NOAA's Global Extratropical Surge and Tide Operational Forecast System (Global ESTOFS)

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NOAA: National Oceanic and Atmospheric Administration;
NOS: National Ocean Service

18th Meeting of the IHO South-West Pacific Hydrographic Commission
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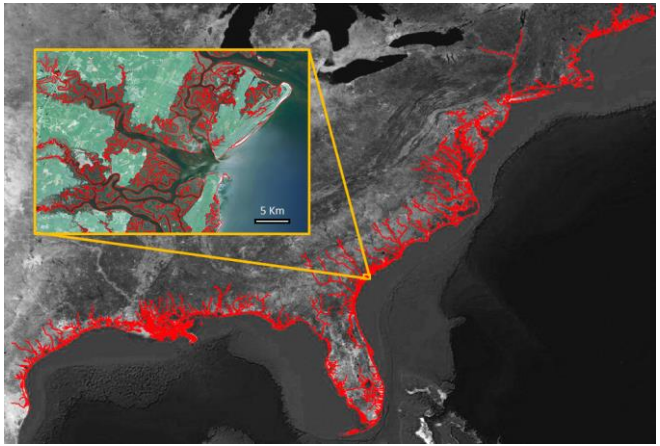
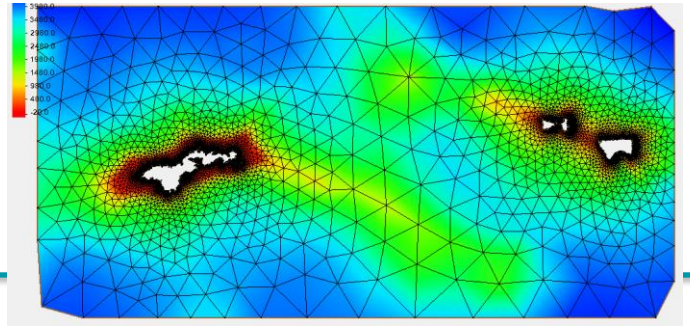
Motivation

1. Flooding from storm surge is a significant risk to coastal cities globally
2. Globalization of maritime commerce drives a need for global navigation solutions
3. **A high resolution, operational, global storm surge model** provides local, official water level forecast guidance across the world for:
   a) Extreme event mitigation, disaster reduction
   b) Marine navigation
4. Support Marine Spatial Data Infrastructure (MSDI)



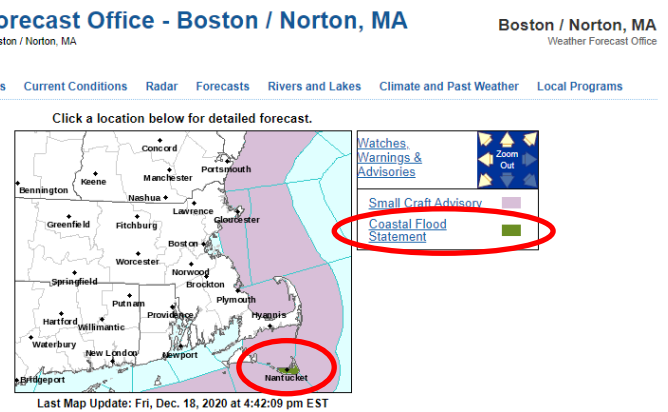
U.S. East Coast



Samoa

End users of a storm surge model

- **Storm surge forecasters**, e.g.
  - NOAA National Weather Service (NWS) Weather Forecast Offices (WFOs) to generate flood forecasts during winter storms
  - NOAA Ocean Prediction Center (OPC) for operational extratropical coastal storm surge forecasts in Marine Weather Discussions
- **Wave forecasters**, e.g.
  - NWS WFOs to generate seas/surf forecasts using NWS's Nearshore Wave Prediction System (storm surge model water levels are an input)
- **Mariners**, e.g.
  - Pilots of ships to navigate into ports safely and efficiently based on tide forecasts



