Research Question

- Mesoscale eddies detected by sea surface height (SSH) fields have been observed to display coherent temperature (SST) structures, which lead to the term of **SSH-SST coherent eddies**. For example,

- **AEs** ---> **SSHA+** ---> **SSTA+**
  CEs ---> **SSHA-** ---> **SSTA-**

- However, recent statistics have shown that ~20% eddies are unconventionally **warm CEs and cold AEs** (e.g., Moschos et al., 2022), which refer to the definition of **SSH-SST incoherent eddies**. For example,

- **AEs** ---> **SSHA+** ---> **SSTA-**
  CEs ---> **SSHA-** ---> **SSTA+**

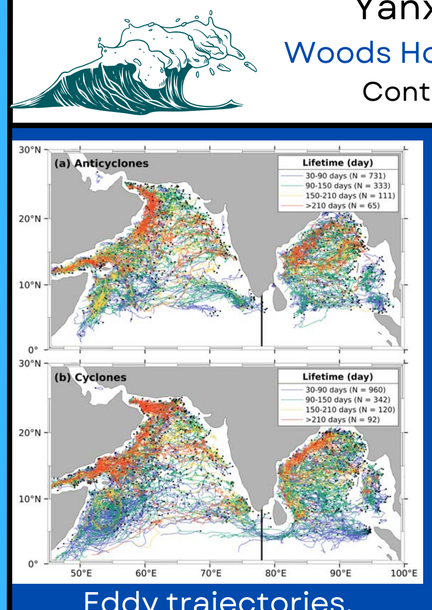
- In this study, we focus on proportions and mechanisms of both eddy types in the **North Indian Ocean** to understand air-sea coupling induced by eddies.

Signature of mesoscale eddies on air-sea heat fluxes: strong compensation between SSH-SST coherent and incoherent eddies

Yanxu Chen and Lisan Yu

Woods Hole Oceanographic Institution

Contact: yanxu.chen@whoi.edu



Eddy trajectories.

Data and methods

Data:

- The air-sea flux datasets are sourced from **OAFlux2**, the second generation of OAFlux sponsored by NASA's MEaSUREs program (Yu, 2023). These datasets consist of 1/4 degree gridded satellite-derived products, including turbulent heat fluxes, wind and wind stress etc.

- The Mesoscale Eddy Trajectories Atlas (**META3.2 DT**) is derived from the altimetric absolute dynamic topography (ADT) (Pegliasco et al., 2022).

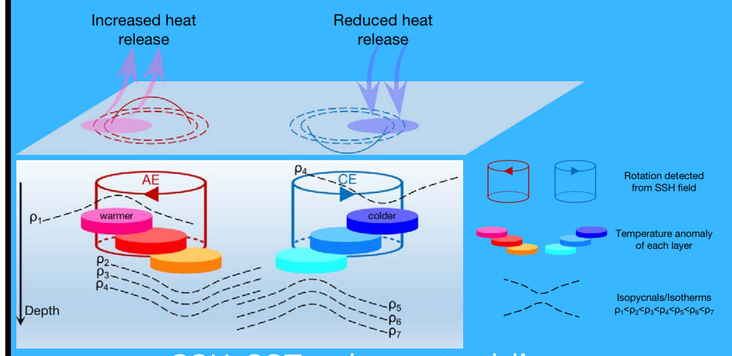
Procedure:

1) For time: apply a band-pass Butterworth window to preserve **7-90 days**;

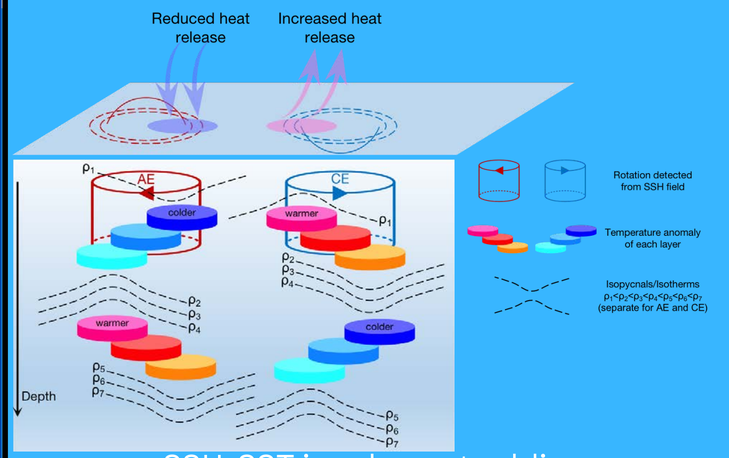
2) For space: employ a moving average Hann window to filter spatial scales larger than **600 km**;

3) Subtract the large scale from time-filtered maps to obtain anomaly signals of the mesoscale.

Eddy paradigms



SSH-SST coherent eddies.



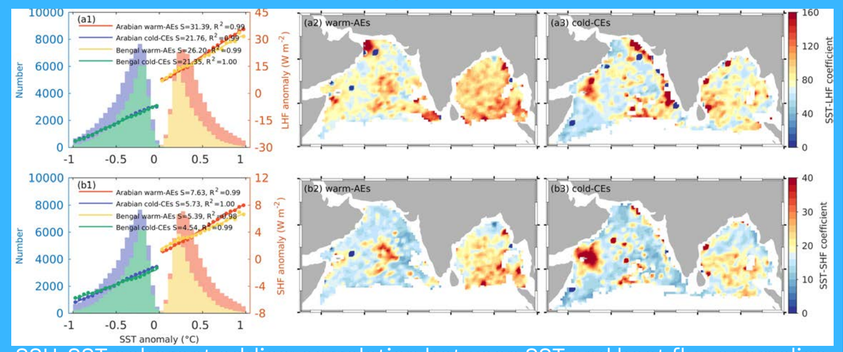
SSH-SST incoherent eddies.

