NOS' Operational Ocean Forecast Modeling Systems for Navigation Services

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Team:
NOAA/NOS/Office of Coast Survey/Coastal Marine Modeling Branch
NOAA/NOS/CO-OPS Modeling Team
NOAA/NOS/IOOS Operations Division
NOAA/NOS/National Geodetic Survey
NOAA/National Weather Service
Academic Partners, including Univ. of Notre Dame; Columbia River Inter-Tribal
Fish Commission; Virginia Institute of Marine Science; Rutgers Univ.; UMass
Dartmouth; and many others

NOAA: National Oceanic and Atmospheric Administration
NOS: National Ocean Service
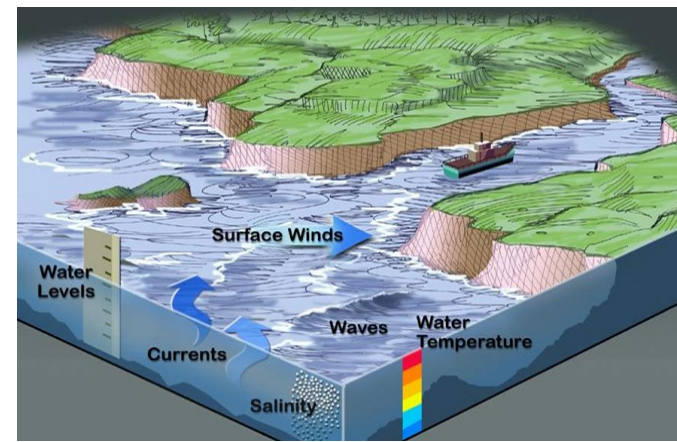*CO-OPS: Center for Operational Oceanographic Products and Services*
*IOOS: U.S. Integrated Ocean Observing System*

NOAA/NOS' Office of Coast Survey

Why is coastal modeling important?

1. Models provide info. in between observation locations

2. Models provide info. about the future (**forecast guidance**)

1. Tide tables predict tides, but not changes in water levels & currents due to **wind**, **atmospheric pressure**, **rivers**, etc.

1. Operational coastal & ocean models provide local, official water level, surface current forecast guidance for:

   a) **Marine navigation**

   b) Coastal resilience, disaster mitigation

   c) Ecology, fisheries science/management
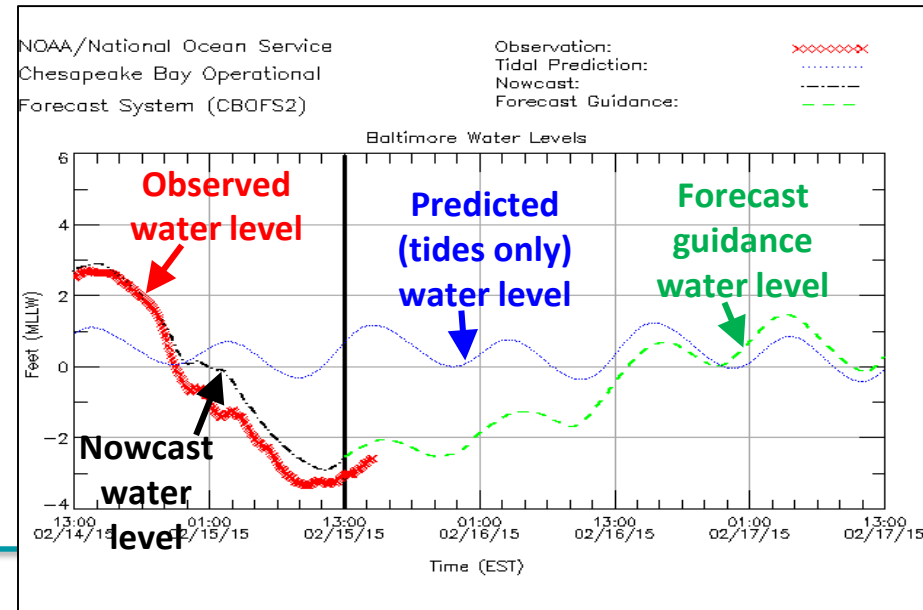
End users of ocean forecast guidance

- **Mariners**, e.g.
  - Pilots of ships to navigate into ports safely and efficiently based on tide, current forecasts