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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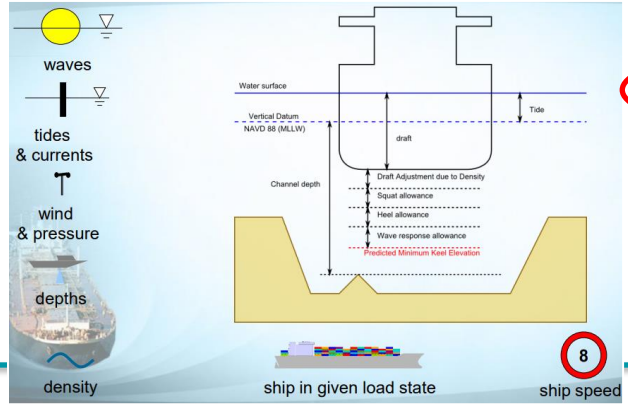
NWS Coastal Flood Statement



Under keel clearance management system

ESTOFS Description

NOAA/NOS' model is, to our knowledge, the highest resolution operational global surge model available today. Coastline resolution is at least 1.5 km, up to 80 m globally.

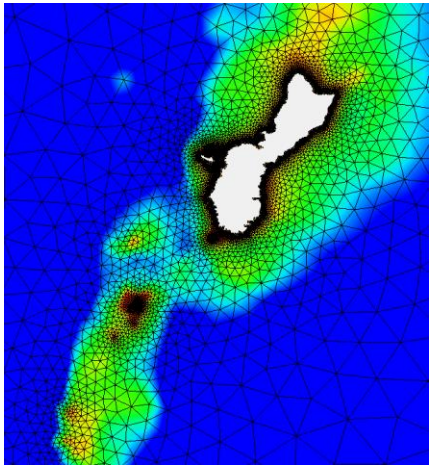
Now, focusing on 1) providing even higher resolution (25 m) in key ports;
2) improving model bathymetry & shoreline

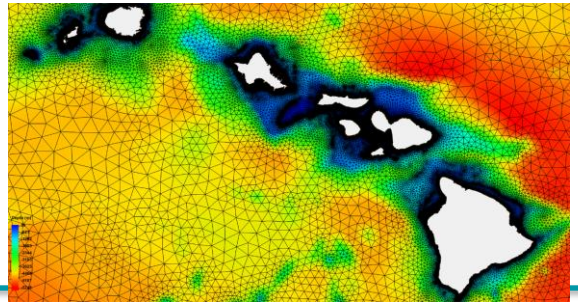
Extratropical Storm Surge & Tide Operational Forecast System (ESTOFS)

- Advanced CIRCulation (ADCIRC) core hydrodynamic model
- Provides 7-day water level forecasts
- Driven by NOAA Global Forecast System (GFS) atmospheric model (10 m winds, mean SLP, sea ice)
- Provides water level forecast guidance: tides, storm surge, and their combination

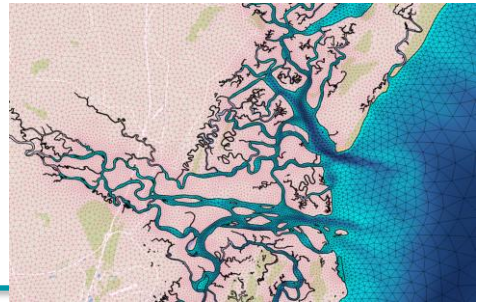
- 4 cycles a day: 00, 06, 12, and 18 UTC

