Mesoscale eddies inform mesophotic reef health

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Overview

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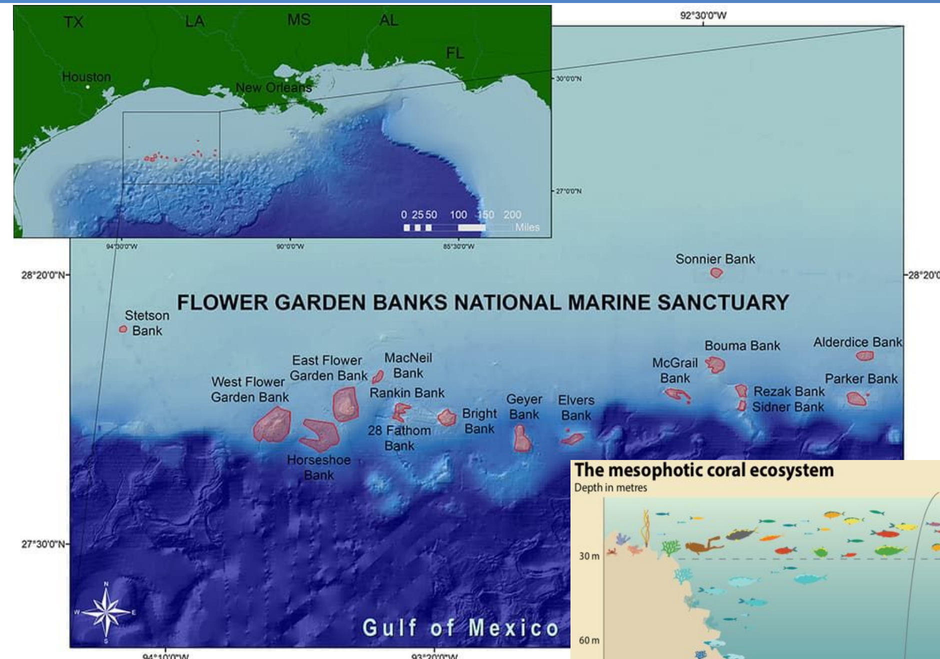
Flower Garden Banks National Marine Sanctuary

- 16 m - 140 m
- Deep water stability >16 m compared to shallow reefs <10 m
- Distance offshore (190 km)
- Federal protections
- Seasonal variability, high latitude reef



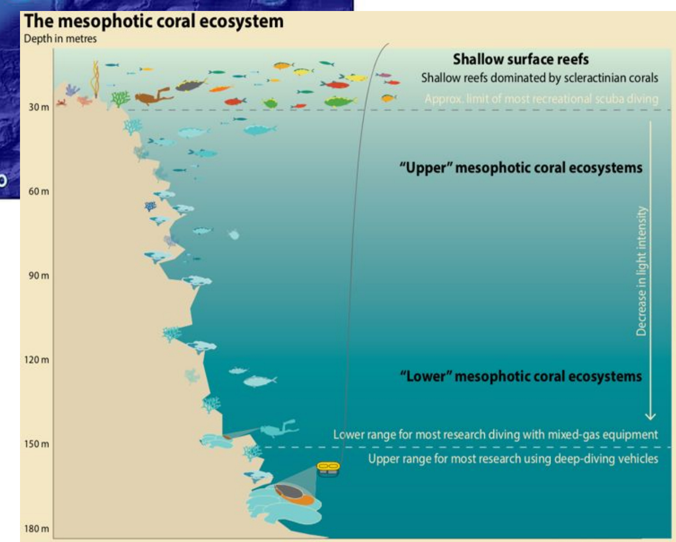
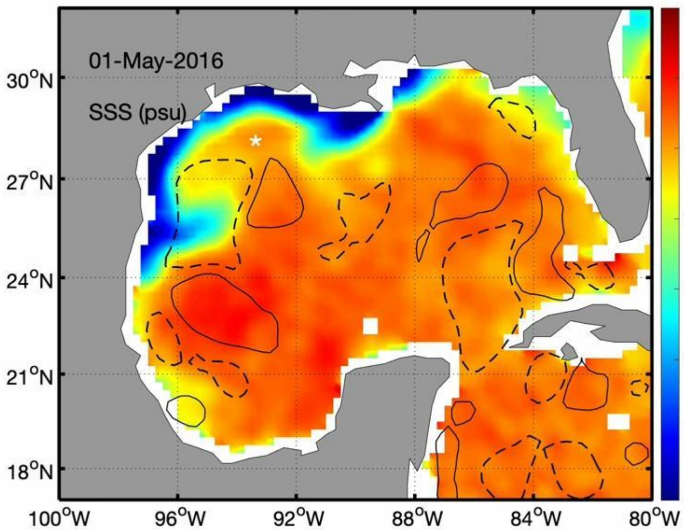



Photo: FGBNMS/UNCW-UVP

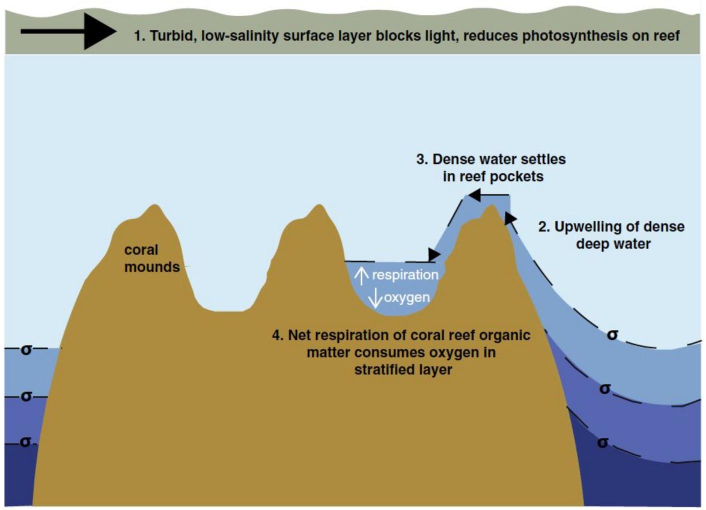
2016 Bleaching Event



- Hypoxia die-off event in late July 2016 over eastern Flower Garden Banks (FGB) only, not the western FGB, caused by low salinity intrusion over FGB due to excessive river runoff

- Anticyclonic eddy (AE) SW of FGB helped pull low salinity water southward and enabled event

- Cyclonic eddy (CE) SSE of FGB helped upwell low dense, deep water southward and assisted in event (potentially one reason by western FGB unaffected)



Conceptual diagram of FGB hypoxia event from *Kealoha et al., (2020).*

Goals

1) Use a combination of mesoscale eddy tracking and Argo floats to create an eddy climatology of the FGB
   a) Better understand how a changing climate may affect the reef

