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 and Global Ocean** to understand air-sea coupling induced by eddies, and related heat transport.

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Mesoscale meridional heat transport inferred from sea surface observations

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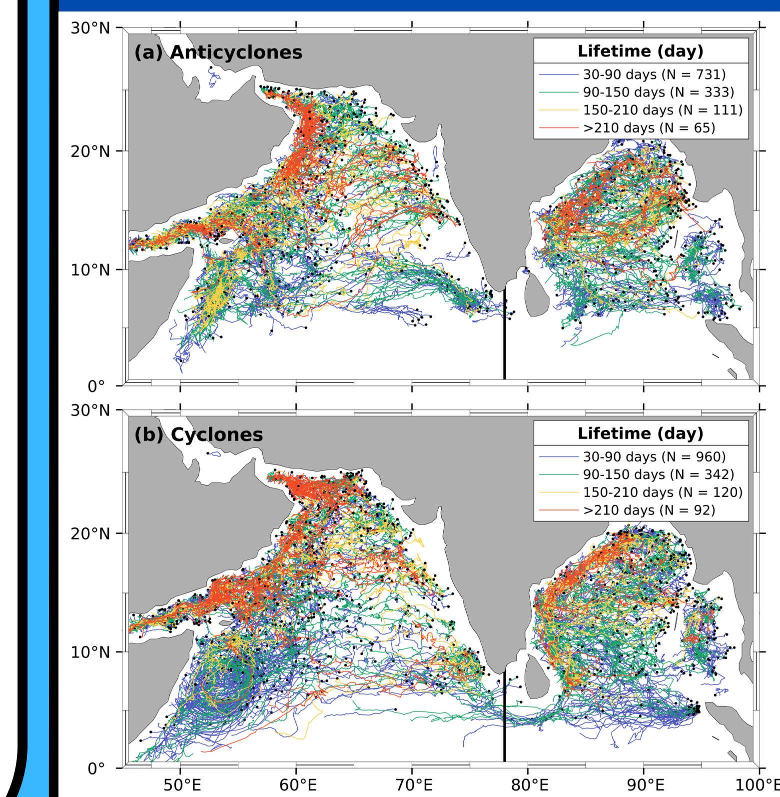


Eddy trajectories.

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).

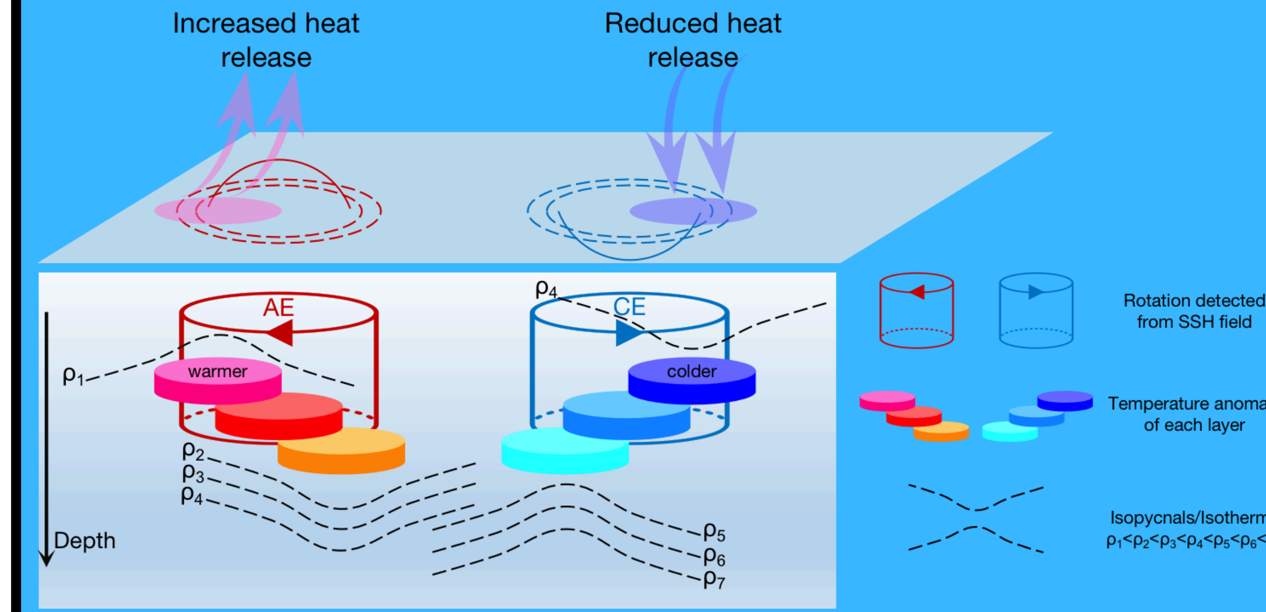
Procedure:

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

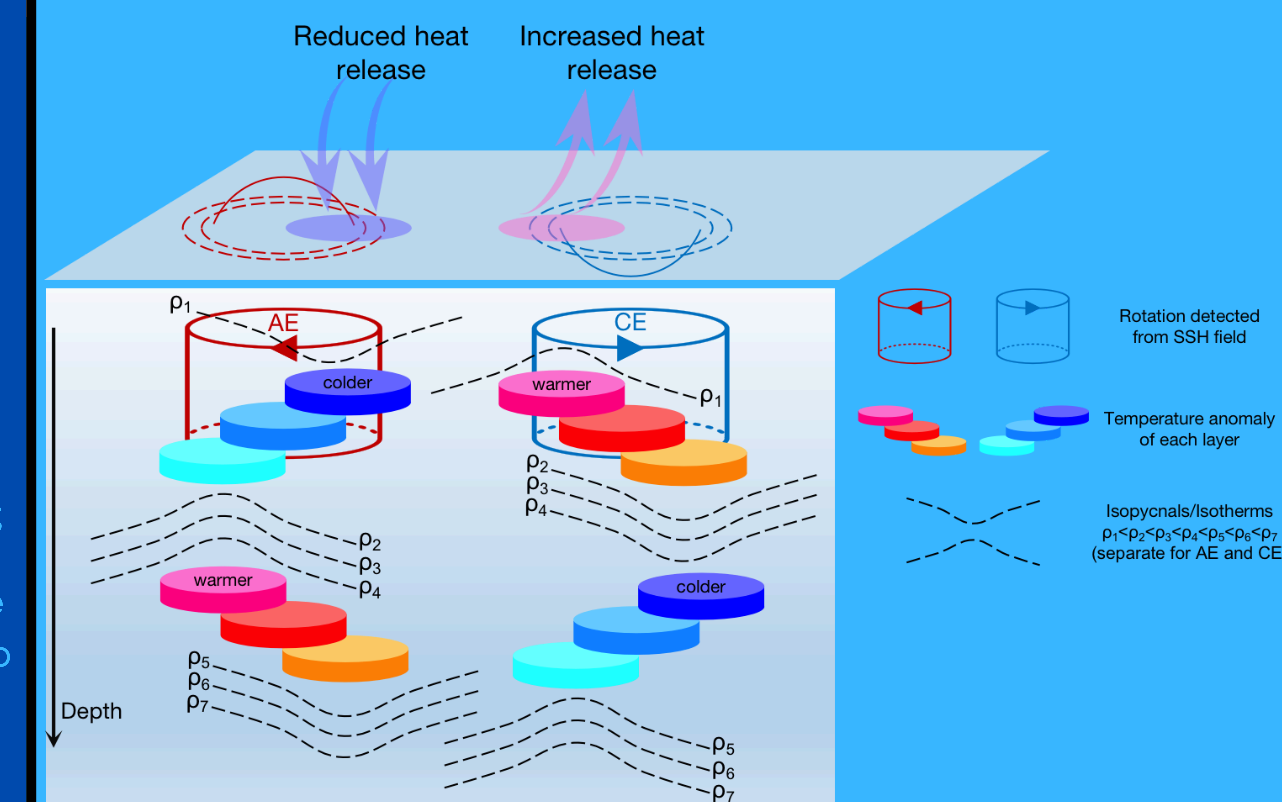
2) For space: employ a moving average Hann window to filter spatial scales larger than **600 km**;

