



Building an improved operational coupled wave/current forecast at the Columbia River Mouth

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Oregon State University



In partnership with



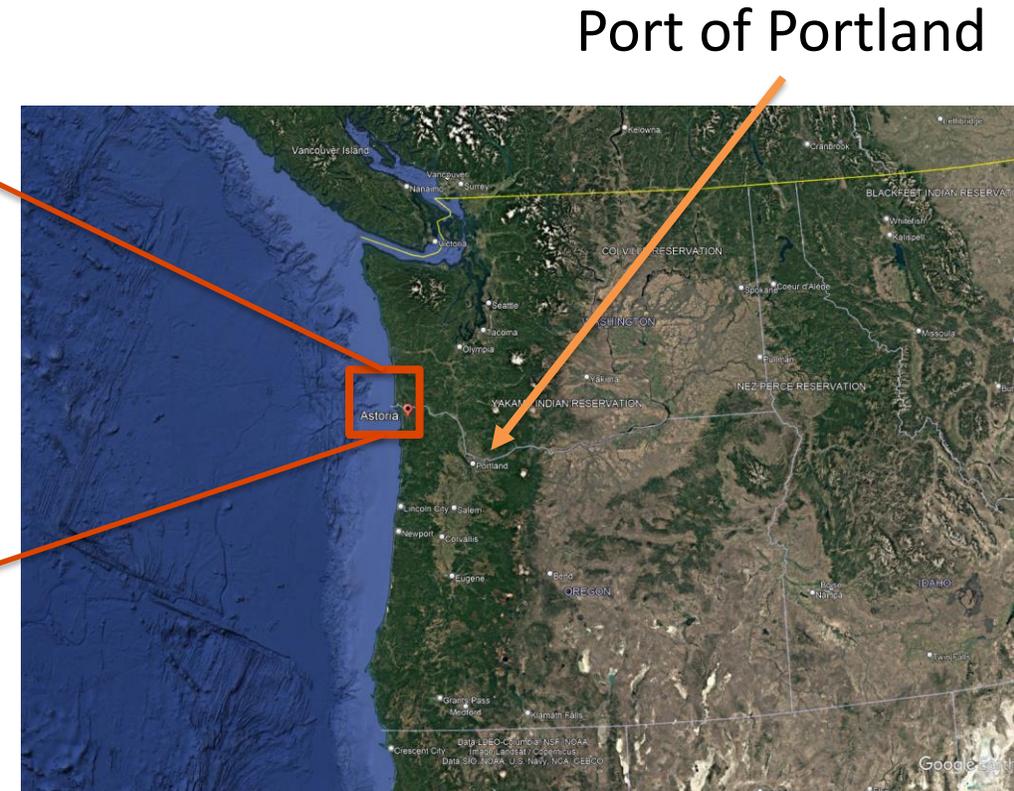
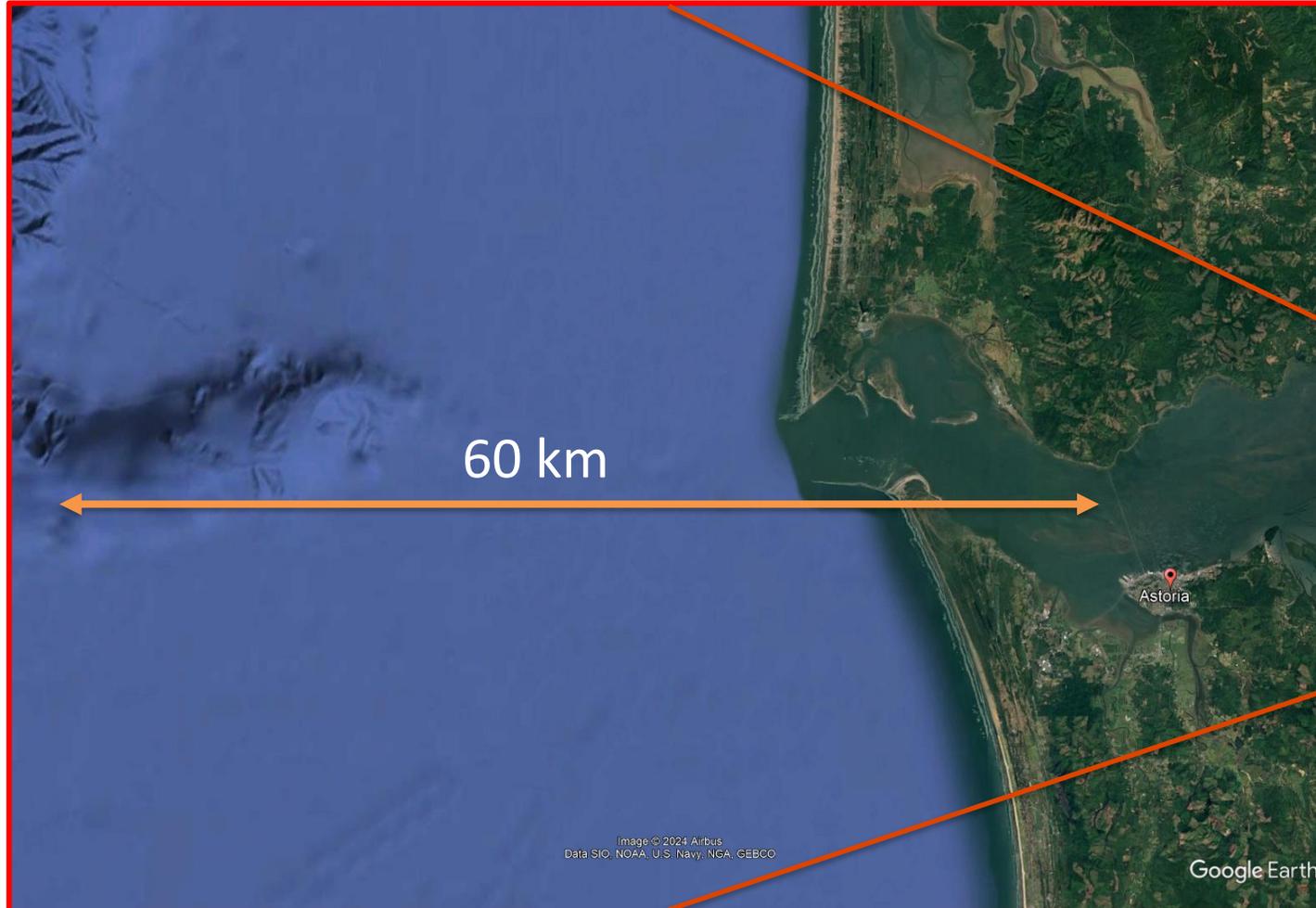
2021 United Nations Decade
2030 of Ocean Science
for Sustainable Development



