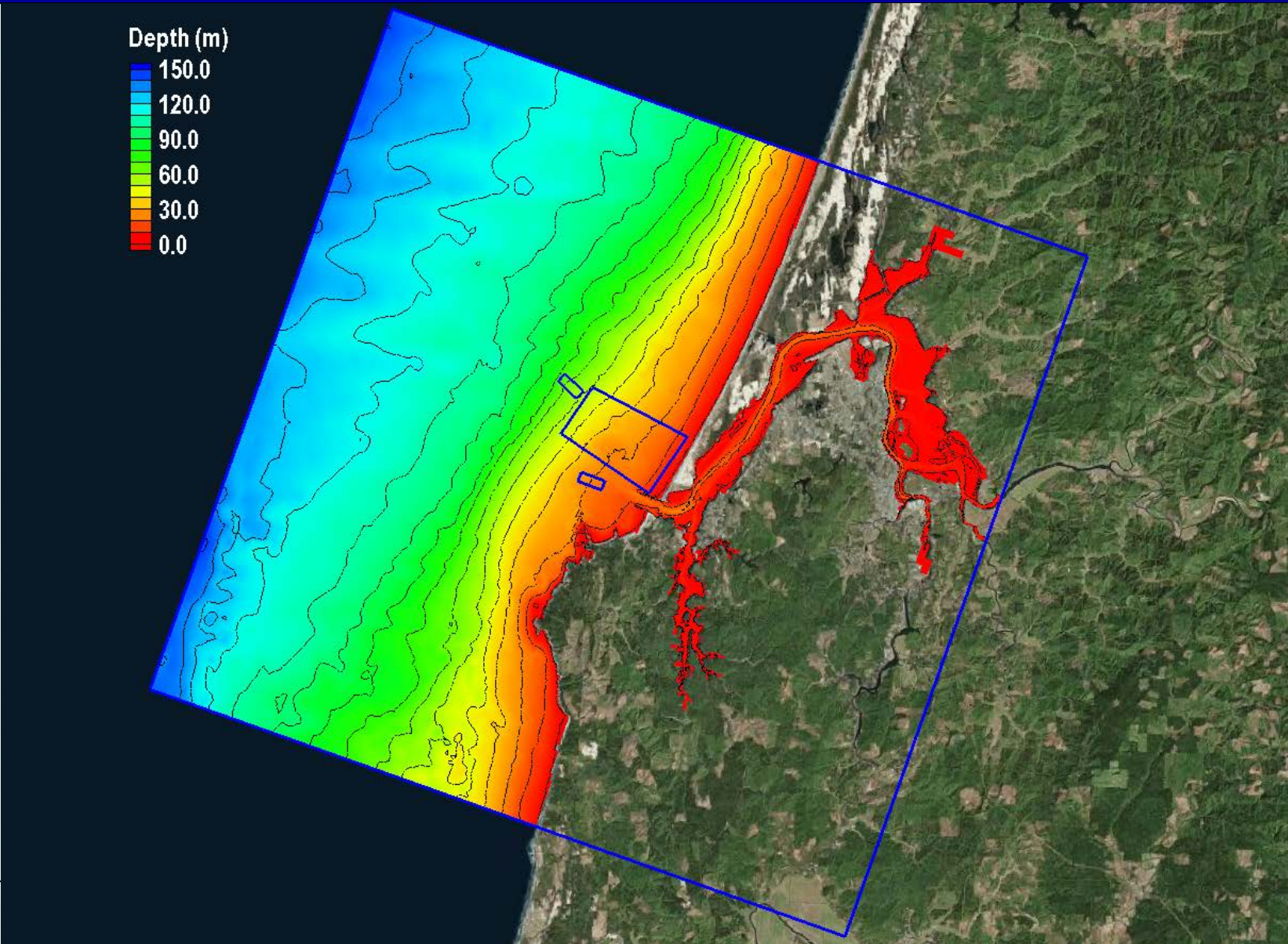
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Contour/Vector Plots



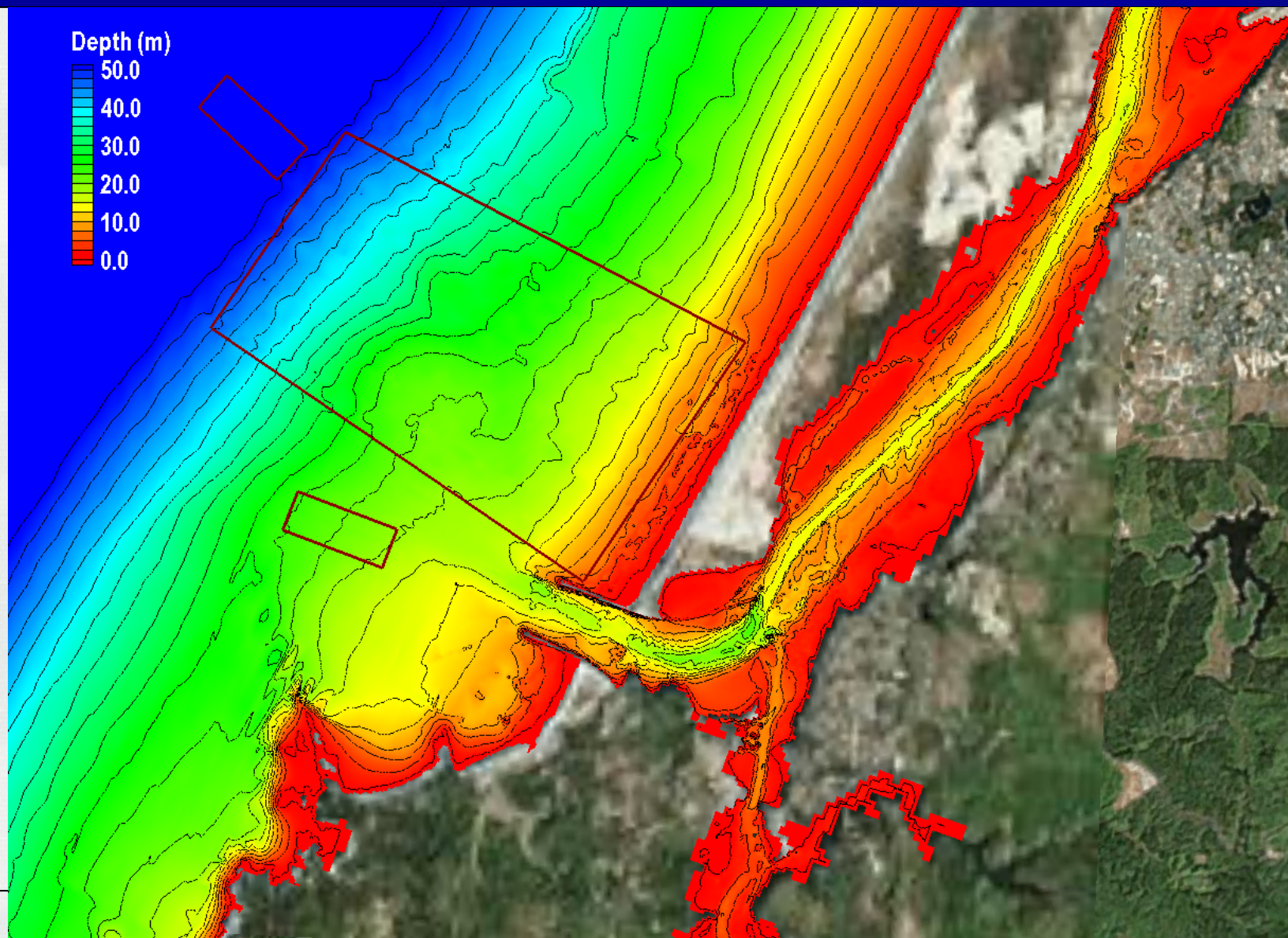


Google Earth (KML) Overlay





Google Earth Overlay (zoom)





