Offshore transport and vertical exchange by mesoscale ocean eddies in an eastern boundary upwelling system

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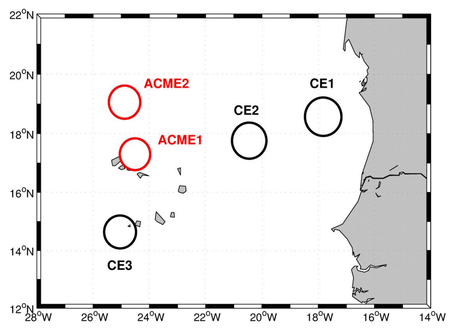
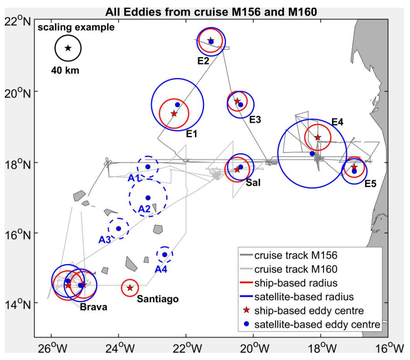
Motivation

Several eddies in the Canary Eastern Boundary Upwelling System off West Africa have been observed in-situ during the REEBUS project (Role of Eddies for the carbon pump in EBUS).
In order to collocate water samples and derive the 3-D dynamic structure of the eddies, it is necessary to work with in-situ velocity measurements, as satellite based remote sensing data are not sufficient for this purpose (Andrae, 2020).
Besides four REEBUS eddies we include a well observed oxygen-depleted modewater eddy of 2014 (ACME2, Karstensen et al., 2017).



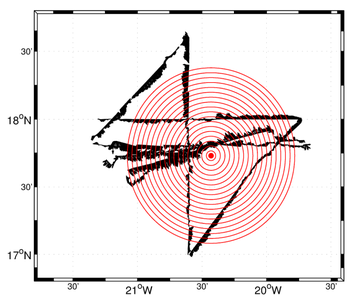
CE: cyclonic eddy
ACME: anticyclonic modewater eddy



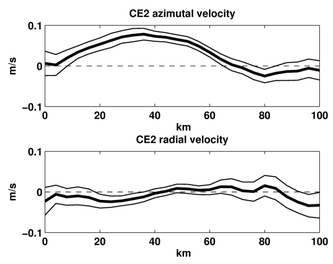
Andrae, 2020

Reconstruction of 3-D eddy structure from velocity observations

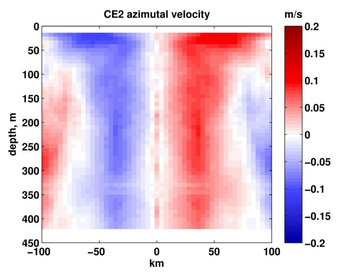
Optimum fit assuming circular symmetry



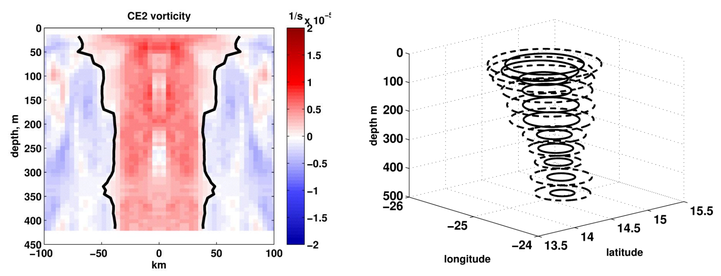
Layer by layer: velocity average along circles



Assembled 3-D structure of velocity components

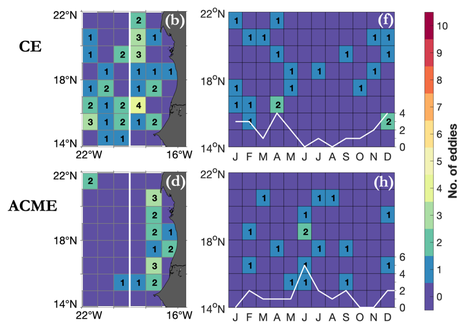


Now derived variables can be obtained:
like vorticity, divergence, vertical velocity, eddy radius



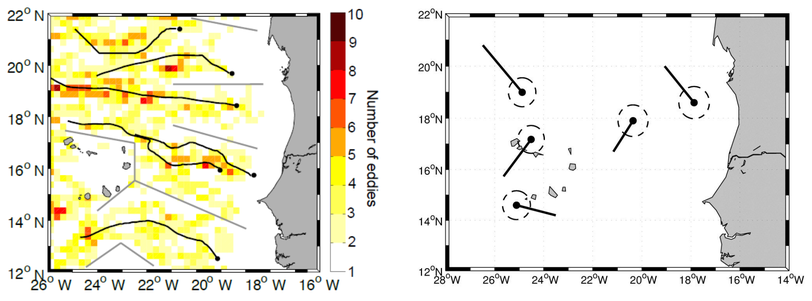
Offshore transport of trapped coastal water

ACEs and ACMEs form close to the coast, CEs rather by eddy interaction



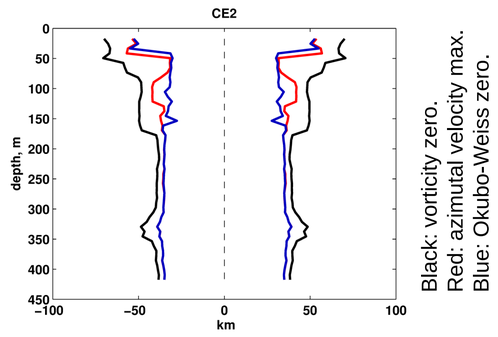
Dilmahamod et al., 2021

They transport trapped water westward at about 3km/d.
The short term observed drifts are roughly consistent.