Mouth of the Columbia River



Oregon State University
College of Engineering



Mouth of the Columbia River



Tidal velocities: 2 m/s flood
3 m/s ebb

Waves: 1.5 m / 8 sec (Summer avg)
3 m / 12 sec (Winter avg)

Columbia River Bar Pilots



Main Office: 503-325-2643 | Dispatch: 503-325-2641 [Red Box] [November 12, 2024 - Bar Status Details >](#)



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In 2021, over 65 million cargo tons traversed the Columbia River mouth amounting to ~\$27 billion in goods.



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Bar Status

The Columbia River Bar is opened and closed to navigation at the discretion of the United States Coast Guard. The Columbia River Bar Pilots provide their status for providing pilotage services as a courtesy based on existing or anticipated weather conditions. This status may be inaccurate if conditions change rapidly or unexpectedly.

Bar Status Signals

- **GREEN:** Normal operations. No delays anticipated.
- **YELLOW:** Some inbound or outbound delays can be expected.
- **RED:** No, or very limited, inbound or outbound traffic.

The information above is also available on the [Merchants Exchange web site](#).



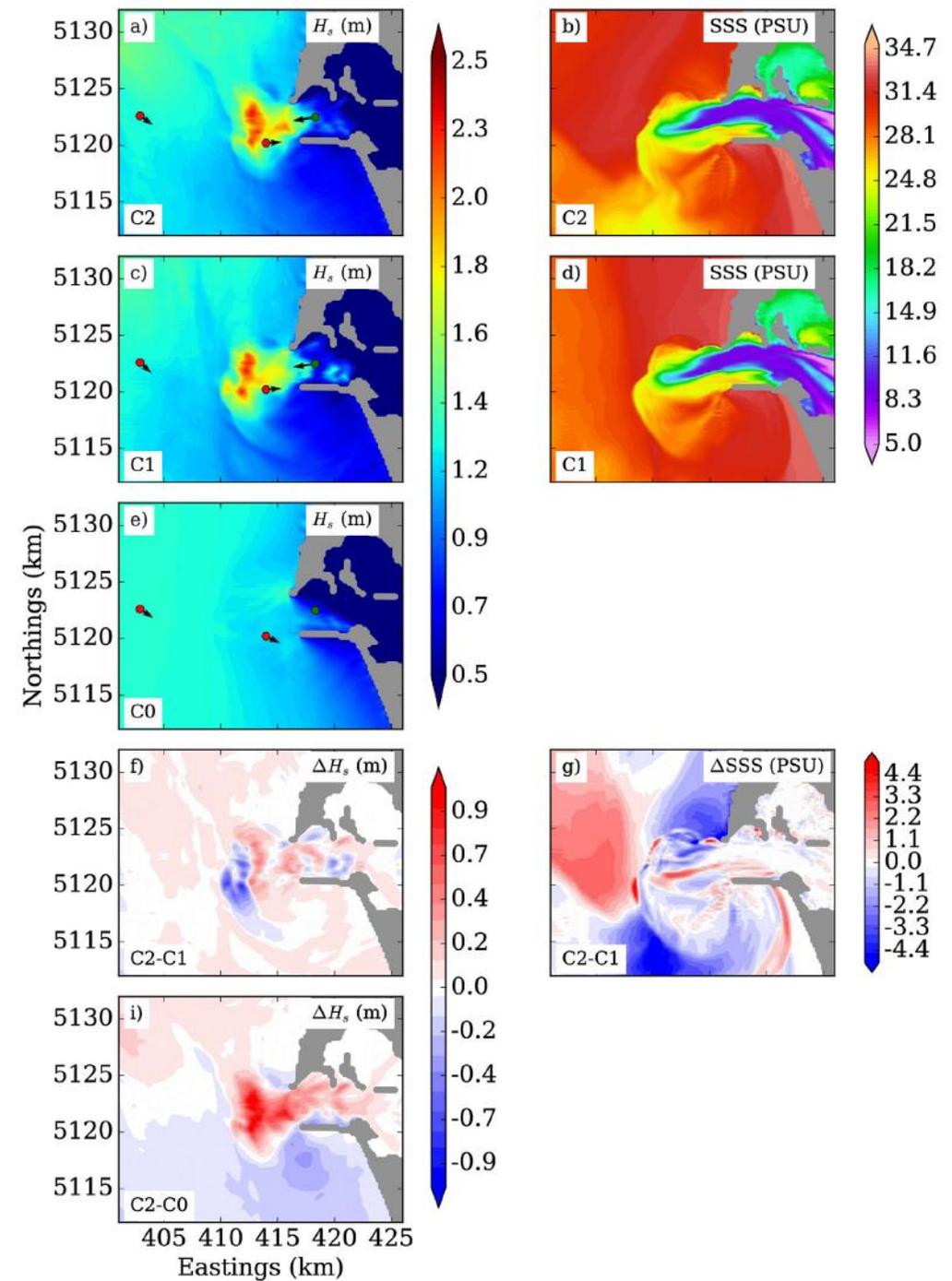
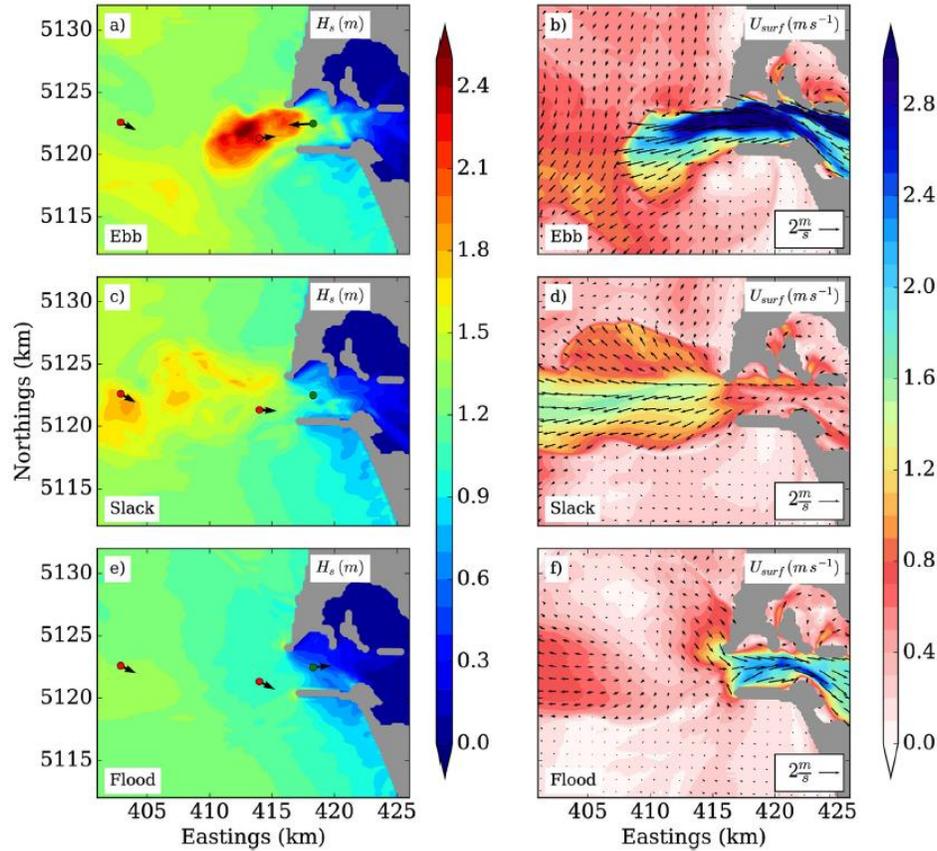
November 12, 2024

