

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

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Team:

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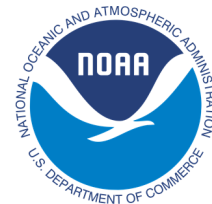
1 NOAA/NOS/Office of Coast Survey; 2 University of Notre Dame; 3 Columbia River Inter-Tribal Fish Commission; 4 Virginia Institute of Marine Science

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

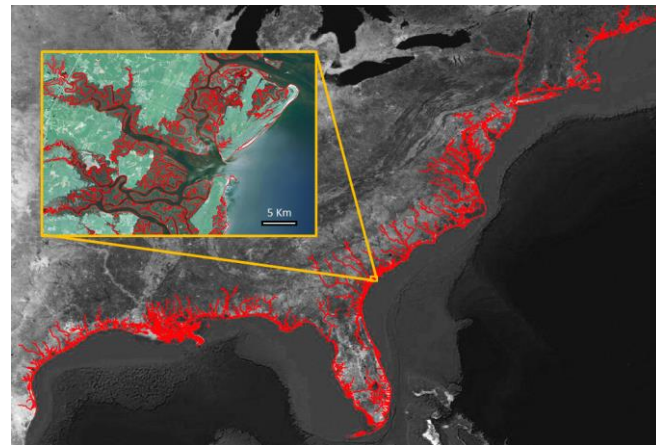


*18th Meeting of the IHO South-West Pacific Hydrographic Commission
February 17-19, 2021*

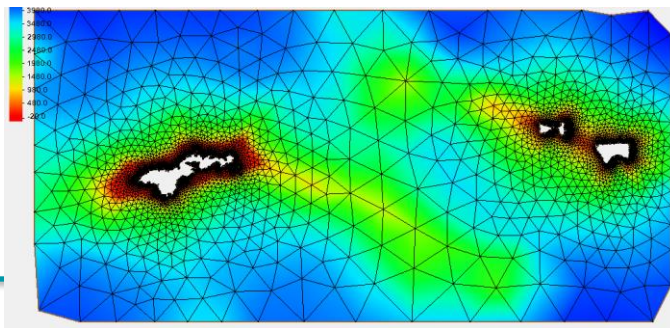
Motivation



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.**

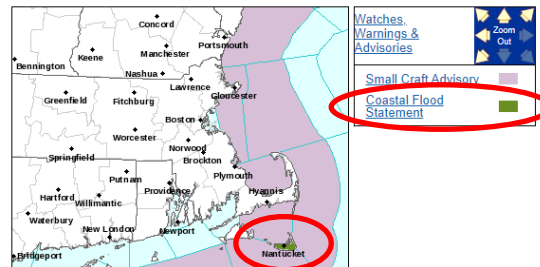
- NWS WFOs to generate seas/surf forecasts using NWS's Nearshore Wave Prediction System (storm surge model water levels are an input)

- **Mariners, e.g.**

- Pilots of ships to navigate into ports safely and efficiently based on tide forecasts



Click a location below for detailed forecast.



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



Coastal Flood Statement

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.

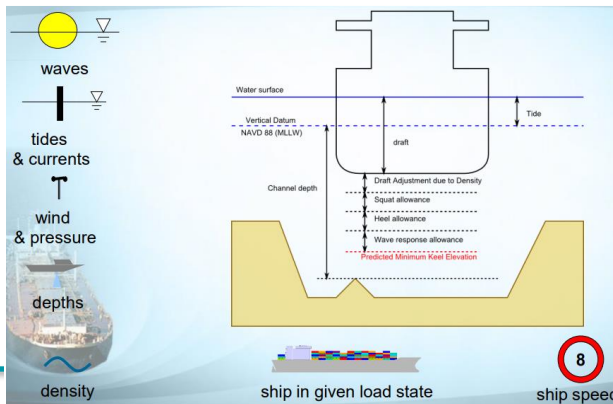
* WHEN...Until 5 PM EST this afternoon.

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

PRECAUTIONARY/PREPAREDNESS ACTIONS...

