Impacts of Wave-Current Interactions on Storm Surge during the Passage of Hurricane Ian (2022): An Application of the UFS-Coastal Modeling Framework

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All model configurations and results are pre-decisional and for official use only.

Coastal Modeling and Evaluation for the Unified Forecast System (UFS) and Other Applications II
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Outline

- Introduction of UFS-Coastal

- Hurricane Ian, 2022

- Workflow

- Results

- Summary

Contact: *<Yunfang.Sun>@noaa.gov*

UFS-Coastal (Coastal Application)

UFS-Coastal

GitHub

https://github.com/oceanmodeling/ufs-coastal/tree/feature/coastal_app

- The Unified Forecast System (UFS) is a community-based, coupled, comprehensive Earth modeling system. The UFS numerical applications span local to global domains and predictive time scales from sub-hourly analyses to seasonal predictions (https://ufscommunity.org).

- The Unified Forecast System Weather Model (**UFS-weather,** https://github.com/ufs-community/ufs-weather-model) is a prognostic model that can be used for short- and medium-range research and operational forecasts.

- Unified Forecast System Coastal model (**UFS-Coastal**) is forked from UFS-weather, and therefore, inherits driver functionality from the UFS weather model, is added coastal ocean models (https://github.com/oceanmodeling/ufs-coastal/), is a modeling framework for coupled coastal applications and regional forecasts.

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UFS-Coastal (Coastal Application)

https://github.com/oceanmodeling/ufs-coastal/tree/feature/coastal_app

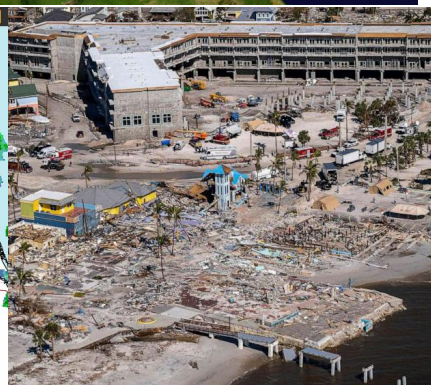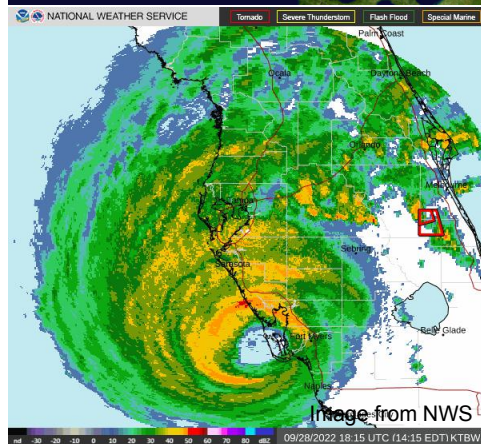UFS Coastal Model Development Team

Hernan G. Arango
Changsheng Chen
Carsten Lemmen
Siqi Li
Saeed Moghimi
Edward Myers
Jianhua Qi
Yunfang Sun
Ufuk Turuncoglu
Panagiotis Velissariou
Joannes Westerink
Damrongsak Wirasaet
Y. Joseph Zhang
And more