Tonight's front is forecasted to be stronger than hoped with seas in the morning up to 25 ft and winds gusting to to 55 kts. At this stage, ship transits will be delayed until late afternoon.



Previous Work

Coupled
ROMS-SWAN



Journal of Geophysical Research: Oceans

RESEARCH ARTICLE
10.1002/2016JC012307

On the dynamics of the Mouth of the Columbia River: Results from a three-dimensional fully coupled wave-current interaction model

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JGR-Oceans, 2017

Previous Work

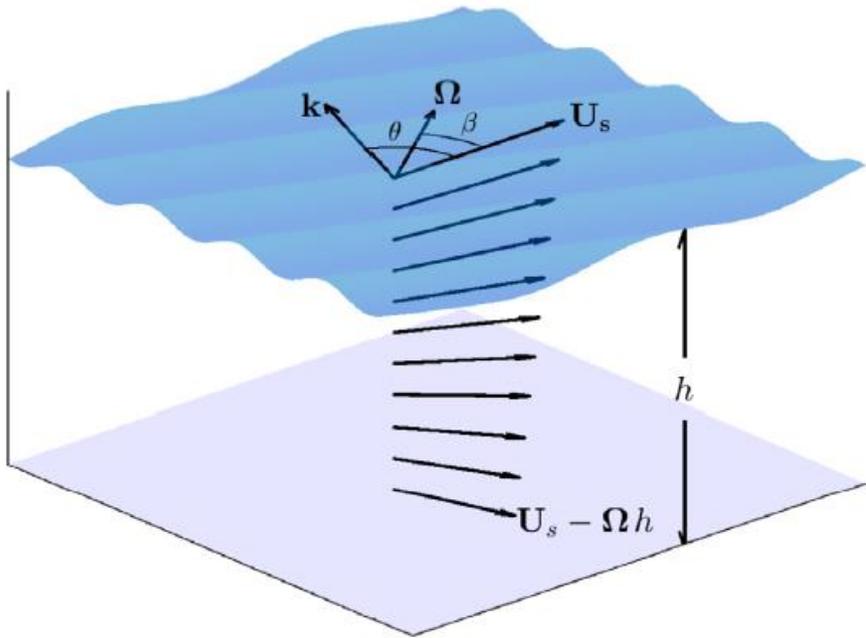


Fig. 1. Definition sketch for linear shear current. The angle between the surface velocity and wave direction is θ while the angle between the surface current and current vertical shear is β .

Ocean Modelling 143 (2019) 101460

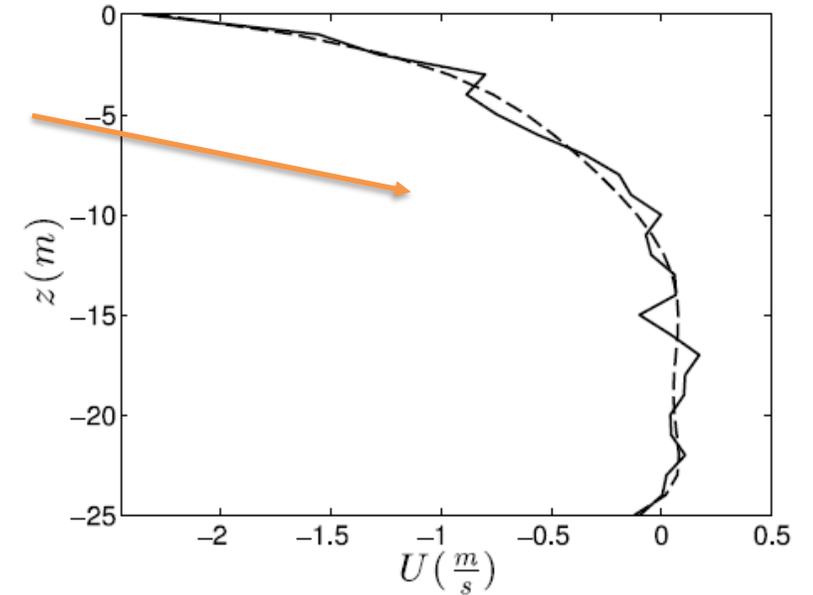
Contents lists available at ScienceDirect