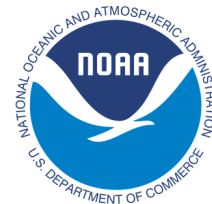
Do not drive through flooded roadways.

NWS Coastal Flood Statement



Under keel clearance management system

ESTOFS Description



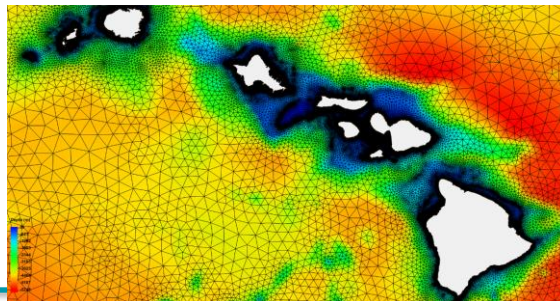
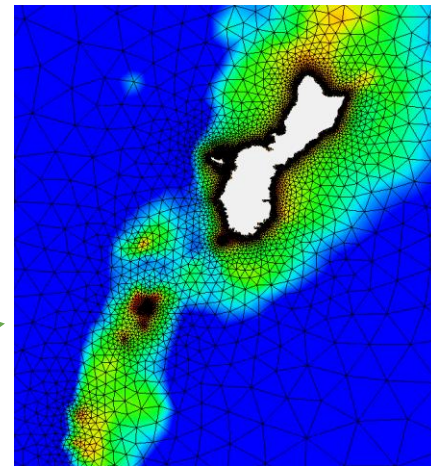
NOAA/NOS' model is, to our knowledge, the highest resolution operational global surge model available today. Coastline resolution is **at least 1.5 km, up to 80 m** globally.

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

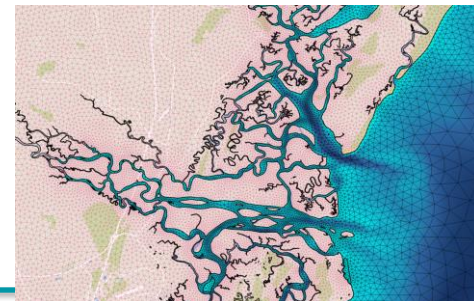
Extratropical Storm Surge & Tide Operational Forecast System (ESTOFS)

- 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 →

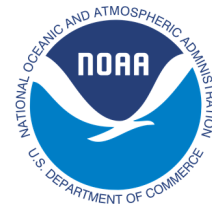


Hawaii



U.S. East Coast

Previous ESTOFS Coverage



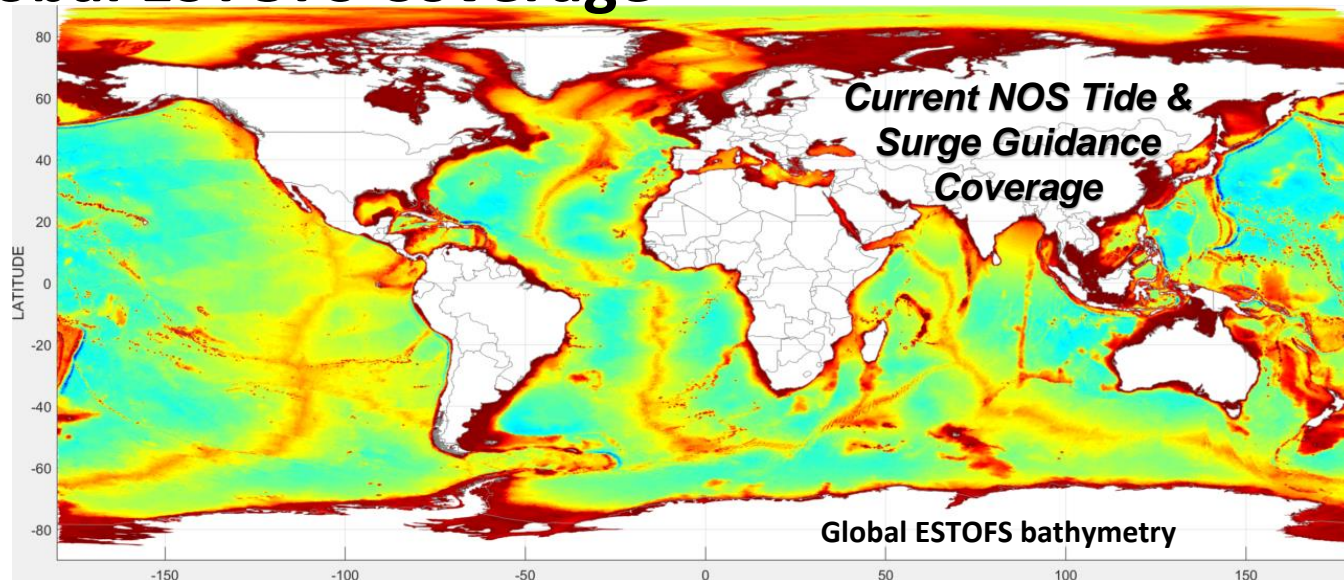
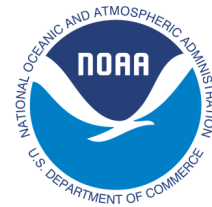
Gaps in Coverage:

- 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

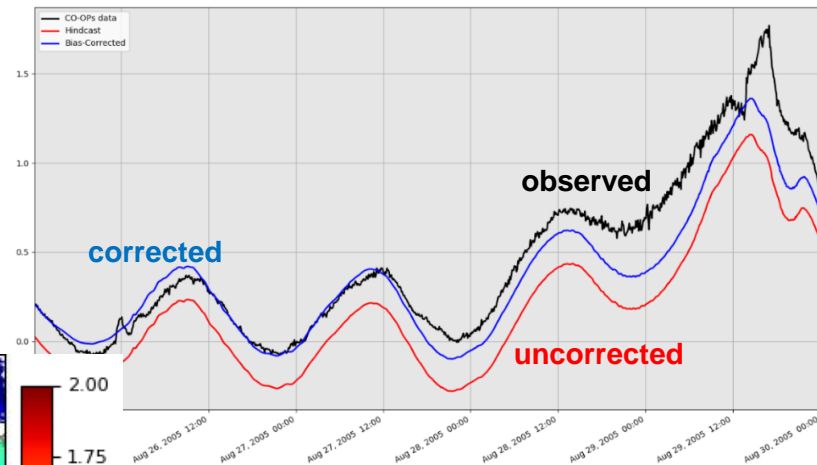
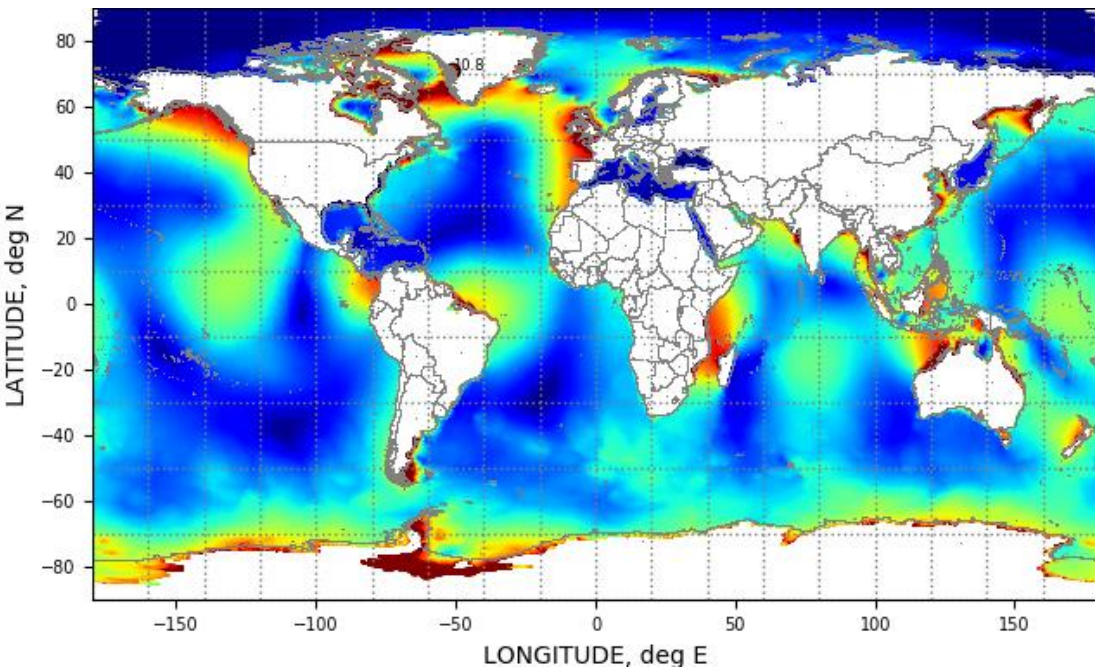
Global ESTOFS Description