2) Determine what role eddies play in bleaching events in the FGB

Photo: FGBNMS/UNCW-UVP

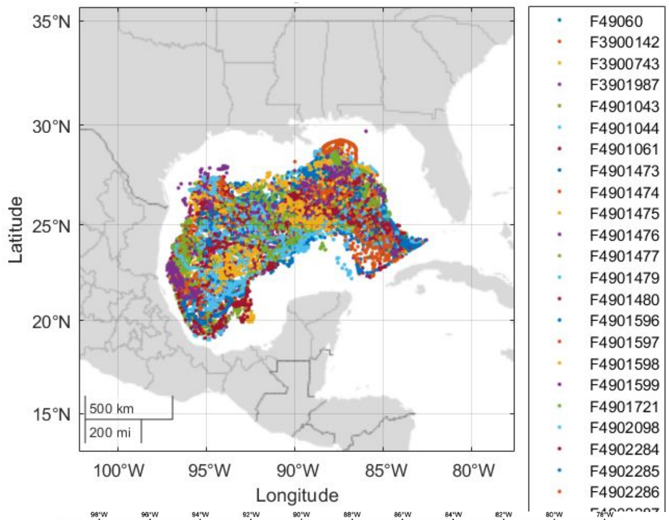
Overview of Eddy Tracking

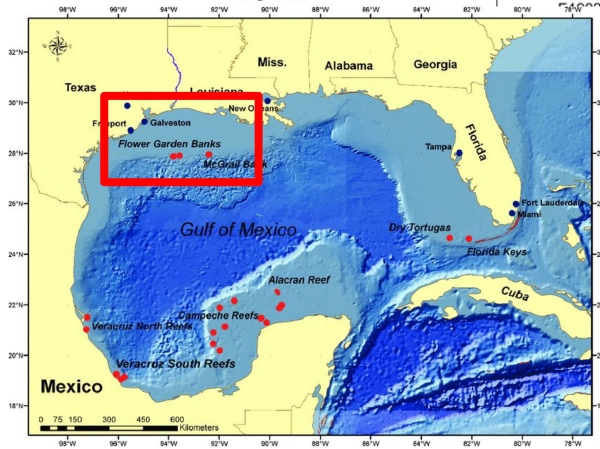
- Inputs:
  - **Original system** uses NOAA Radar Altimetry Database System (RADS) NRT Altimetry 0.25° x 0.25° daily grids (Sea Level Anomalies (SLA), U, V)
  - **System adapted for FGBNMS climatology** uses CMEMS DUACS DT Altimetry 0.25° x 0.25° daily grids (SLA, U, V)
  - NOAA Geo-Polar Blended NRT L4 Analysis 5 km daily grids (night SST)
- Uses a closed-contour eddy tracking method adapted from Chaigneau et al. (2008, 2009) and Pegliasco et al., (2015)
- Trajectories considered valid if eddy tracking run for 100+ days, calculated using a cost-function:

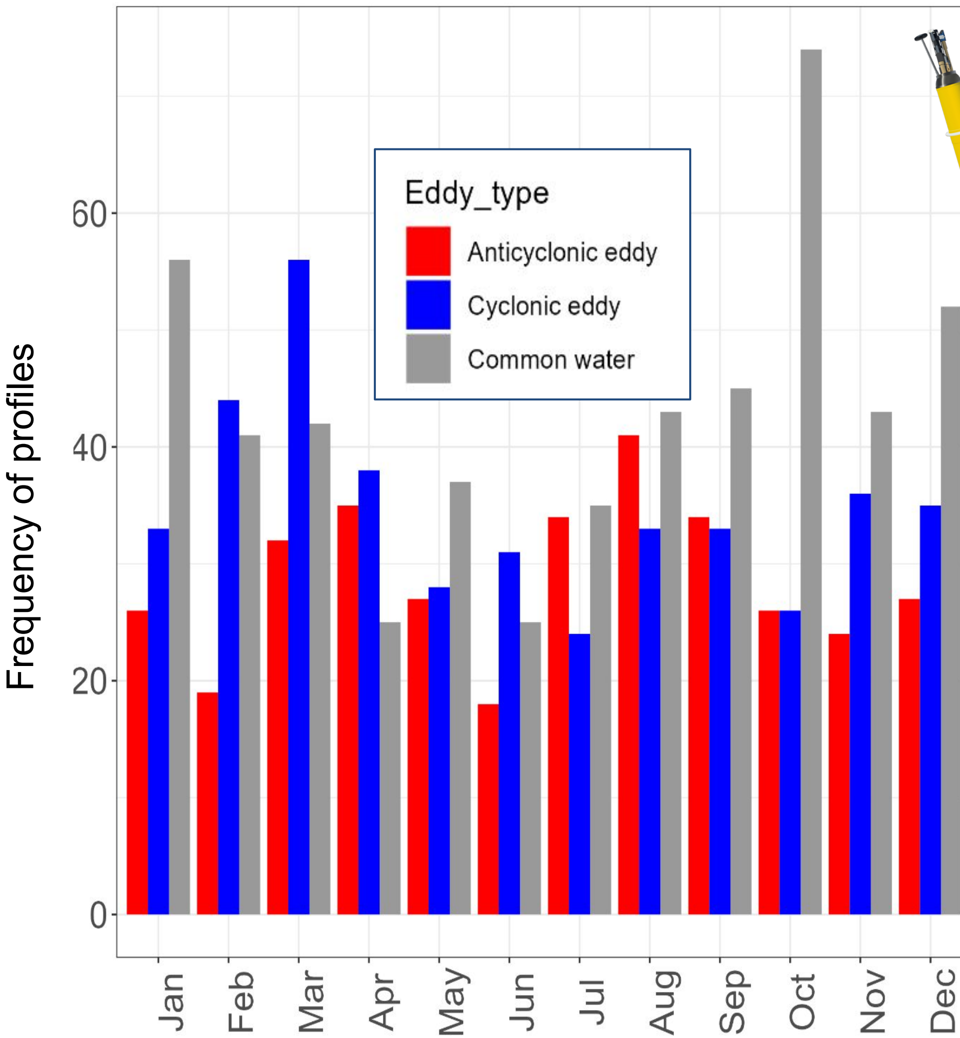
$$CF_{e_1,e_2} = \sqrt{\left(\frac{\Delta R - \overline{\Delta R}}{\sigma_{\Delta R}}\right)^2 + \left(\frac{\Delta A - \overline{\Delta A}}{\sigma_{\Delta A}}\right)^2 + \left(\frac{\Delta EKE - \overline{\Delta EKE}}{\sigma_{\Delta EKE}}\right)^2}$$

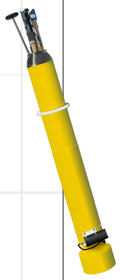
- Uses a high-pass 10° latitude, 20° longitude Gaussian filter (Chelton et al., 2011; Mason et al., 2014)
- Threshold free to allow for tracking and analysis of transient systems
- Run for Gulf of Mexico (80-100°W, 17-30°N) from September 1, 2002 to July 31, 2022 (start of Geo-polar SST, end of CMEMS DT SLA)
- Observation based in entirety, does not require model input