Ocean Modelling

journal homepage: www.elsevier.com/locate/ocemod



Vertical profile of
Columbia River ebb
current



$$\mathcal{N}_{,t} + \nabla_h \cdot \mathcal{F} = 0 \quad (1)$$

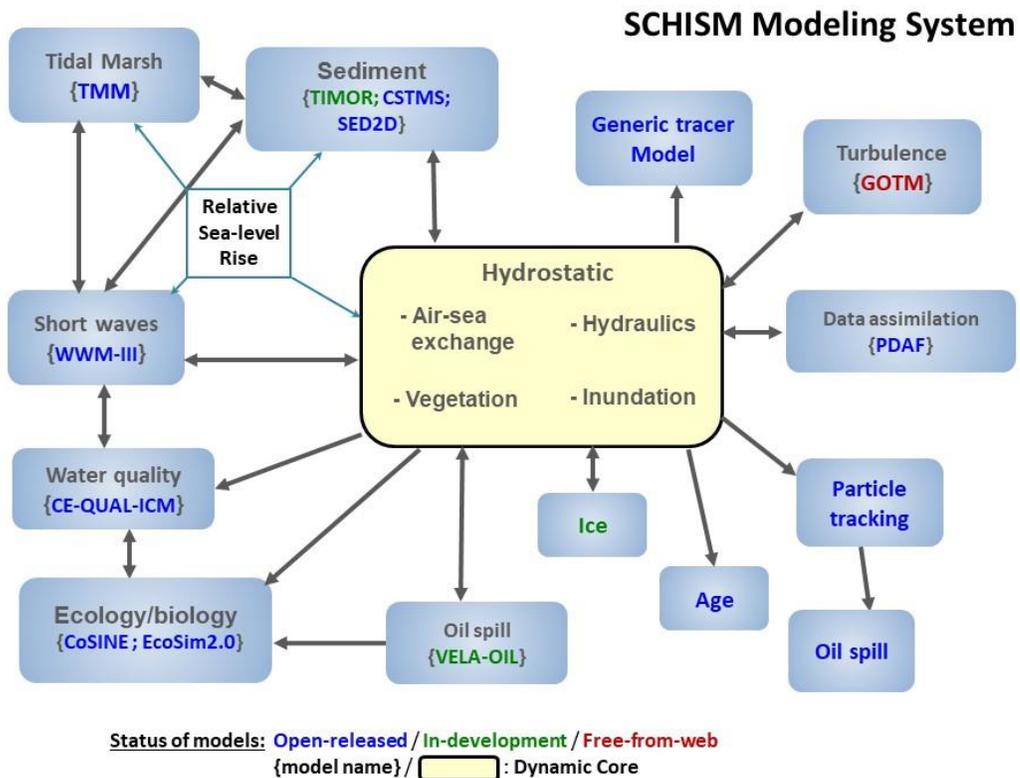
$$\mathcal{N}_{,t} + \nabla_h \cdot (\mathcal{N} \mathbf{c}_{ga}) + (c_\sigma \mathcal{N})_{,\sigma} + (c_\theta \mathcal{N})_{,\theta} = \frac{S}{\sigma} \quad (2)$$

$$\tilde{\mathcal{N}} = \frac{E_0}{\tilde{\sigma}} + O(\epsilon^2) \quad (21)$$

$$\tilde{\mathcal{F}} = \frac{E_0}{\tilde{\sigma}} \left[\hat{\mathbf{U}} + \tilde{\mathbf{c}}_{gr} \right] + O(\epsilon^2) \quad (23)$$



Existing Ocean Current Forecasting Models



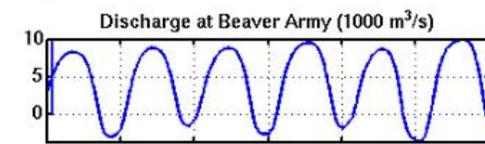
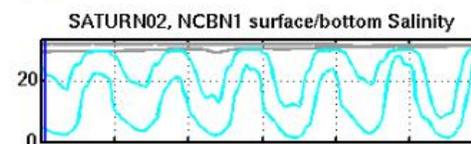
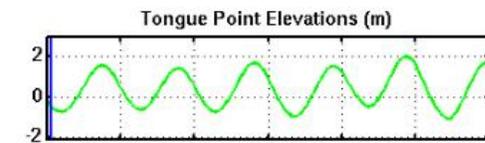
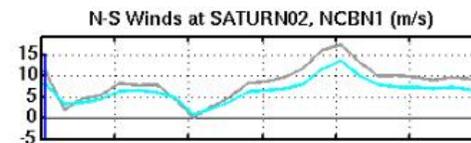
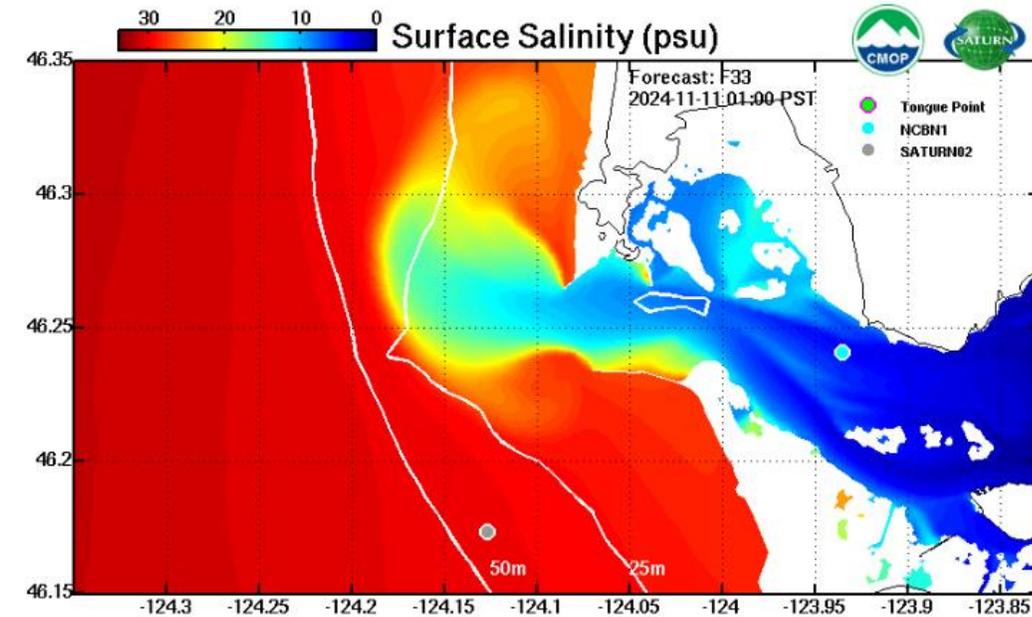
SCHISM modeling system (<https://ccrm.vims.edu/schismweb/>).

