NOAA's Coastal Ocean Reanalysis (CORA): Cloud optimized data to inform flood predictions

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IOOS DMAC Annual Meeting, Silver Spring, MD Apr 30, 2025

CORA: Background

What is CORA?

NOAA's **C**oastal **O**cean **R**e**A**nalysis (CORA) is a collaborative, community-based model effort

- Includes a coupled model of ADCIRC and SWAN, forced by ERA5 reanalysis data.
- Assimilates long-term water level observation records to improve performance.
- Bridges gaps in coastal long term water level observations, providing 44 years of hourly water level and wave data at native mesh nodes and interpolated onto a 500m resolution grid.



Cloud Optimization

CORA-GEC

- Gulf and East Coast uses HSOFS Mesh (~1.8 million nodes)
- 44 years of hourly data along the coast, including within bays, estuaries, and coastal river mouth entrances
- Full model output is ~70 TB



Data Processing & Cloud Optimization

- Original data had a chunk size of ~1.8 GB which was leading to slow access times
- Rechunked the underlying netCDF to manageable chunk sizes
- Leveraging Kerchunk (to create virtual zarr representations) and intake catalogs (to provide aggregations)
- Much faster access time for both extracting a time-series and the entire grid
- Interpolation to 500-m grid: inverse distance weighted interpolation using surrounding nodes from triangular mesh



Cloud Optimization



CPU times: user 300 ms, sys: 16.7 ms, total: 317 ms Wall time: 2.24 s



2 s to extra a one-month time series 3 m to extract 141 annual time series 6 s to compute the daily max for the grid

%%time

zeta_sel = ds['zeta'].sel(time=slice('1985-01-01','1985-01-01'))
grid_max = zeta_sel.max(dim='time').load()
plot_gridded_output("Daily maximum", grid_max, "turbo", 500,250)

CPU times: user 1.18 s, sys: 285 ms, total: 1.46 s Wall time: 6.31 s



CORA Data Availability

AWS S3 Explorer noaa	-nos-cora-pds	🗖 Hide folders? 🚿 Folder 🛛 Bucket 🔅 🧲	G A n
50 🛊 entries per page		Search:	
Object	Last Modified	Timestamp Size	
V1.1/			
V1/			
CORA_intake.yml	a year ago	2024-05-23 09:35:51 3	КВ
CORA_V1.1_intake.yml	4 months ago	2025-01-06 10:54:11 5	KB
fort.14	2 months ago	2025-03-05 09:08:19 223	MB
Showing 1 to 5 of 5 entries		« < 1 >	»

- V1 & V1.1
- Intake Catalogs (YAML)
- Native grid (fort.14)

CORA Data Availability

AWS S3 Explorer	noaa-no	os-cora-pds / V1.1 / assimilated				-
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500m_grid/						
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Model output available as

- Native Grid (1.8 million nodes)
- 500m Grid (1.1 million cells)

CORA Data Availability

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zarr/								
fort.63_1979.nc		5 months ago	2024-11-27 01:46:32	119 GB				
fort.63_1980.nc		4 months ago	2025-01-09 14:11:37	119 GB				
fort.63_1981.nc		5 months ago	2024-11-26 21:34:47	119 GB				
fort.63_1982.nc		5 months ago	2024-11-26 19:34:24	119 GB				
fort.63_1983.nc		5 months ago	2024-11-26 17:25:14	119 GB				
fort.63_1984.nc		5 months ago	2024-11-26 14:50:59	119 GB				
fort.63_1985.nc		5 months ago	2024-11-26 11:41:10	119 GB				

Native Grid (yearly netCDF):

- Hourly water level (~119 GB)
- Daily max water level (~110 MB)
- Wave direction (~119 GB)
- Significant wave height (~119 GB)
- Peak period (~119 GB)

500m Grid (daily netCDF)

Hourly water level

Zarr:

• Aggregations

Native Grid: ~20TB of data; ~5TB per variable

500m Grid: ~3.5 TB of data (hourly water level)

CORA Derived Products (500m Grid)

Product	Description	Status
Daily Maximum Water Level	Highest water level in every calendar day for all 500m grid cells	Complete; post to NODD pending
Monthly Statistics (mean sea level, mean high higher water, mean low lower water, variance, maximum)	Uses a low pass filter to remove high frequency variability; cells must be wet for two weeks per month with no more than a 3-hour gap	Draft approved, processing final this week
Peaks over Threshold	Calculated in half foot increments over MHHW (8301 EPCOH)	MHHW datum calculation in progress: Computed the % wet for each node, using 95% threshold. MHHW.