Distribution of Core Argo





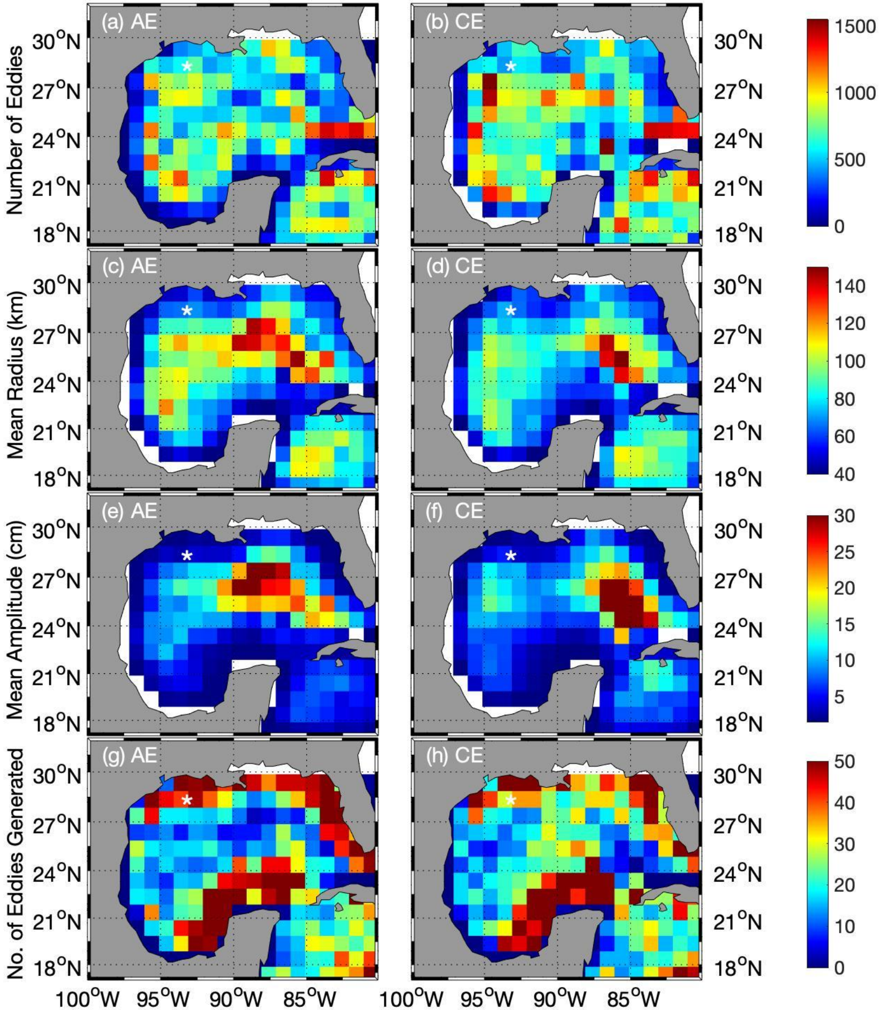




Schmahl et al., (2008)

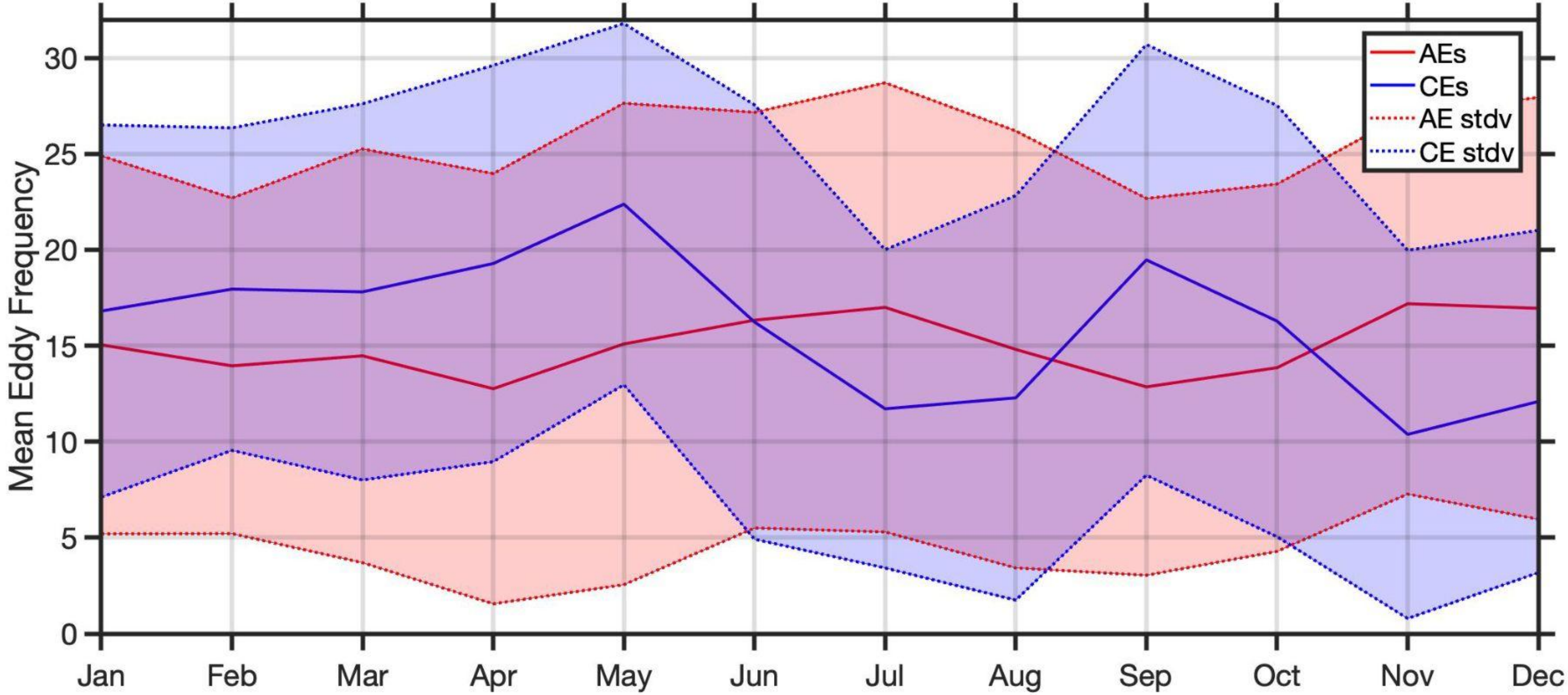
Eddy Climatology from Mesoscale Eddy Tracking

Eddy Climatology



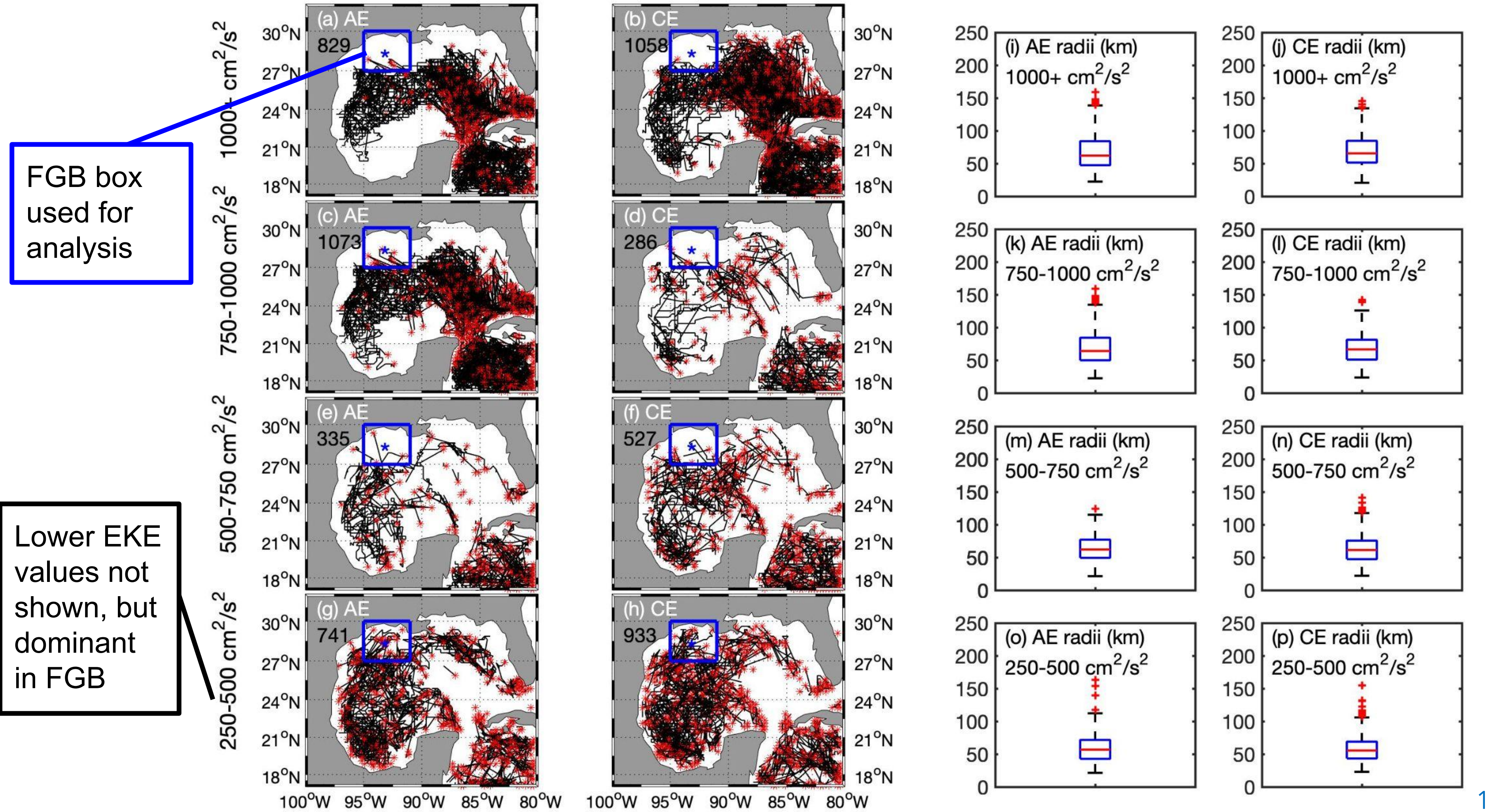
- Basic eddy characteristics for Sep 1, 2002 – Jul 31, 2022
- Eddies sorted into anticyclonic (AE) and cyclonic (CE) eddies
- FGB indicated by a star (*)
- Resulting eddy characteristics shown in 1° bins (4 grid points per bin)
- Distribution of characteristics highlights Loop Current Eddies (Radius, No. of eddies generated, Amplitude)
- FGB eddies are low amplitude, small radius