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

Eddy paradigms

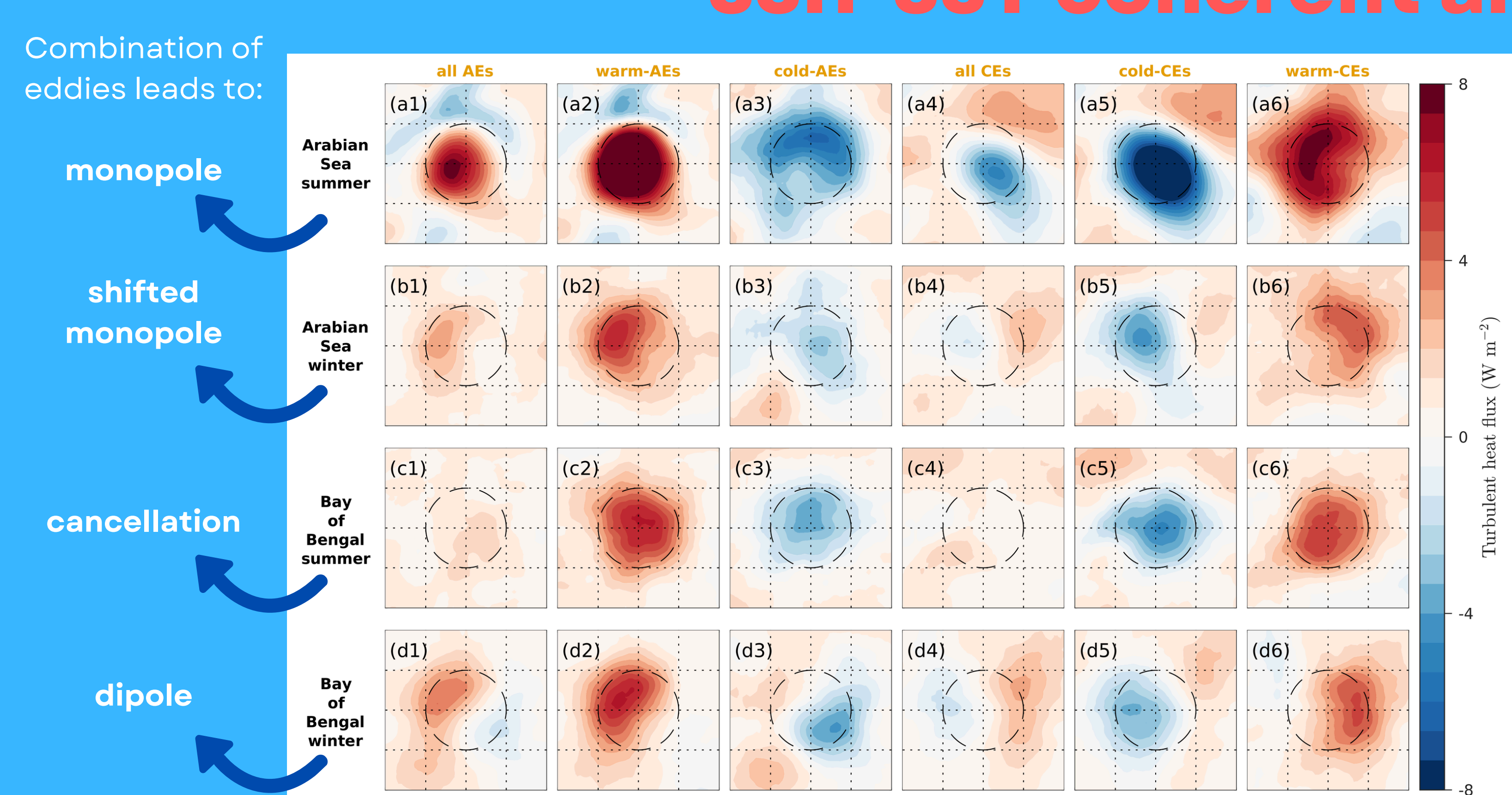


SSH-SST coherent eddies.

