Eulerian and Lagrangian sampling of water masses along hurricanes

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Acknowledgment to the NOAA/EMC HAFS Team, Copernicus Marine Service

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Do you want to know:

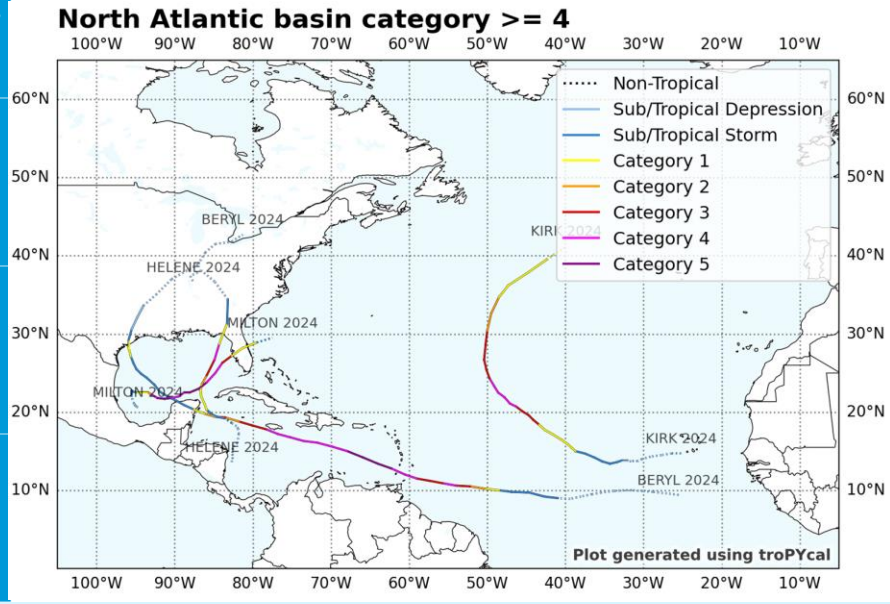
1. How does the ocean surface change before/after a hurricane passes? (Exemplified using a recent hurricane.)
2. How different satellite derived data products (e.g., SSH, SST, SSS, surface currents, etc) compare to (“high-res”) ocean reanalysis?
3. What happens to the water column (temperature and salinity) under the hurricane track?

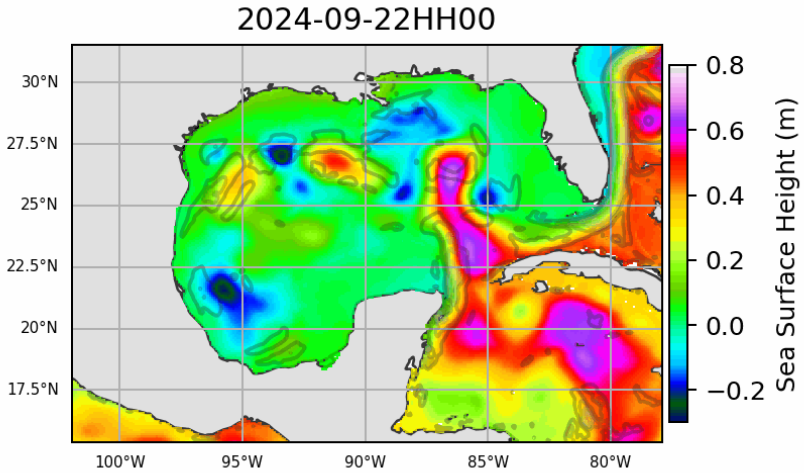
Recall/Remember:

- Ocean is sparsely observed; it gets worse in severe weather (e.g., high wind speed, waves/swell, intense rain rate, etc), hence relying on reanalysis data.

2024 Atlantic Hurricane season

- 4 Major (Cat 3+) hurricanes.
- $190B damage.
- 388 fatalities.