Obtaining and Activating SMS



<http://cirp.usace.army.mil/products/SMS.php>

USACE District and ERDC staff –

Contact sms@erdc.usace.army.mil and request a password for any version of SMS. If no response in one business day, contact mitchell.e.brown@usace.army.mil to facilitate.

Others –

- Visit http://www.aquaveo.com/password_request for a temporary password.
- Contact Aquaveo sales at sales@aquaveo.com or call (801) 302-1400.
- Request evaluation version from within the SMS registration form.



Overview of Presentation



- Introduction to the Surface-water Modeling System (SMS v.13.0)
 - What is it?
 - Tools, Modules, Data Tree, Images, etc.
 - CMS Models interface
- Introduction to the Coastal Modeling System (CMS)
 - CMS-Flow – Hydrodynamics, Sediment Transport, Morphology Change
 - CMS-Wave – Half-plane waves and Full-plane wind forcing.



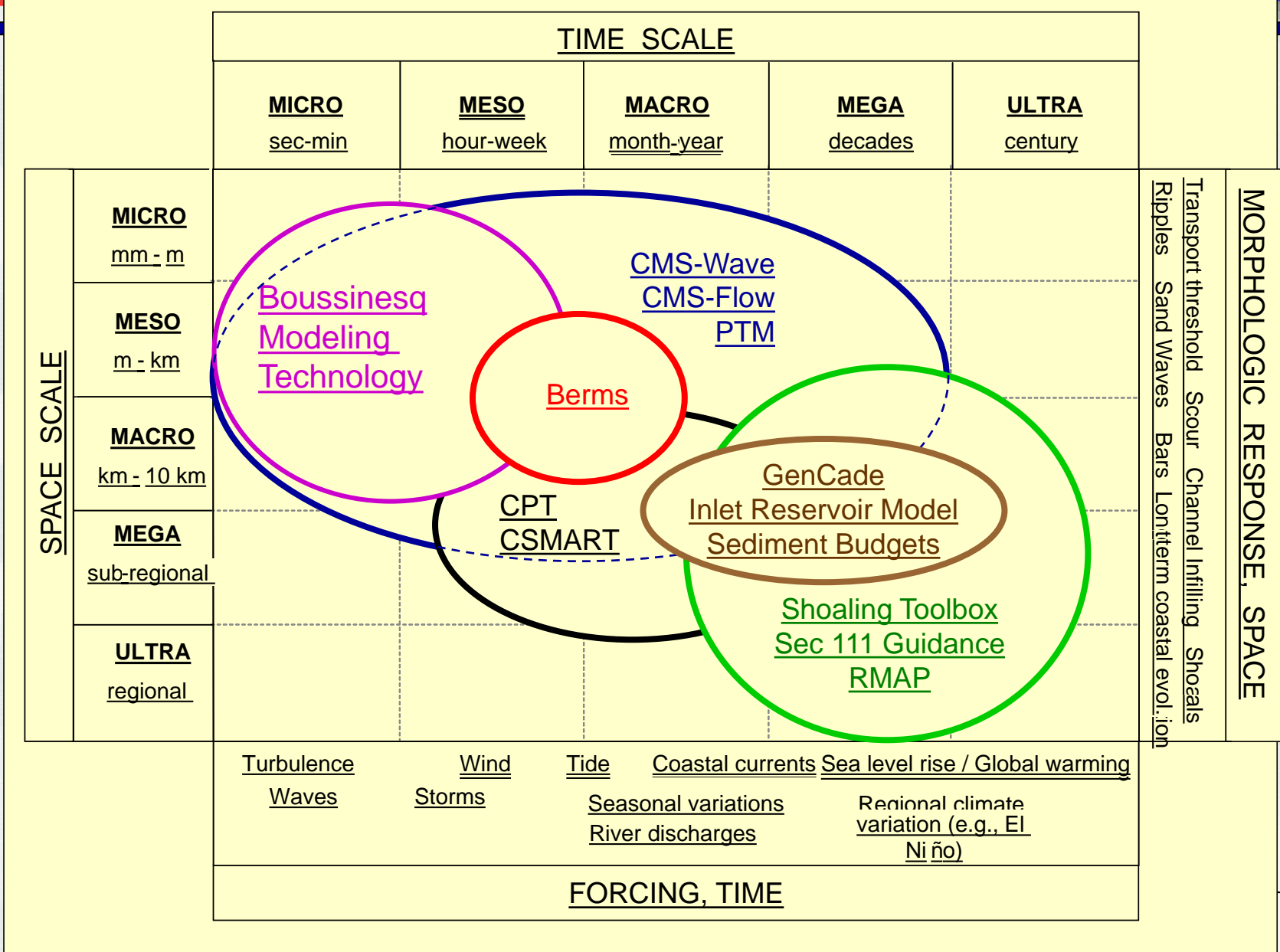
Objective



- **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.