Eddy Climatology

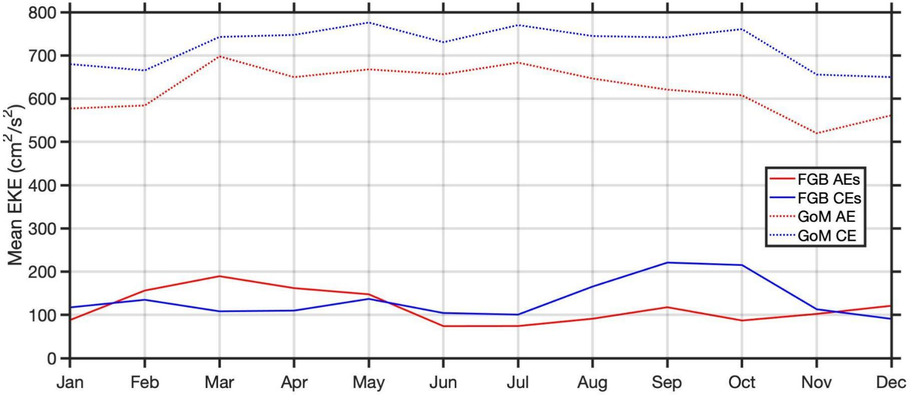


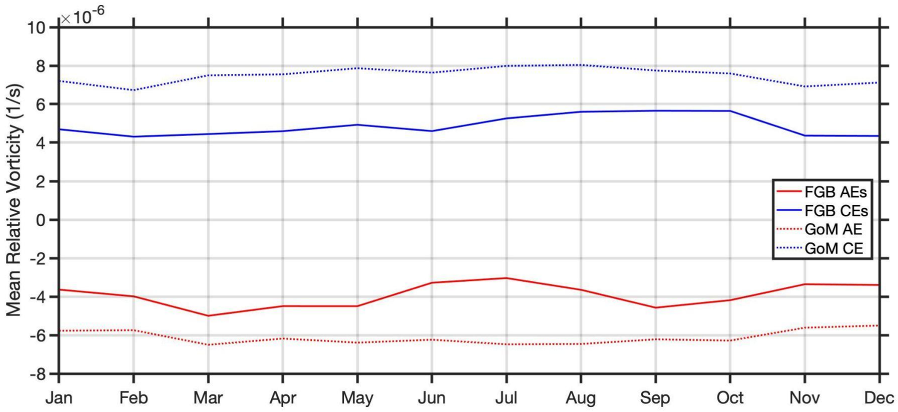
- Time series of mean eddy frequency (# of eddy days/month) in the FGB 2002-2022
- May/Sep = highest for CEs, Aug/Dec = highest for AEs
- Clear seasonal cycle present, more apparent in CEs than AEs