Guam





Hawaii



U.S. East Coast

Previous ESTOFS Coverage

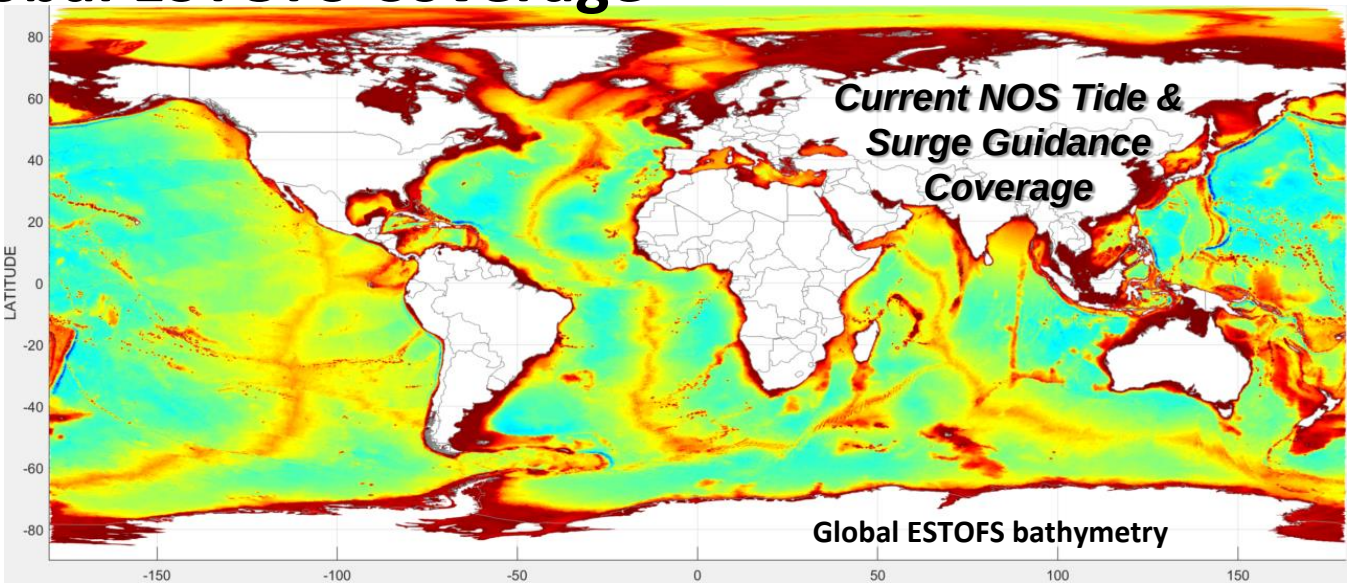
Gaps in Coverage:

- 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



Global ESTOFS mesh
8,063,409 nodes
15,478,900 elements

Point output
558 locations

Implemented 24 Nov 2020

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

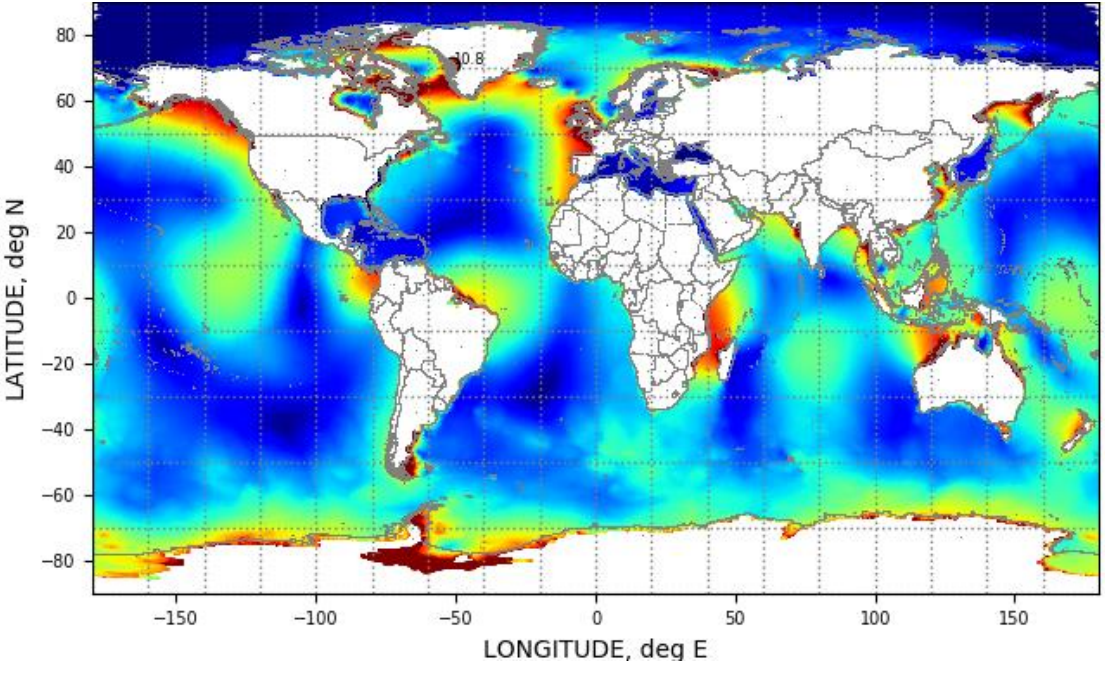
Bias Correction

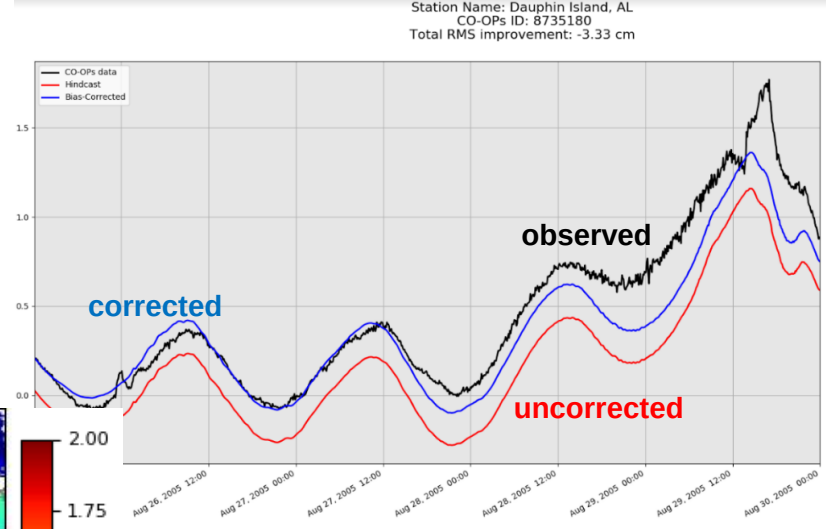
Global ESTOFS Description

Bias Correction Validation

- Correct bias in simulated water levels based on observations

Sample imagery





2005 Katrina water levels at Dauphin Island, AL

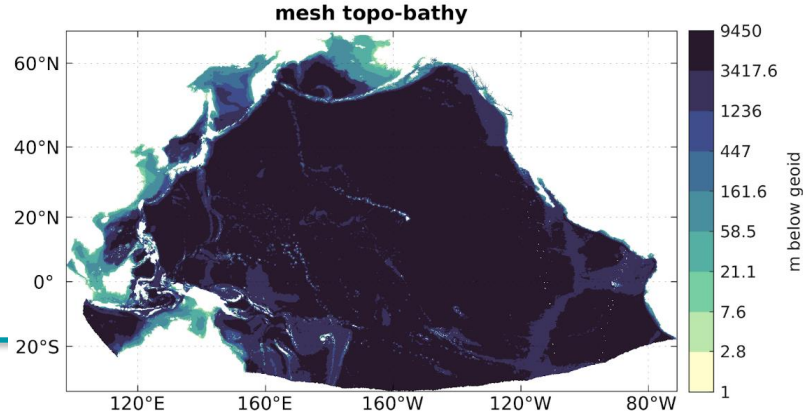
Maximum forecast water levels (m MSL) from a forecast cycle of Global ESTOFS.

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**

Proposed boundary location for Pacific mesh that will be enhanced



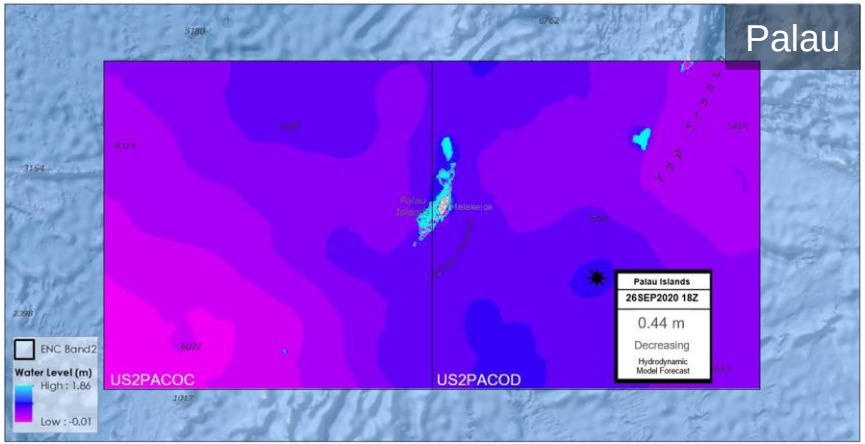
Extract for Pacific topography and bathymetry using boundary location above