Scales of Coverage

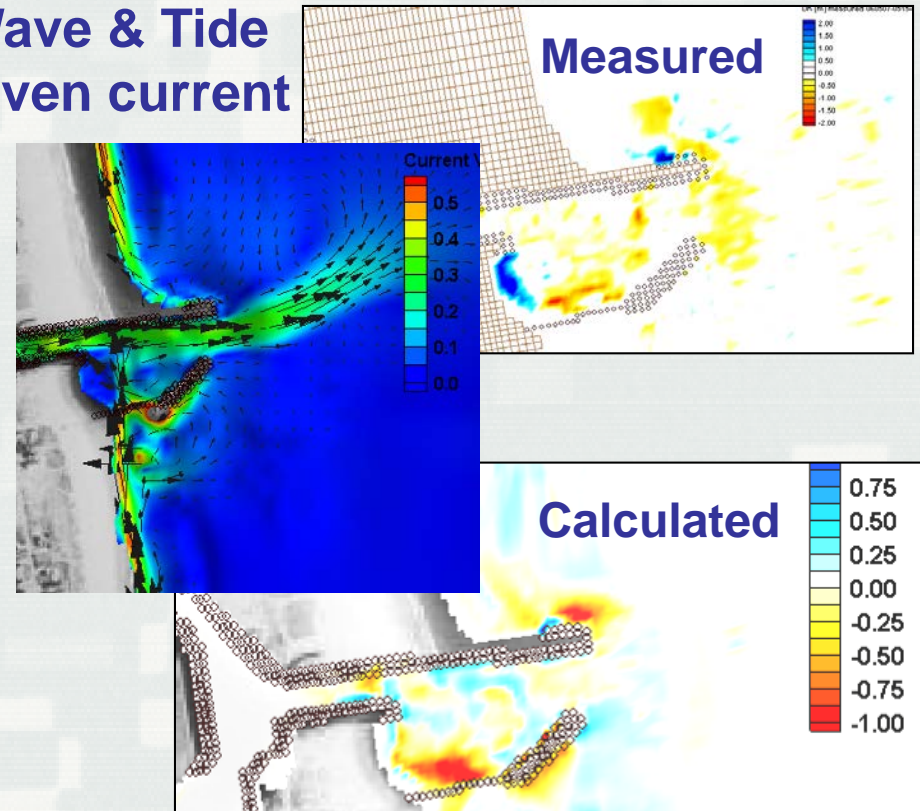




CMS-Flow Key Features

- 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
- Multiple Sediment Grain Sizes & Bed Layering

Wave & Tide driven current



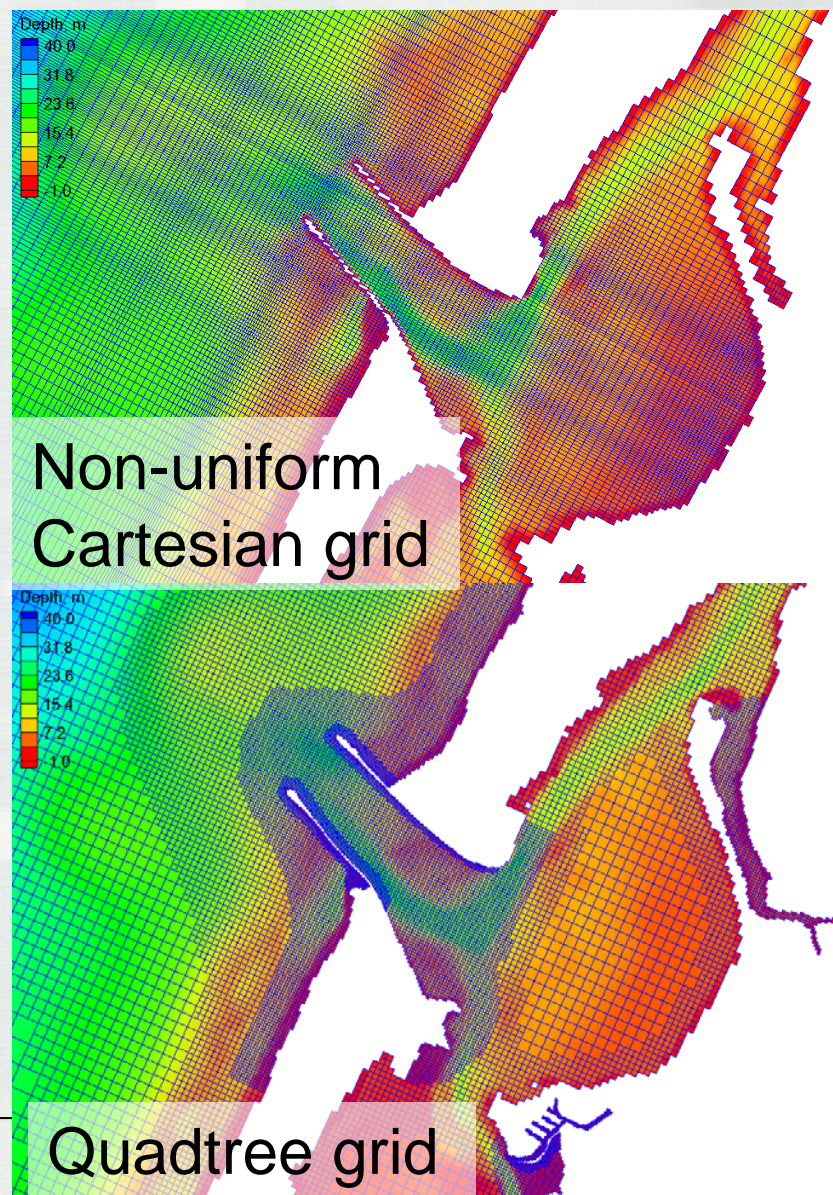


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CMS-Flow Key Features



- Grid options
 - Non-uniform Cartesian grid: Easy to setup (< SMS 12.0)
 - Telescoping (quadtree) grid: Efficient, flexible (SMS 11.0+)
- Solver options
 - Implicit: Tidal flow, long-term morphology change.
~10 minute time step
 - Explicit: Flooding, breaching, super-critical flow. ~1 second time step, parallel processing





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)