Eddy Climatology

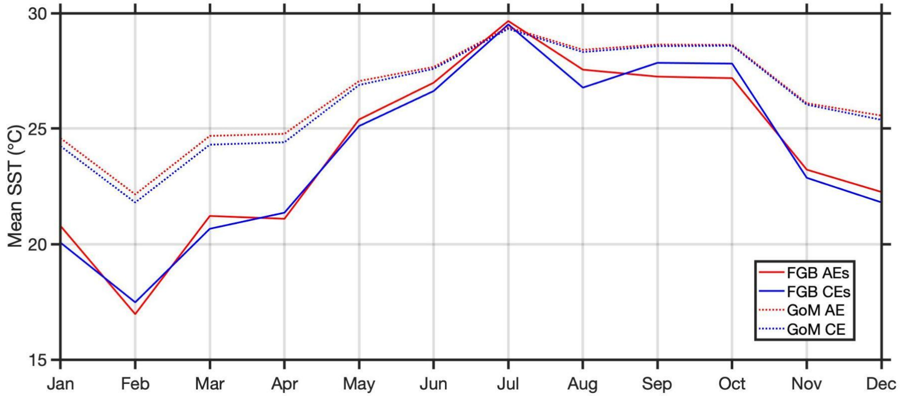


Eddy Climatology

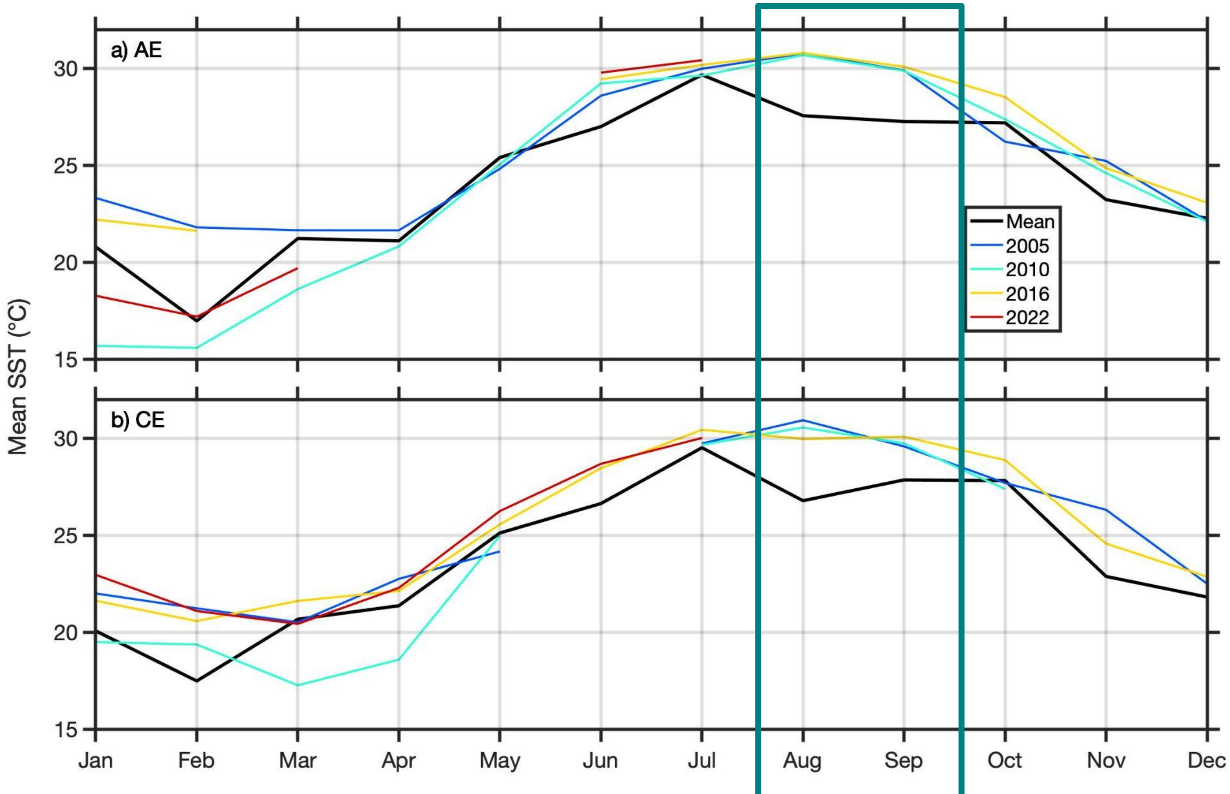




- FGBNMS eddies are 22% as energetic as those in the greater GoM
- AEs (CEs) more energetic Winter/Spring (Summer/Autumn)
- FGBNMS eddies are colder those in the greater GoM, except in July
- AEs only slightly warmer than CEs (CEs warmer in Sep-Oct)
- Persistently warm through Oct → may contribute to bleaching conditions



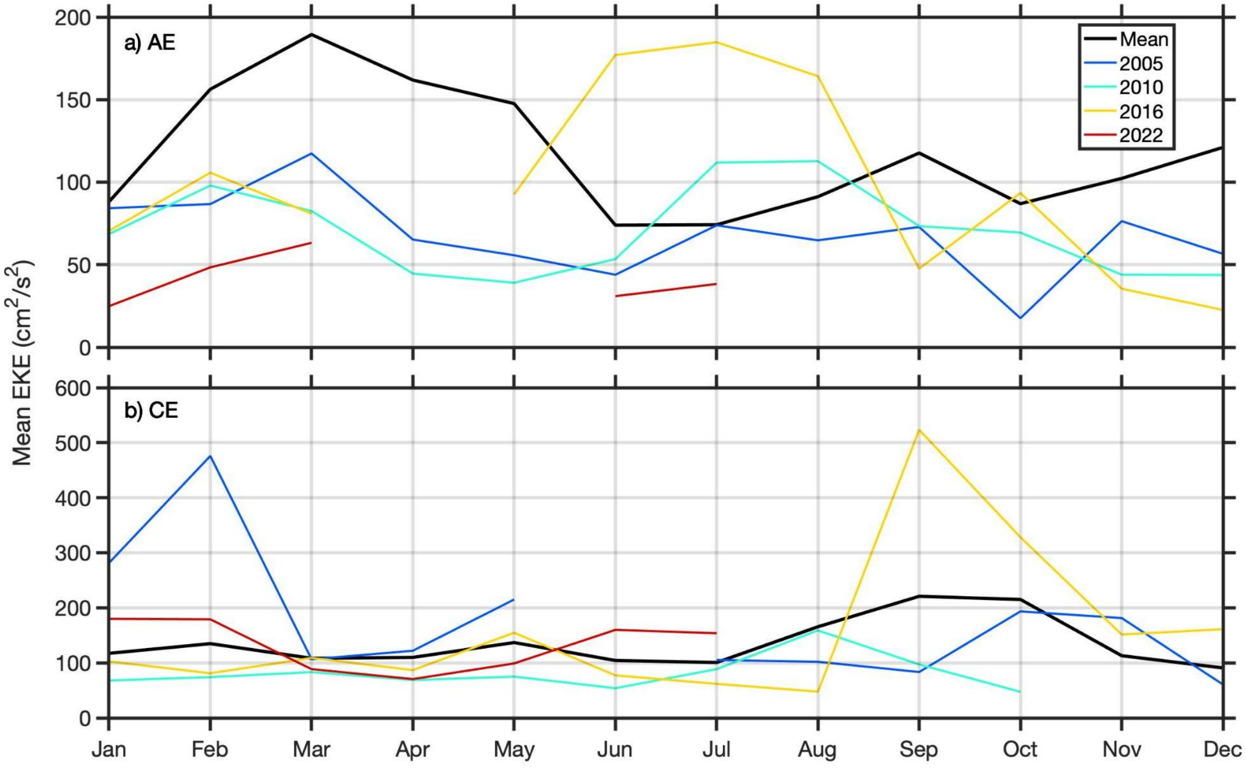
Bleaching Years



Most bleaching occurs Aug-Sep!

- SSTs warmer than 20-yr mean (and 30+ deg. C) for Jul-Oct during bleaching years
- Suggests that eddy activity is unlikely to directly cause bleaching events, but can be a contributing factor
- 2016 event shows eddies can still play a more indirect role in bleaching

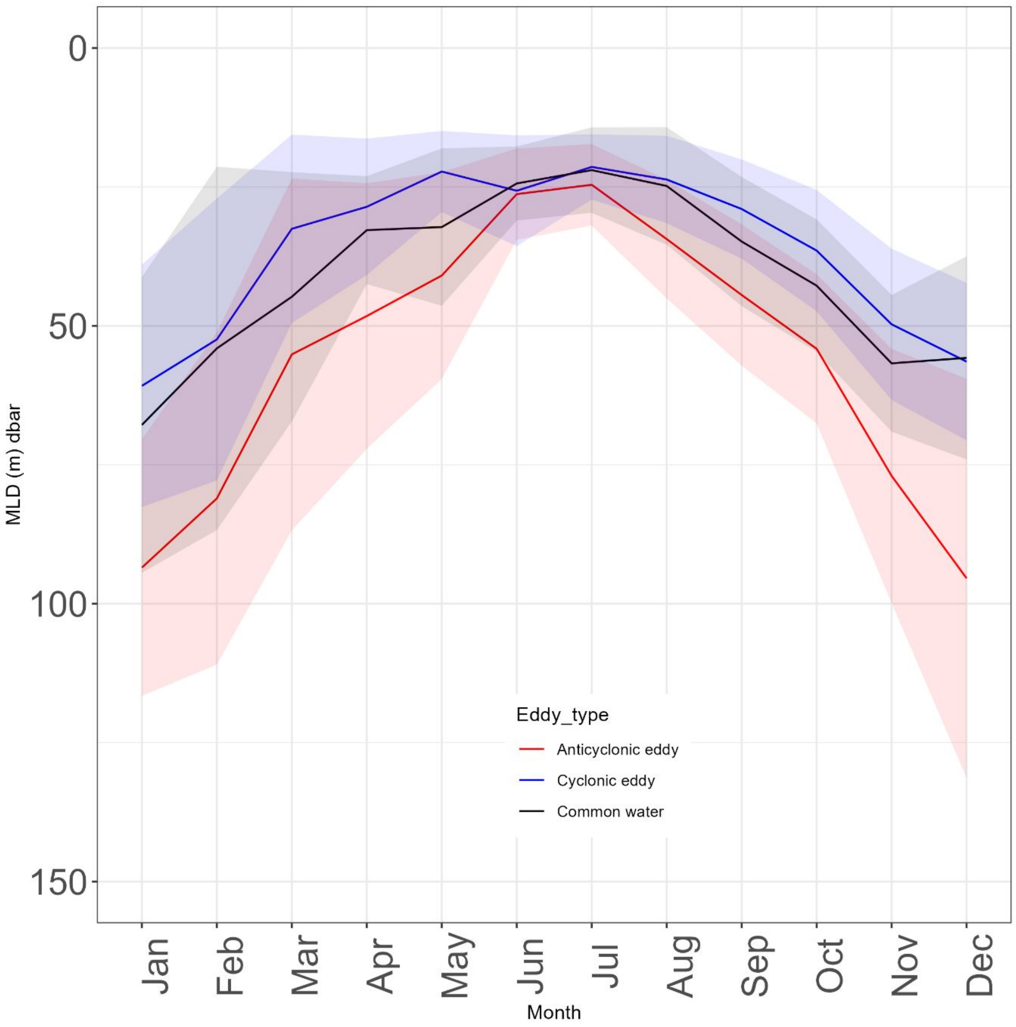
Bleaching Years



- No clear pattern in EKE for bleaching years compared to SST
- EKE generally lower than mean for bleaching years
- Suggests that warm, slow moving water is sitting over the reef before bleaching events

