

Use of CoastWatch data and products for hurricane research

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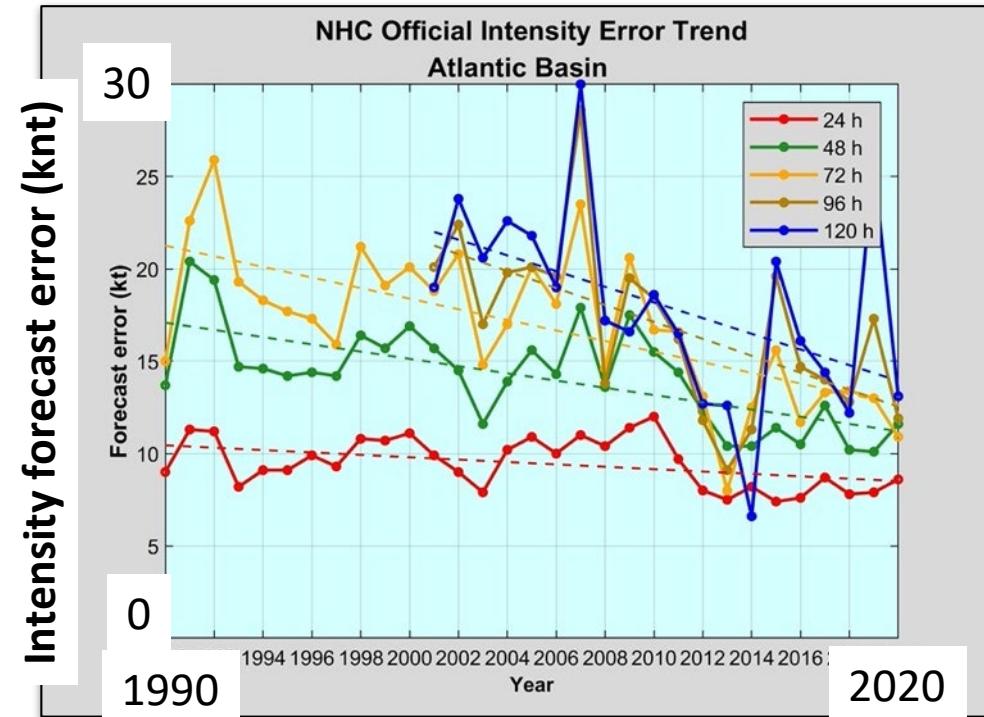
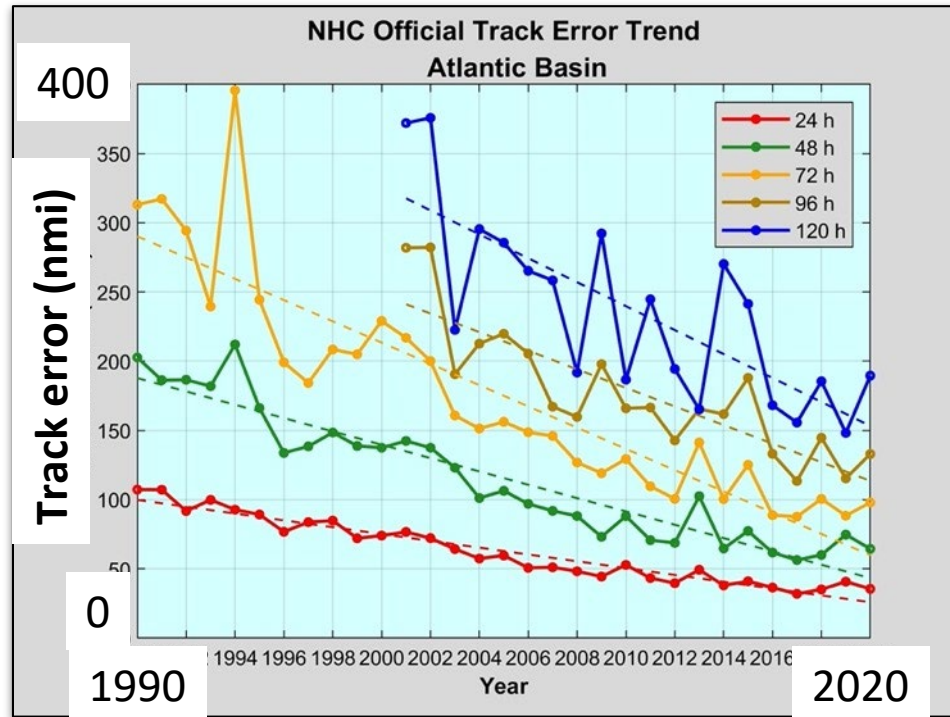
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CoastWatch Seminar Series

July 13, 2023

Atlantic Hurricanes



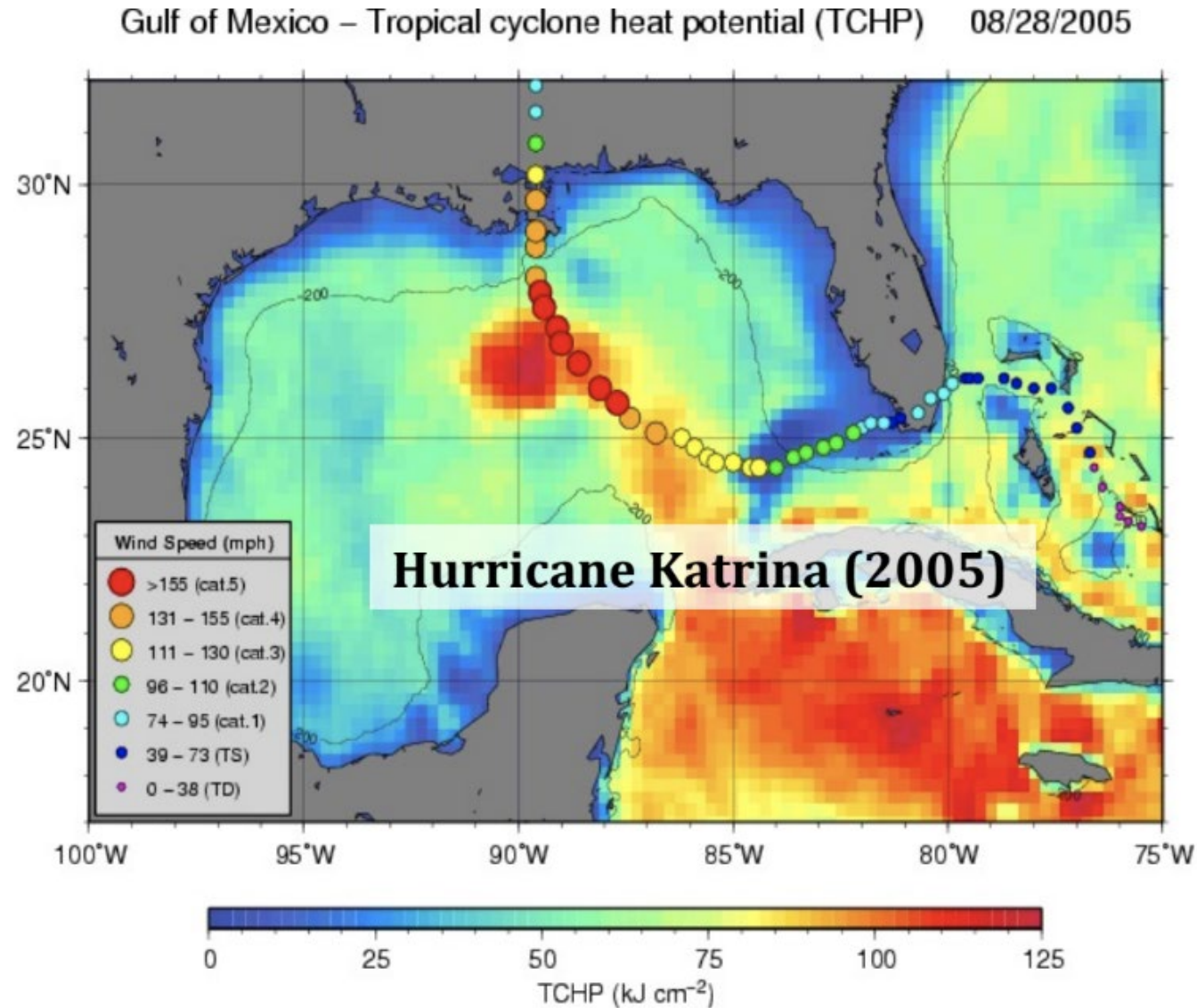
Track forecasts have improved by a factor of 2-4