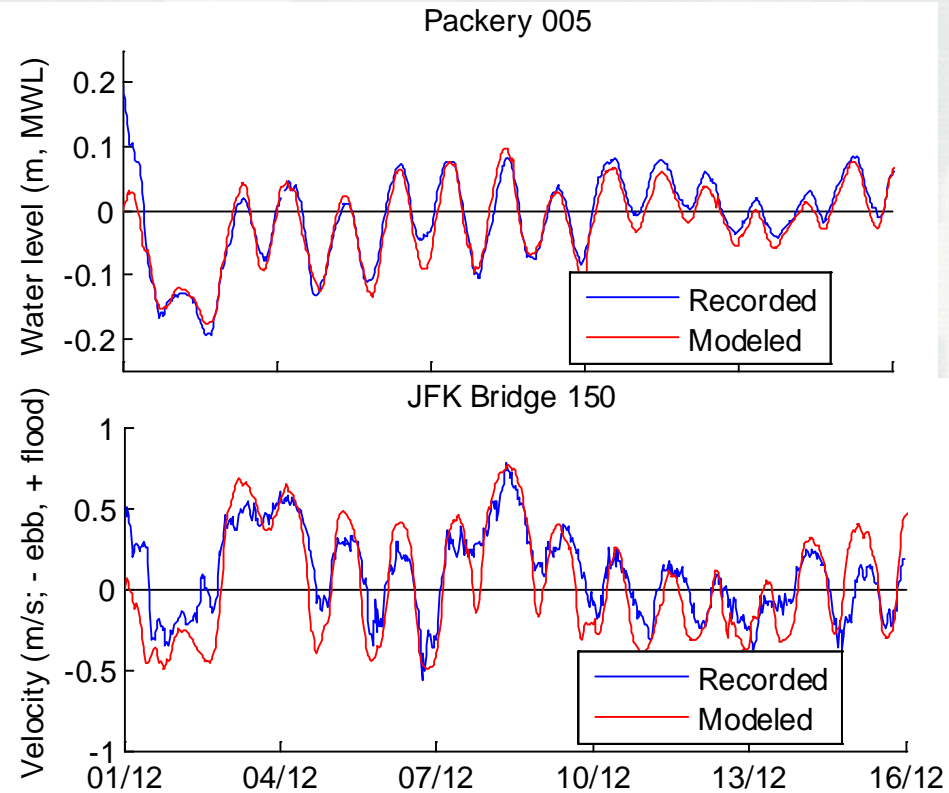
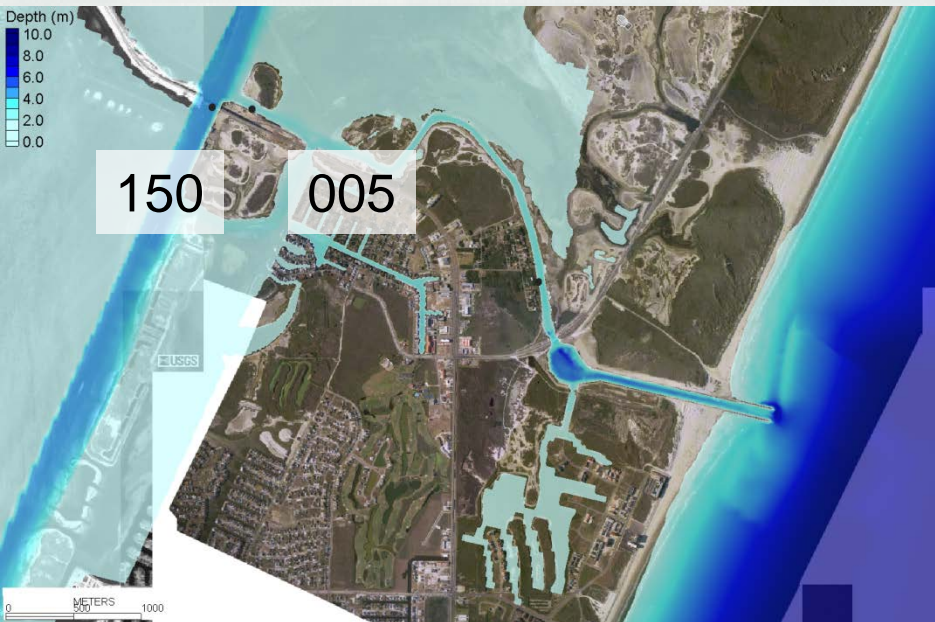
Wave stress (forcing)

Wind stress



Packery Channel, TX

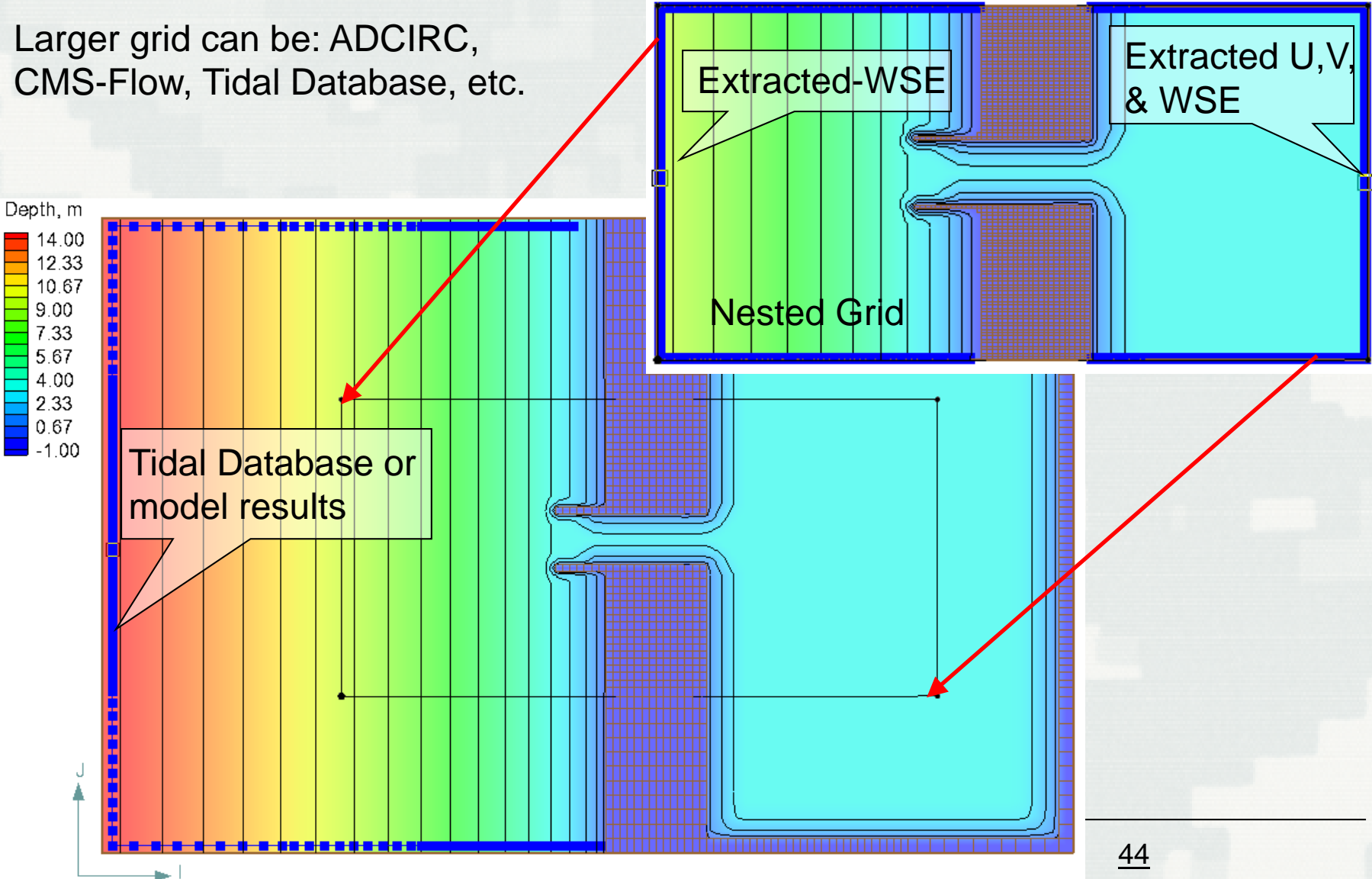
(very quickly setup and run)





Nested Grid Capability

Larger grid can be: ADCIRC,
CMS-Flow, Tidal Database, etc.