Driver - UFS

MOM6 · WW3 · NOAHMP · FV3ATM (FV3 Dycore, CCPP)
HYCOM
SCHSIM · ADCIRC · FVCOM · ROMS · PaHM
CMEPS Mediator
CDEPS Data Comp. · CICE · GOCART · CMAQ
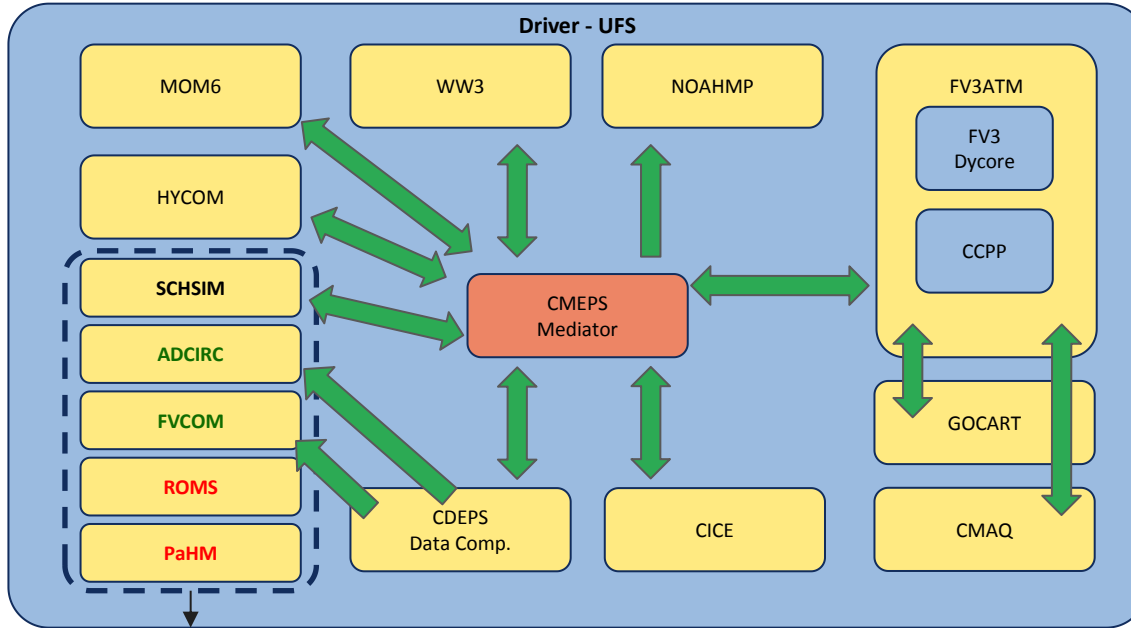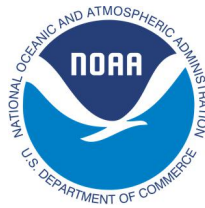
additional components under ufs-coastal

NOAA/NOS' Office of Coast Survey
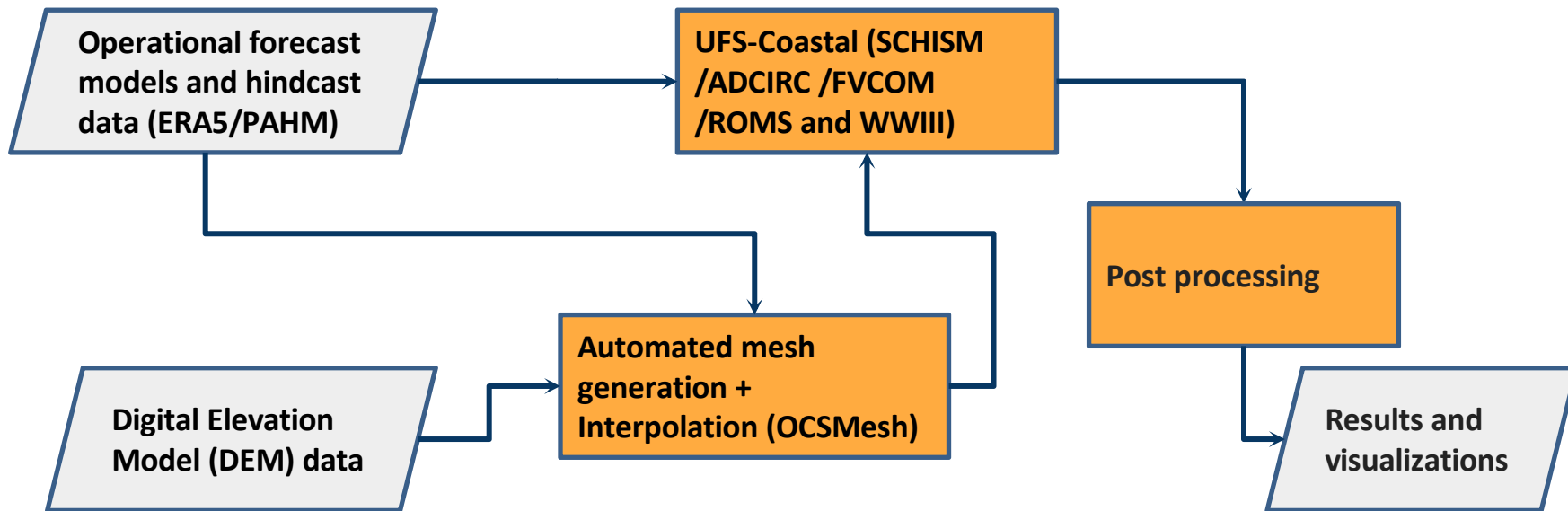
Contact: <Yunfang.Sun>@noaa.gov

Hurricane Ian

Hurricane Ian originated from the coast off west Africa, moved northwestward through the Caribbean Sea. Upon entering the Gulf of Mexico, it landed in southwest Florida on **September 28, 2022**, with peak marine winds reaching up to 72 m/s (161 mph). Storm surge heights exceeded 2.1 m in Fort Myers and approximately 4 m in Fort Myers Beach. After traversing central Florida, it returned offshore into the Atlantic and made its final landfall in South Carolina.