Intensity forecasts improvement are marginal for short lead times

\$1.1 Trillion in damages

56% of billion dollar disasters

Atlantic Hurricanes: Hurricane Katrina (2005)



Atlantic Hurricanes: the ocean matters

We have learned that the ocean matters. What is it in the ocean that really matters ? :

The upper ocean $T(z)$ $S(z)$

Mesoscale features

Mixing matters

Vertical stratification

Barrier layers, subsurface cold waters

Location of frontal areas, eddies, rings

Waves

Heat fluxes

Continuous model initialization

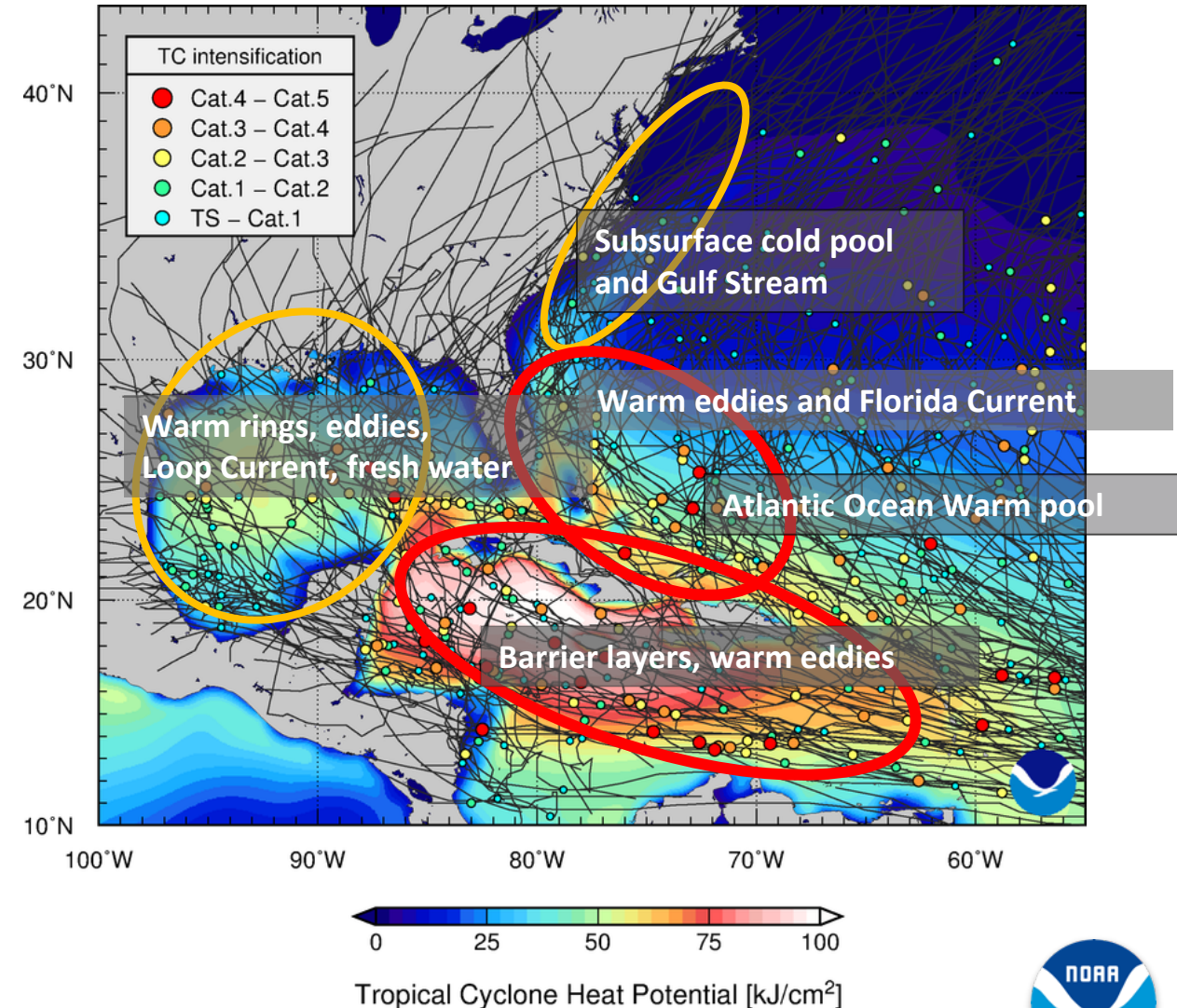
et cetera

There is no single observing platform that can monitor all needed parameter/processes:

Multiple observing platforms, including satellite data and products

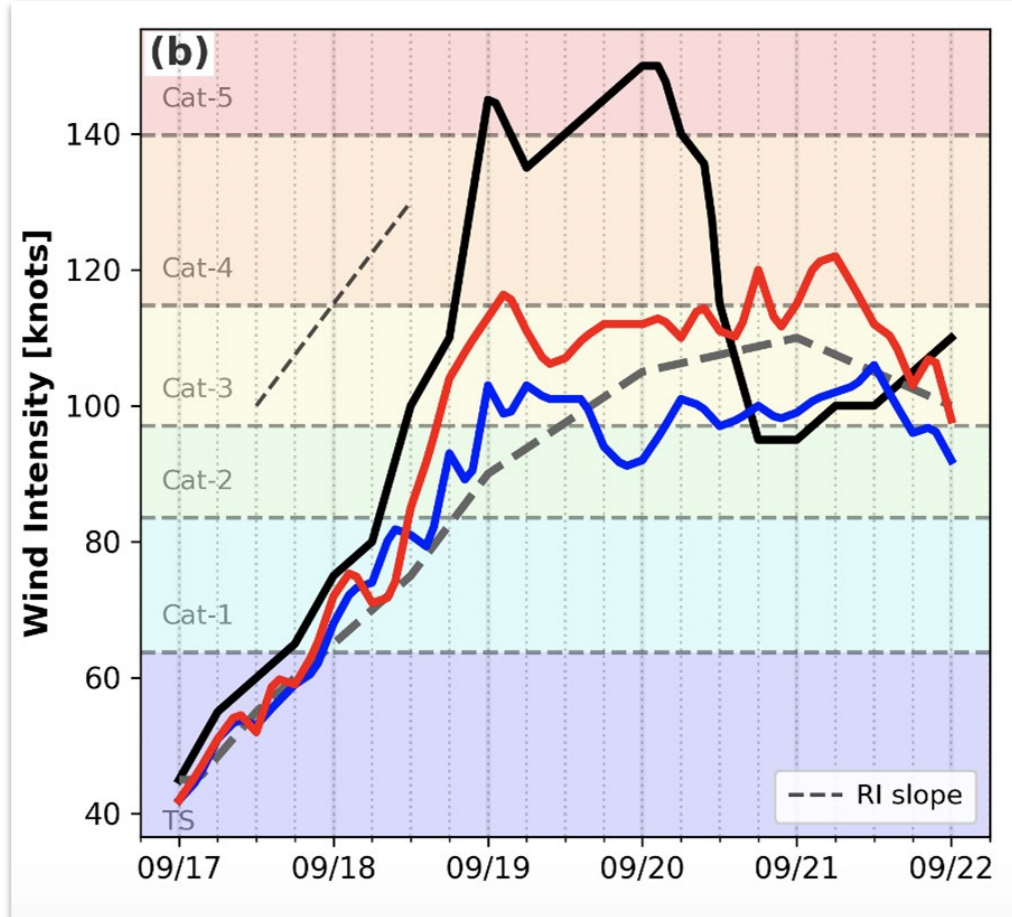
Data integration and data assimilation

Collaboration and partnerships



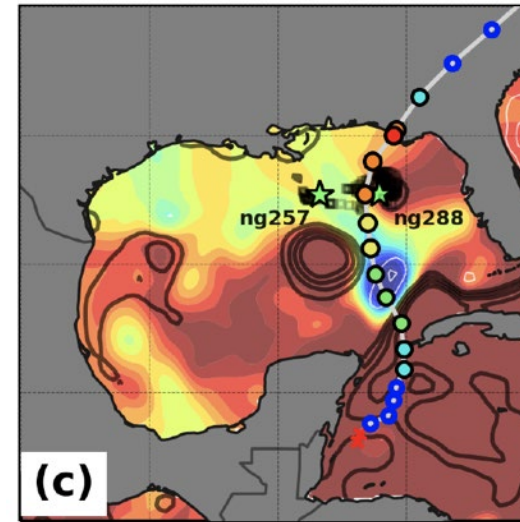
The correct representation of the ocean for TC forecasts MATTERS