Home » Data » Virtual Columbia River » Forecasts » Forecast Products

Image Animator

“Virtual Columbia River”

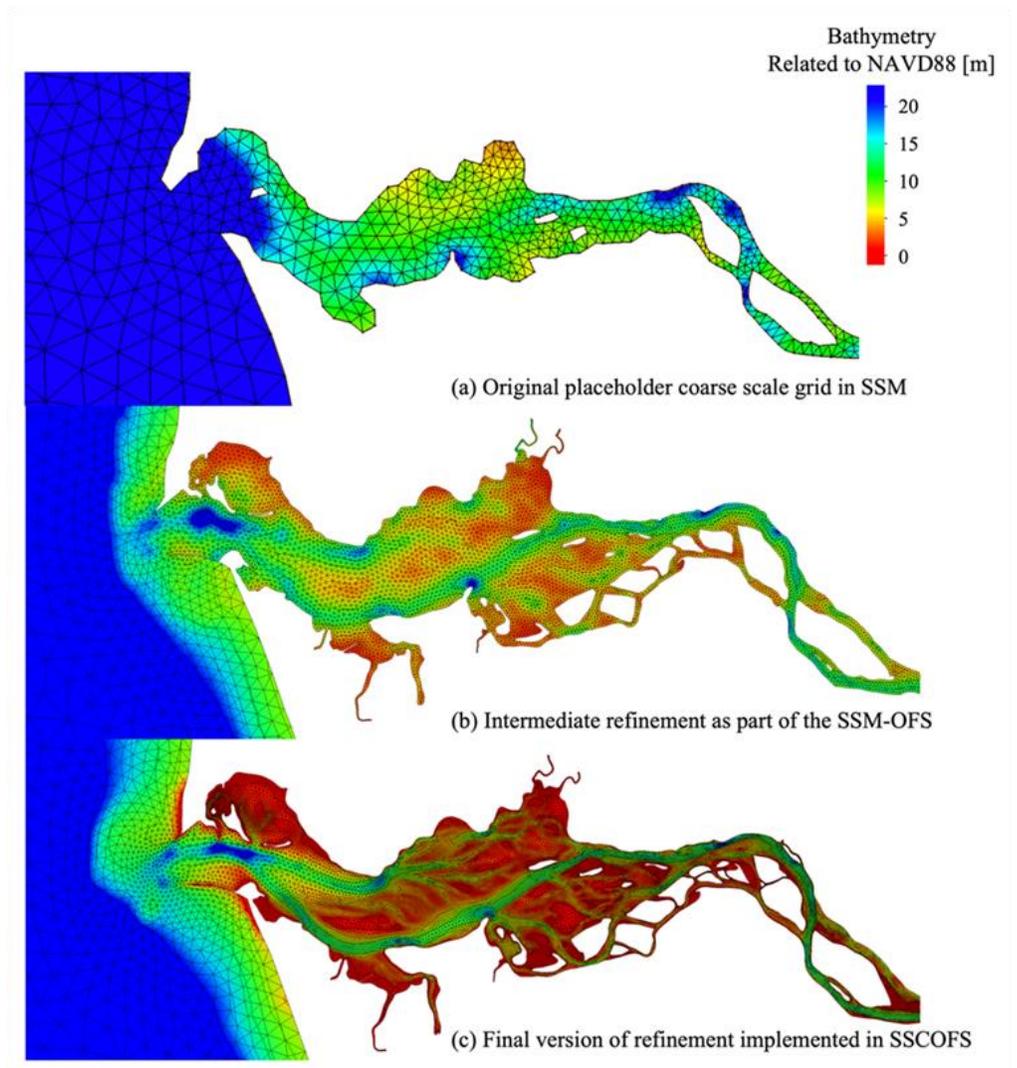
Image size: Extra-large



Days

Salish Sea and Columbia River Operational Forecast System (SSCOFS)