Hurricane Ian was classified as a Category 5 Atlantic hurricane, resulting in significant wind damage and flooding, becoming one of the most costly natural disasters on record.

Image from wiki

Image from NWS

Image from ABC news
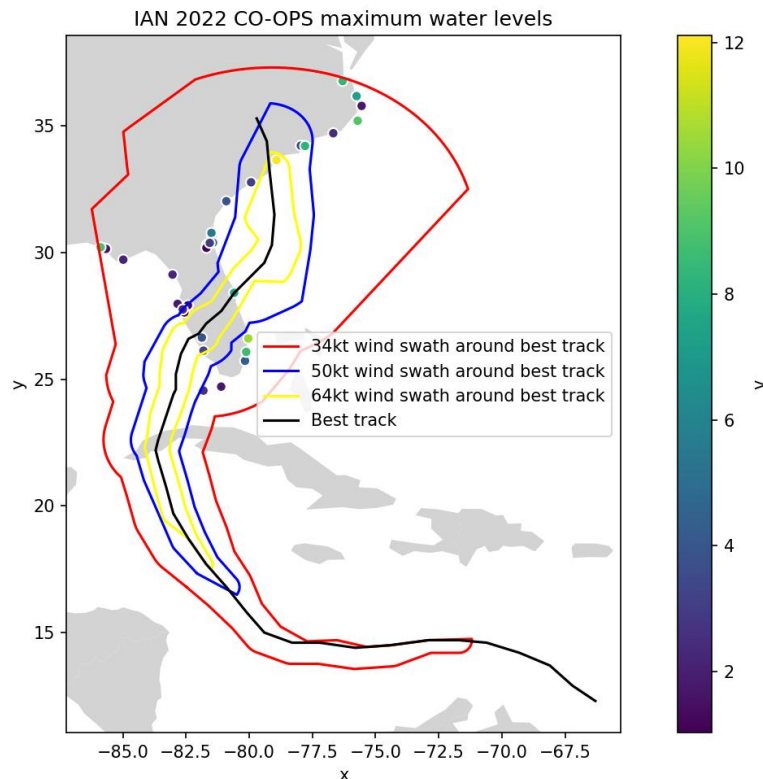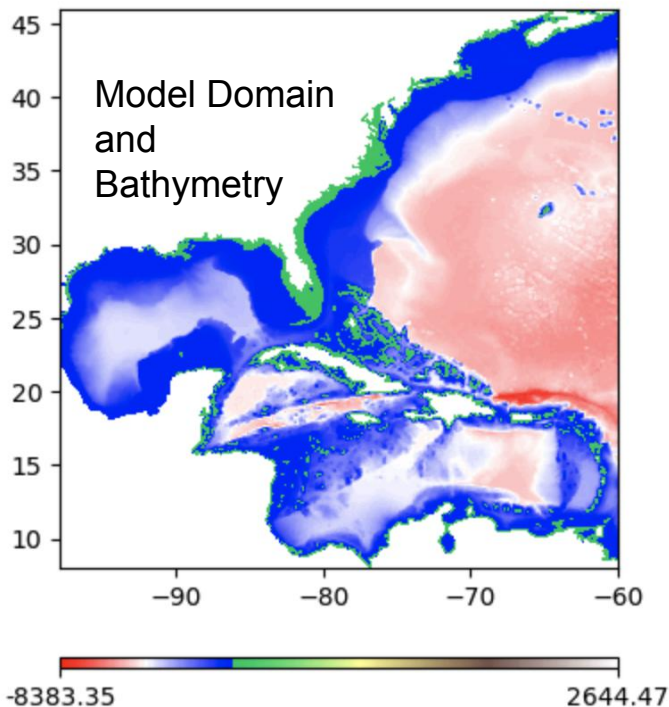Contact: <Yunfang.Sun>@noaa.gov

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On-demand Storm Surge Workflow based on UFS-coastal