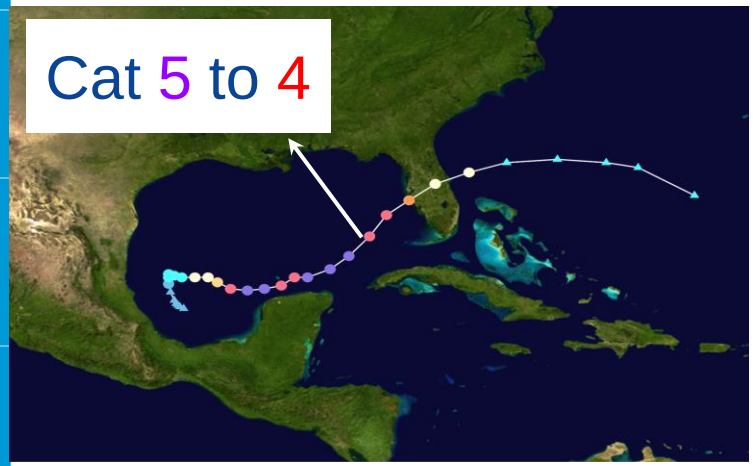


[Real-Time Ocean Forecasting System](#) (RTOFS)

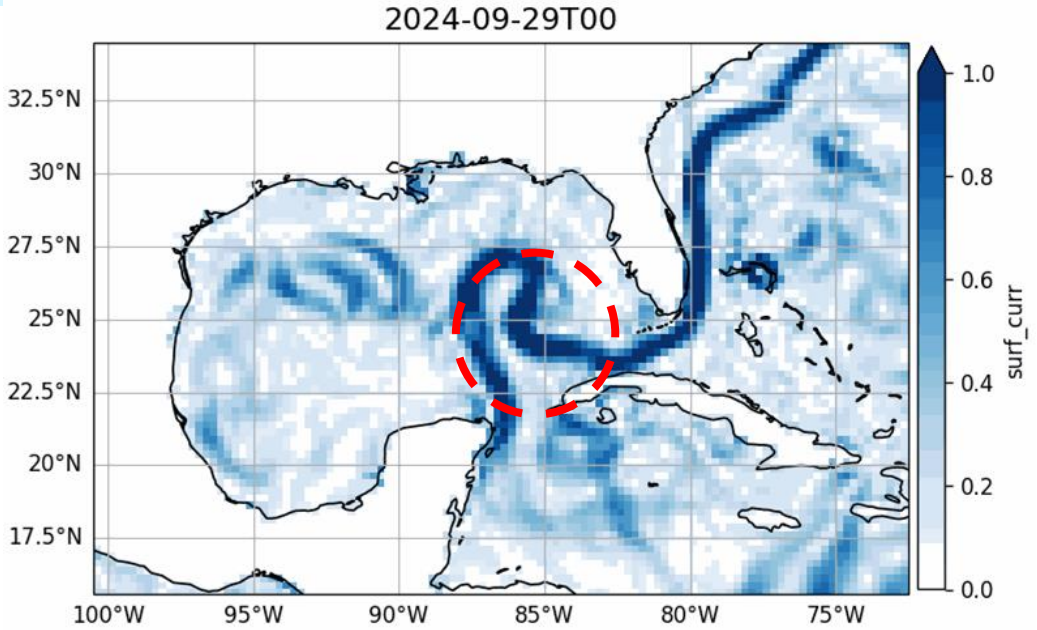
- Hourly SSH (shaded).
- Barotropic surface speed (contour).

Example: Hurricane Milton (2024)

- **Formed**: Oct 05, 2024.
- **Dissipated**: Oct 12, 2024.
- **Fatalities**: 35; 6 missing.
- **Damage**: $85 billion (est).
- Second most intense Atlantic hurricane in GoM.



Source: https://en.wikipedia.org/wiki/Hurricane_Milton



Data: SSALTO/DUACS Geostrophic speed (Copernicus)

[Q] What happened to the loop current after the hurricane passed around October 10, 2024?