CORA's impact: Spatially continuous high tide flooding outlooks

King Tides, rain bring more flooding threats as Charleston seeks broader mitigation strategy

BY EMMA WHALEN EWHALEN@POSTANDCOURIER.CO



Police block King Street in Charleston after heavy rain flooded the road on July 10, 2022. Matthew Fortner/Staff

LOCAL NEWS

Charleston area roads close due to flooding

by: <u>Tim Renaud</u> Posted: Dec 22, 2022 / 07:20 AM EST Updated: Dec 22, 2022 / 09:40 AM EST



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Charleston State of the City address touches on flooding, affordable housing and crime

BY EMMA WHALEN EWHALEN@POSTANDCOURIER.COM JAN 24, 2023



NOAA's Monthly High Tide Flooding (HTF) model/outlook

A novel statistical approach to predict seasonal high tide flooding

Frontiers | Frontiers in Marine Science

Gregory Dusek^{1*}, William V. Sweet¹, Matthew J. Widlansky², Philip R. Thompson^{2,3} and John J. Marra⁴

Data-driven Subseasonal to Seasonal (S2S) Prediction

Daily likelihoods (probability of threshold exceedance) for each day up to 12 month lead time.





Relative to a flood threshold

Jar



Monthly distribution Pe



Persistence, previous monthly anomaly

NOAA's Monthly High Tide Flooding (HTF) model/outlook



This map shows the maximum daily likelihood of high tide flooding at National Water Level Observation Network stations for the selected month represented by color-ooded pins. The National Ocean Service minor flooding threshold layer is supplied by NOAA's Office for Coastal Management.

Last model run: 2025-03-10

Region	Calendar	S	easonal	A	bout												
Portland, ME [8418150] 12 Month Outlook View: Station Links V Export																	
	F	looding	days a	re relati	ve to th	e mino	flood th	nreshold	d of 2.0	4 Fee	t 🗸	above	MH	W v	0		
		Co	astal I	Flood	_ikelih	ood: 🤇		Unl	ikely		Possib	le	Lik	ely			
			N	loon P	hase:	0	•	New	Moon		O F	ull Moc	n				
April 2025 May 2025																	
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	_		1	2	3	4	5						1	2	3		
<	6	7	8	9	10	11	12		4	5	6	7	8	9	10	Σ	
	13	14	15	16	17	18	19		11	12	13	14	15	16	17	6	
	20	21	22	23	24	25	26		18	19	20	21	22	23	24		
	27	28	29	30					25	26	27	28	29	30	31		

Likelihood of high tide flooding is based on a probabilistic statistical model derived from past tide predictions, sea level rise trends, and seasonal changes in coastal sea level. Percentages represent the daily likelihood that a higher than normal high tide may lead to at least minor coastal flooding in flood prone areas. Tides tend to be higher on and around the dates of the full and new moon. Real-time weather conditions may still cause flooding outside of dates identified in this product. Within 5 days, refer to the National Weather Service for forecasts of potential flooding.

Only at tide gauges

Goal: Community-level HTF predictions

- Move from point (tide gauge) to gridded product using data from NOAA's Coastal Ocean Reanalysis (CORA)
 - Build regional demonstration in the southeast
 - Develop website display and functionality through stakeholder engagement



Goal: Community-level HTF predictions





How accurate are CORA-derived HTF predictions?

- HTF predictions from CORA similar to those from tide gauges
- Same events captured
- Cases of overprediction and underprediction both visible, qualitatively minimal



How accurate are CORA-derived HTF predictions?

Accuracy of daily highest water level predictions

- Average change in CRPS for CORA input is a 4% increase (performance reduction)
- Largest average change in the Northeast, 7% increase
- Some stations show smaller CRPS (better performance) for CORA input



Demonstration of high-res HTF predictions around Charleston



National Oceanic and Atmospheric Administration | National Ocean Service | Center for Operational Oceanographic Products and Services | www.tidesandcurrents.noaa.gov 19

Thank you!

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Additional Resources:

• CORA Data on NODD

NOAA's Coastal Ocean Reanalysis (CORA) Dataset

griculture agriculture climate disaster response environmental oceans transportation weather

Description

NOAK's Coastal Ocean Reanaysis (CORA) for the Guif of Mexico and East Coast (GEC) is produced using verified hourly vater levels from the Center of Operational Oceanographic Products & Services (CO-OPS), through hydrodynamic modeling from Advanced Circulation 'ADCIRC' and Simulating WAves Nearshore "SWM* models. Data are assimilated, processed, corrected, and processed again before quality assurance and skill assessment with additional verified tide station-based observations.

Details for CORA Dataset

Resources on AWS

Description NOAA's Coastal Ocean Reanalysis (CORA) Dataset NetCDF Resource type S3 Bucket

Amazon Resource Name (ARN)

arn:aws:s3:::noaa-nos-cora-pds



GitHub Repositories





- CORA: Coastal-Ocean-Reanalysis-CORA
- Monthly HTF Outlook: Seasonal High Tide Flooding Prediction

