Unraveling the Eddy-driven Heat Transport in the Agulhas Leakage Region

Lansu Wei[1,3], Chunzai Wang[1,2*]

[1]State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China.

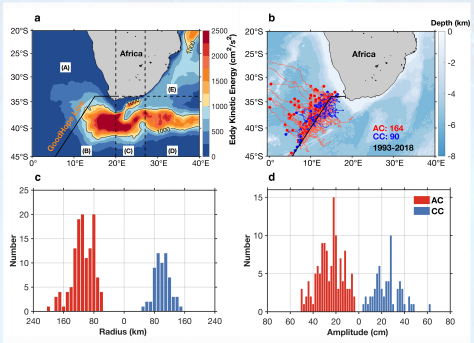
[2]Global Ocean and Climate Research Center, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China.

[3]University of Chinese Academy of Sciences, Beijing, China.

EGU General Assembly 2024

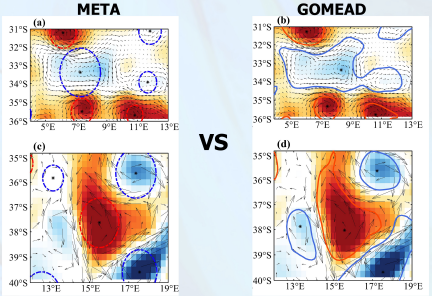
Introduction

Mesoscale eddies are the primary form of the Agulhas leakage, bringing warm and saline Indian Ocean water into the Atlantic Ocean. Observations and models both indicate that anticyclonic eddies transport a significant amount of warm water to the Atlantic Ocean. However, the stirring effect of these eddies can also transport heat. Here we utilize satellite data and Argo float data to reconstruct the vertical temperature profiles of both cyclonic and anticyclonic eddies within the Agulhas Leakage (AL) region. Simultaneously, we quantify the transport generated by these eddies through their respective mechanisms.



Method: Selection of the eddy datasets

Numerous eddy dataset products have been developed. However, the objectivity of the eddy dataset is not absolute and is somewhat contingent upon the algorithms employed.



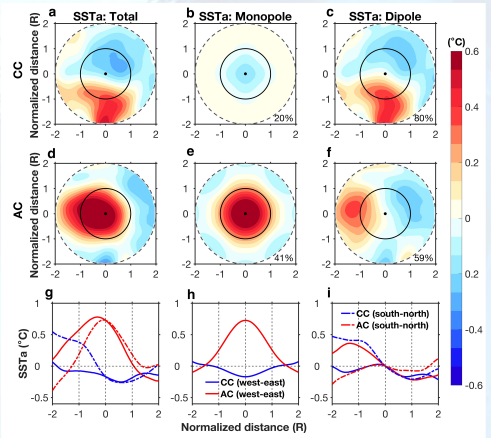
GOMEAD dataset: algorithm based on geometric features of the velocity field (eddy situation closer to the AL region).

META dataset: algorithm based on physical parameters.

Eddy-induced temperature anomaly

Sea surface (OISST)

The eddy-induced SSTA can be decomposed into two components: monopole and dipole structures.

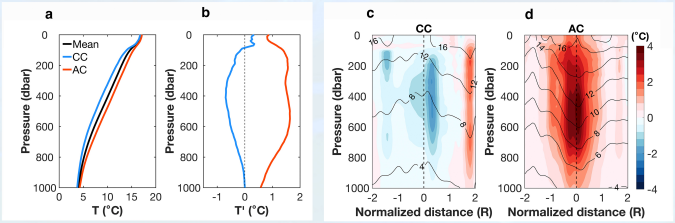


cyclonic eddy:
Cold maximum values shifted towards the equator;
Monopole: 20%
Dipole: 80%

Anticyclonic eddy:
Warm maximum values exhibit little meridional shift.
Monopole: 41%
Dipole: 59%

Deep sea (Argo)

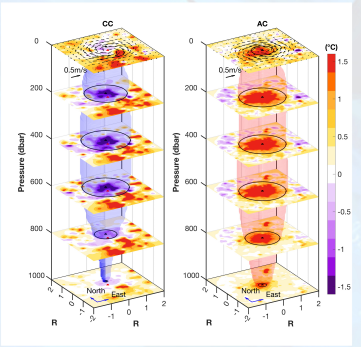
Vertical structure of eddy temperature:



cyclonic eddy:
An extreme value -0.7°C at a depth of approximately 400 dbar;

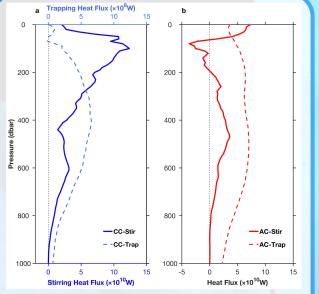
Anticyclonic eddy:
An extreme value 1.6°C at a depth of 550 dbar.

3-D structures



Both cyclonic and anticyclonic eddies in the Agulhas leakage region have an impact on temperature that extends beyond a depth of 1000m. Anticyclonic and cyclonic eddies decay with depth and weaken rapidly below 600m.

Heat content



The heat content caused by stirring (10^{10} W) is two orders of magnitude greater than that caused by trapping (10^{8} W), mainly because the eddy meridional propagation velocity is relatively small compared to the eddy swirl velocity. In contrast, for anticyclonic eddies, except in the subsurface, eddy trapping (10^{10} W) causes a heat flux that is larger than that caused by stirring.

Summary

The Agulhas leakage, which transports warm and salty Indian Ocean water into the Atlantic Ocean, plays a crucial role in global ocean circulation and climate. The mesoscale eddies from the leakage supply the primary source of heat and salt for the Atlantic meridional overturning circulation. This study combines eddy data with Argo profiles from 1993 to 2018 to investigate the three-dimensional structures of eddies, advancing our understanding of eddy-induced transport. Both the trapping and stirring processes of eddies influence eddy-induced transport. Anticyclonic eddies are found to transport heat in the meridional direction mainly through propagation (~60%). On the other hand, cyclonic eddies transport heat meridionally to the Atlantic Ocean primarily through the stirring of isotherms in the background field (~25%). These results further confirm that the stirring effect of cyclonic eddies is crucial for evaluating the impact of the Agulhas leakage on the Atlantic Ocean.

References

Wei, L., and C. Wang (2023), Characteristics of ocean mesoscale eddies in the Agulhas and Tasman leakage regions from two eddy datasets, Deep Sea Research Part II: Topical Studies in Oceanography, 105264.

Wei, L., and C. Wang (2023), Unraveling the Eddy-Driven Heat Transport in the Agulhas Leakage Region (under review).