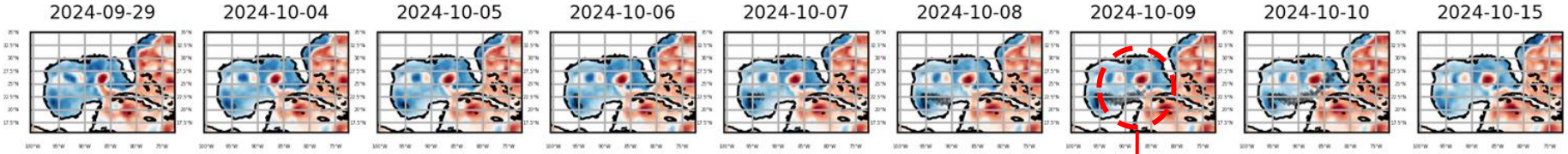
Data

Field	Satellite Data Product	**Ocean reanalysis** (Mercator GLO12)
Sea Surface Height (**SSH**)	cmems_obs-sl_glo_phy-ssh_nrt_allsat-l4-duacs-0.25deg_P1D (ADT; SSALTO/DUACS AVISO)	cmems_mod_glo_phy_anfc_0.083deg_PT1H-m
Surface Temperature (**SST**)	METOFFICE-GLO-SST-L4-NRT-OBS-SST-V2 (OSTIA SST)	As above
Surface Salinity (**SSS**)	cmems_obs-mob_glo_phy-sss_nrt_multi_P1D (CNR SSS)	As above
Surface **Currents**	cmems_obs_mob_glo_phy-cur_nrt_0.25deg_PT1H-i (GLOBCURRENT)	As above

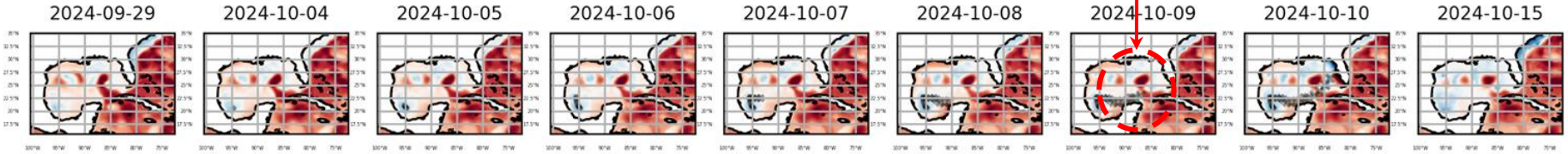
Storm track data from: Hurdat2. Thanks to tropycal python API.

SSH comparison (5 days before/after + during storm)

AVISO ADT



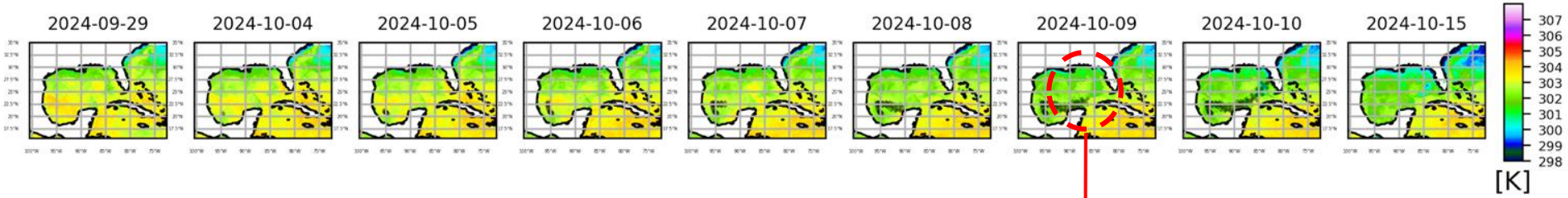
Mercator GLO12 (zos)



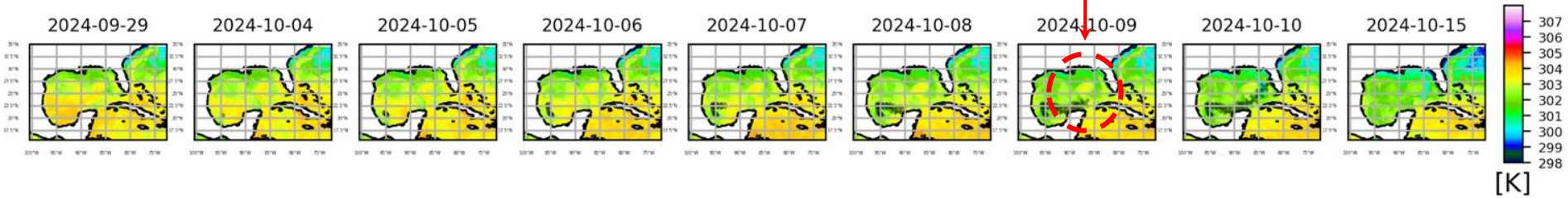
- Virtually identical looking fields (satellite/reanalysis), considering MDT.
- Did the hurricane intensity drop (cat 5 to 4) coincide with loop current crossing?