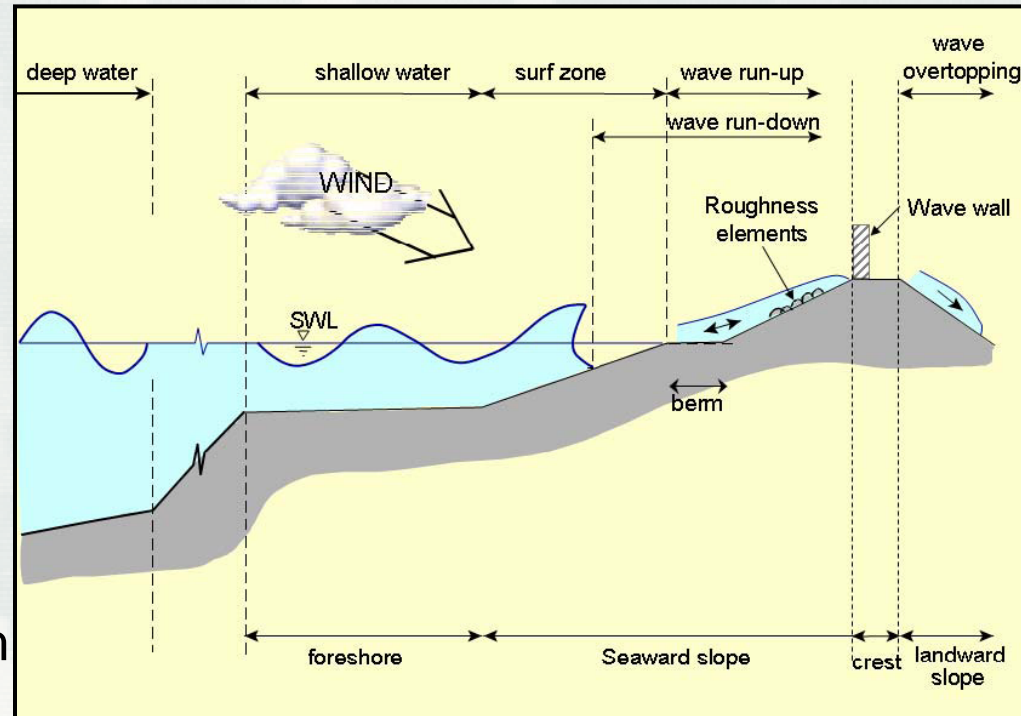




CMS-Wave: Key Features

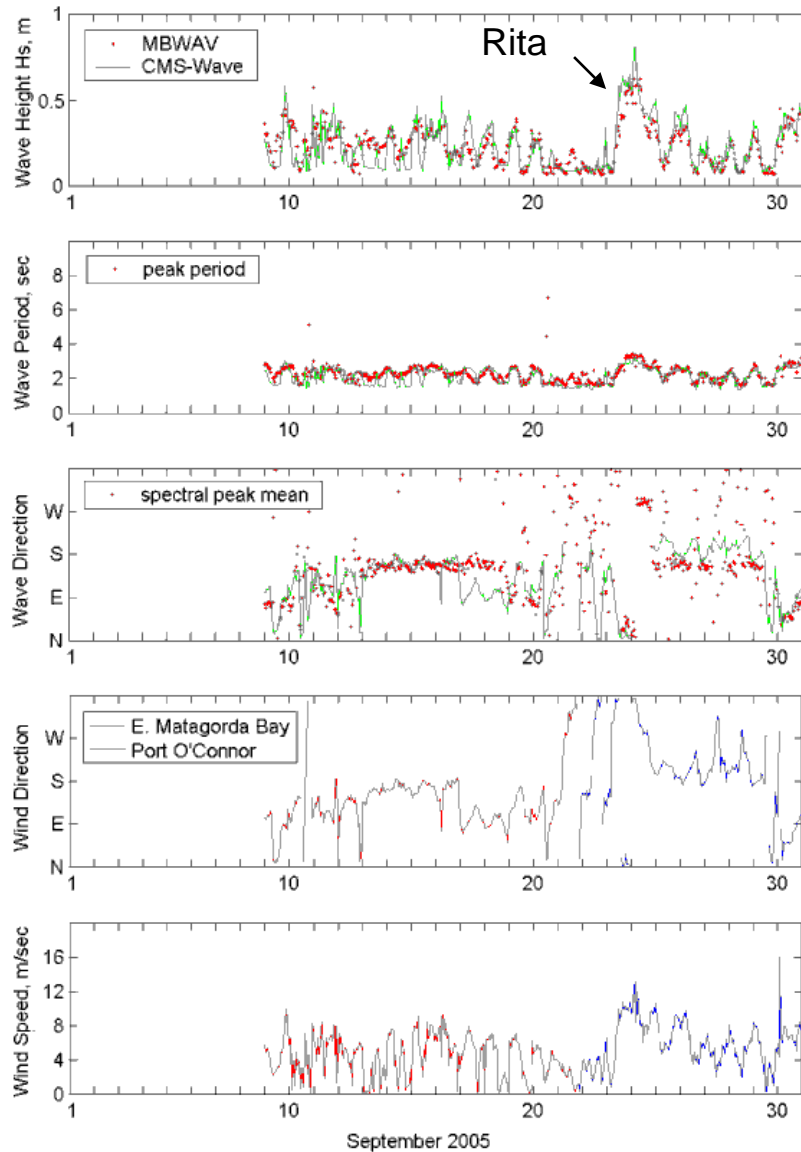


- Shoaling, refraction, diffraction, reflection
- Bottom friction
- White capping
- Wave breaking (4 options)
- Wind generation
- Wave-current, and wave-wave interactions
- Transmission, runup and overtopping
- Muddy bottom
- Automatic grid rotation
- Non-uniform Cartesian grid with nesting capability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