OSE (Observing System Experiment) for Hurricanes Maria (2017) and Michael (2018)



— Actual forecast
— Forecast with ocean data
— Forecast with no ocean data

Domingues et al,2021

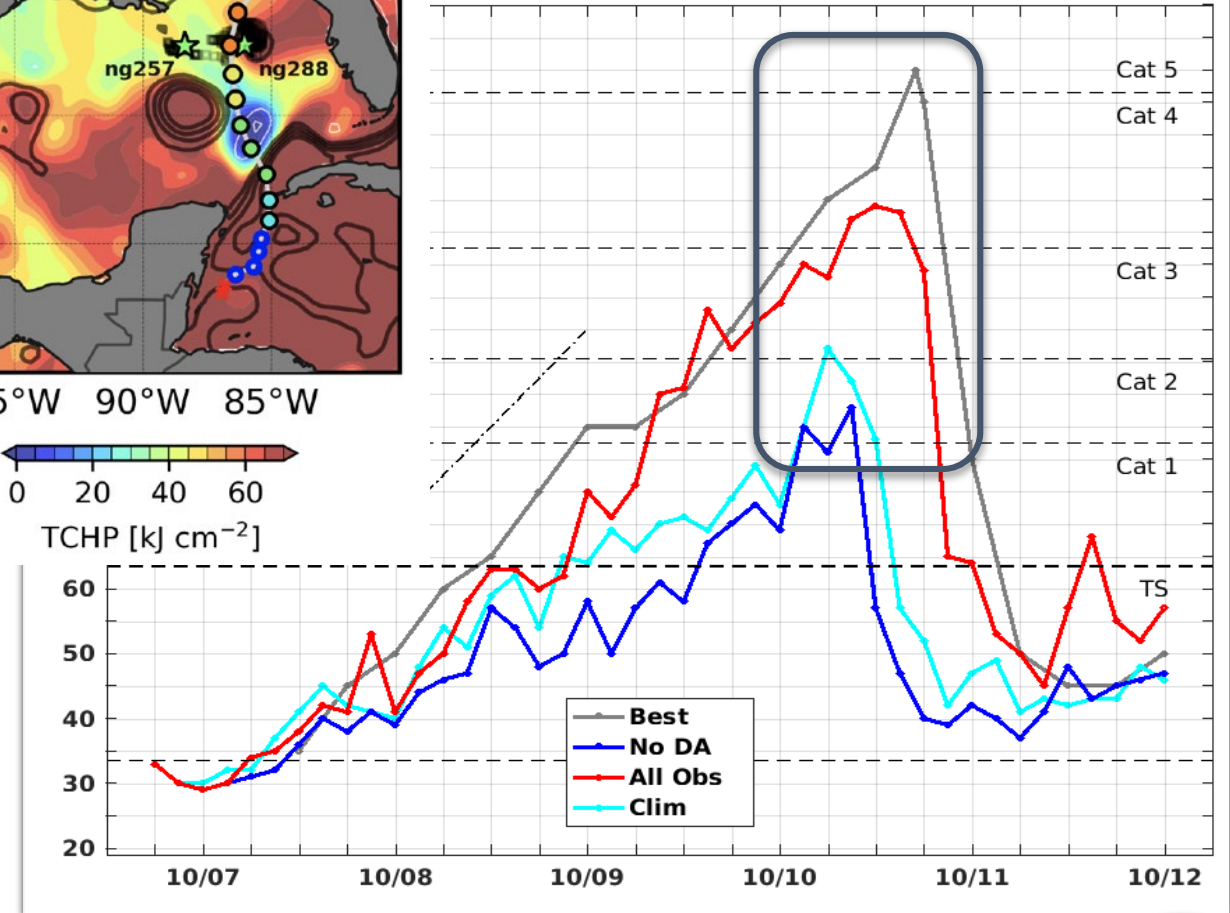


95°W 90°W 85°W

0 20 40 60

TCHP [k] cm⁻²

Michael intensity fcst (Max Wind Speed)



LeHenaff et al,2021



Observing the ocean for hurricane research and forecasts

https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_phod.html

NHC official track

Sea surface temperature

Sea surface height

Ocean currents

Cloud coverage

Ocean color

Sea surface salinity

Ocean heat content

Winds

Weather radar

Goes true color

Saildrone

Argo floats

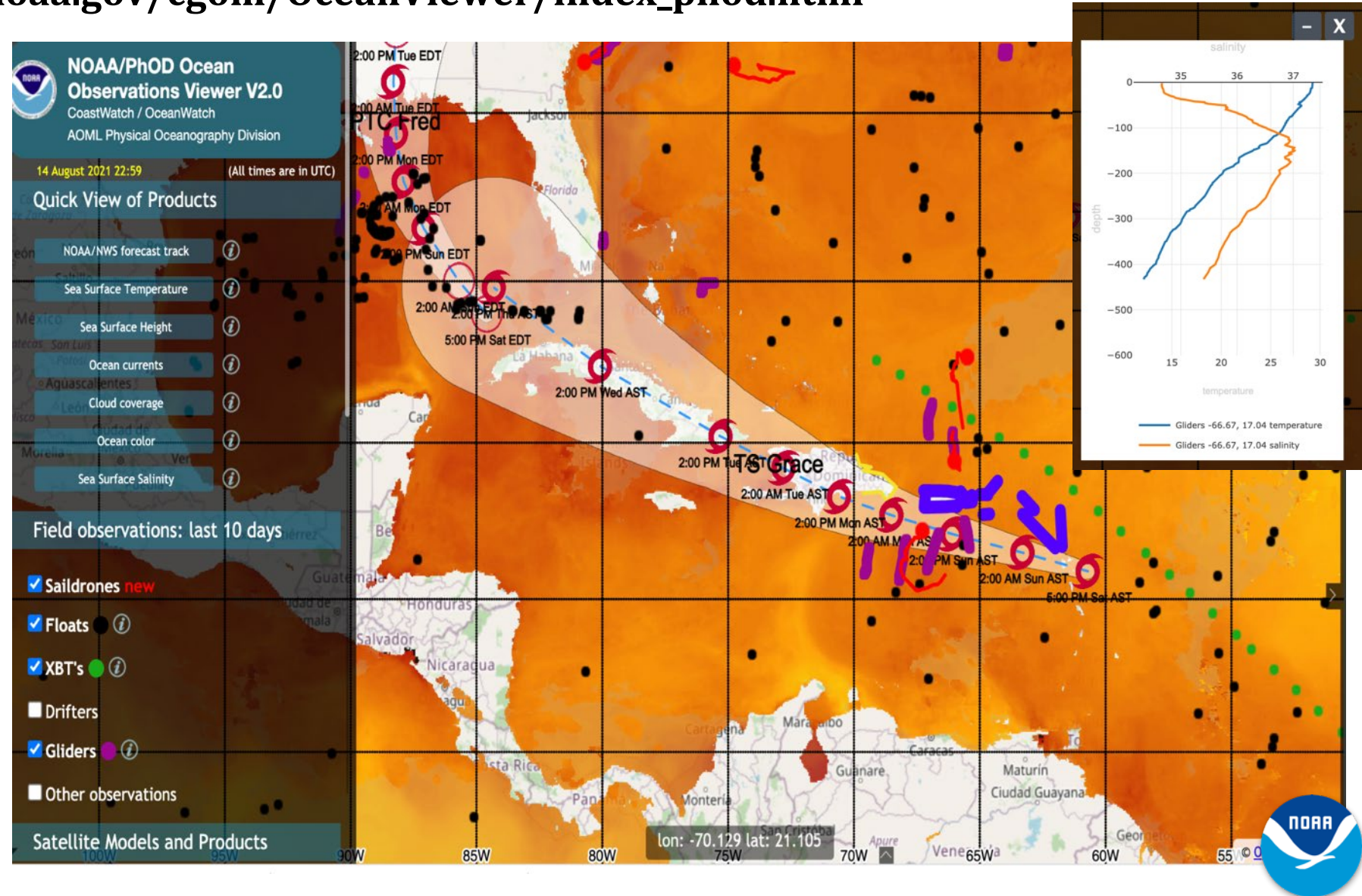
XBTs, AXBTs

Surface drifters

Ocean gliders

Moorings buoys

...