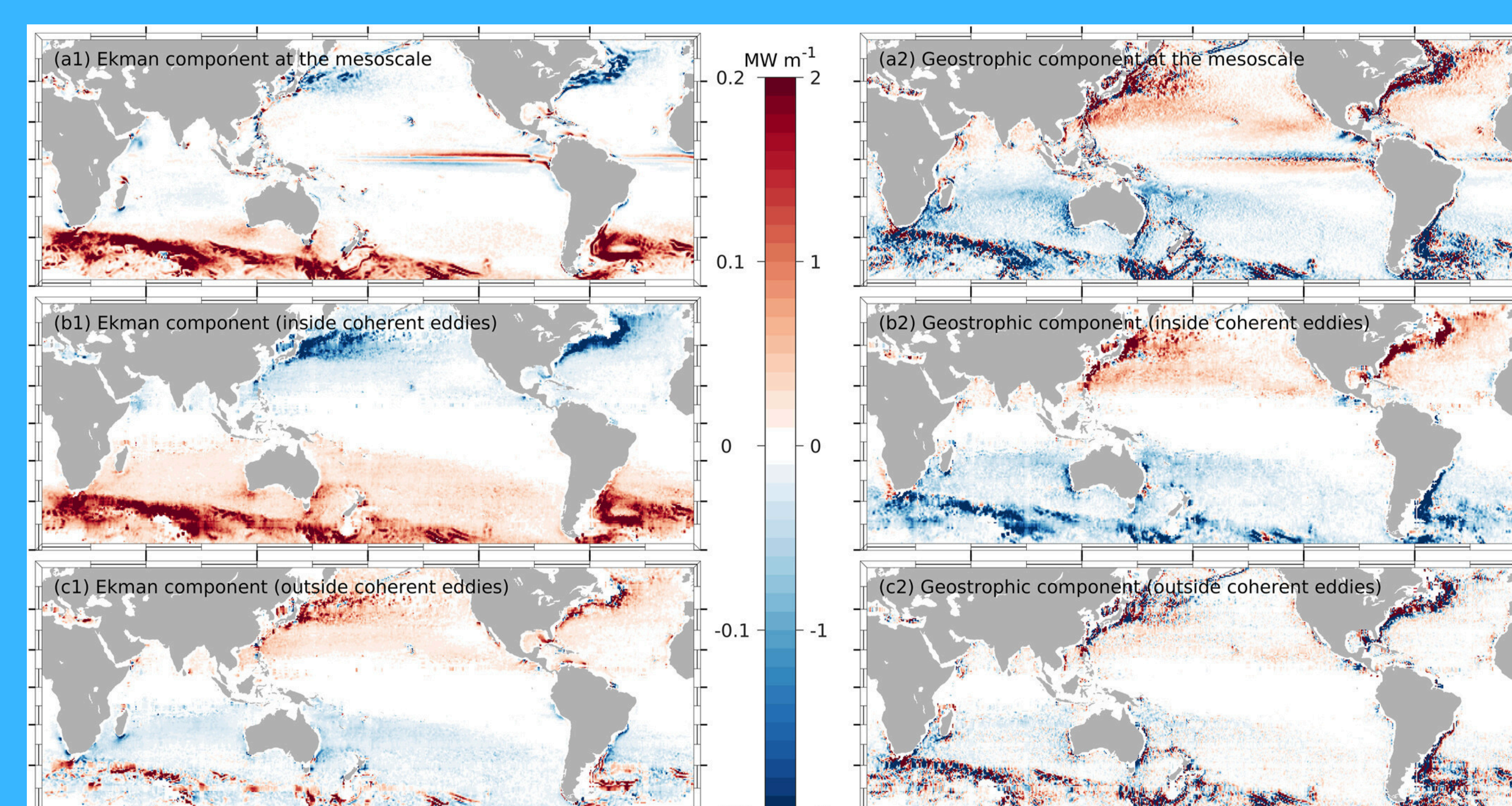


SSH-SST incoherent eddies.

SSH-SST coherent and incoherent eddies



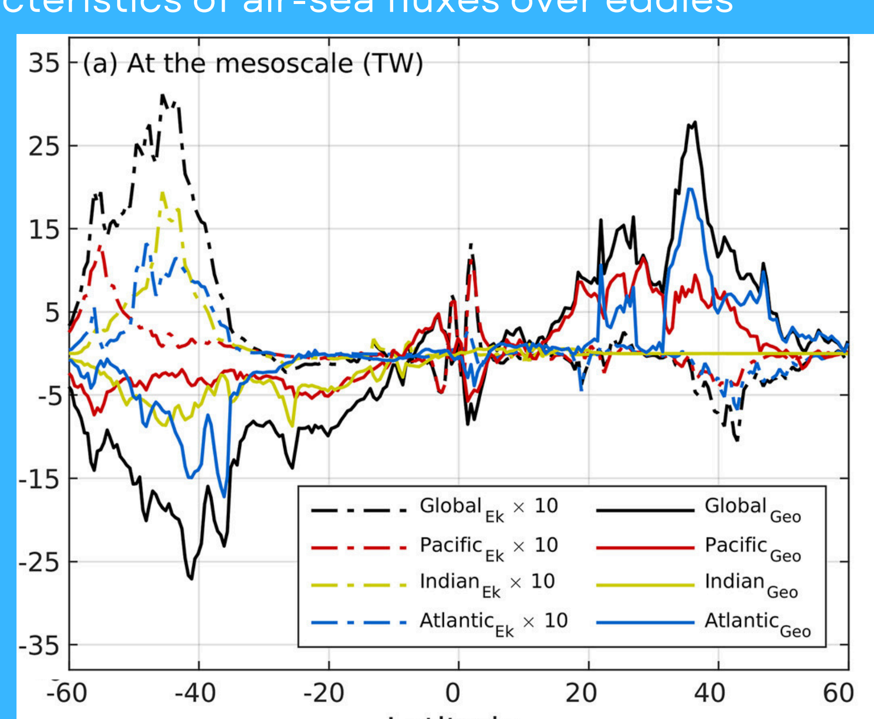
Seasonal characteristics of air-sea fluxes over eddies