- **Storm surge forecasters**, e.g.
  - NOAA National Weather Service (NWS) Weather Forecast Offices (WFOs) to generate flood forecasts during winter storms
  - NOAA/NWS Ocean Prediction Center (OPC) for operational extratropical coastal storm surge forecasts in Marine Weather Discussions
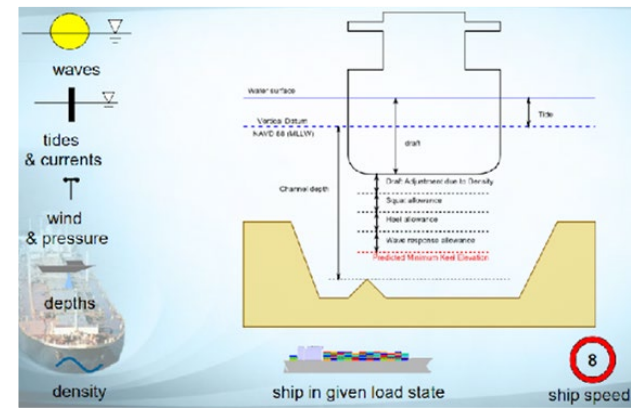
Under keel clearance management system

National Weather Service
Watches, Warnings & Advisories

Local weather forecast by "City, St" or zip code | City, St | Go

Coastal Flood Statement

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Coastal Hazard Message
National Weather Service Boston/Norton MA
1239 PM EST Fri Dec 18 2020

MAZ024-182200-
/O.NEW.KBOX.CF.S.0015.201218T1800Z-201218T2200Z/
Nantucket MA-
1239 PM EST Fri Dec 18 2020

* WHAT...1 foot or less of inundation above ground level expected
  in low-lying areas near shorelines and tidal waterways
  (4.6 to 5.1 feet Mean Lower Low Water).

* WHERE...Nantucket MA County.

* WHEN...Until 5 PM EST this afternoon.

* IMPACTS...Some water on low lying roads and property.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Do not drive through flooded roadways.
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NWS Coastal Flood Statement

NWS Forecast Office - Boston / Norton, MA
Weather.gov > Boston / Norton, MA

Boston / Norton, MA
Weather Forecast Office

Current Hazards Current Conditions Radar Forecasts Rivers and Lakes Climate and Past Weather Local Programs

Click a location below for detailed forecast.

Watches, Warnings & Advisories

Small Craft Advisory

Coastal Flood Statement

Last Map Update: Fri, Dec. 18, 2020 at 4:42:09 pm EST

NOS Operational Ocean Forecasting Model Systems

1. **Operational Forecast Systems (OFS)**
   - NOAA operational models for U.S. coastal waters & Great Lakes
   - Short-term nowcasts, 2- to 5-day forecast guidance: water currents, water levels, water T, salt

17* OFS in Operations

2 new OFS under development for FY21 implementation
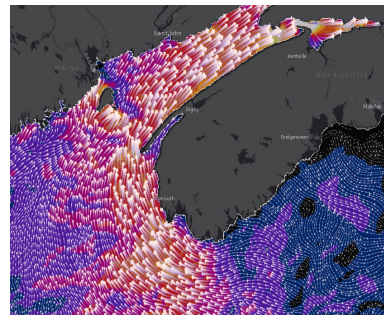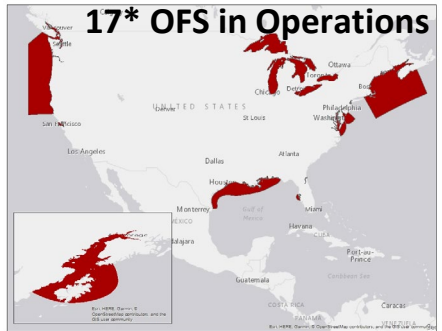
Gulf of Maine Operational Forecast System (GoMOFS)