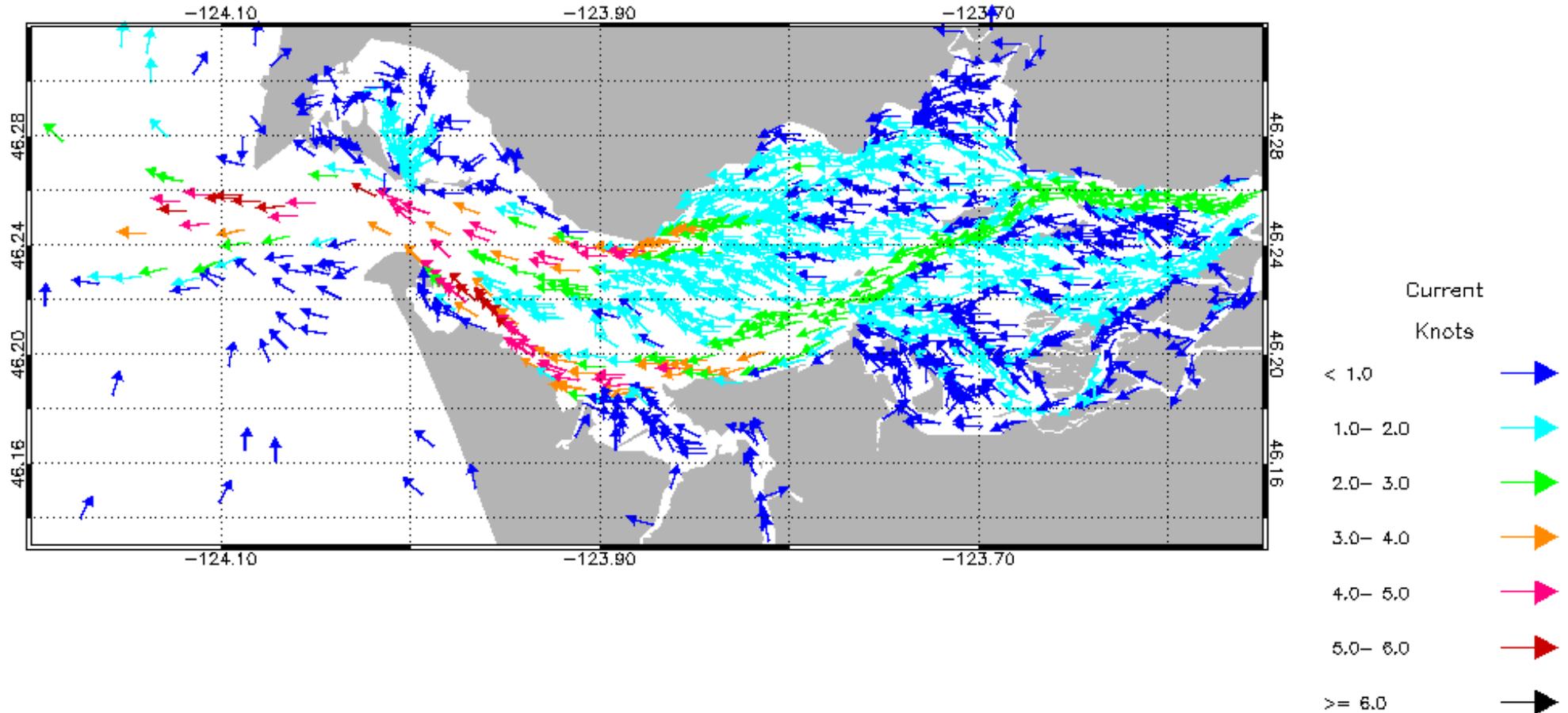
- The Salish Sea faces increasing ship traffic and wastewater discharges from major cities, raising environmental concerns.
- NOAA/NOS developed SSCOFS, including the Columbia River domain based on the unstructured grid finite volume formulation (FVCOM).
- 100-500 m resolution nearshore



Columbia River estuary region of the Salish Sea Model:
(a) Original placeholder coarse scale grid in SSM;
(b) Intermediate refinement as part of the SSM-OFS;
(c) Final version of refinement implemented in SSCOFS model
(https://comt.ioos.us/projects/salish_sea).

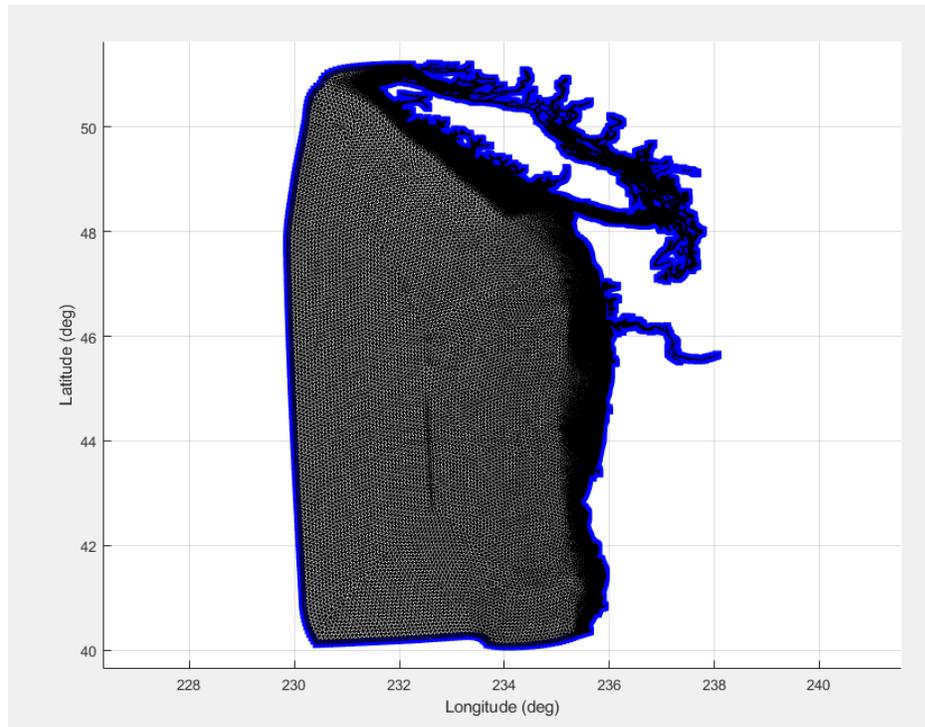
Existing Ocean Current Forecasting Models

NOAA is monitoring water levels and winds for Tropical Storm Man Yi. Click to view real-time water level and meteorological data.