Observing the ocean for hurricane research and forecasts

Field and satellite observations to observe the ocean with different temporal and Spatial sampling strategies

- **Sea surface temperature (SST) is larger than 26°C** the average sea surface temperature for hurricane genesis and to maintain hurricane strength winds;
- **Values of Tropical Cyclone Heat Potential (TCHP, or upper ocean heat content), are above $50 \text{ kJ}/\text{cm}^2$** , which are areas where temperatures above 26°C reach at least 50 m deep;
- **The Sea Surface Salinity (SSS), mostly originating from riverine outflows, have values lower than 35 psu**, representative of barrier layers that are warm upper ocean waters of very low density; and
- **Values of Dust Aerosol Optical Depth at 550 nm (AOD) are greater than 0.1 (Dunion, 2011)**, representative of the Saharan Air Layer. Approx 2000-4500m height.

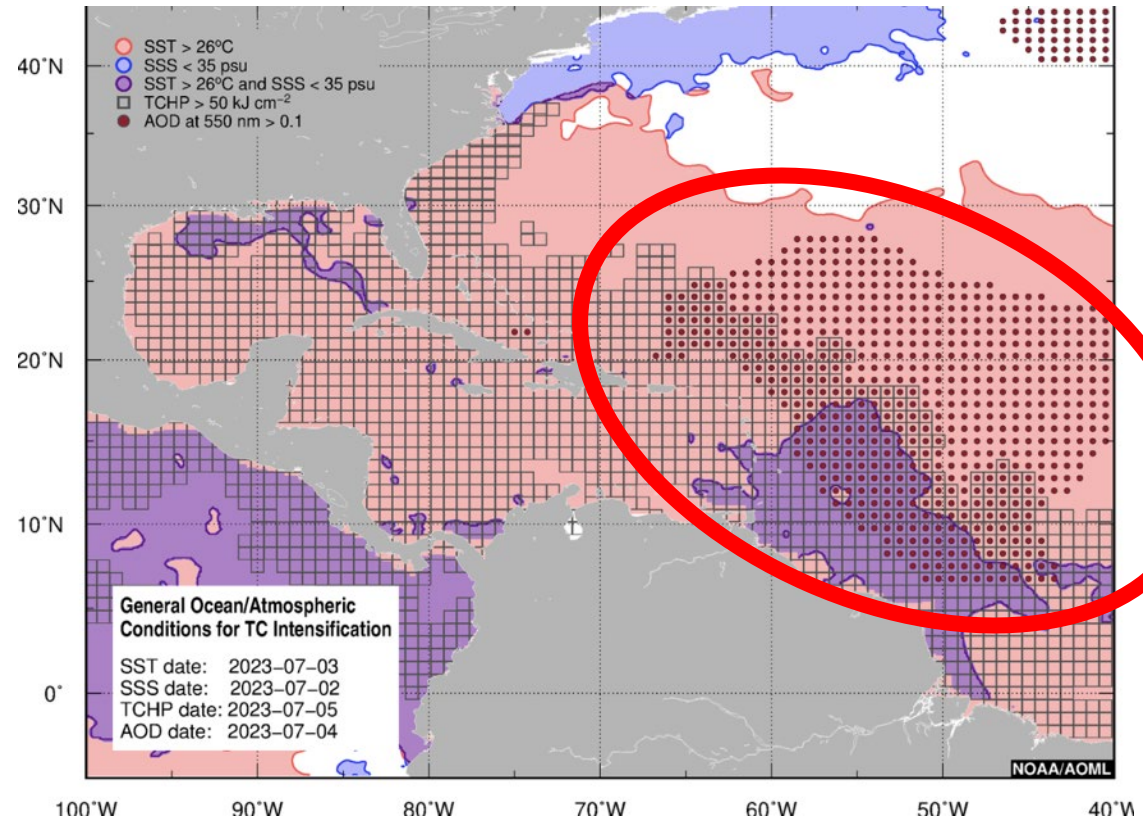
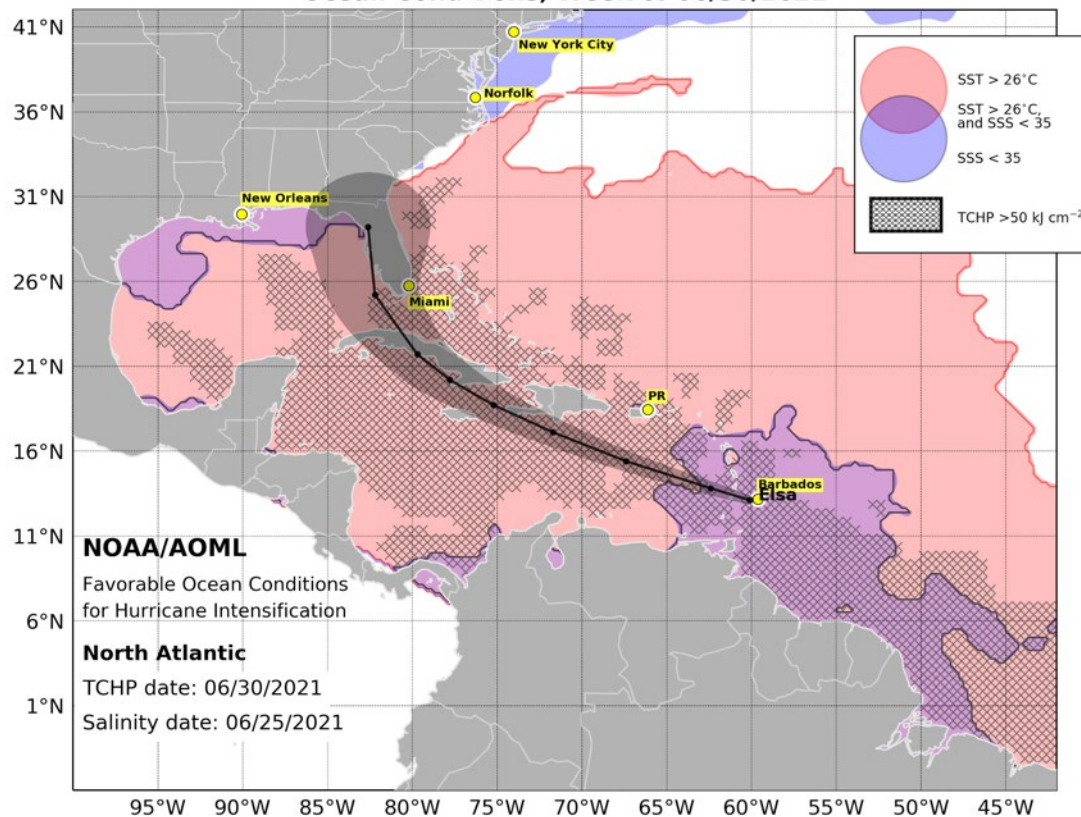