Navigation Support: S-104 water levels

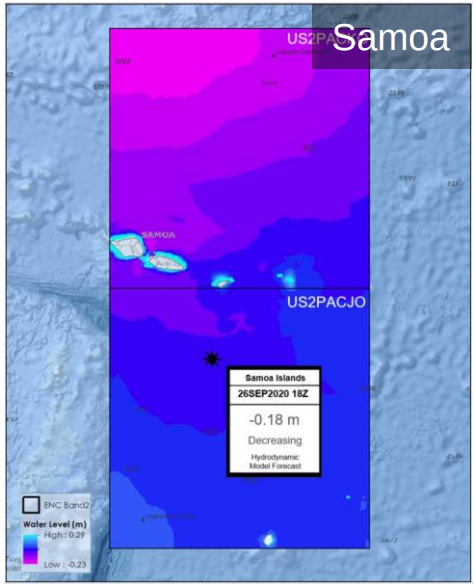
- One of our biggest challenges: our coastal ocean models are referenced to MSL.
  For charting and navigation, we need to use chart datum, e.g. MLLW or LAT.

- Global ESTOFS forecast guidance is being encoded in formats following International Hydrographic Organization's (IHO) S-100 Universal Hydrographic Data framework

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

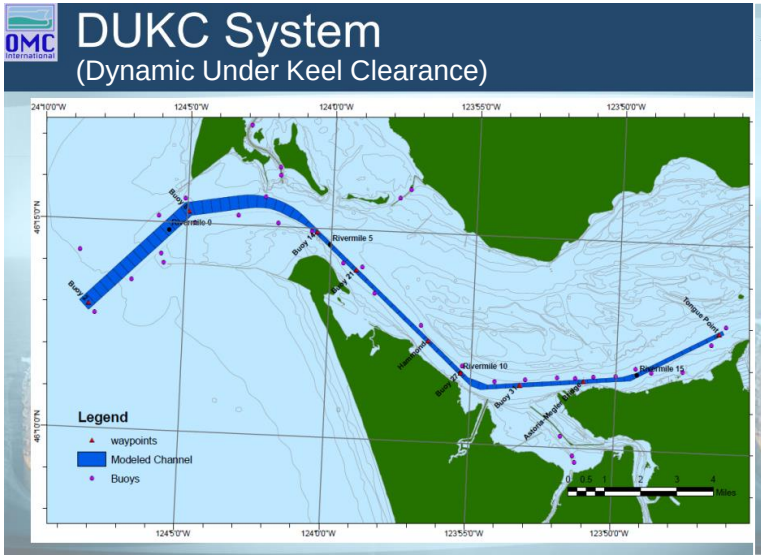


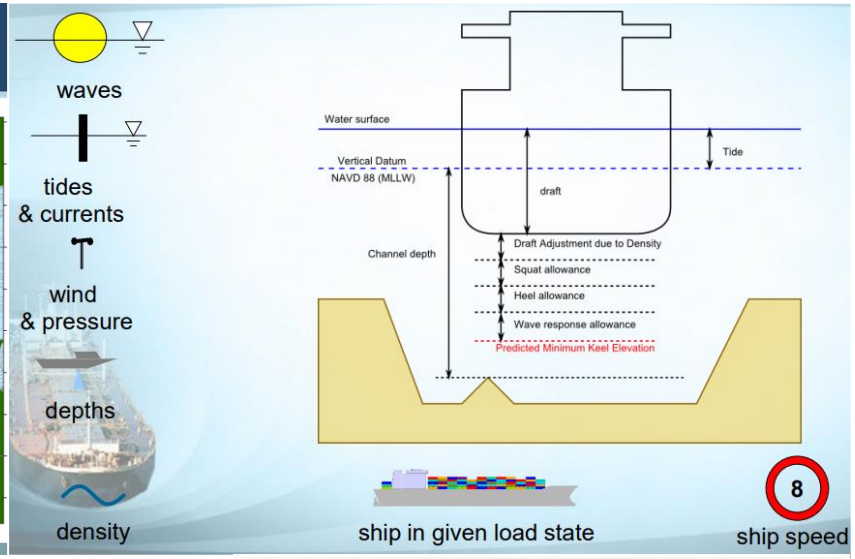
Prototype **S-104 water level forecast guidance from Global ESTOFS, produced and displayed on Electronic Navigational Chart (ENC) Band 2 tiles for Palau in the Pacific Ocean.**



Same as figure to left, but for Samoa in the Pacific Ocean.