*Including NWGOFS, NEGOFS, LMOFS, LHOFS

2. **Global Extratropical Surge & Tide Operational Forecast System (Global ESTOFS)**
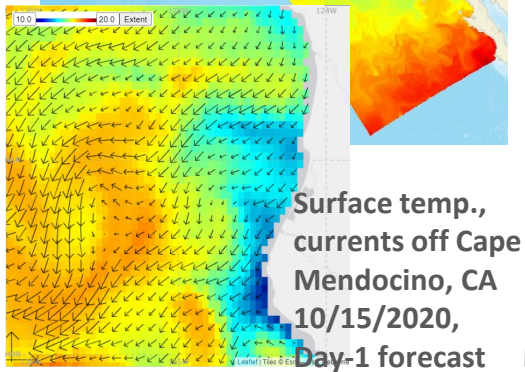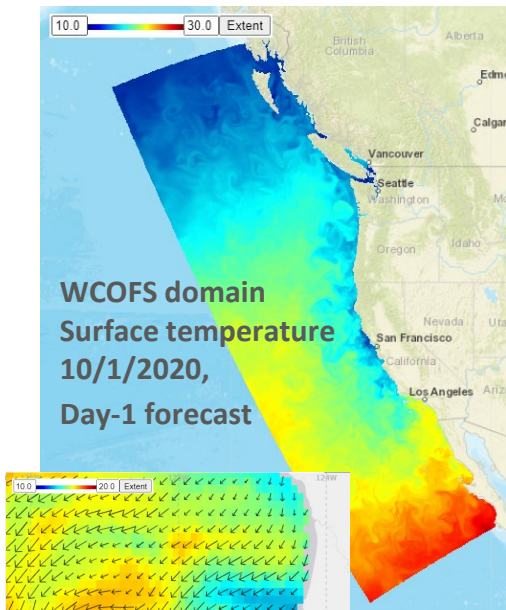   - NOAA operational storm surge modeling system for world
   - Nowcasts and 7.5-day forecast guidance of water levels: tides, storm surge, and their combination
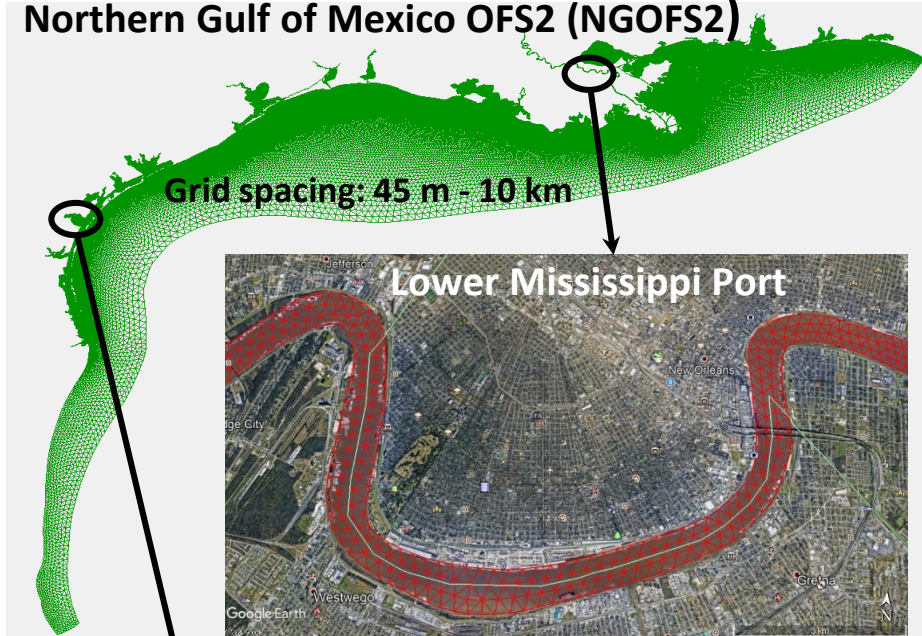

Global ESTOFS bathymetry
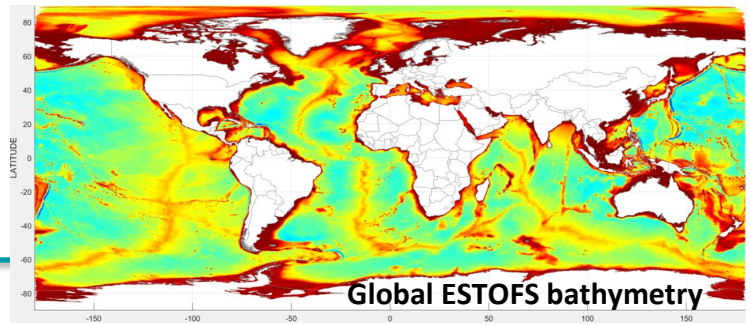
Examples of OFS

West Coast OFS (WCOFS)

- First "data assimilative" OFS: assimilates **SST, HF radar surface currents, satellite altimetry**

- 4 km (2.5 mi) grid spacing

- Supports **route planning** (1 knot speed reduction = 10-15% fuel savings), **search and rescue**, **hazard response**


WCOFS domain Surface temperature 10/1/2020, Day-1 forecast

Surface temp., currents off Cape Mendocino, CA 10/15/2020, Day-1 forecast

Northern Gulf of Mexico OFS2 (NGOFS2)

Grid spacing: 45 m - 10 km

Lower Mississippi Port

Corpus Christi Bay

# Navigation Support: S-111 surface currents

- As part of the **Precision Marine Navigation Data Processing & Dissemination System**, OFS surface current forecast guidance is being encoded in formats following International Hydrographic Organization's (IHO) S-100 Universal Hydrographic Data framework