Bias Correction Validation

- Correct bias in simulated water levels based on observations



Sample imagery

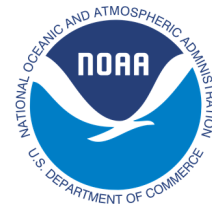


2005 Katrina water levels at
Dauphin Island, AL

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

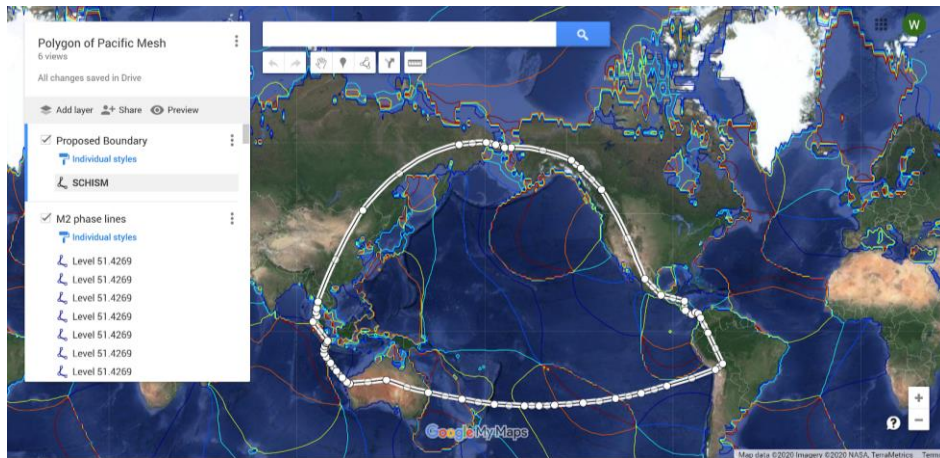
Station Name: Dauphin Island, AL
CO-OPs ID: 8735180
Total RMS improvement: -3.33 cm

Pacific Enhancement Project

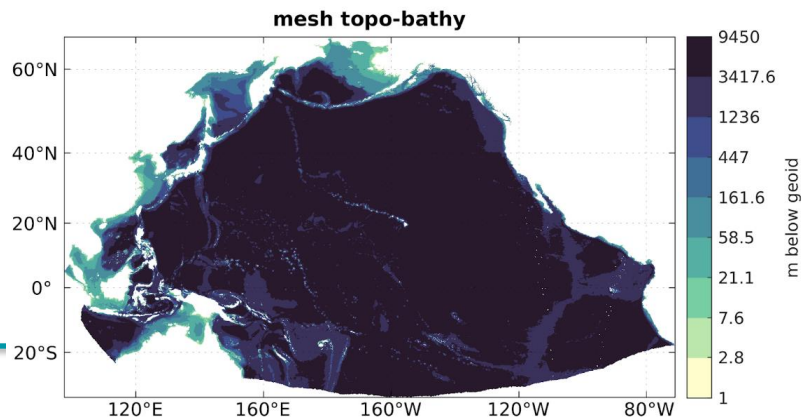


Pacific Ocean enhancements to Global ESTOFS:

- 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**

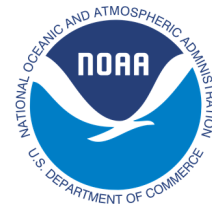


Proposed boundary location for Pacific mesh that will be enhanced

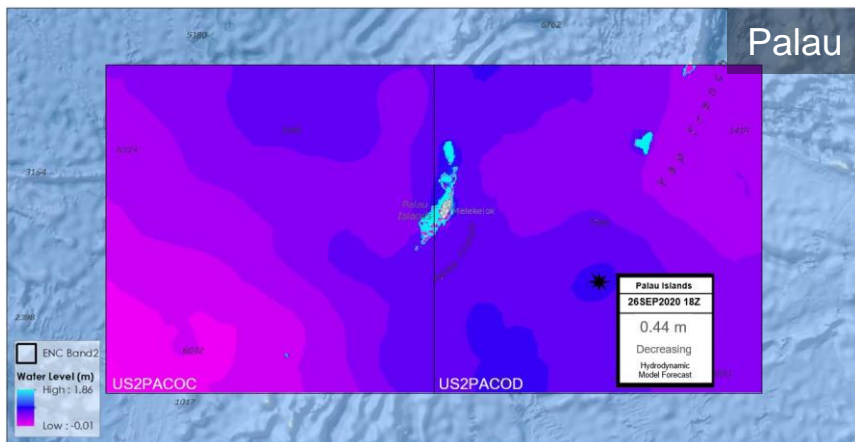


Extract for Pacific topography and bathymetry
using boundary location above

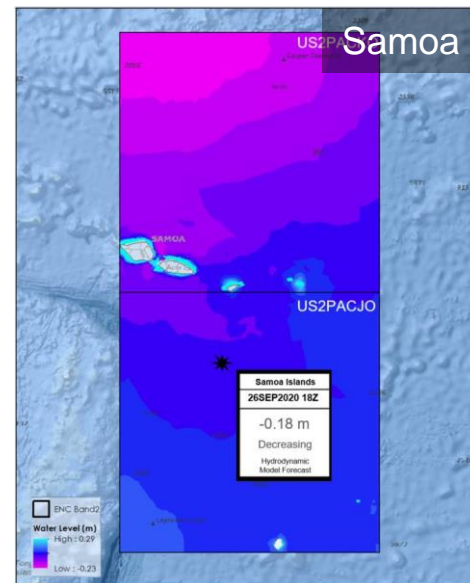
Navigation Support: S-104 water levels



- 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**

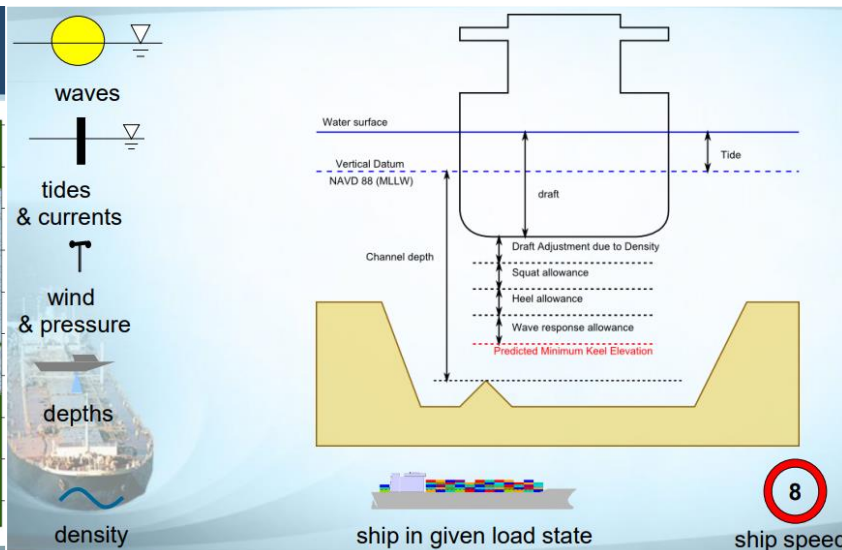
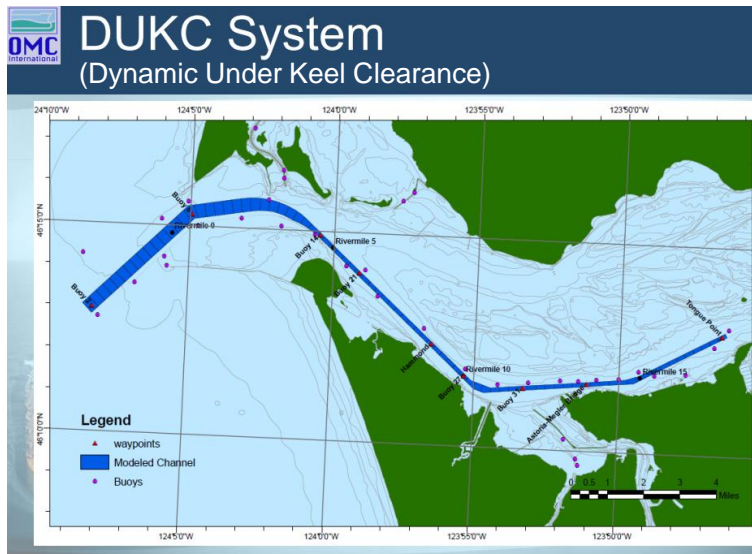