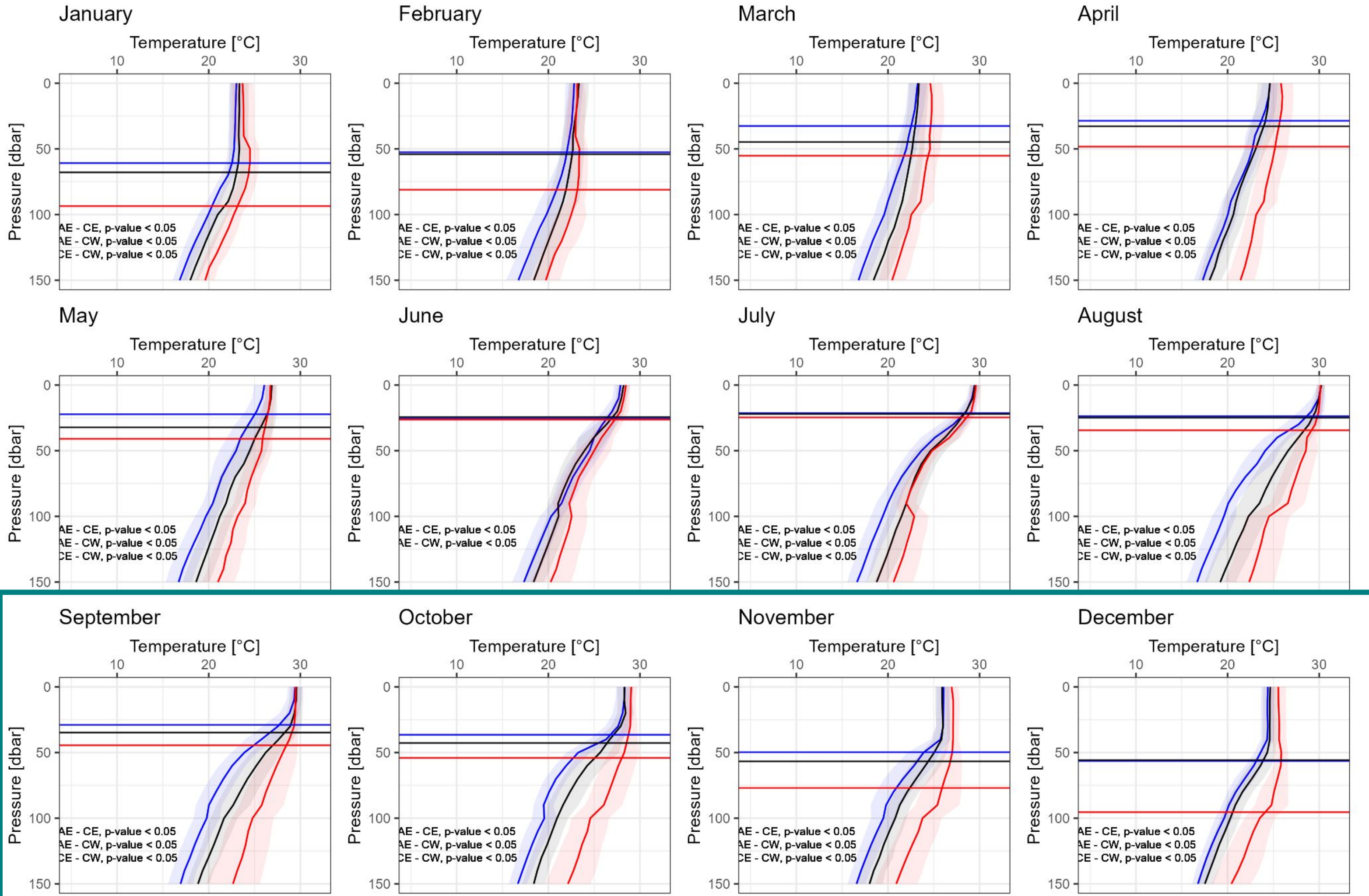
Eddy Climatology from Argo

Argo MLD



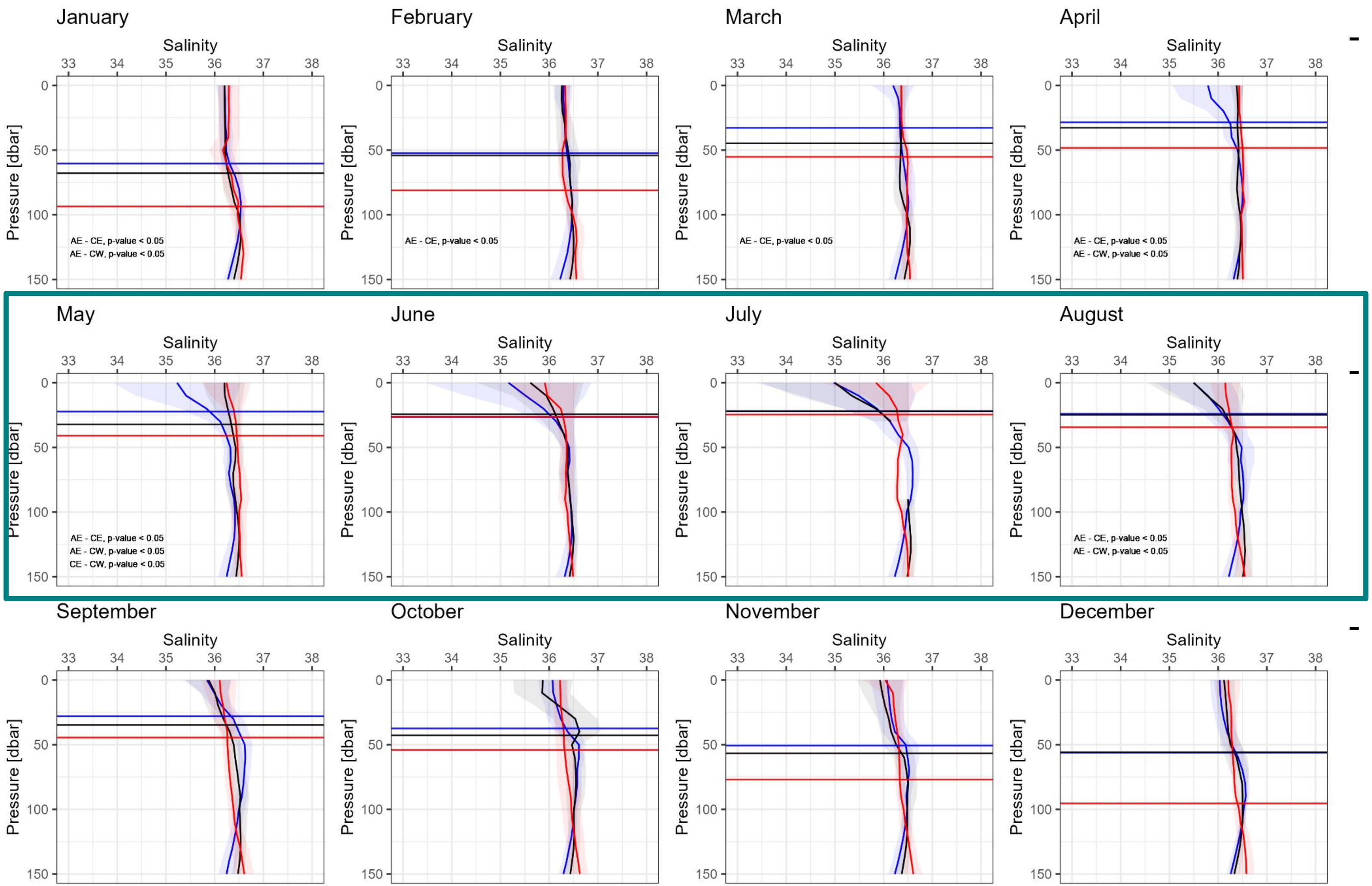
- Time series of MLD (m) from core Argo in **AEs**, **CEs**, and **common water**
- Clear seasonal cycle present, more apparent in CEs than AEs
- Peak in CEs in Apr/Jul and
- Peak in AEs in Jun/Jul
- Most variability in winter months