- **S-111 surface currents**

- Mariners can use current forecasts to plan optimal routes, avoid hazards
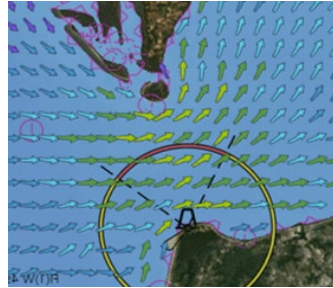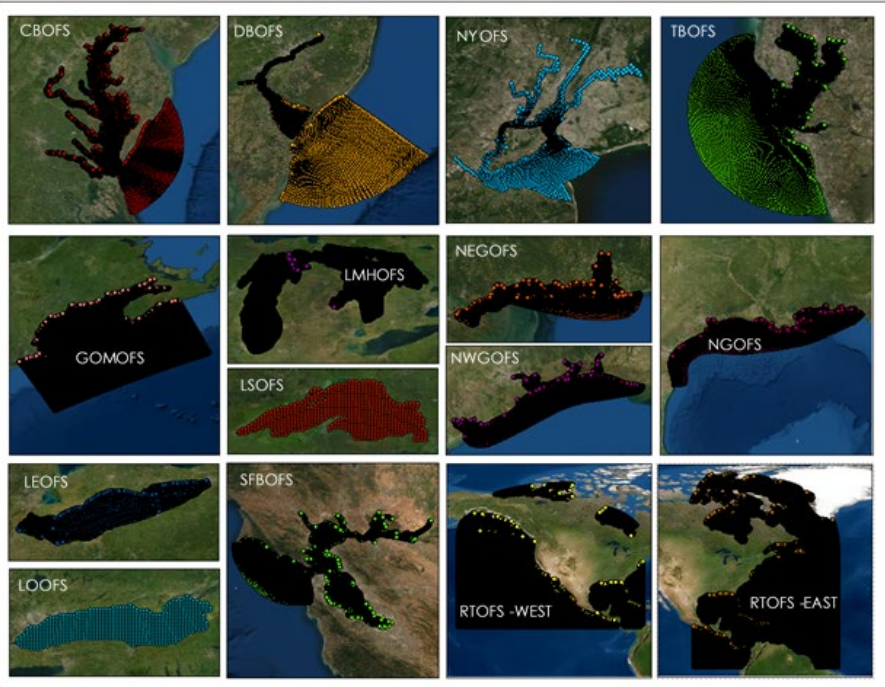
Current OFS being encoded in S-111 format

Sample S-111 display
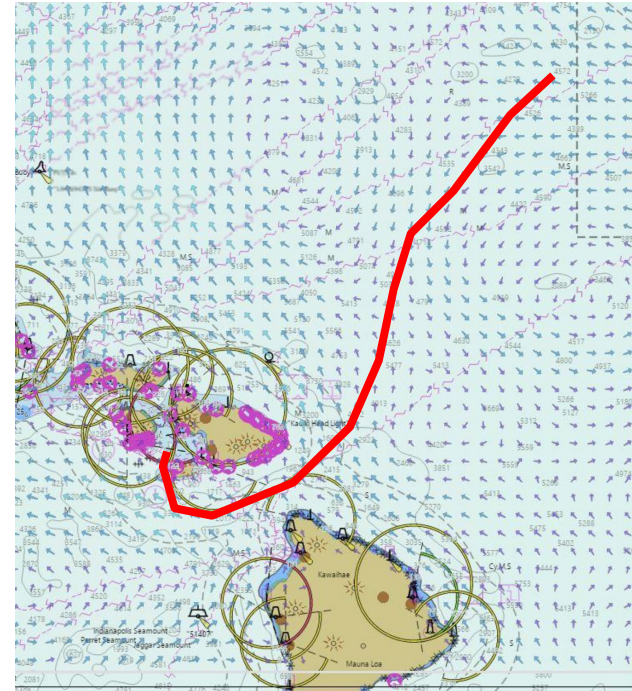
Sample display of S-111 surface currents (not to standard) with possible optimized ship route into port
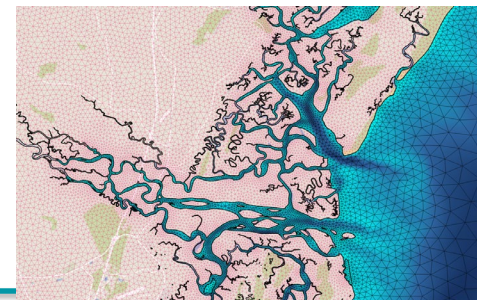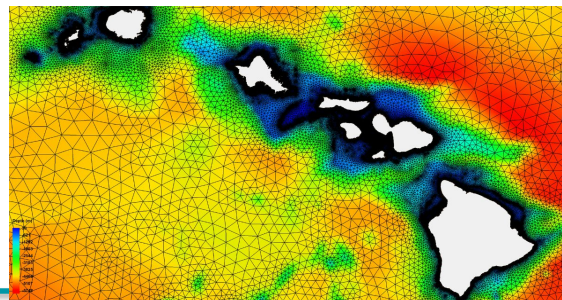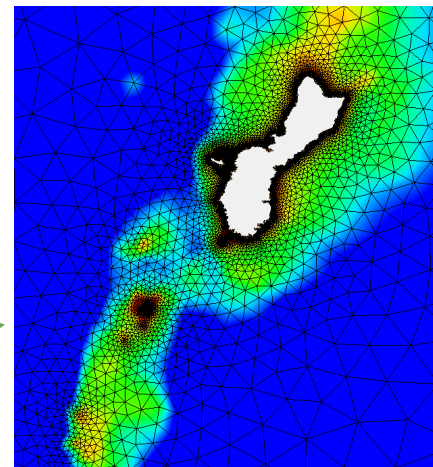
Global ESTOFS Description