SST comparison (5 days before/after + during storm)

OSTIA SST



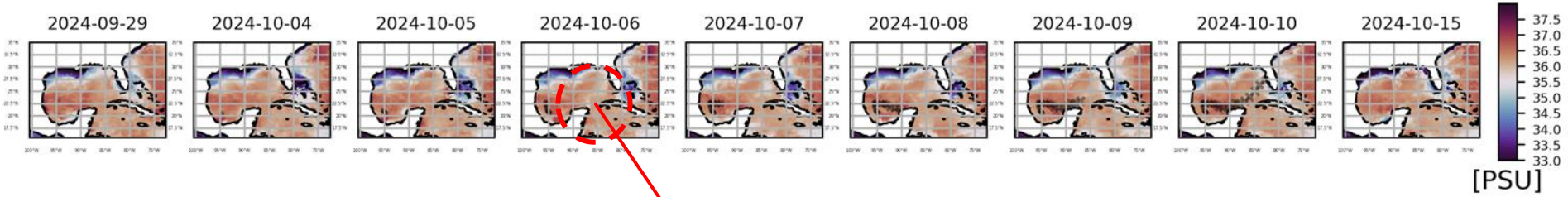
Mercator GLO12 (thetao; potential temperature [K]!)



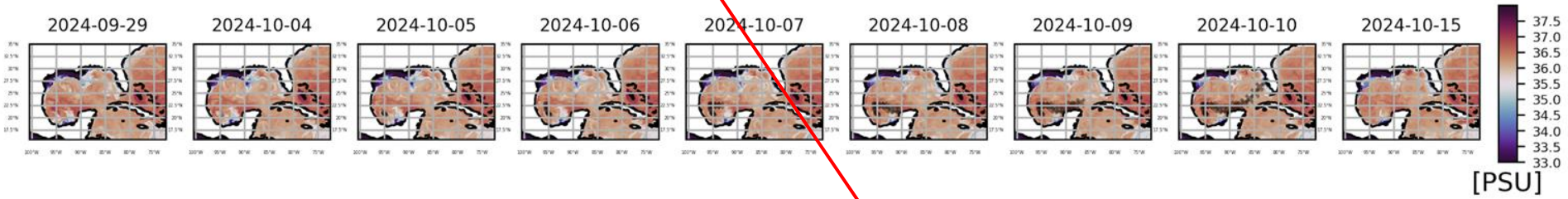
- Decrease in SST after passage.
- GLO12 SST > OSTIA SST; though note GLO12 SST is hourly and at about 0.5 m depth.

SSS comparison (5 days before/after + during storm)

CNS SSS



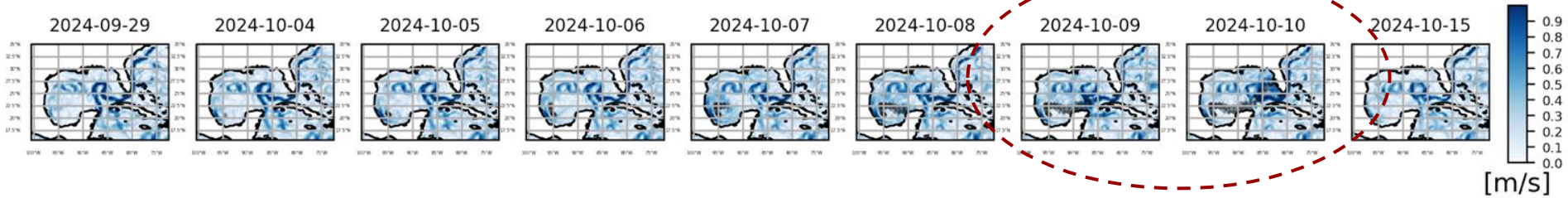
Mercator GLO12 (so)