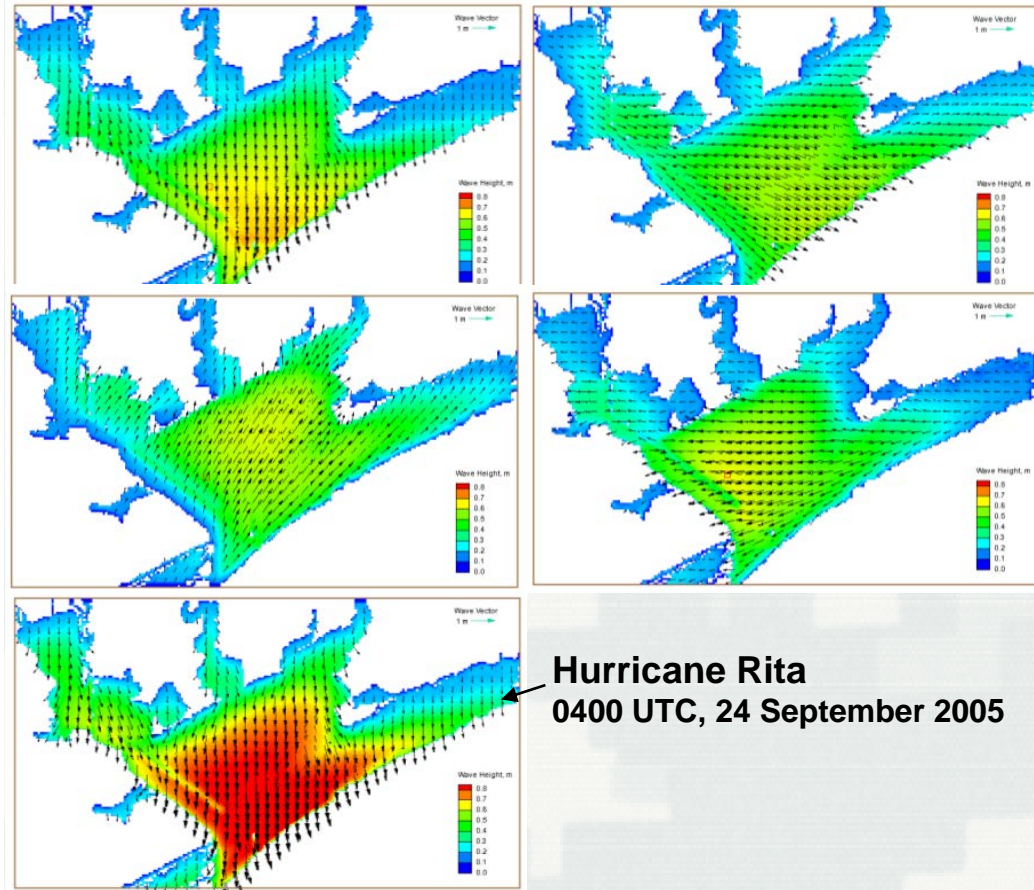




Wave Generation



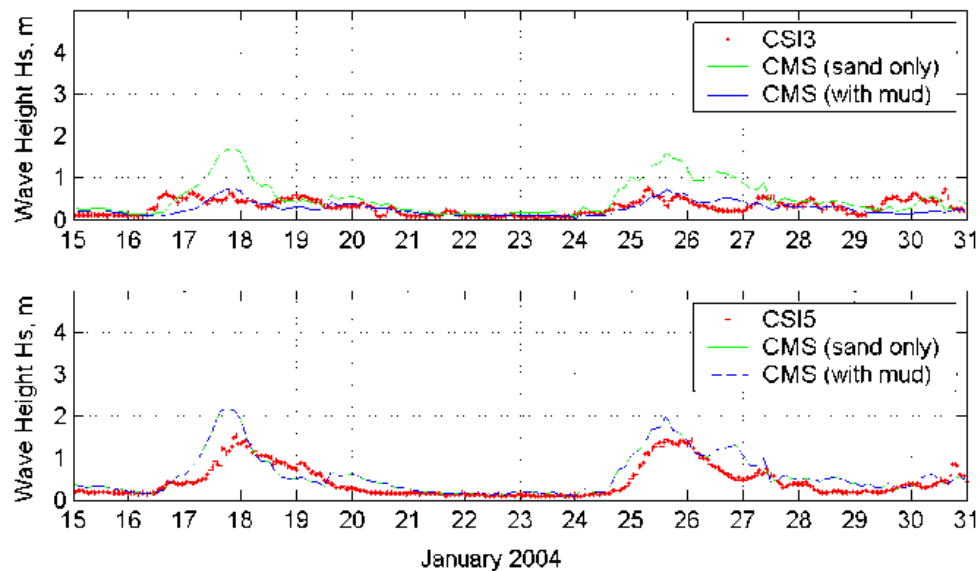
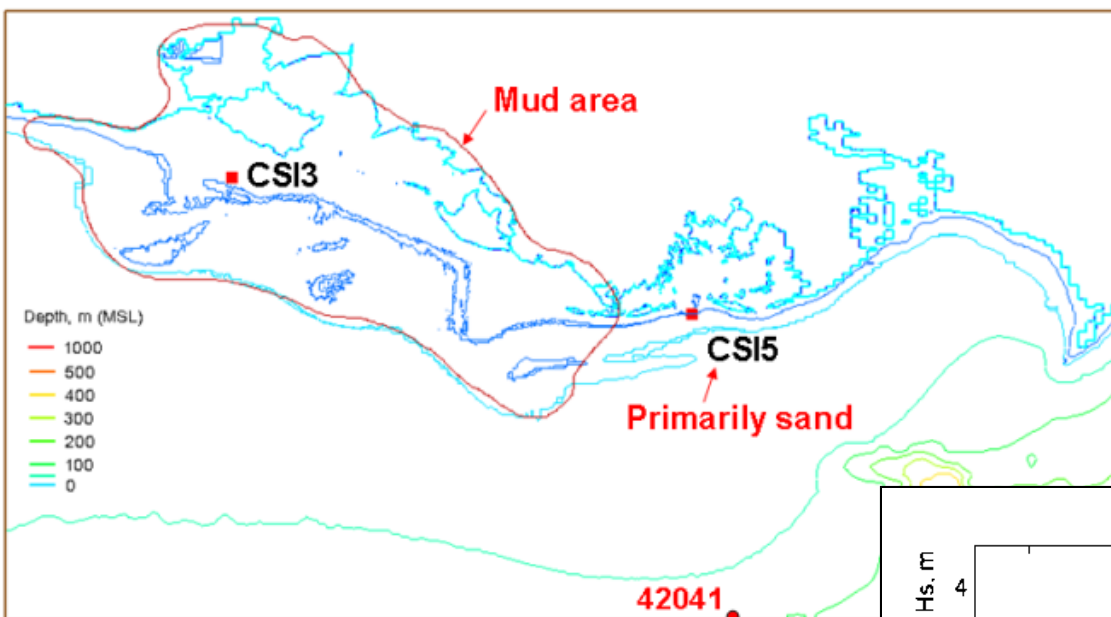
Matagorda Bay, TX