NOAA/NOS' Global ESTOFS provides, to our knowledge, the highest resolution operational global surge forecast guidance today. Coastline resolution is at least 1.5 km, up to 80 m globally.

Now, focusing on 1) providing even higher resolution (25 m) in key ports; 2) improving model bathymetry & shoreline

Extratropical Storm Surge & Tide Operational Forecast System (ESTOFS)

- Advanced CIRCulation (ADCIRC) core hydrodynamic model
- Provides 7-day water level forecasts
- Driven by weather forecast guidance from NOAA's Global Forecast System (GFS) (10 m AGL winds, mean sea level pressure, sea ice)
- Provides water level forecast guidance: tides, storm surge, and their combination **for mariners and storm surge forecasters**

- 4 cycles a day: 00, 06, 12, and 18 UTC

Guam

Hawaii

U.S. East Coast

Previous ESTOFS Coverage

ESTOFS-PAC
2014-2020

ESTOFS-ATL
2012-2020

Previous NOS Tide & Surge Guidance Coverage

ESTOFS-MIC
2014-2020

Gaps in Coverage:

- Western Alaska
- American Samoa
- Northwest Pacific

Operational Needs:

- Unification of ESTOFS modeling infrastructure
- Reduction of bias and errors due to removal of the grid boundaries
- Inclusion of internal tide-induced dissipation in deep ocean
- Sea-ice effect on wind drag
- Bias correction

Global ESTOFS Coverage

Current NOS Tide & Surge Guidance Coverage
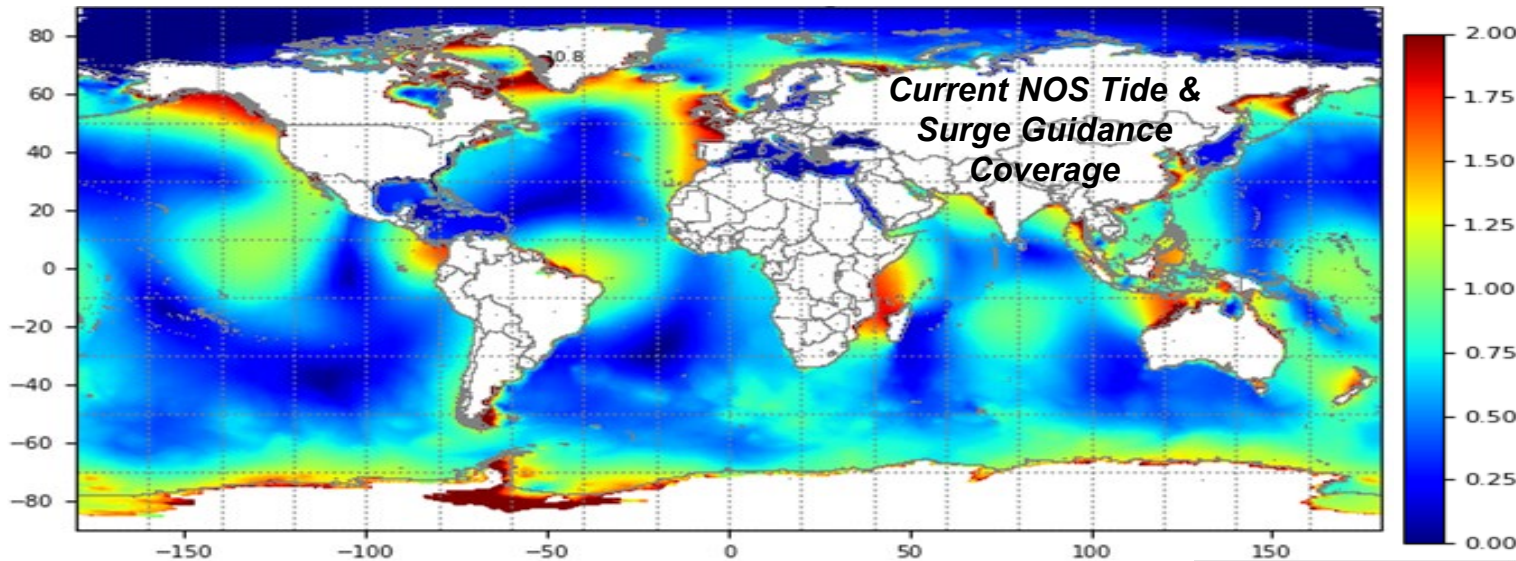
Maximum forecast water levels (m MSL) from a forecast cycle of Global ESTOFS.