All model configurations and results are pre-decisional and for official use only.
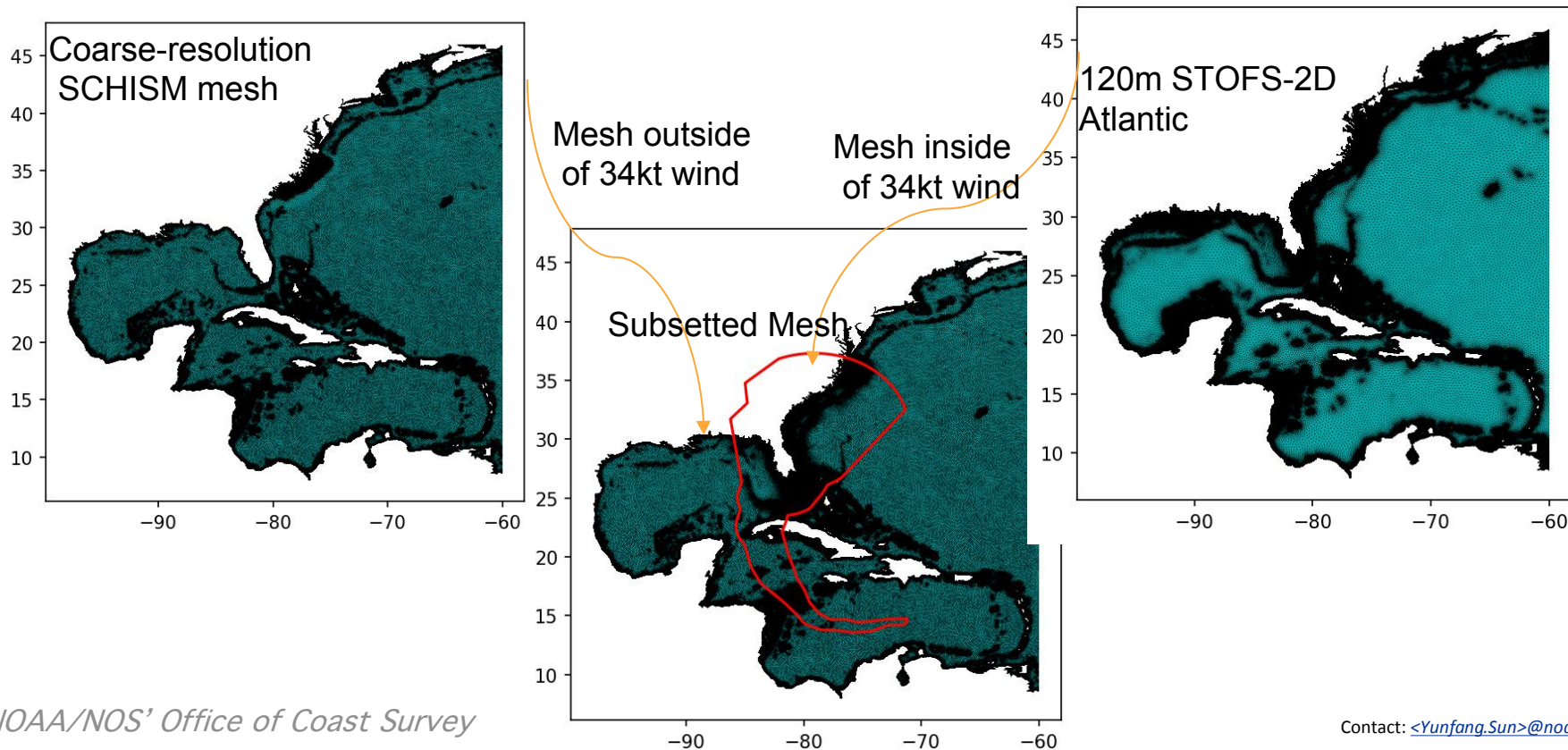
STOFS Atlantic Domain

https://github.com/noaa-ocs-modeling/OCSMesh
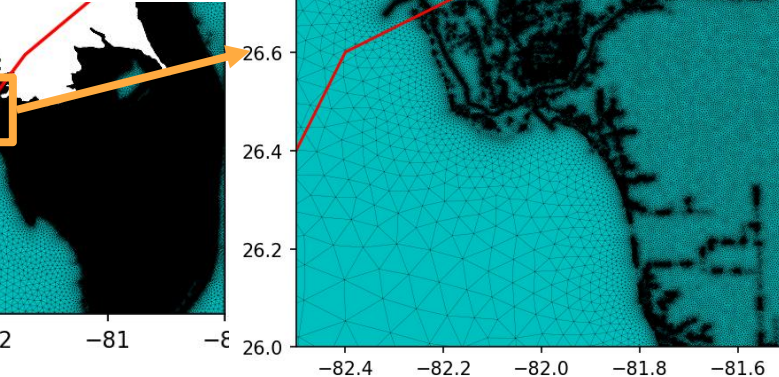