Observing the ocean for hurricane research and forecasts

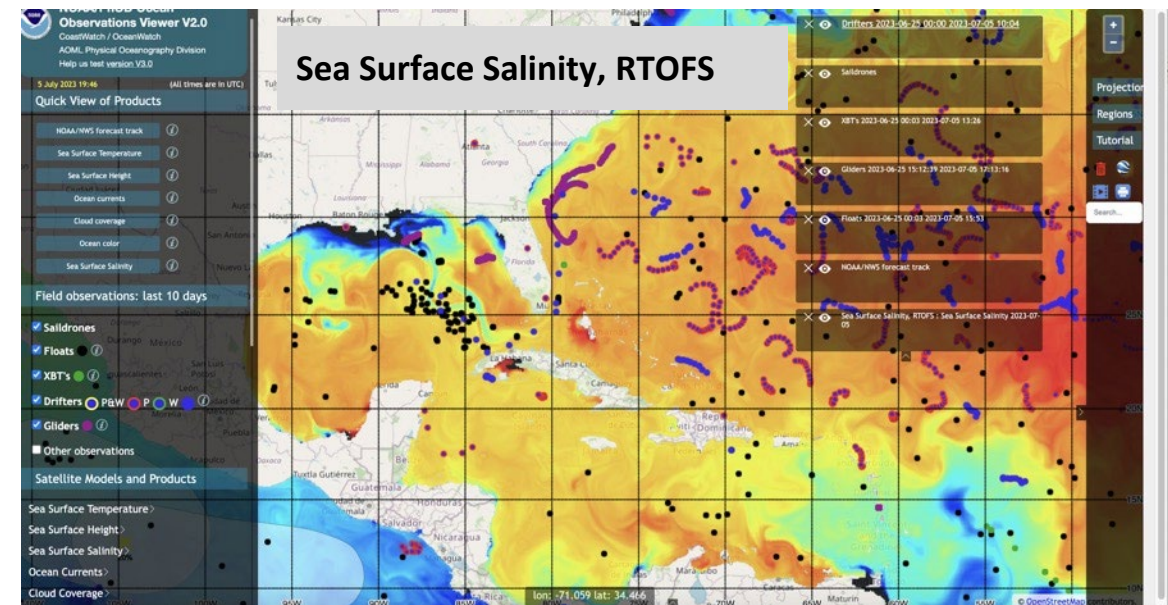
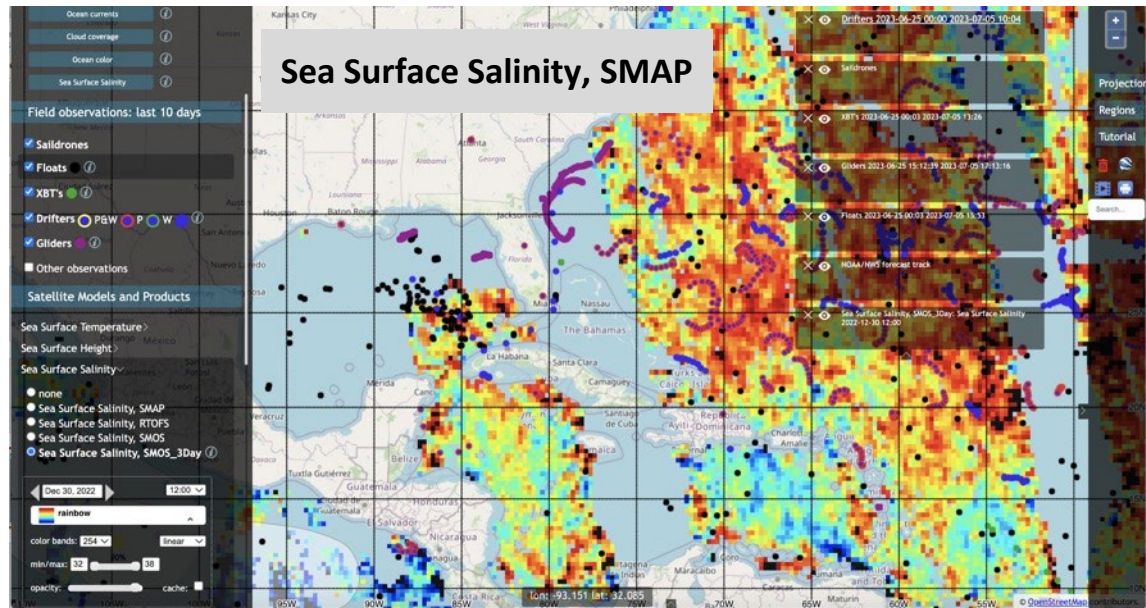
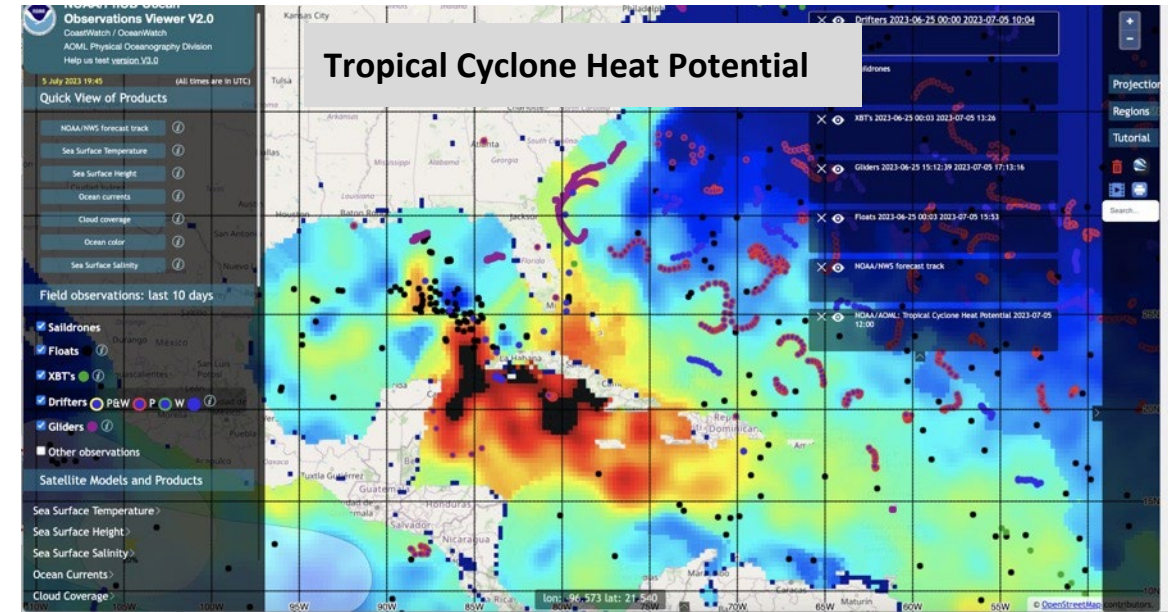
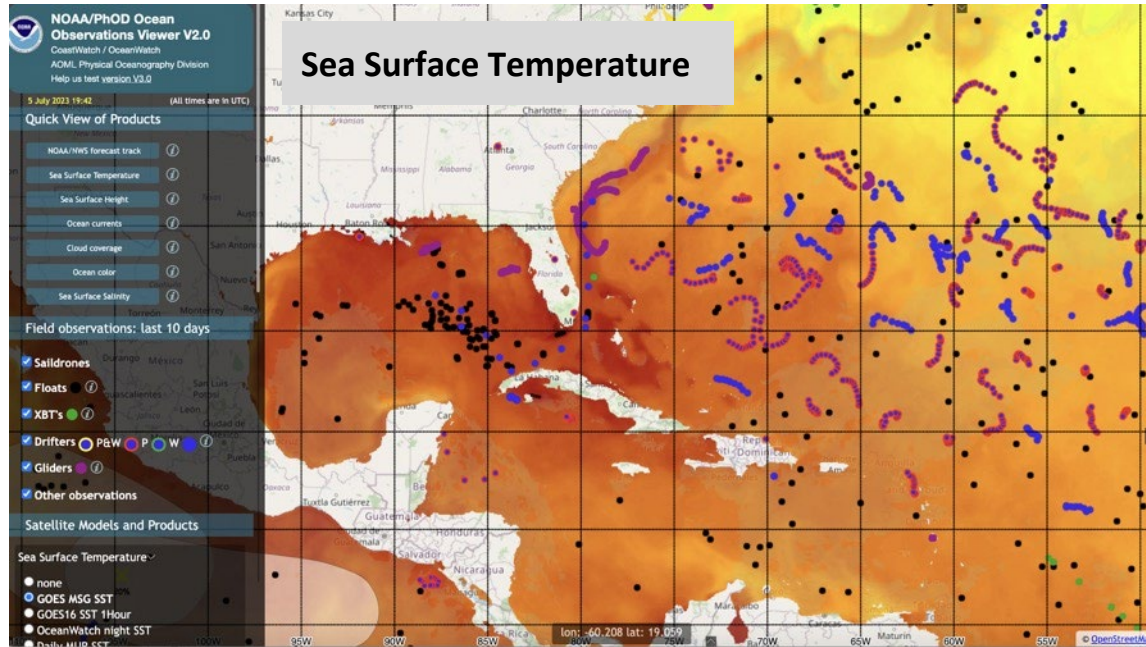
Ocean Conditions:

https://www.aoml.noaa.gov/phod/goos/gliders/ocean_conditions.php

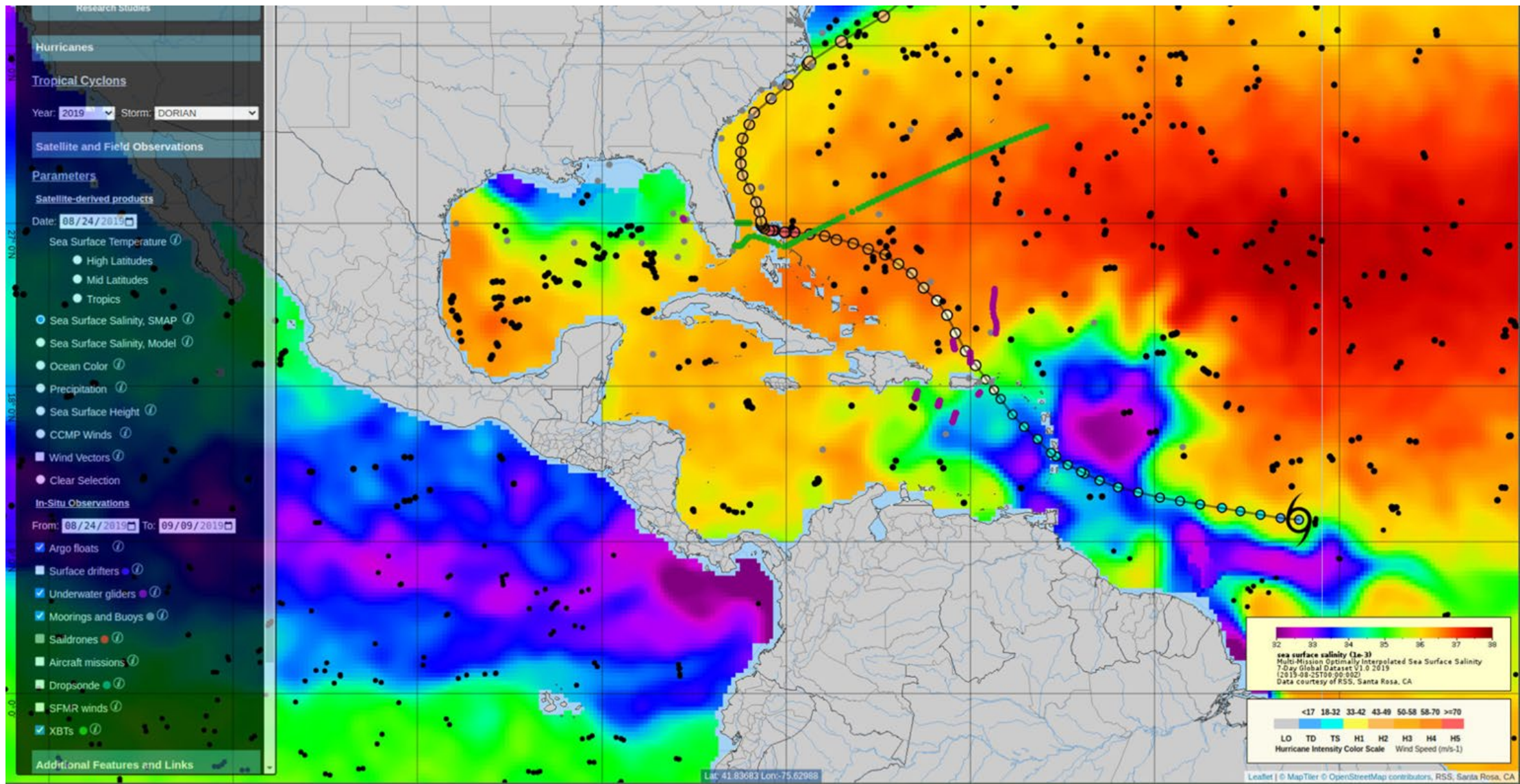
Ocean Conditions, Week of 06/30/2021

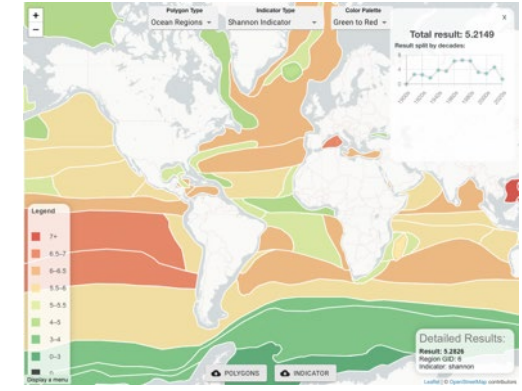


A few views of the CW-AOML Ocean Observations Viewer



Historical data and products for hurricane research (CoastWatch and AOML)





Facilitates producing, sharing and using data

Utilization: Regional and global, multipurpose, ML, Big Data,...



Data discovery, distribution, delivery

Data Discovery: Traditional TDS and ERDDAP capabilities. OV: enhanced with search capabilities and Webmap. Metadata available for evaluating data quality.

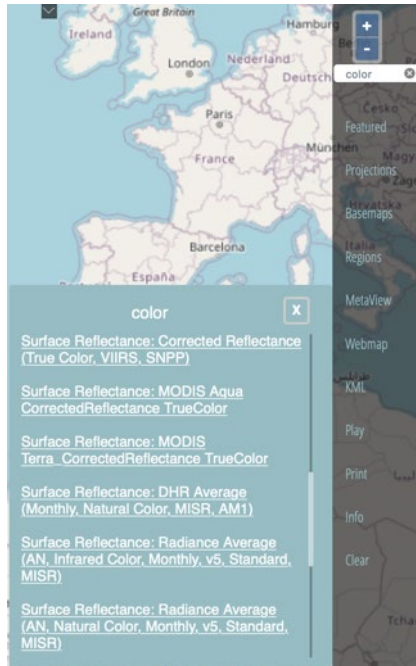
Data Distribution: Interoperable Middleware.

Data Delivery: AOML OOS (GTS), reports, customized products (e.g. saildrone timeseries) and backup