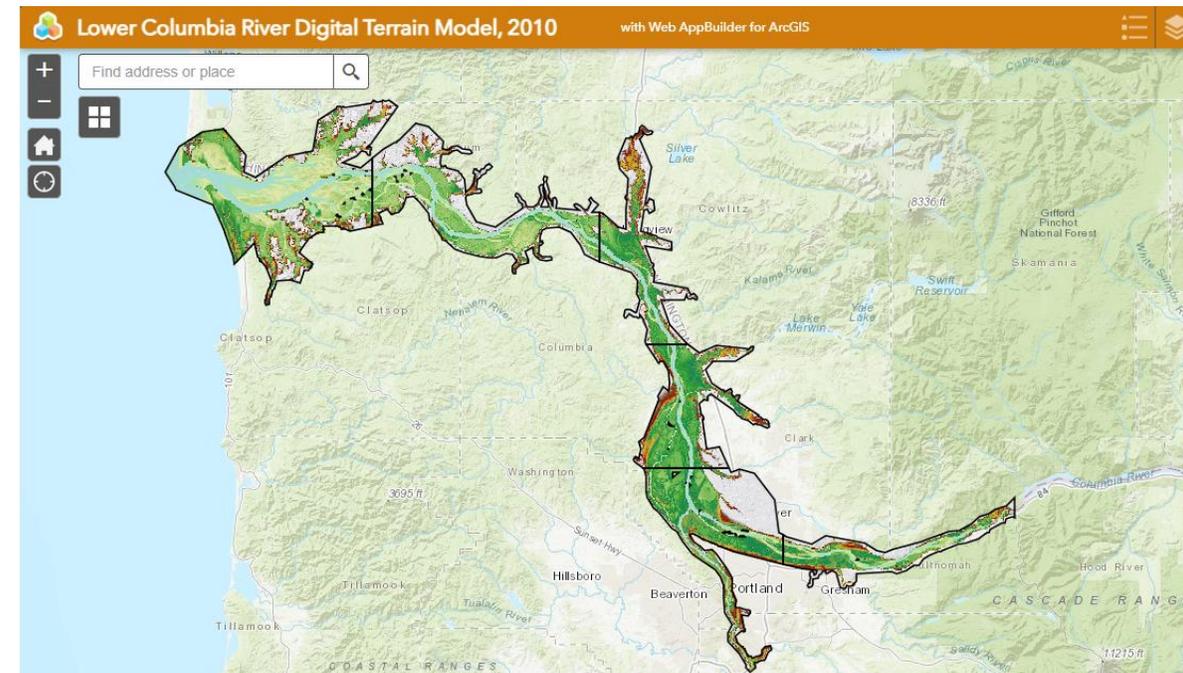


Initial grid development

- Charles Seaton (CRITFC) provided the Columbia River model grids:
 - (1) The subset of the CPOEM (full Pacific) grid using for the Virtual Columbia River
 - (2) The lower Columbia River bathymetry from the Estuary Partnership



The subset of the CPOEM (full Pacific) grid using for the Virtual Columbia River.



Lower Columbia River Digital Terrain Model, 2010
(<https://www.estuarypartnership.org/>).

Project Summary



- WAVEWATCH III for high-resolution wave forecasting on unstructured grids.
- One-way coupling with estuarine circulation models (SCHISM & SSCOFS).
- Comparing WWIII wave prediction accuracy using the different flow models.
- Using remote sensing and in situ wave data for verification.

Schedule

- Aug 2024 – July 2025: Establish WWIII grids and start model/data comparisons.
- Aug 2025 – July 2026: Complete one-way coupled model hindcasts and document results.
- Aug 2026 – July 2027: Add forecasting to the NANOOS-NVS data stream and test two-way coupling.
- Aug 2027 – July 2028: Complete testing and publish results.

Expected Outcomes

- Improved wave forecasting accuracy with wave/current interaction and circulation models developed in parallel.
- Enhanced maritime economic benefits and coastal resilience by enhancing navigational safety.

Thank you.

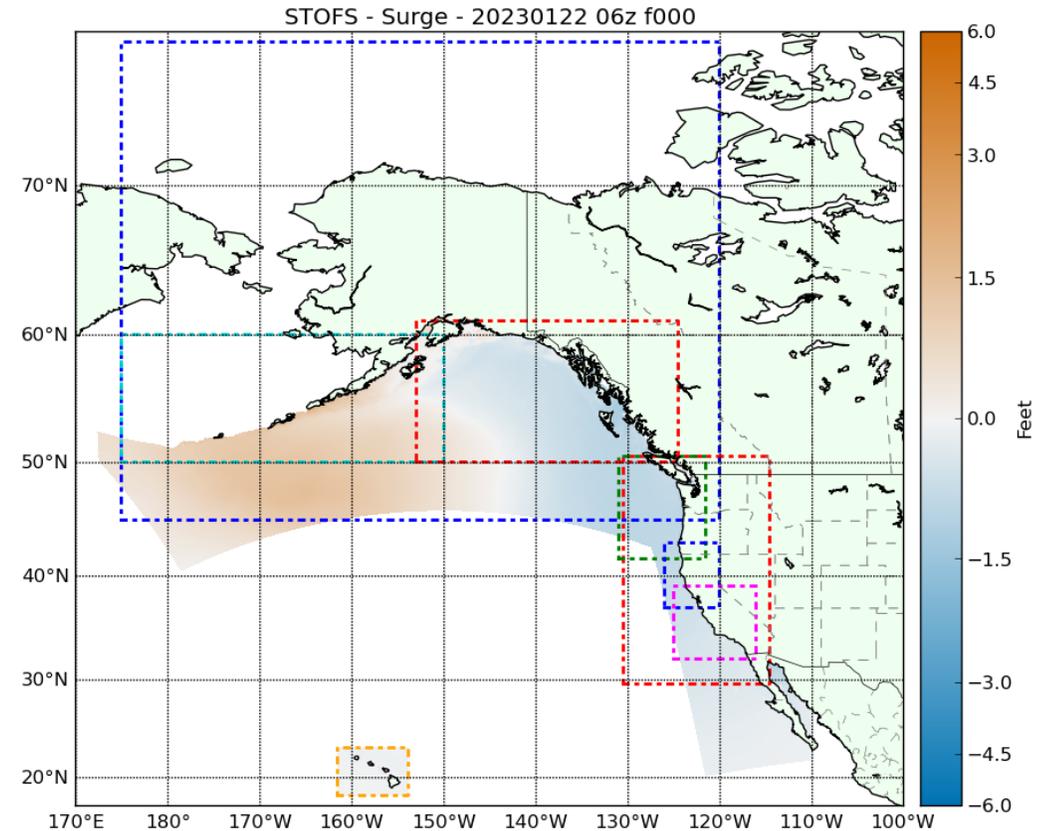


**Oregon State
University**



Surge and Tide Operational Forecast System (STOFS)