Prototype S-104 water level forecast guidance from Global ESTOFS, produced and displayed on Electronic Navigational Chart (ENC) Band 2 tiles for Palau in the Pacific Ocean.



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

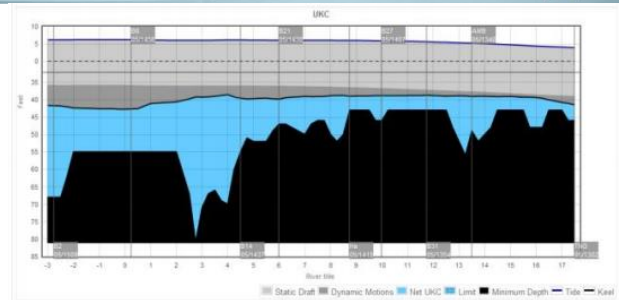
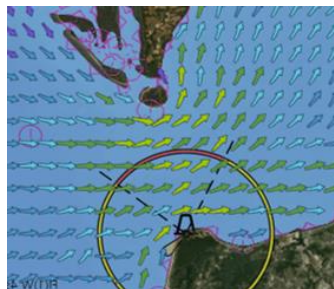
Next generation of surge models



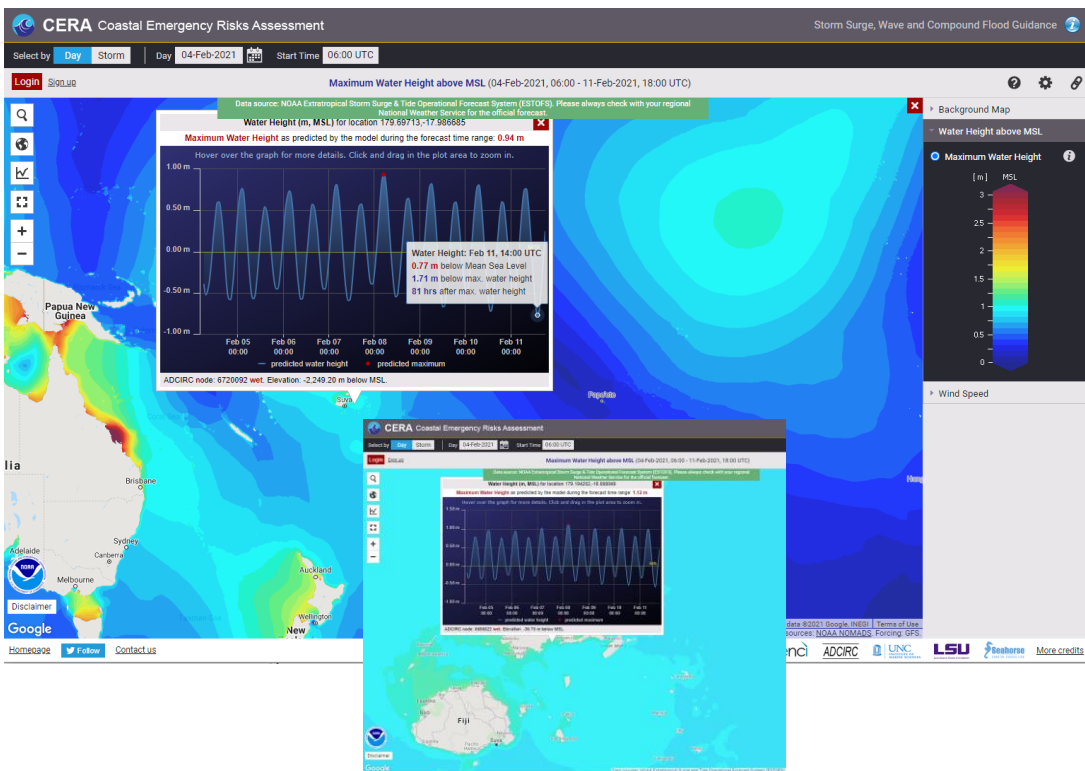
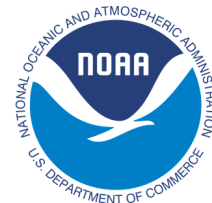
Water levels and currents

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 of Open Data on AWS

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

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Description

NOAA's Global Extratropical Surge and Tide Operational Forecast System (Global ESTOFS) provides users with nowcasts (analyses of near present conditions) and forecast guidance of water level conditions for the entire globe. Global ESTOFS has been developed to serve the marine navigation, weather forecasting, and disaster mitigation user communities. Global ESTOFS was developed in a collaborative effort between the NOAA/National Ocean Service (NOS)/Office of Coast Survey, the NOAA/National Weather Service (NWS)/National Centers for Environmental Prediction (NCEP) Central Operations (NCO), the University of Notre Dame, the University of North Carolina, and The Water Institute of the Gulf. The model generates forecasts out