Argo Temperature



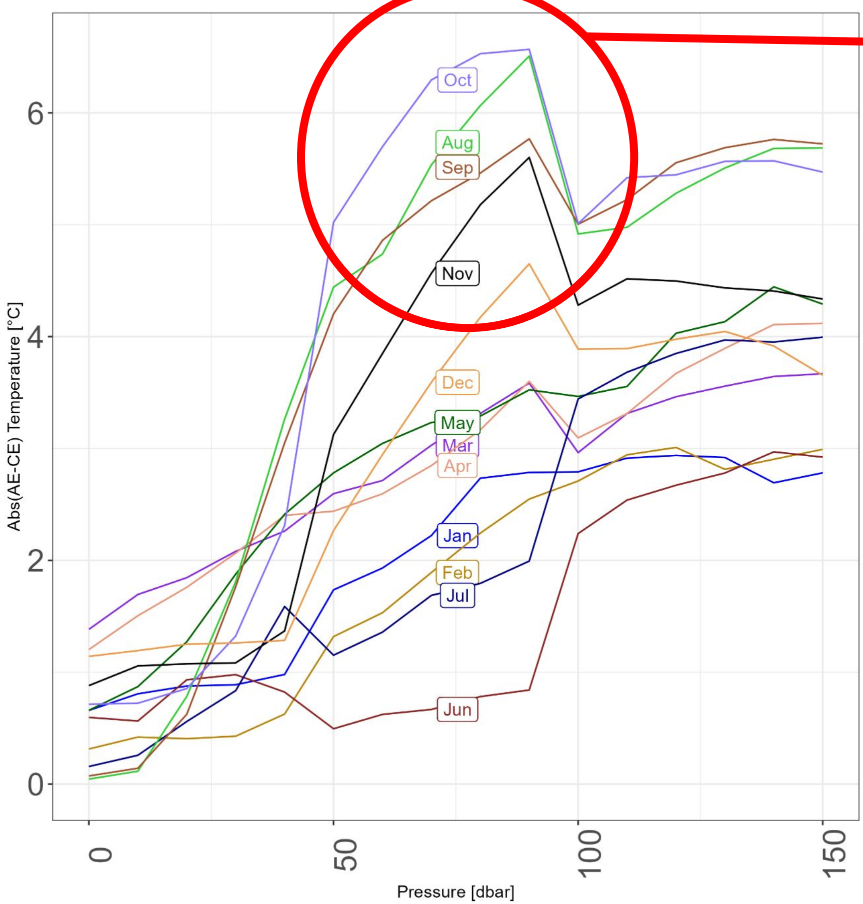
- Variability is more pronounced below the MLD during Sep-Dec
- Surface differences are greater in AEs

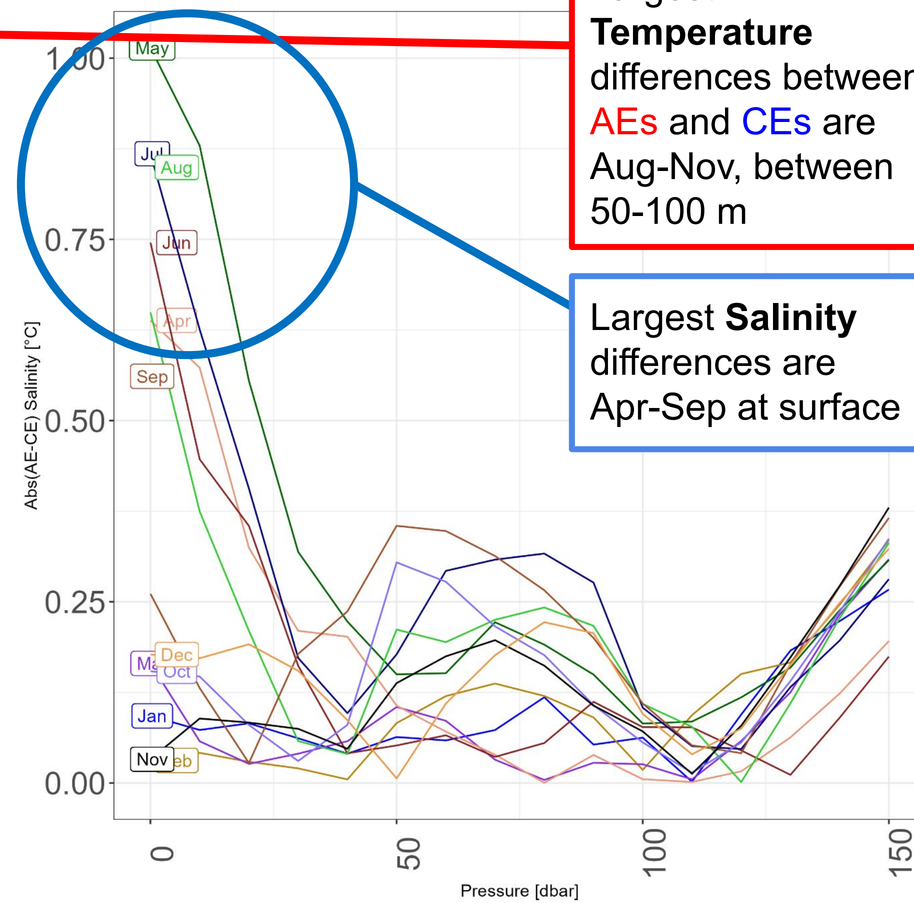
Argo Salinity



- Surface variability is more pronounced above the MLD in May-Aug than in other months
- Also see largest difference between AEs and CEs in summer
- Freshening is seasonal, pronounced in the summer likely due to river inputs

Eddy Climatology





Largest **Temperature** differences between AEs and CEs are Aug-Nov, between 50-100 m

Largest **Salinity** differences are Apr-Sep at surface

Conclusions

- Eddies help provide a resilient environment over the FGB
- Eddies over the FGB are lower energy than the rest of the GoM
- Eddy days occur over half of each month
- Previous stress events are not directly connected to eddy signals (2016 event), but eddies can indirectly impact upwelling and guide low salinity waters that can contribute to bleaching
- Largest differences in AE and CE profiles during Aug-Nov
- Deepening of the MLD in winter months is exacerbated by AEs
- Shoaling of MLD in summer months
- Persistent warm (eddy) temps, low salinity in Jul-Oct can contribute to bleaching conditions in Aug-Sep

Photo: FGBNMS/UNCW-UVP

Thanks for listening!