Model Domain and Bathymetry

IAN 2022 CO-OPS maximum water levels

- 34kt wind swath around best track
- 50kt wind swath around best track
- 64kt wind swath around best track
- Best track

StormEvents: https://github.com/oceanmodeling/StormEvents

OCSMesh Subset

Coarse-resolution SCHISM mesh

Mesh outside of 34kt wind

Mesh inside of 34kt wind

Subsetted Mesh

120m STOFS-2D Atlantic

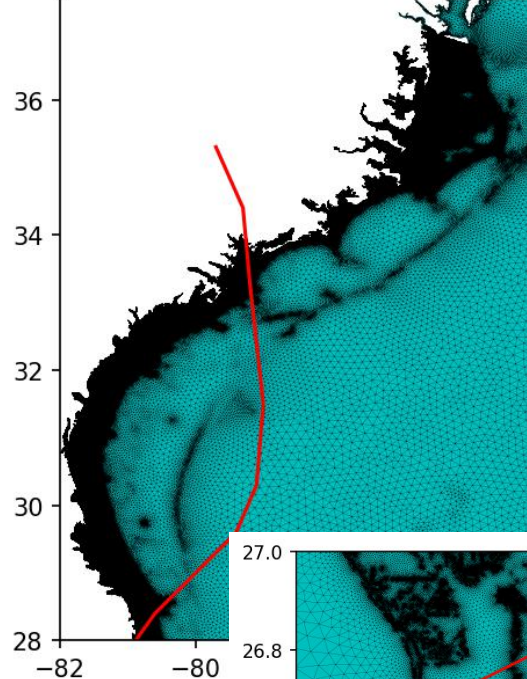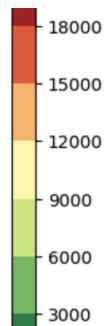*All model configurations and results are pre-decisional and for official use only.*

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Mesh Size

The final mesh included approximately 4.9 million elements 2.4 million nodes.

boundaries

-decisional and for official use only.

oceanmodeling / ufs-coastal Public

forked from ufs-community/ufs-weather-model

<> Code   ⊙ Issues 22   ⣩ Pull requests   ⣚ Discussions   ▶ Actions   ⊞ Projects 1   📖 Wiki   ⊘ Security   📈 Insights
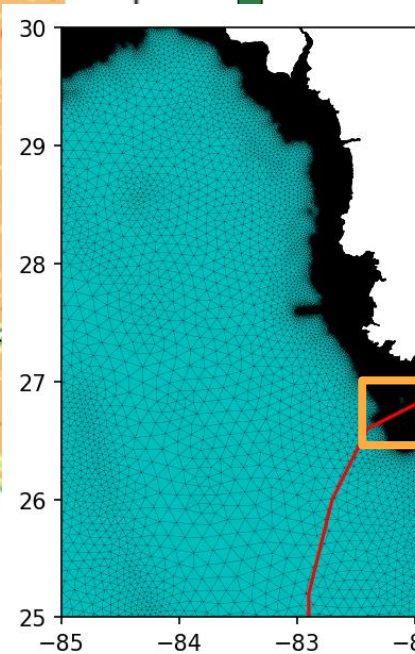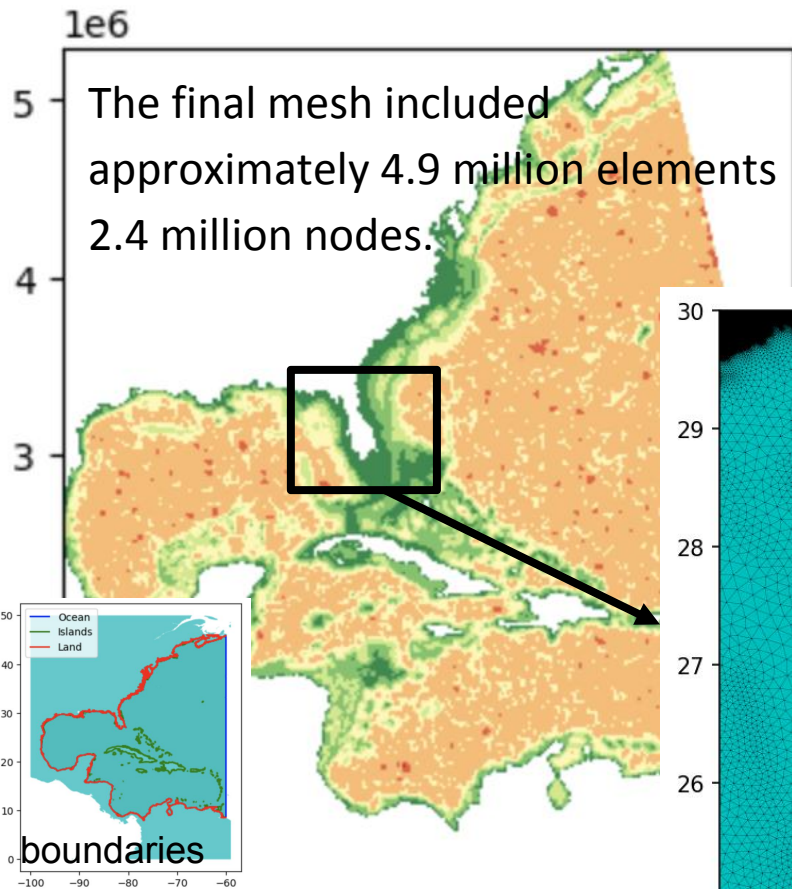
Current Status of UFS-Coastal Implementation