to 180 hours four times per day; forecast output includes water levels caused by the combined effects of storm surge and tides, by astronomical tides alone, and by sub-tidal water levels (isolated storm surge).

The hydrodynamic model employed by Global ESTOFS is the Advanced CIRCulation (ADCIRC) finite element model. The model is forced by GF's winds, mean sea level pressure, and sea ice. The unstructured grid used by Global ESTOFS consists of 8,063,409 nodes and 15,478,900 triangular elements. Coastal resolution is up to 80 m for Hawaii and the U.S. West Coast; up to 90-120 m for the Pacific Islands including Guam, American Samoa, Marianas, Wake Island, Marshall Islands, and Palau; and up to 120 m for the U.S. East Coast, Puerto Rico, Micronesia, and Alaska. The flood plain extends overlaid to approximately 6 m elevation ASL for the U.S. East Coast, and up to 20 m elevation ASL for the Pacific Islands. Global ESTOFS a) reduces bias and errors due to the removal of the open ocean boundaries that were included in previous ESTOFS regional domains (ESTOFS-Atlantic, -Pacific, -Micronesia); b) includes internal tide-induced dissipation in the deep ocean; c) includes sea ice effect on wind drag; and d) incorporates a bias correction using 2-day average water level observations from CO-OPS tide stations that are interpolated spatially across the Global ESTOFS mesh.