Global ESTOFS mesh:
8,063,409 nodes

Point output:
558 locations
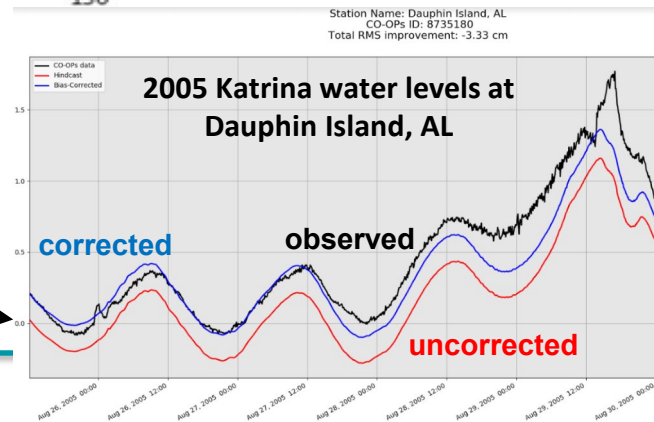
Operational 24 Nov 2020

Coastal resolution:
Up to 80 m for Hawaii and US West Coast
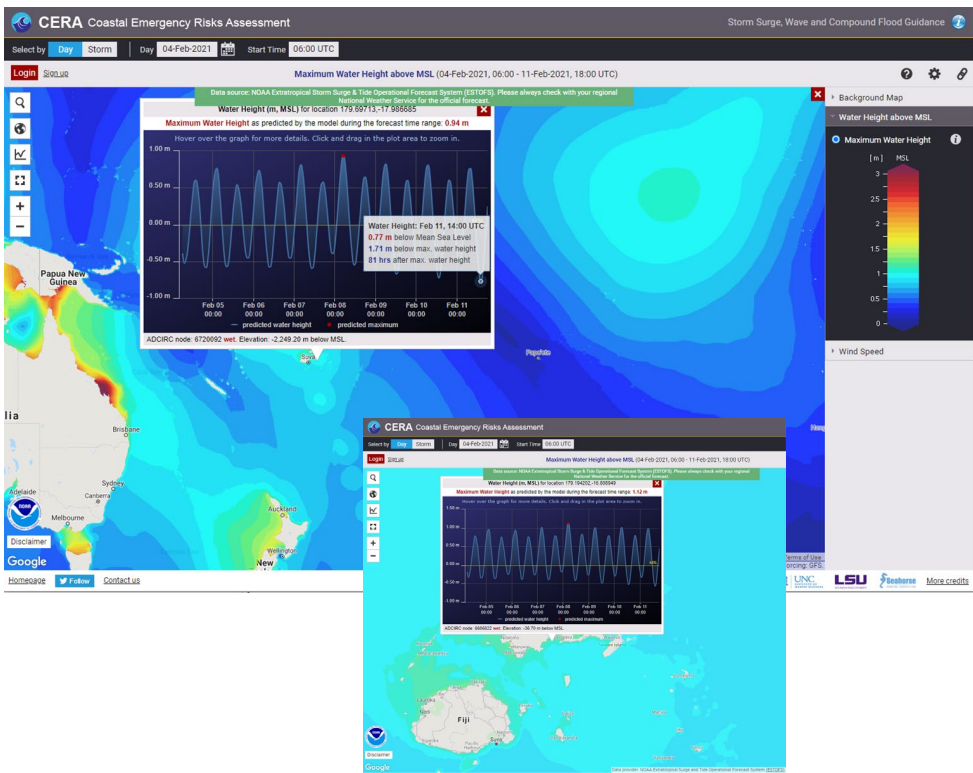Up to 90-120 m for Pac Islands (e.g. Guam, Samoa)
Up to 120 m for US East Coast, PR, Micronesia, AK

Bias Correction:
Correct bias in simulated water levels based on obs

Station Name: Dauphin Island, AL
CO-OPs ID: 8735180
Total RMS improvement: -3.33 cm