Ufuk Turunçoğlu edited this page on Nov 14, 2023 · 6 revisions

List of Model Components:

Component	Build	Tested	Issues
ADCIRC	Done	Partly	Trying to finalize the RTs and check export states. NUOPC "cap" needs to be cleaned.
FVCOM	Done	Partly	Trying to finalize the RTs and check export states. NUOPC "cap" needs to be cleaned.
SCHISM	Done	Done	Trying to finalize the RTs.
ROMS	Done	Done	None. It is fully functional.
WW3	Done	Partly	Trying to finalize the RTs and resolve the issue with standalone test

UFS-Coastal: Application Configuration Steps

- Compile the UFS-Coastal executable file by using one of the predefined regression test cases (see it in UFS-Coastal github wiki page)
- Configure each model component as usual for the application (as a standalone run)
- Generate ESMFmesh files for: (a) atmospheric forcing (requited by CDEPS) and (b) Wave mesh file (if WWIII is used)
- Collect all model component configuration and input files into the work folder where the UFS executable (fv3.exe) is located.
- Configure the model_configure, ufs.configure etc.
- Submit the job using the SLURM, PBS or other scheduler

Contact: <Yunfang.Sun>@noaa.gov

UFS-Coastal Application demonstration (examples)

- ## coastal_ian_atm2sch2ww3 (on going process)
  - ATM= ECMWF atmospheric reanalysis V5 (ERA5)/ Parametric Hurricane Modeling System PaHM (https://github.com/noaa-ocs-modeling/PaHM), SCH=2D Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) , WW3=WAVEWATCH III® (WWIII)

- ## coastal_ian_atm2sch2wav
  - ATM=ERA5/PAHM, SCH=SCHISM , WAV=WWM

- ## coastal_ian_atm2sch
  - ATM=ERA5/PAHM, SCH=SCHISM

- ## coastal_ian_atm2ww3
  - ATM=ERA5/PAHM , WW3=WWIII

https://github.com/oceanmodeling/ufs-coastal/wiki/Current-Status-of-UFS%E2%80%90Coastal-Implementation

Workflow / Model Setup / Demo

https://github.com/oceanmodeling/searvey

IAN 2022 CO-OPS maximum water levels

Simulation time Sep 15 - Oct 6, 2022, with a one-week spinup, SCHISM inputs are generated by PySCHISM (https://github.com/schism-dev/pyschism)
Open boundary is forced by tidal forcing (TPXO9).