Resources on AWS

Description

NOAA Global ESTOFS Water Level Forecast Guidance

Resource type

S3 Bucket

Amazon Resource Name (ARN)

`arn:aws:s3:::noaa-gestofs-pds`

AWS Region

us-east-1

AWS CLI Access (No AWS account required)

`aws s3 ls s3://noaa-gestofs-pds/ --no-sign-request`

Explore

[Browse Bucket](#)

Description

NOAA Global ESTOFS Water Level Forecast Guidance New Dataset

Notification

Resource type

SNS Topic

Amazon Resource Name (ARN)

`arn:aws:sns:us-east-1:123981341784:hwdeSTOFS00ject`

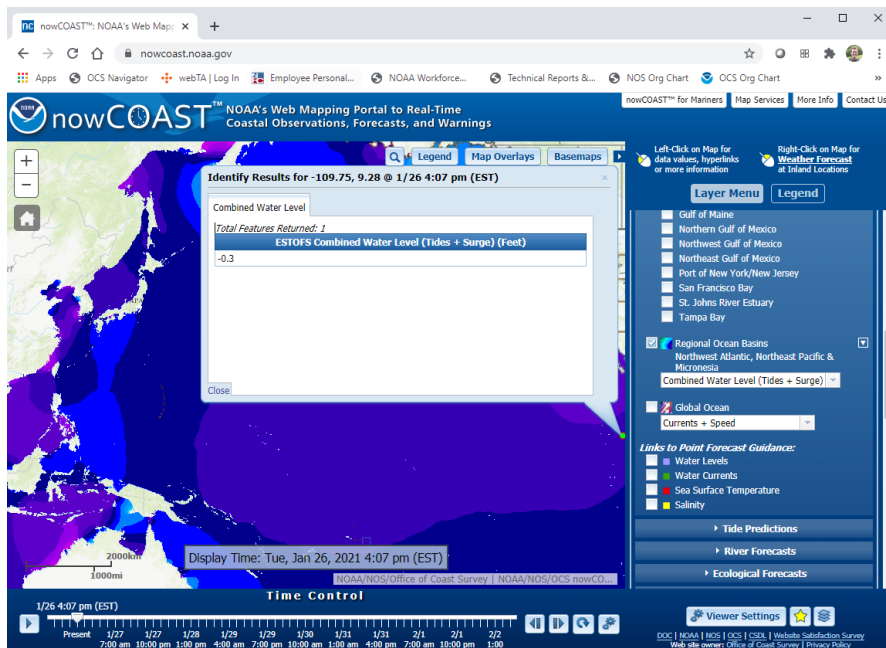
AWS Region

us-east-1

registry.opendata.aws/noaa-gestofs

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

How to access Global ESTOFS results

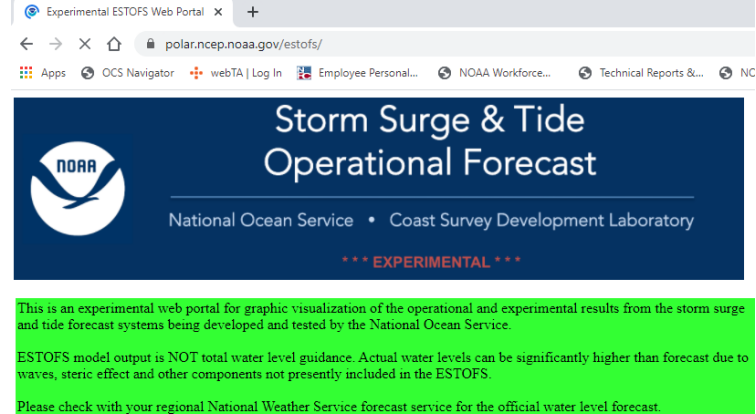


nowcoast.noaa.gov

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

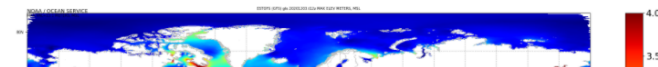
****We are more than happy to provide training workshops for the end user community to learn how to use the model forecast guidance**

NOAA/NOS' Office of Coast Survey



Global ESTOFS (Operational) Latest Forecast Cycle:

- [Latest autovalidation report](#)



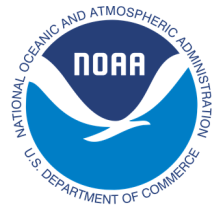
polar.ncep.noaa.gov/estofs/

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!