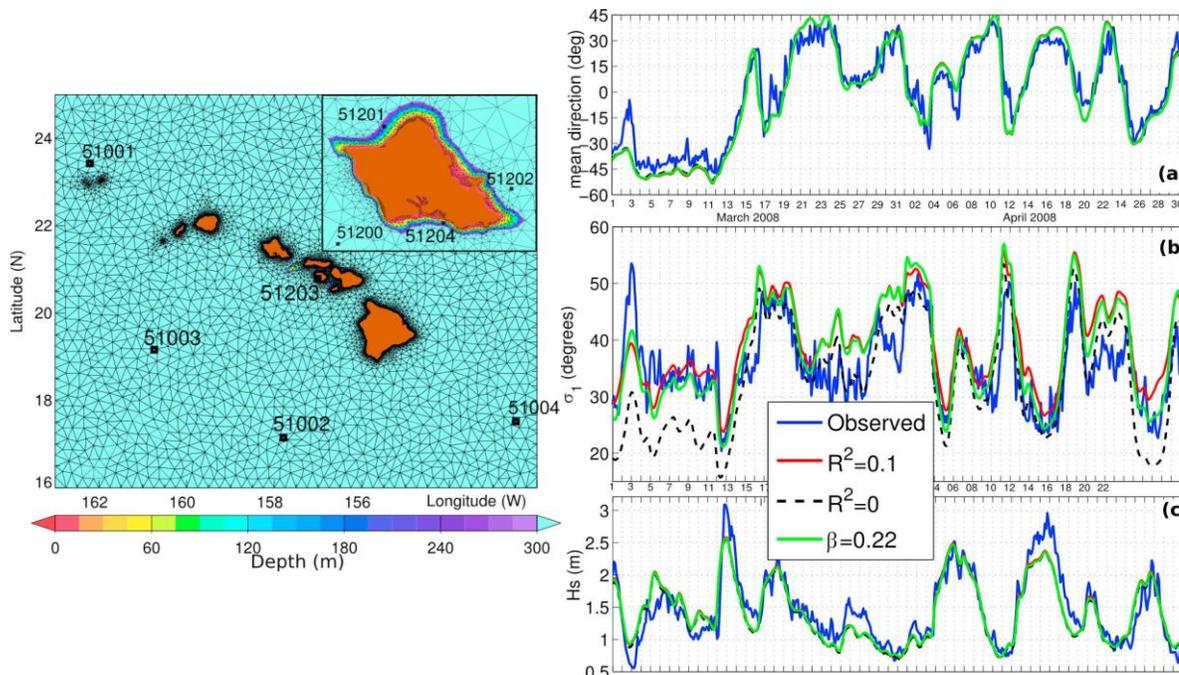
- The end target of this effort is integration into NOAA-NOS Surge and Tide Operational Forecast System (STOFS), enhancing its predictive accuracy for estuarine and coastal environments.



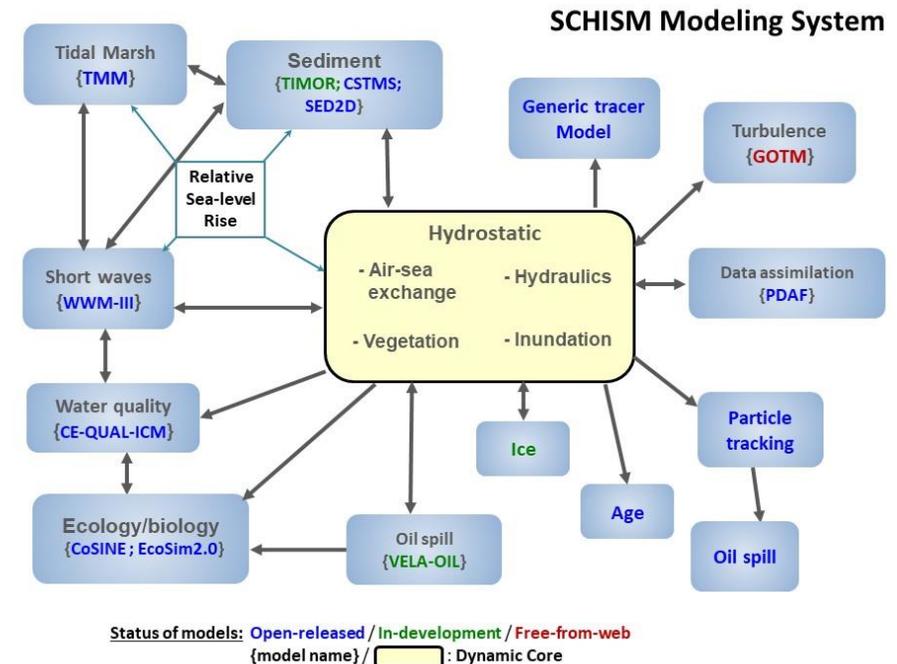
Global STOFS Pacific Region Storm Surge Model Guidance
(https://ocean.weather.gov/stofs/stofs_pacific_surge_info.php).

Model construction

- A high-resolution wave forecasting system for PNW estuaries, focusing on the Columbia River, will be developed by including wave-current interaction through one-way coupling between the WAVEWATCH III model (unstructured grids) and new circulation models (e.g., SCHISM).



Example of WAVEWATCH III run on unstructured grids for the Hawaiian Islands (Arduin and Roland, 2012).



SCHISM modeling system (<https://ccrm.vims.edu/schismweb/>).