Manning's n
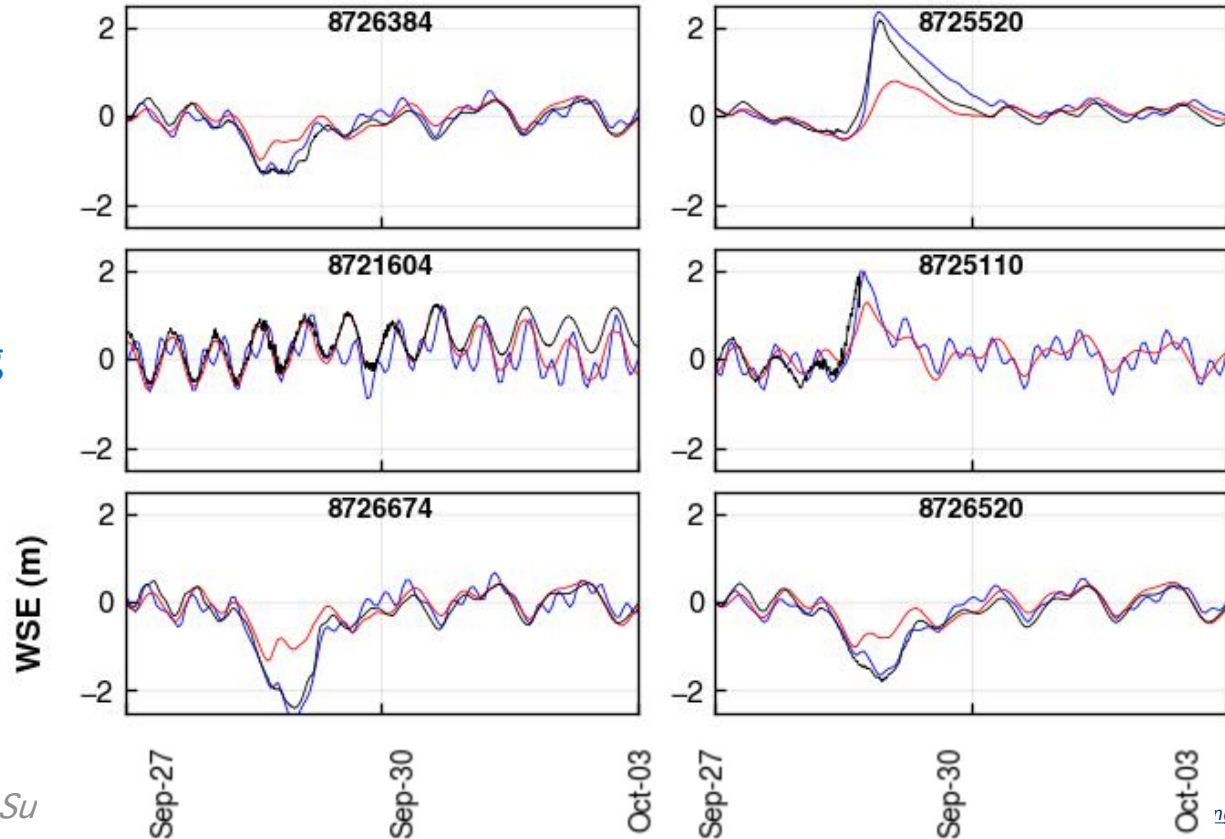
Contact: *<Yunfang.Sun>@noaa.gov*
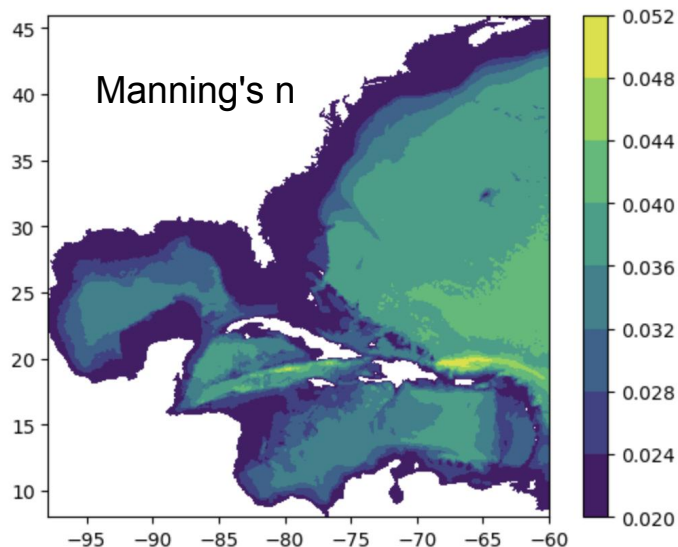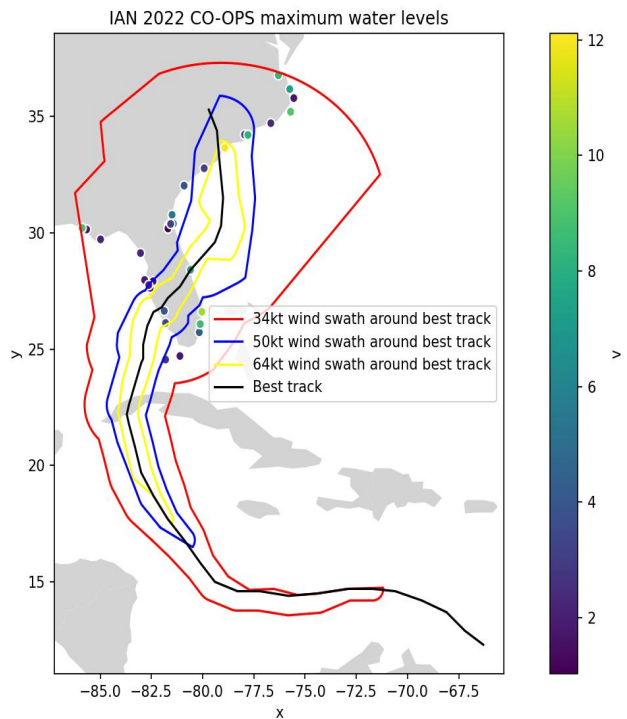
Results / Demo / Sea Level Comparisons