Air-sea coupling of SSH-SST coherent and incoherent eddies

Air-sea coupling coefficients (units: W/m2/C)

Arabian Sea
warm AEs: 39
cold CEs: 28

Bay of Bengal
warm AEs: 31
cold CEs: 26



SSH-SST coherent eddies: correlation between SST and heat flux anomalies.

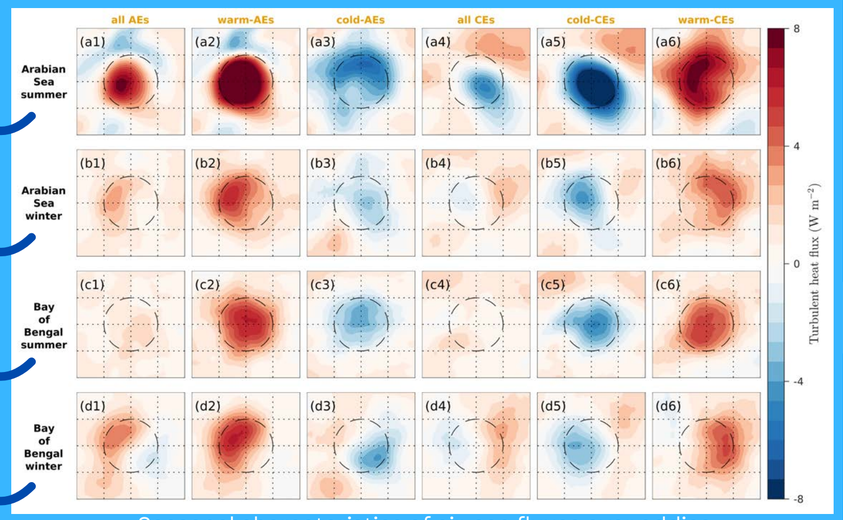
Combination of eddies leads to:

monopole

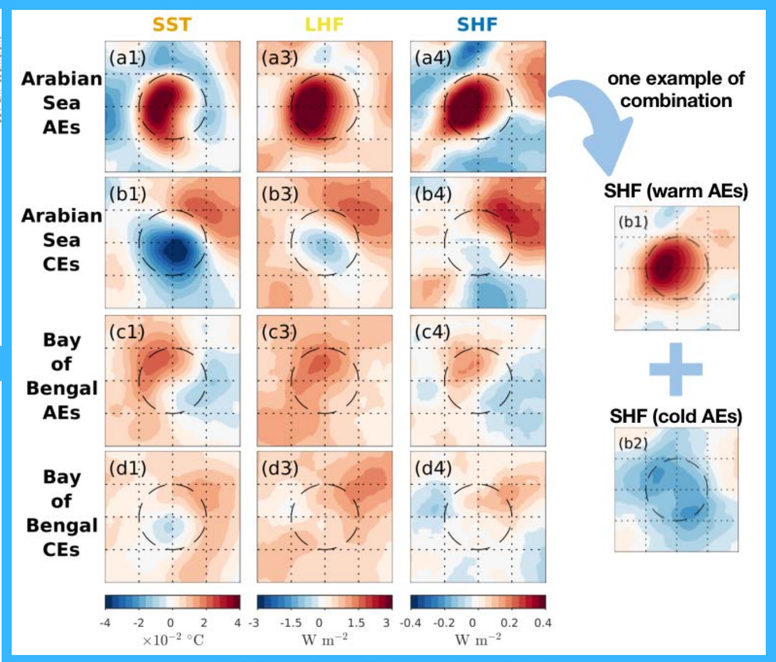
shifted monopole

cancellation

dipole



Seasonal characteristics of air-sea fluxes over eddies.



Eddy-induced SST, LHF and SHF
(LHF and SHF were separated in terms of SST)

Region	Arabian Sea				Bay of Bengal			
Eddy types	warm-AEs (50.1%)	cold-AEs (34.6%)	cold-CEs (44.0%)	warm-CEs (39.8%)	warm-AEs (50.7%)	cold-AEs (44.4%)	cold-CEs (46.0%)	warm-CEs (49.3%)
SST	0.32 ± 0.19	-0.31 ± 0.19	-0.32 ± 0.22	0.27 ± 0.16	0.25 ± 0.15	-0.27 ± 0.17	-0.26 ± 0.16	0.25 ± 0.15
Coef	62.5 ± 17.9	46.8 ± 22.6	52.1 ± 15.1	58.8 ± 25.2	75.1 ± 12.1	63.2 ± 6.2	63.0 ± 10.0	73.1 ± 16.1

Both SST anomalies and coupling coefficients are comparable for SSH-SST coherent and incoherent eddies.

Conclusions

- Air-sea coupling: a direct relationship between intensities of eddy-induced SST and turbulent heat fluxes.

- Semi-annual reversal of monsoon winds influences the proportion of coherent and incoherent eddies.

- The combination of coherent and incoherent eddies leads to:

1. **monopolar structure similar to coherent eddies;**
2. **compensation resulting in null net flux;**
3. **dipolar pattern known as eddy-stirring effect.**

- Mechanisms of incoherent eddies might include:

1. **continuous air-sea heat exchange along eddy pathways;**
2. **subsurface diffusion below the mixed layer;**
3. **interior mode waters resulted from water mass subduction.**

Acknowledgement:
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References:
Yu, 2023: OAFlux2: The second generation of the Objectively Analyzed Air-sea Fluxes of turbulent heat, moisture, and momentum (in prep).

Chen and Yu, 2023: Signature of mesoscale eddies on air-sea heat fluxes in the North Indian Ocean (in prep).