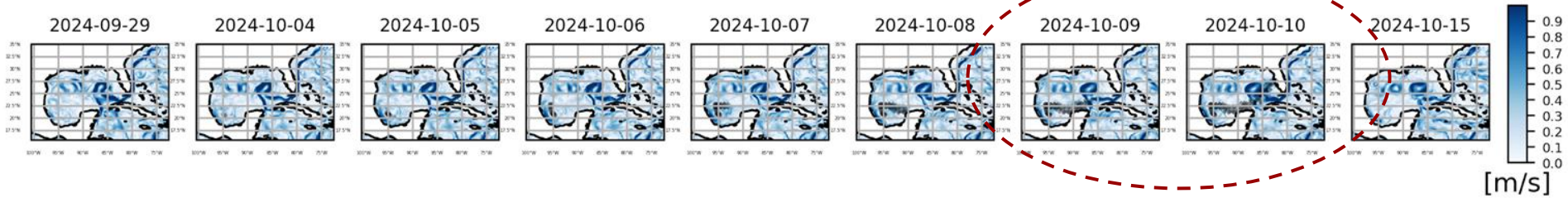
- Saltier after passage.
- Substantial differences between datasets. Is this hurricane path?

Surface speed comparison (5 days before/after + during storm)

GlobCurrent [surface speed (z=0)]

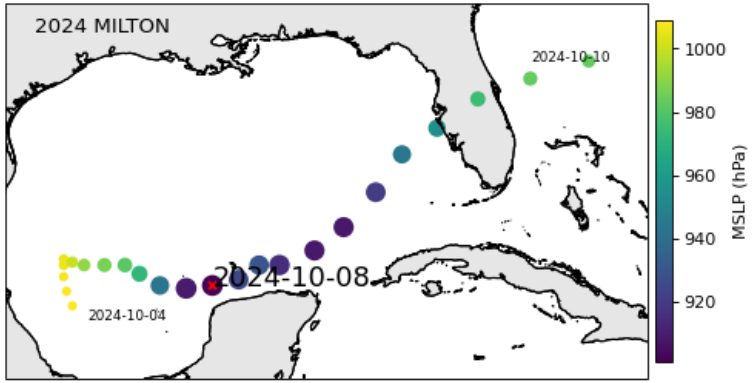


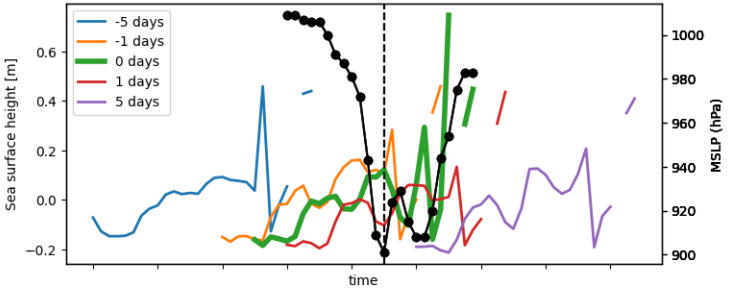
Mercator GLO12

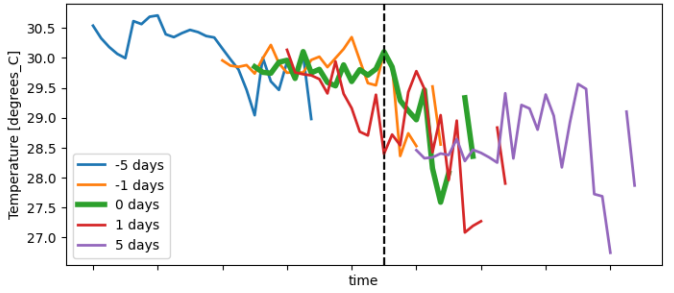


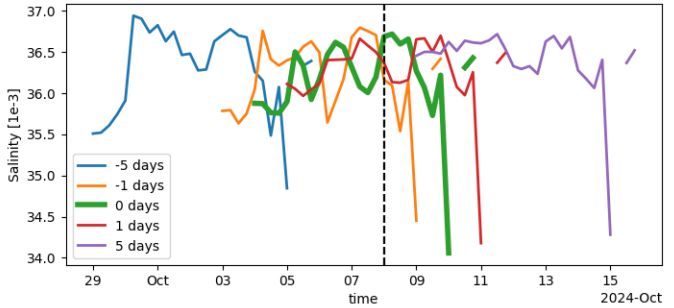
- [Q] What happened to the loop current after the hurricane passed around October 10, 2024?
- [A] Seems to have been broken!