Black Line: Observation

Blue Line: PaHM forcing
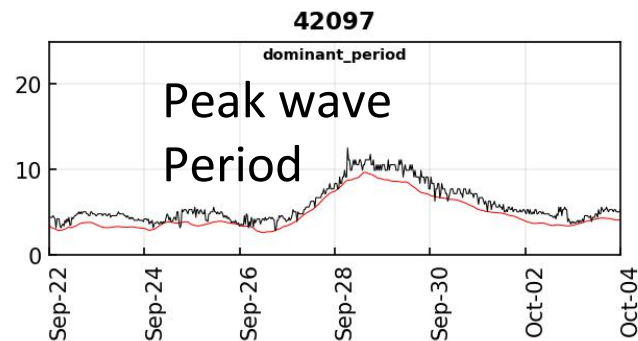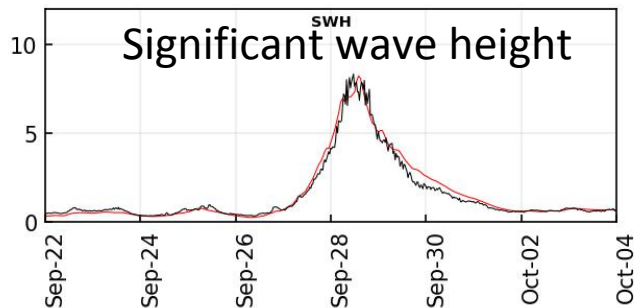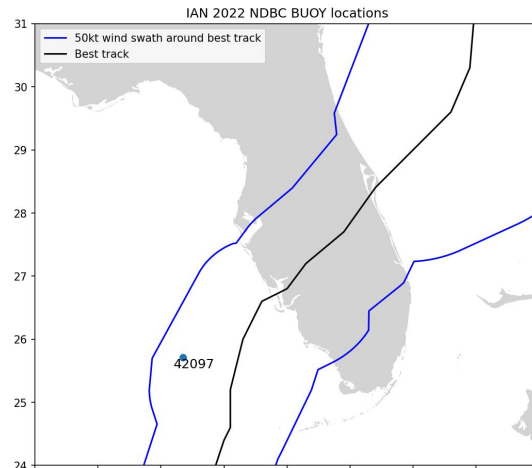
Red Line: ERA5 forcing

ng.Sun>@noaa.gov

Results / Demo / Wave Comparisons

Station 42097 - Pulley Ridge, FL

Black line: Observation
Red line: Model results

https://www.ndbc.noaa.gov/station_page.php?station=44097
https://github.com/NOAA-EMC/WW3-tools/tree/develop/ww3tools

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Summary

- The workflow for Hurricane Ian demonstrates the predictive capabilities of UFS-Coastal in hindcasting / forecasting total water levels, wave heights, and flood inundation regions.
- Next step, we will continue to update the regression tests, and fix the existing issues, develop user manual, and make the UFS-Coastal versatile to different applications.

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The End

- Thank you for your attention!

- Q/A

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