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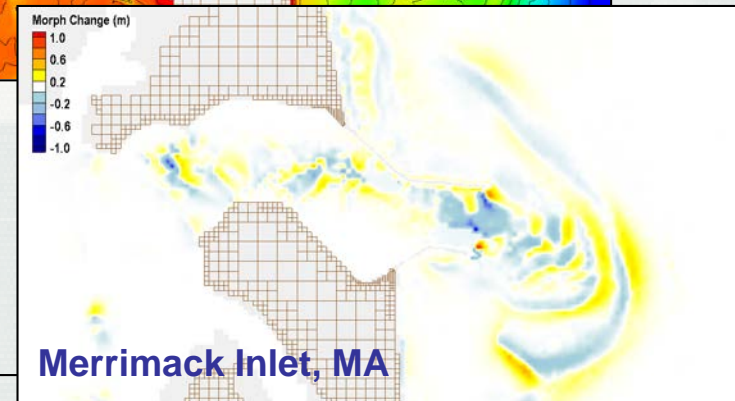
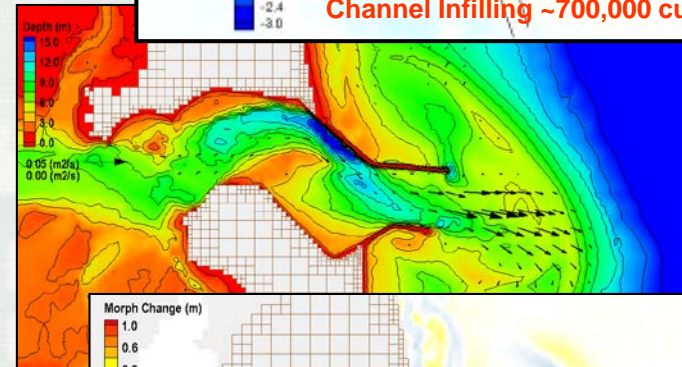
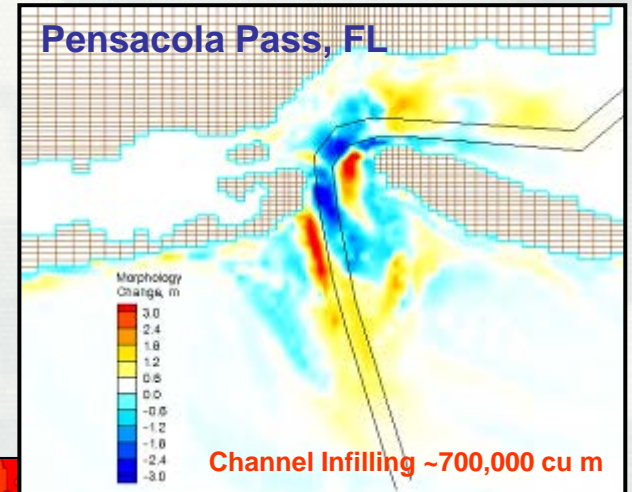
Wave Dissipation over Muddy Coast





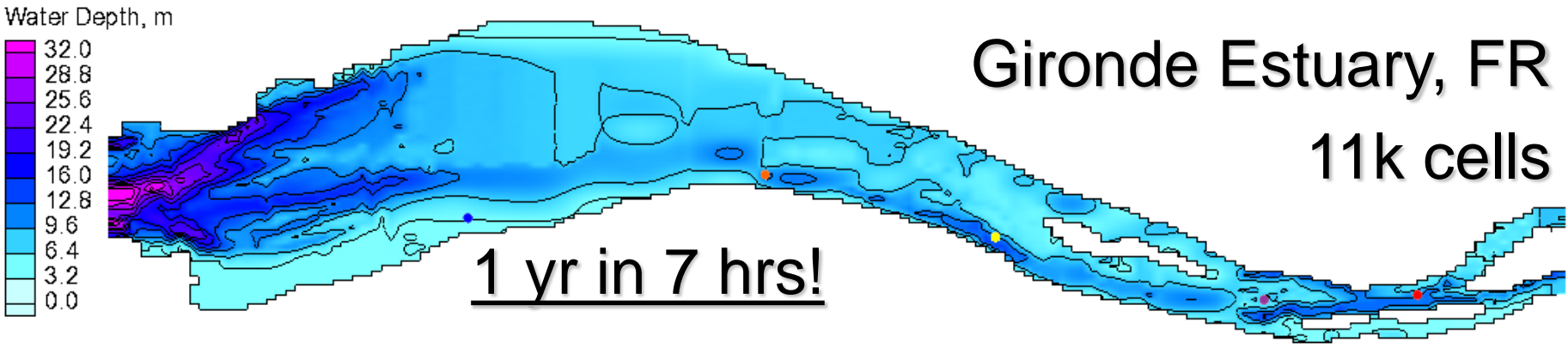
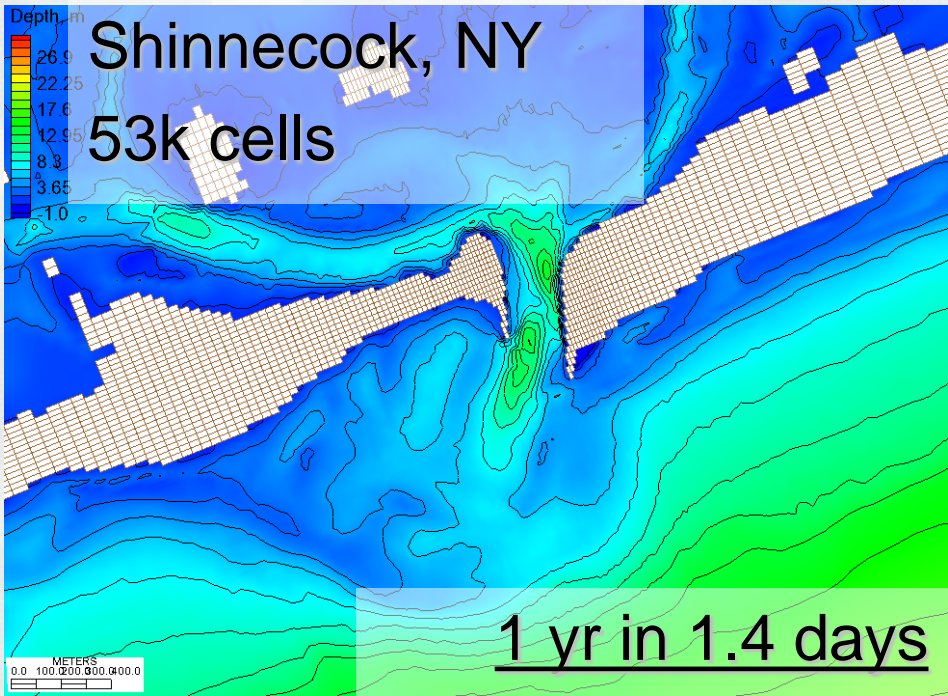
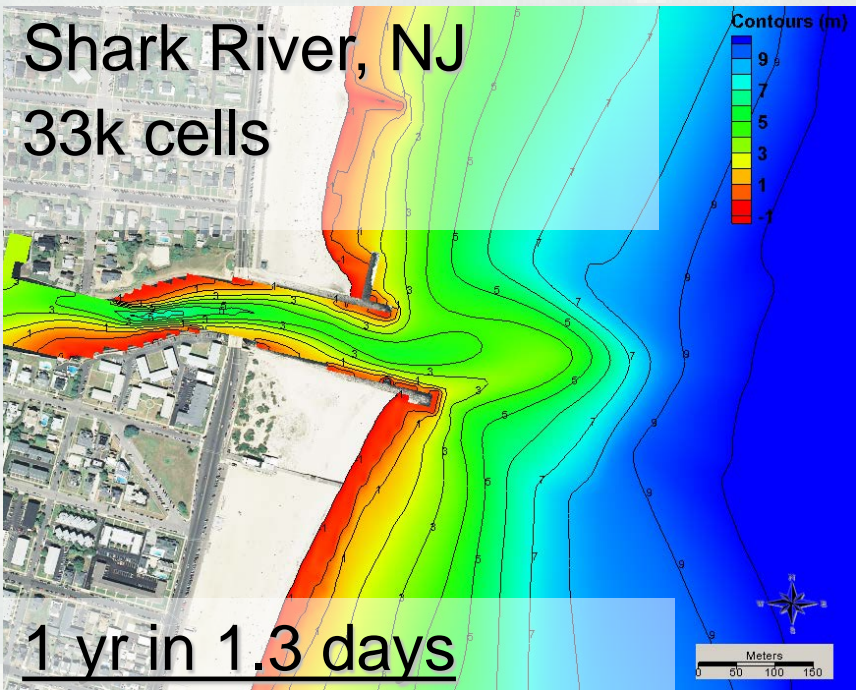
Sediment Transport: Key features