2005 Katrina water levels at Dauphin Island, AL

corrected   observed

uncorrected

How to access Global ESTOFS results

cera.coastalrisk.live
Screenshots of Global ESTOFS storm surge forecast guidance for SW Pacific displayed on CERA's map viewer (zoomable)
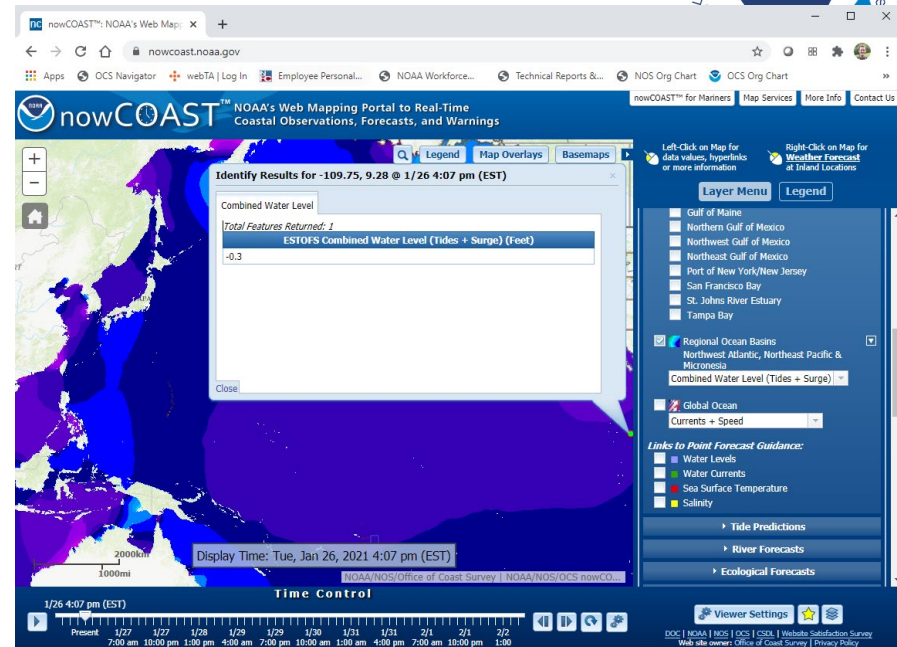
nowcoast.noaa.gov
Screenshot of Global ESTOFS storm surge forecast guidance for Pacific region displaying nowCOAST's map viewer (zoomable)

**We will be providing training workshops for the end user community to learn how to use the model forecast guidance**

Navigation Support: S-104 water levels

- One of our biggest challenges: our coastal ocean models are referenced to MSL. **For charting and navigation, we need to use chart datum, e.g. MLLW or LAT.**

- Global ESTOFS forecast guidance is also being encoded in IHO S-100 formats

- For example, **S-104 water levels relative to chart datum**

- Mariners can use water level forecasts for improved route monitoring
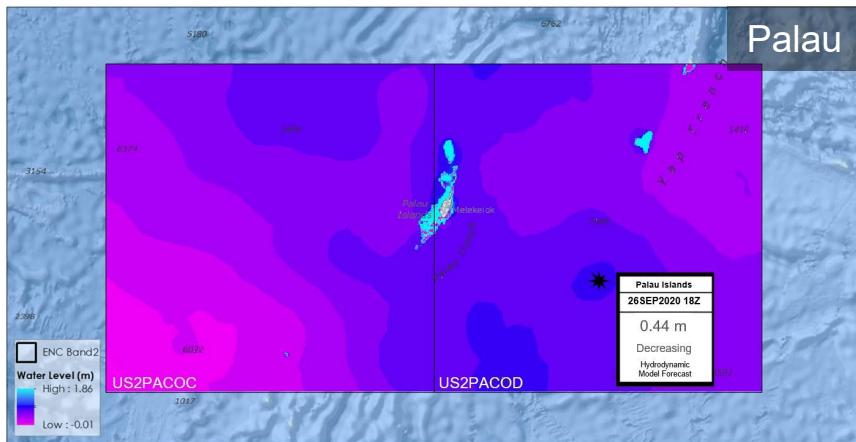

Prototype S-104 water level forecast guidance from Global ESTOFS, produced and displayed on Electronic Navigational Chart (ENC) Band 2 tiles for Palau in the Pacific Ocean.
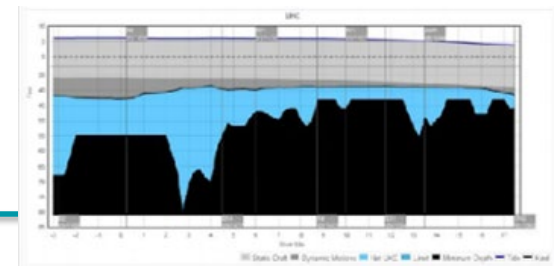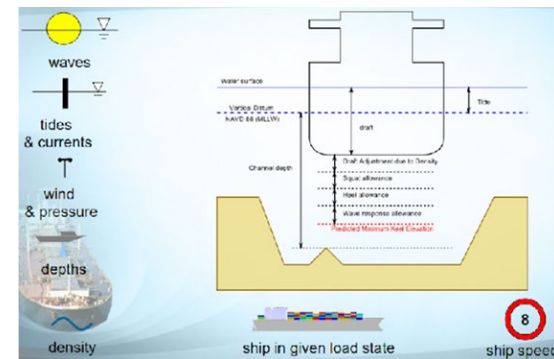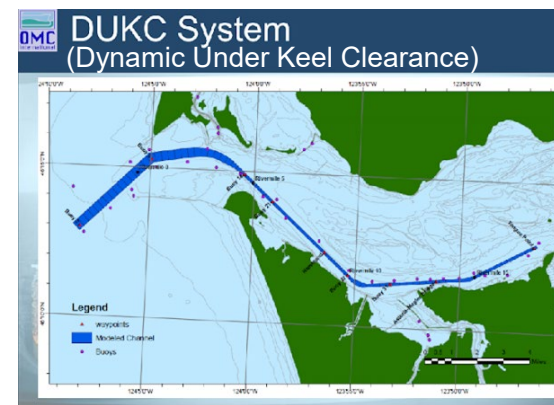
Pacific Enhancement Project