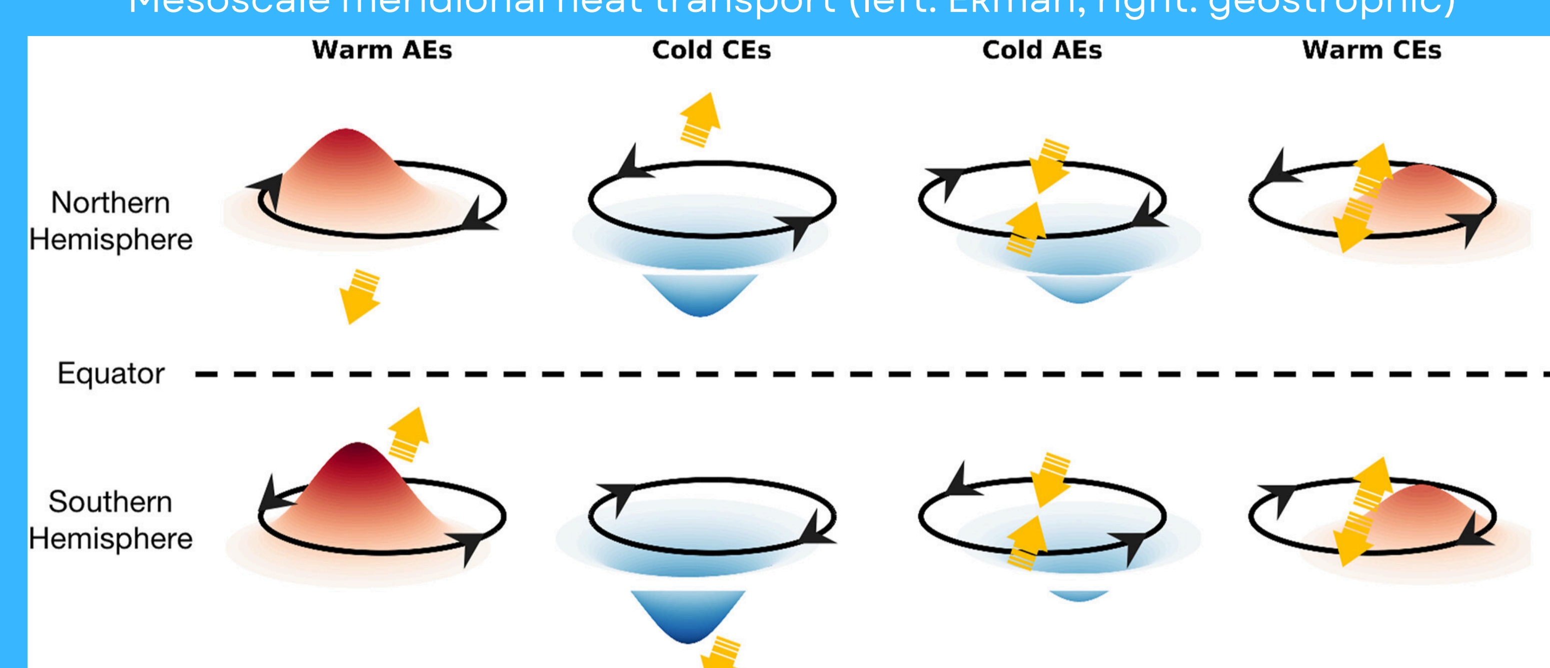


Mesoscale meridional heat transport (left: Ekman; right: geostrophic)

Mesoscale meridional heat transport carried by geostrophic components is **10 times** larger than (and opposite in direction to) that of the wind-driven Ekman components.

An offset between SSH-SST coherent and incoherent eddies in the Ekman heat transport is apparent, whereas the geostrophic heat transport is contained within coherent eddies.





Schematic of meridional heat transport (black: geostrophic; yellow: Ekman)

Conclusions

In the North Indian Ocean, 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 water resulted from water mass subduction.

The geostrophic component of meridional heat transport (MHT) at the mesoscale is 10 times larger than the Ekman component.

SSH-SST coherent eddies dominate the spatial patterns of MHT at the mesoscale.

References:

Chen and Yu (2024). Mesoscale Meridional Heat Transport Inferred From Sea Surface Observations. Geophysical Research Letters.

Chen and Yu (2024). Signature of Mesoscale Eddies on Air-Sea Heat Fluxes in the North Indian Ocean. JGR: Oceans.