- 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
- Bed Layering
- Eulerian Tracking (via Class Fractions)





Computational Speed (Implicit)

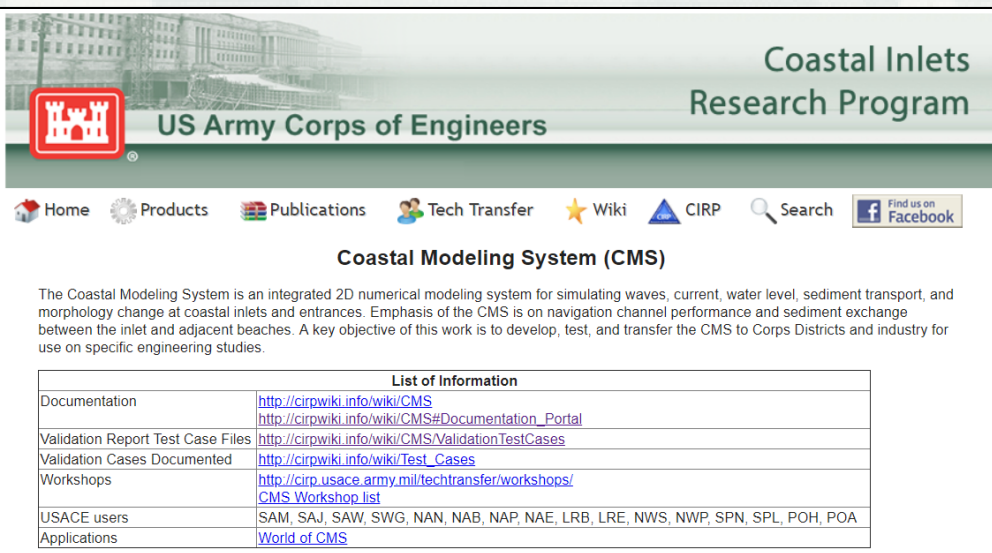




Documentation




■ CIRP website



The screenshot shows the homepage of the Coastal Inlets Research Program. It features the US Army Corps of Engineers logo and a navigation bar with links to Home, Products, Publications, Tech Transfer, Wiki, CIRP, Search, and Facebook. The main heading is "Coastal Inlets Research Program". Below this is a section titled "Coastal Modeling System (CMS)" with a paragraph describing it as an integrated 2D numerical modeling system. A table titled "List of Information" provides links to various resources.

List of Information	
Documentation	http://cirpwiki.info/wiki/CMS
Validation Report Test Case Files	http://cirpwiki.info/wiki/CMS#Documentation_Portal
Validation Cases Documented	http://cirpwiki.info/wiki/CMS/ValidationTestCases
Workshops	http://cirp.usace.army.mil/techtransfer/workshops/CMSWorkshopList
USACE users	SAM, SAJ, SAW, SWG, NAN, NAB, NAP, NAE, LRB, LRE, NWS, NWP, SPN, SPL, POH, POA
Applications	World of CMS

■ Wiki Website



The screenshot shows the main page of the CIRP Wiki. It features the CIRP logo and a navigation bar with links to Main page, CIRP publications, CIRP products, CMS main page, CMS Doc Portal, Help, links, wiki resources, Toolbox, and Forum Menu. The main heading is "Main Page". Below this is a section titled "Welcome to the CIRP Wiki" with a paragraph describing it. A table titled "CIRP Products" lists various tools and systems. A section titled "Other Links" provides links to various resources.

CIRP Products
<ul style="list-style-type: none">Coastal Modeling System (CMS)Channel Prioritization Tool (CPT)Coastal Structures Management, Analysis, and Ranking Tool (CSMART)GenCodeSediment Budget Analysis System (SBAS)Other Products

Other Links
<ul style="list-style-type: none">CIRP PublicationsCIRP WebsiteCIRP Event HorizonAquaveoSurface-water Modeling System (SMS) Wiki

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

<http://cirpwiki.info>



Documentation

Website (cirp.usace.army.mil)



■ Products

- CMS
- GenCade
- Others

■ Publications

- Technical Reports
- CHETNS
- Journal Articles
- Others

■ Tech Transfer

- Webinars
- Workshops
- Video Clips

The screenshot shows the Coastal Inlets Research Program website. The header includes the US Army Corps of Engineers logo and the text "Coastal Inlets Research Program". The navigation bar contains links for Home, Products, Publications, Tech Transfer, Wiki, CIRP, Search, and Facebook. The Tech Transfer menu is open, showing options for Webinars, Workshops, Meetings, and Video Clips. The Workshops option is selected, displaying a list of workshops including "CPT-AISAP Workshop 2016", "Dunes Management Challenges Workshop - Kitty Hawk, NC", "13th Annual Workshop - Philadelphia, PA", "CMS / GenCade - San Diego, CA", "12th Annual Workshop - Jacksonville, FL", and "All Workshops". Below the menu, a table provides details for the "CPT-AISAP Workshop 2016" held from August 30-31, 2016, in Dallas, TX.

Tuesday, March 6th	Wednesday, March 7th
CPT User's Manual (DRAFT) <ul style="list-style-type: none">• Introduction to CPT Capabilities• Selecting Locations• Filters and Selections• Shoaling Scenario Queries• Map Outputs to Google Earth• Dredging Work Package Formulation• Reach Administrator• How to re-draw CPT graphs in Excel	AISAP <ul style="list-style-type: none">• AIS Data Background• AISAP Introduction• First Login and Data Acquisition via AISAP• Creating Projects and AOIs in AISAP• Analysis Capabilities in AISAP• Beyond AISAP

cirp.usace.army.mil/techtransfer/workshops/CPT-AISAP2016/CPT-AISAP.php#



Documentation Wiki (cirpwiki.info)



- 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
Kenneth.n.mitchell@usace.army.mil
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.





SMS and CMS



Questions?

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