Pacific Ocean enhancements to Global ESTOFS:

- area of high priority for the U.S.
- higher resolution, improved mesh in key areas
- improved bathymetry
- **ocean model enhancements to provide not only water level forecast guidance but also surface currents for navigation**
- **end goal is to support under keel clearance, route planning for key Pacific ports**
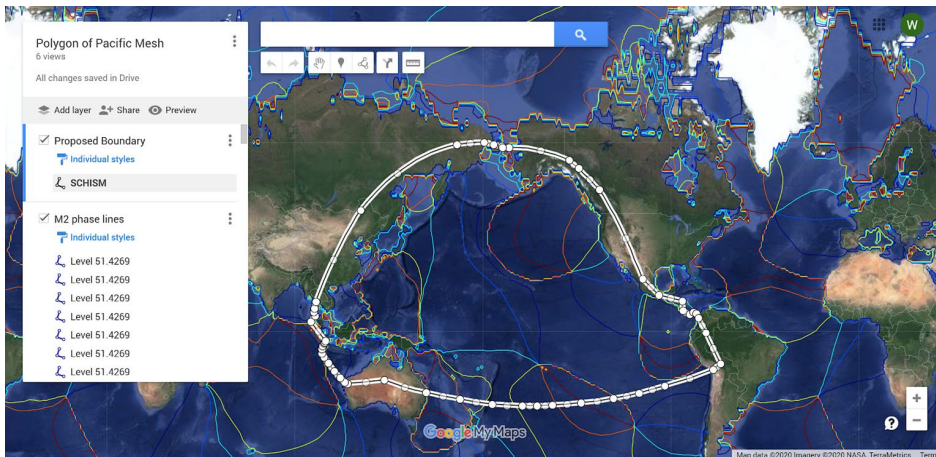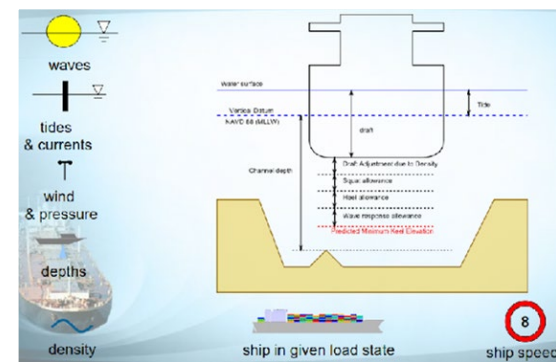
Proposed boundary location for Pacific mesh that will be enhanced

mesh topo-bathy
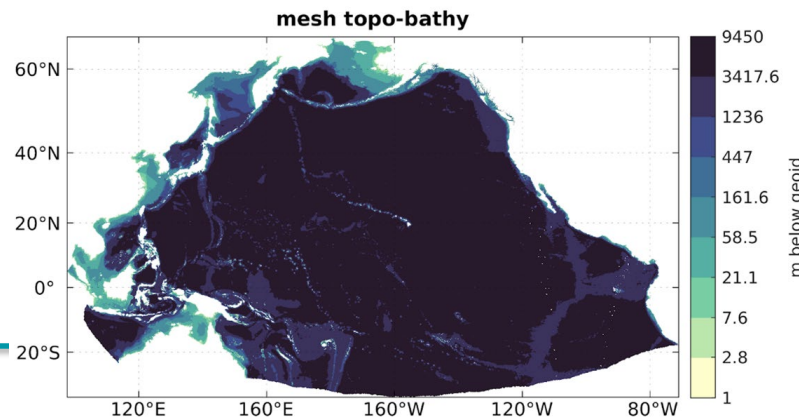
Extract for Pacific topography and bathymetry using boundary location above

Thanks for your attention!

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