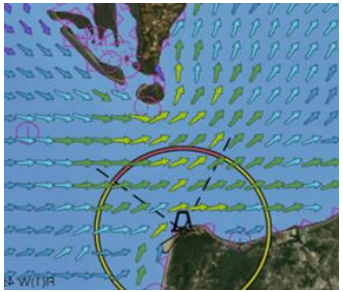
Next generation of surge models

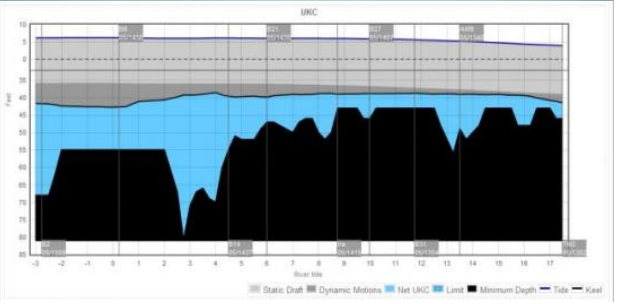




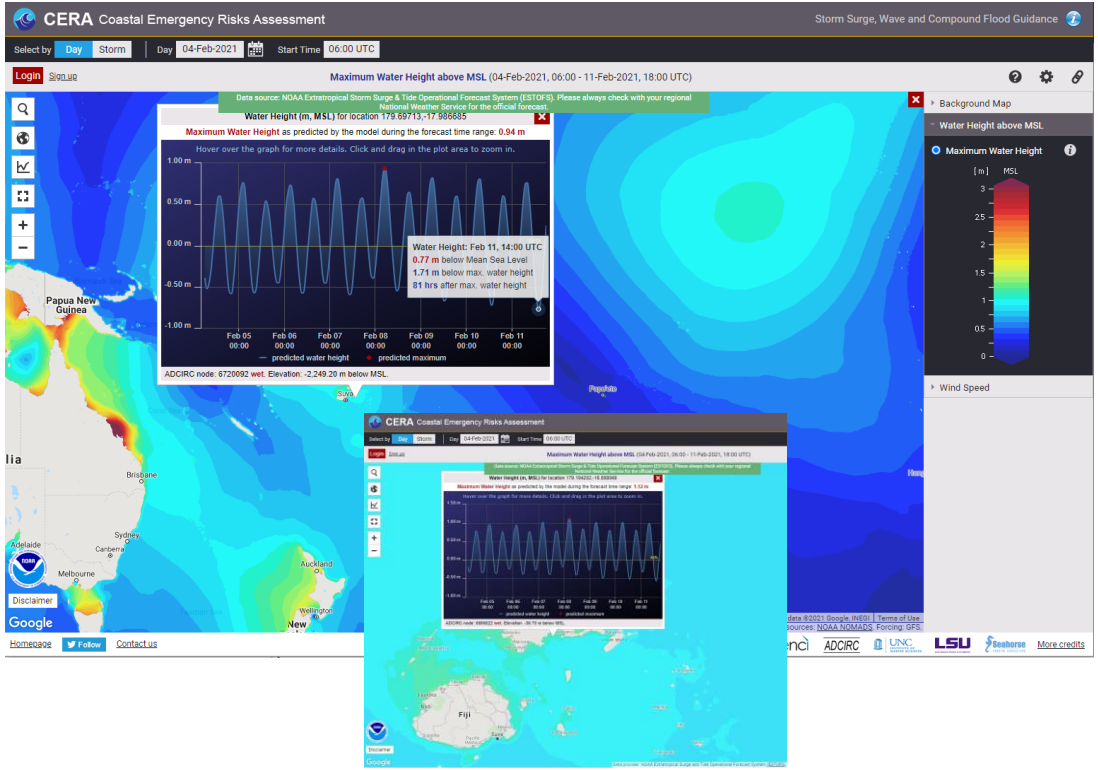
Water levels and currents
support improved:

- route monitoring/berthing
- route planning





How to access Global ESTOFS results



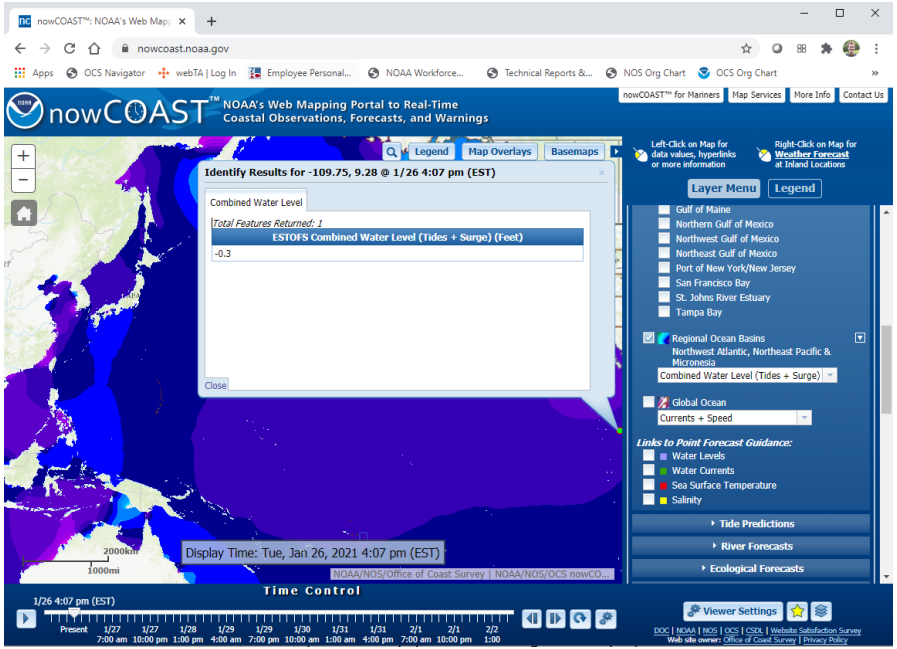
cera.coastalrisk.live

Screenshots of Global ESTOFS storm surge forecast guidance for SW Pacific displayed on CERA's map viewer (zoomable)

registry.opendata.aws/noaa-gestofs

Screenshot of Global ESTOFS output on Amazon cloud (AWS) via NOAA Big Data

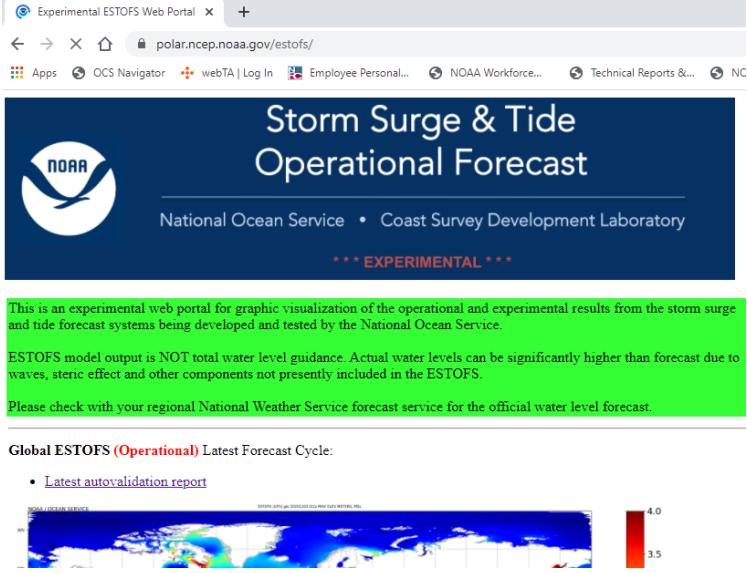
How to access Global ESTOFS results



nowcoast.noaa.gov

Screenshot of Global ESTOFS storm surge forecast guidance for Pacific region displaying nowCOAST's map viewer

****We are more than happy to provide training workshops for the end user community to learn how to use the model forecast guidance**



polar.ncep.noaa.gov/estofs/

Screenshot of experimental ESTOFS landing page

Other options:

National Weather Service (NWS) Ocean Prediction Center: https://ocean.weather.gov/estofs/estofs_surge_info.php

NWS NOMADS: https://nomads.ncep.noaa.gov/

Thanks for your attention!