Data Aggregator: Multisource

Data Discovery

Metadata search in ERDDAP/OV



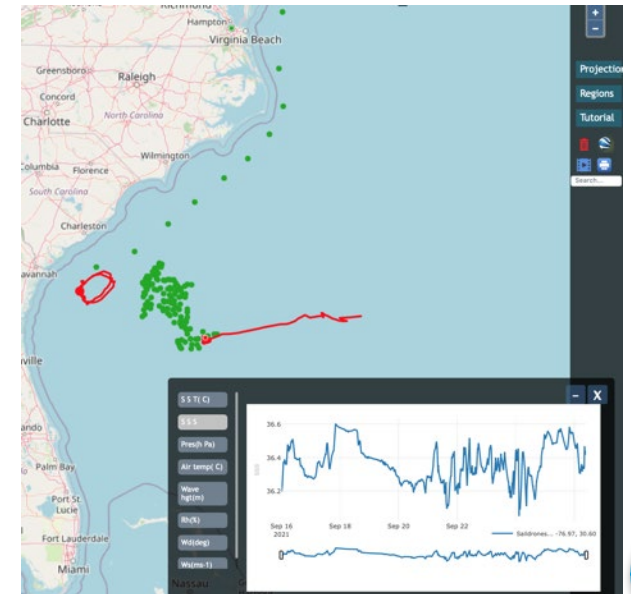
Distribution

TDS/ERDDAP/OV/Tile Server

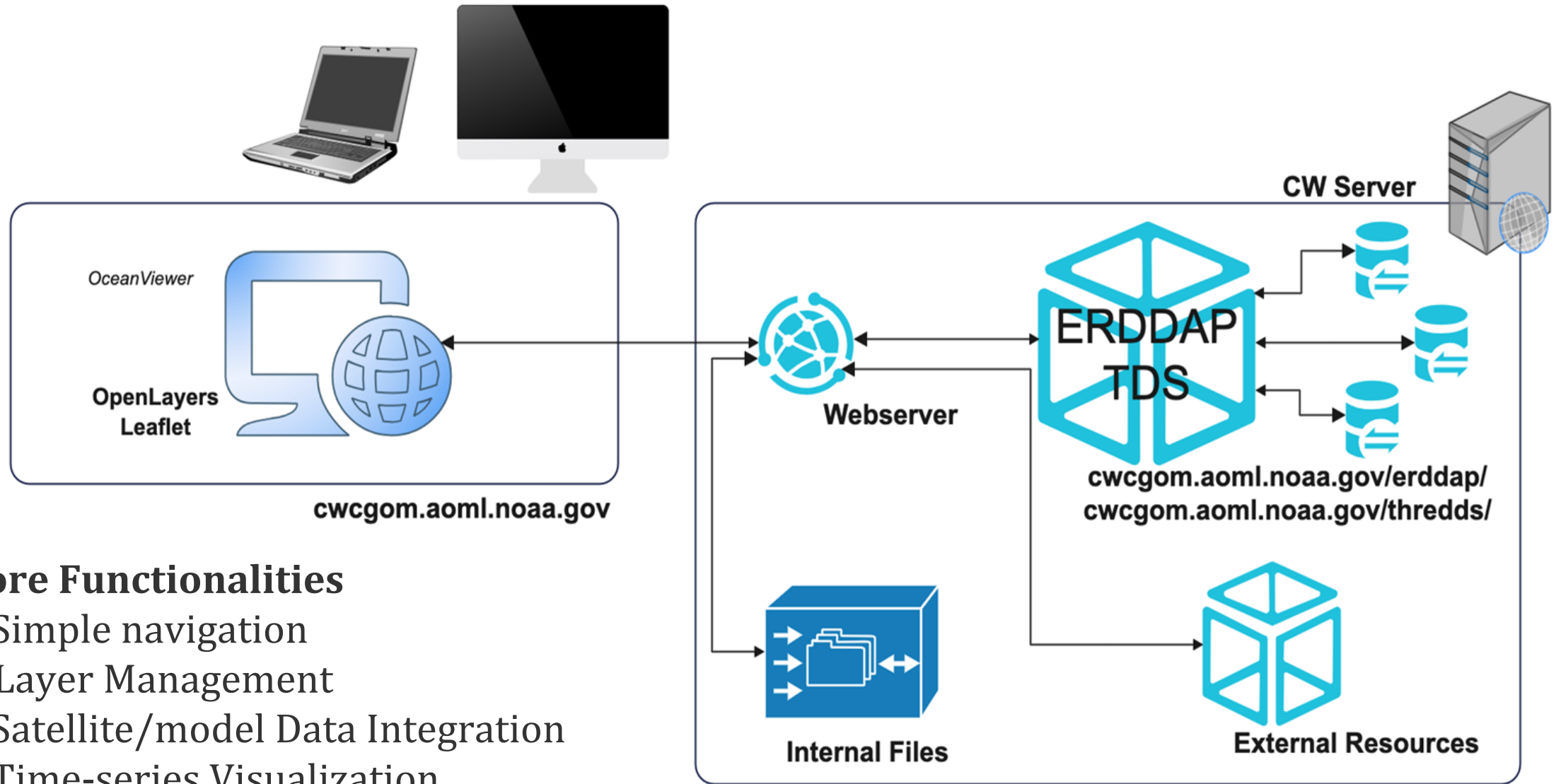
Tile Server
OCEANVIEWER
ERDDAP
TDS

Delivery

Customized products



OceanViewer: Architecture and main functionalities



Core Functionalities

- Simple navigation
- Layer Management
- Satellite/model Data Integration
- Time-series Visualization
- Easy Customization

CW-AOML Ocean Observations Viewer

Help to coordinate hurricane field observations by providing a user friendly platform that incorporate key ocean and atmospheric observations and fields, identify Essential Ocean Features: areas of high ocean heat content, barrier layers, warm eddies, Loop Current, Gulf Stream, etc.

Modular design

SWOT (Strengths, Weakness, Opportunities and Threats) **Analysis**

Agile approach: Constantly adapting to new requirements and new data needs.

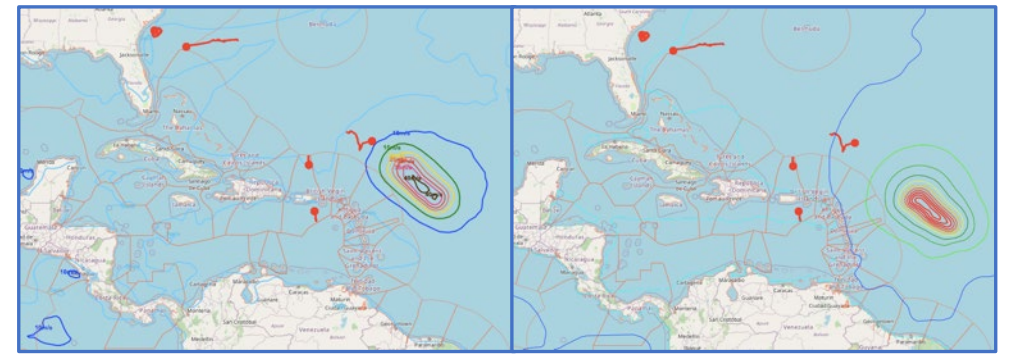
Reducing latency, adaptative sampling, identify type of platforms and sensors, integration of TAC/BUFR GTS and IOOS datasets, upload client data, ...

Sea surface salinity fields, 10-min GOES Truecolor, atmospheric pressure and wave-height.

New layers:

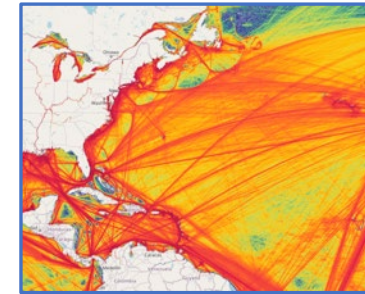
Local: satellite vector fields, GFS wind contours, saildrone time-series, WW3 wave height contours, SST anomalies, monthly WOA temperature and salinity climatology, ...

Remote: Ship traffic density map, NOAA nautical chart, NDBC Marine Observations, ...



Wind Speed (source GFS)

Wave Height (source WaveWatch III)



Ship density (source MarineTraffic)



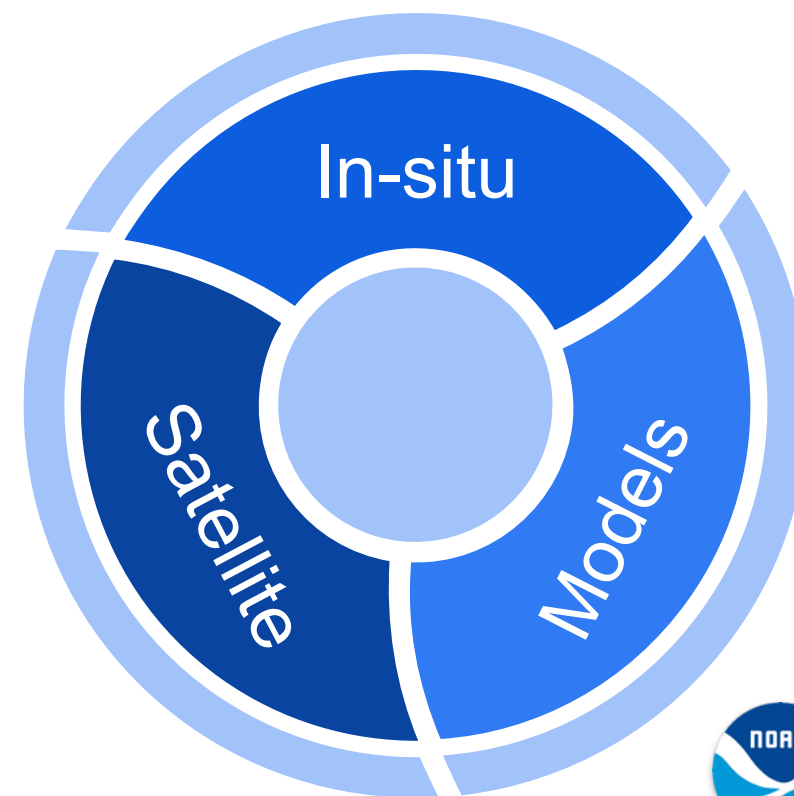
Data Acquisition

CoastWatch/AOML distinctive products:

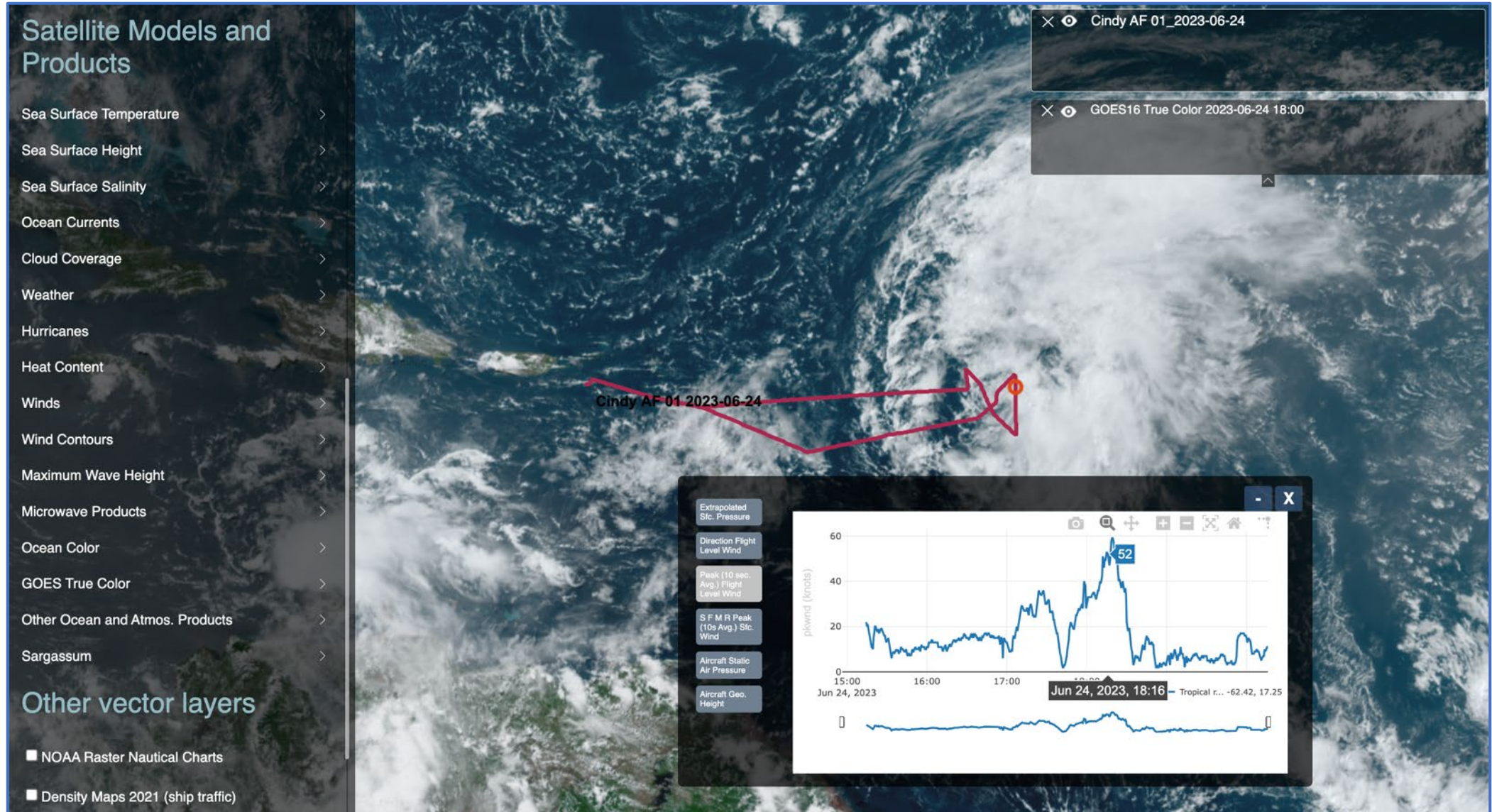
Caribbean OA	Ocean geostrophic currents	Monthly and seasonal carbon fluxes	Vibrio Suitability Index (daily, cumulative and short term forecast)
GOES 16/17 truecolor	Blended SST+frontal boundaries	In-situ glider/Argo/drifter/XBT	RSS MW products
Underway carbon SOOP	USF AFAI (daily, 3D and weekly) and MCI	Seascapes (8day and monthly)	30day cumulative VIIRS chlor_a
Aggregated K490/Rrs667 GoM	AVHRR SST anomaly	In-situ sargassum	AOML TCHP and OSPO OHC
SIR	ASCAT Winds	TO/SOA MSI	4-hr and daily AOD/AOT



Animations (leaflet)



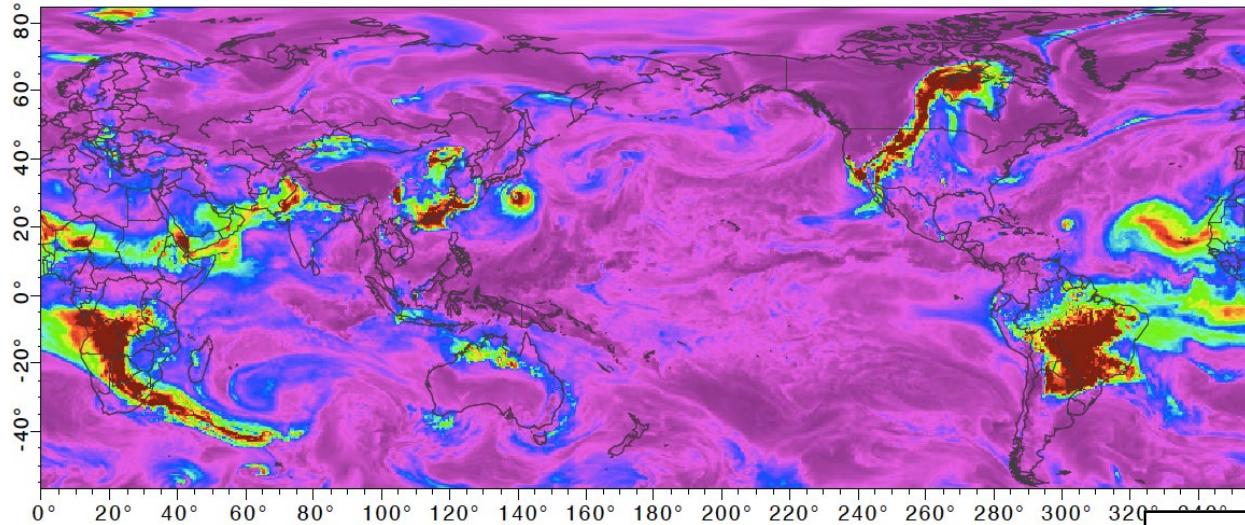
Aircraft Reconnaissance, Tropical Storm Cindy (2023)



Saildrone Operations

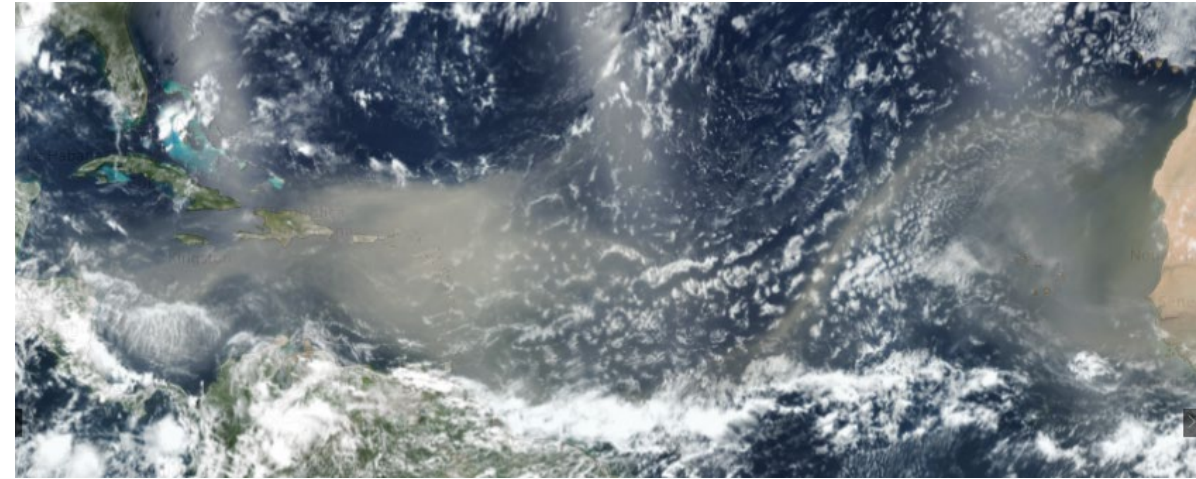


New products: Aerosols



3 hour 550nm AOT forecast from GEFS-Aerosols

VIIRS True Color



Potential Uses:

- Public Health
- Air quality
- Hurricane Intensification
- Effects on Sargassum



Summary

- Rapid hurricane intensification represents a challenge for forecasters and decision makers.
- Some atmospheric and oceanic key drivers for hurricane intensification, included rapid intensification, have been identified. The role of the ocean is essential to understand rapid intensification.
- Different observational efforts support research on this field, including surface (e.g. saildrone) and subsurface (e.g. gliders, XBTs) observations.
- Satellite provide multiple advantages to support research and operations: coverage, short latency, multispectral, resolution, ...
- CW-AOML Ocean Observation Viewer offers an integrated view to monitor and track hurricane-related activities in the Atlantic, using interoperable middleware for data access.
- Key features: Multipurpose, easy to customize, local&remote datasets, dynamic environment, data integration, animations, time-series, ...
- CW-AOML Ocean Observation Viewer represents a collective and coordinate effort to support hurricane field operations in the Atlantic and globally.