SSH, SST, SSS (GLO12) before and after storm

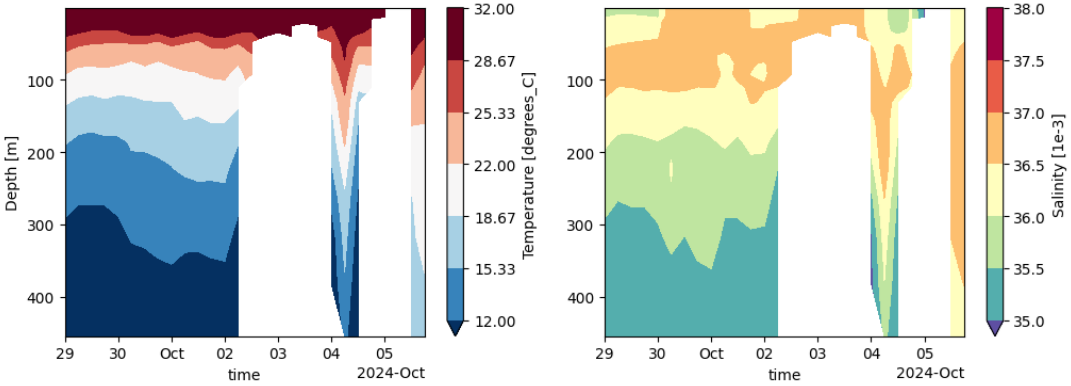




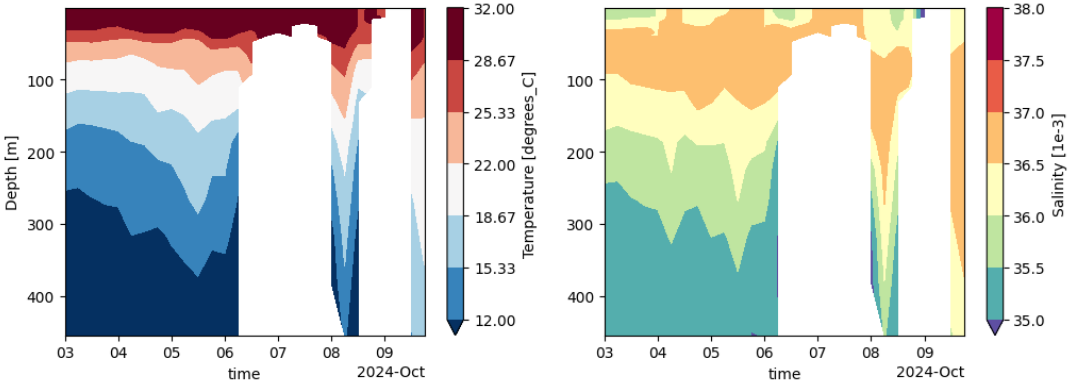




Subsurface T and S (GLO12) before and after storm

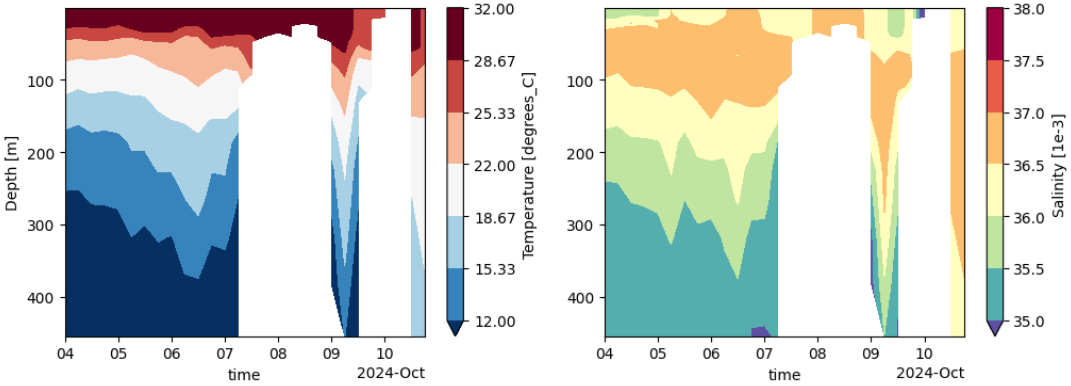


5 days before

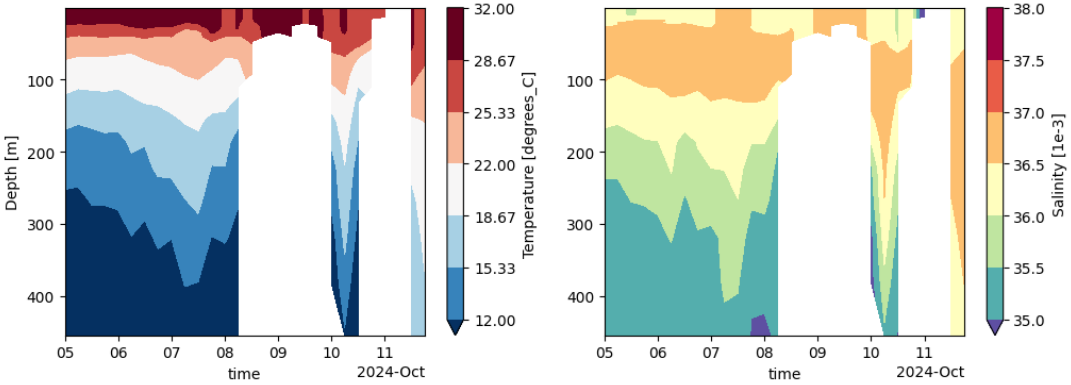


1 day before

Subsurface T and S (GLO12) before and after storm

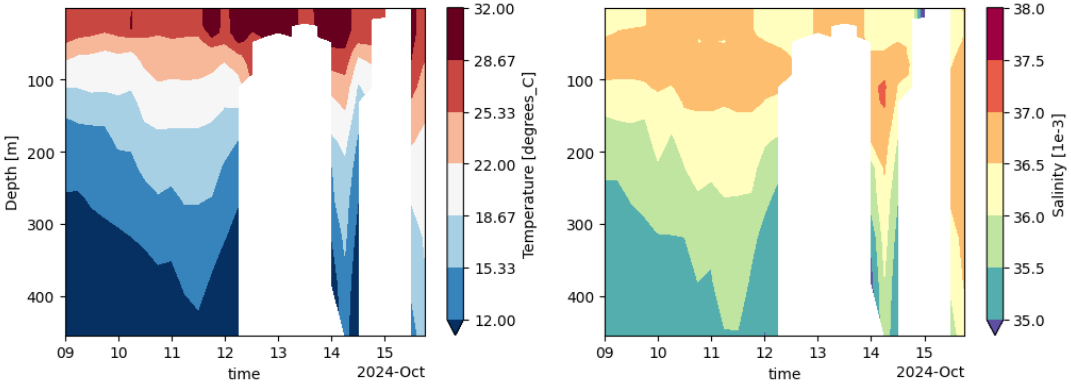


Along storm track



1 day after

Subsurface T and S (GLO12) before and after storm



5 days after

Notes:

- Upwelling along the hurricane path.
- Titling of isotherms/isohalines.
- Loss of stratification in the wake of the storm.

Summary:

- Ocean reanalysis (Mercator GLO12) compares *well* with satellite data products of SSH, SST, SSS; many similarities in patterns.
  - Differences in resolution of datasets is apparent (GLO12 at 1/12-deg vs typical ¼-deg satellite datasets).
- What happens to the hurricane is a result of complex interaction with the ocean: air-sea fluxes are vital. Resolve dynamical interactions:
  - **Ocean**: Surface and subsurface T, S, currents, etc.
  - **Atmosphere**: Clouds, winds, aerosols/spray, etc.
  - **Waves**: Swell, wind-wave roughness/drag, etc.
- It remains to be seen how coupled models and assimilation systems depict hurricane atm-ocn-wav response with feedbacks.

Questions?