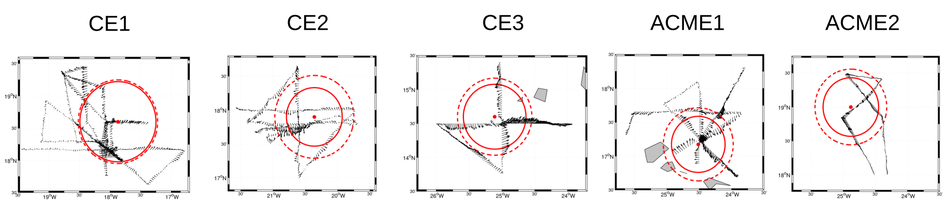
Schütte et al., 2016

Different trapping criteria result in different volumina of 1500 to 4000 km^3 per eddy.
The total offshore transport for the entire upwelling system is of order 1 Sverdrup.

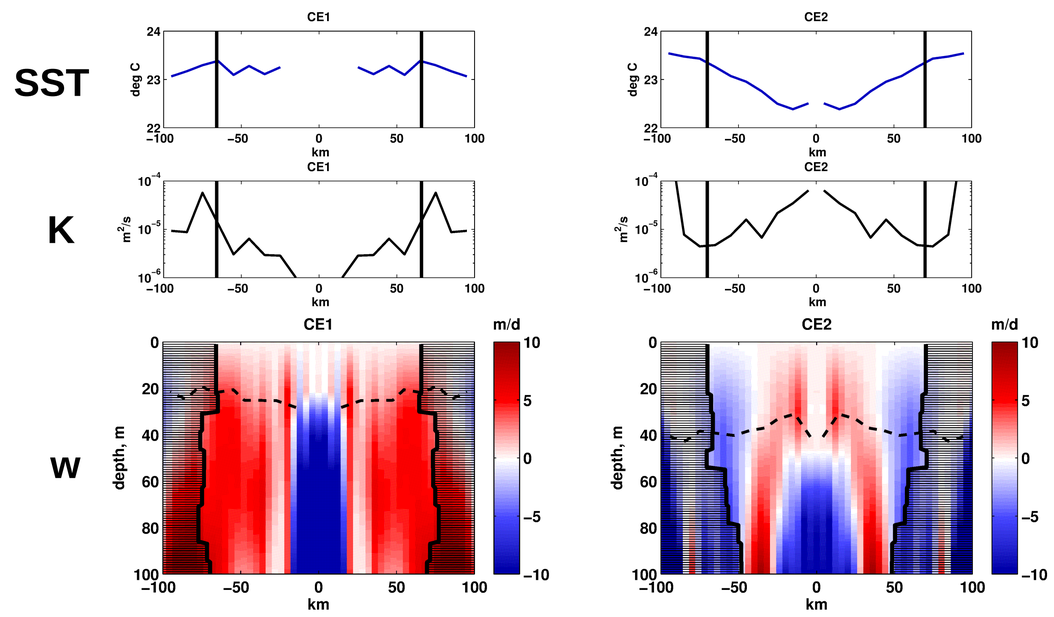


Vertical exchange

Vertical advection and diapycnal diffusivity at the Mixed Layer base show a contrasting though consistent picture of Sea Surface Temperature and secondary circulation for two cyclones.
Vertical velocity can be estimated reliably from velocity observations of more than about 4 inertial periods.



Observation time in inertial periods



Dashed lines: Mixed Layer Base. Grey areas: distances beyond the eddy limits
SST: sea surface temperature. K: diapycnal diffusivity. w: vertical velocity.

References: **Andrae**, A. (2020): Comparison of different methods for the detection of mesoscale eddy characteristics in the eastern tropical North Atlantic. Bachelor thesis, CAU Kiel. **Dilmahamod**, A.F., Karstensen, J., Dietze, H., Loeptien, U., and Fennel, K. (2021): Generation mechanisms of mesoscale eddies in the Mauritanian Upwelling Region. Journal of Physical Oceanography, DOI: https://doi.org/10.1175/JPO-D-21-0092.1. **Karstensen**, J., Schütte, F., Pietri, A., Krahmann, G., Fiedler, B., Grundle, D., Hauss, H., Körtzinger, A., Löscher, C.R., Testor, P., Vieira, N., and Visbeck, M. (2017): Upwelling and isolation in oxygen-depleted anticyclonic modewater eddies and implications for nitrate cycling. Biogeosciences, 14, 2167-2181, DOI: https://doi.org/10.5194/bg-14-2167-2017. **Schütte**, F., Brandt, P., and Karstensen, J. (2016): Occurrence and characteristics of mesoscale eddies in the tropical northeastern Atlantic Ocean. Ocean Science, 12, 663-685, DOI: https://doi.org/10.5194/os-12-663-2016.

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