Extra Slides

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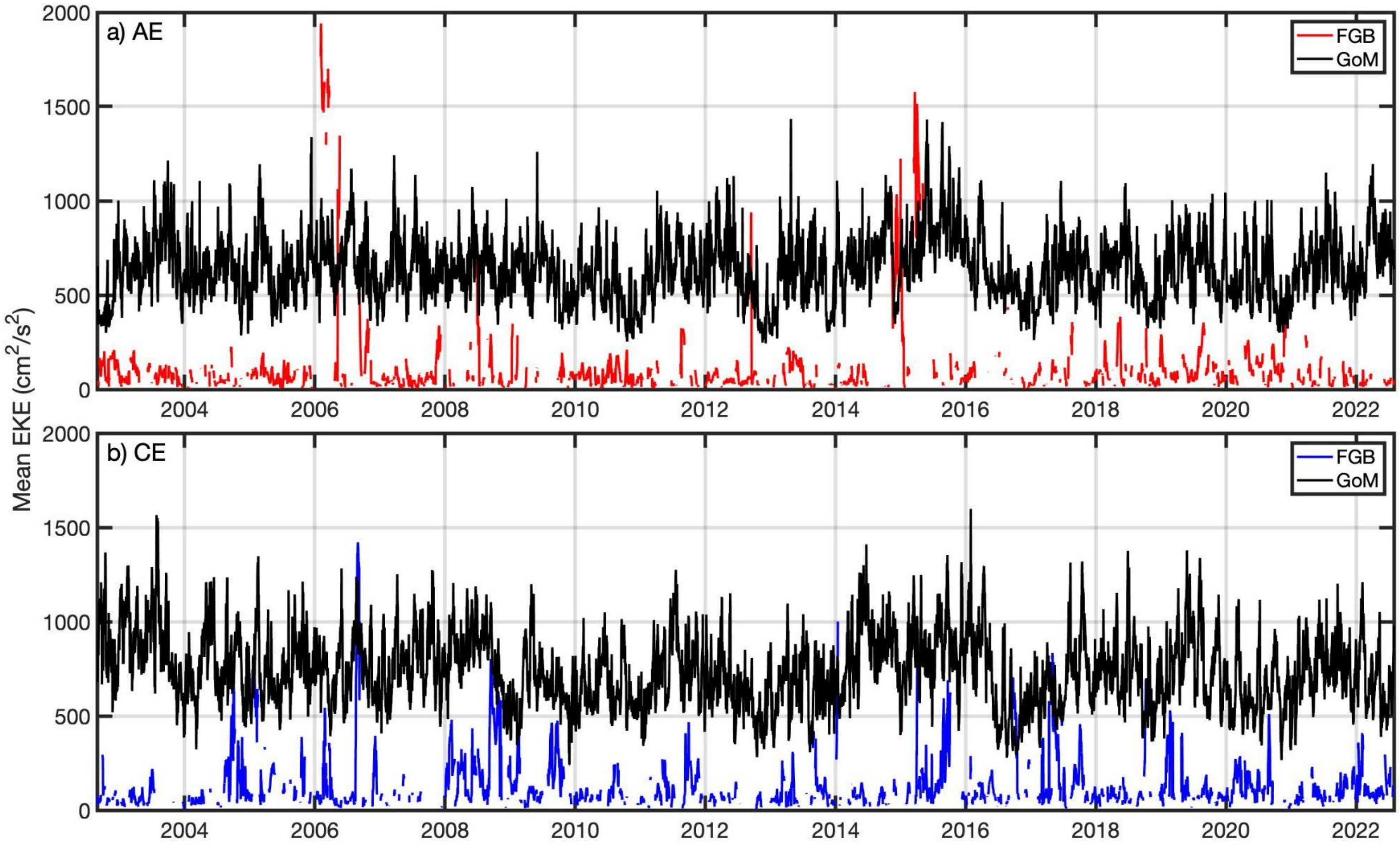
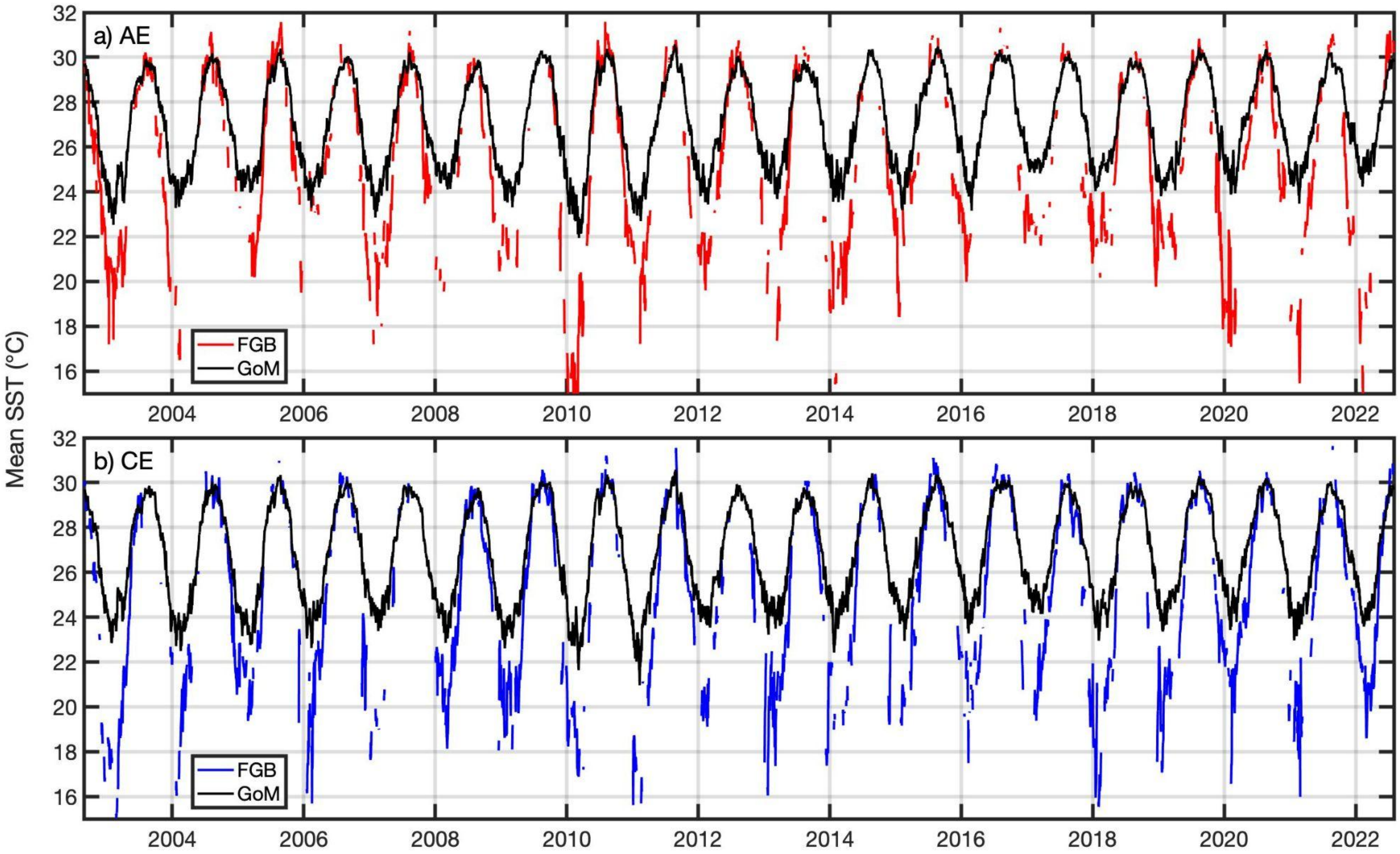
Eddy Climatology



Eddy Climatology



Eddy Climatology