Dipartimento di Ingegneria
Dottorato in Ingegneria Civile - Ciclo XXXV

THE ROLE OF THE AGULHAS SYSTEM IN THE GLOBAL CLIMATE USING A LAGRANGIAN APPROACH

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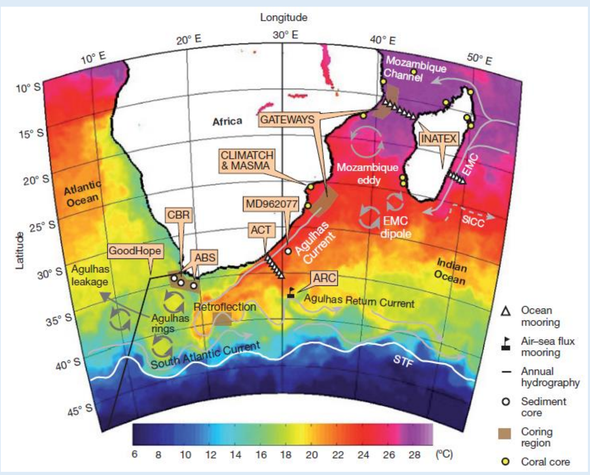
BACKGROUND

Agulhas Current is the **Western boundary current** (WBC) of the Southern Indian Ocean; it has a mean transport of $\sim 70\ Sv$ [1], it flows along the coast of Mozambique and South Africa to the homonymous Cape Agulhas and it carries waters originated from different parts of the Indian Ocean.

Once reached Cape Agulhas the current changes direction (Agulhas Retroflection) and start flowing eastward along the Sub-Tropical Front. Due to instability and nonlinear effects, it sheds eddies in the Atlantic Ocean (**Agulhas Rings**).

Warm and salt water from the Indian Ocean meets the colder and fresher South Atlantic waters. **Agulhas Leakage** (the water escaping from the main current) can affect Atlantic Meridional Overturning Circulation through buoyancy forces, wind stress changes and planetary waves perturbations. Interacting with Atlantic currents; it can affects the **global climate** propagating northward eddies that carry warm and salty Indian Ocean waters. The study of this current can lead to understand the importance of the influence of this system at global scale.

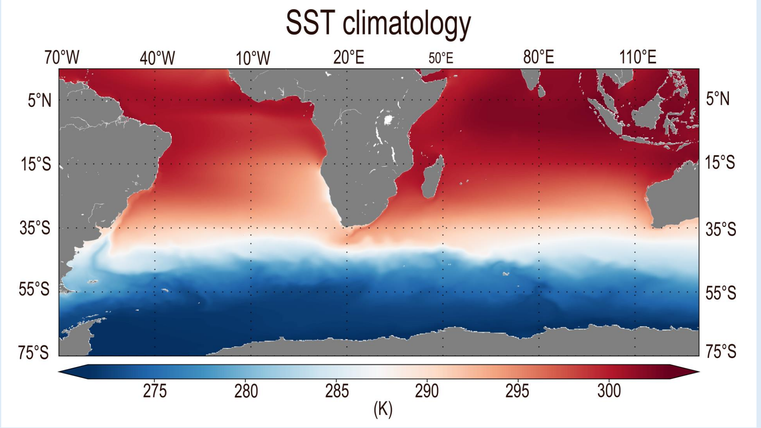
[Beal et al. (2011)]

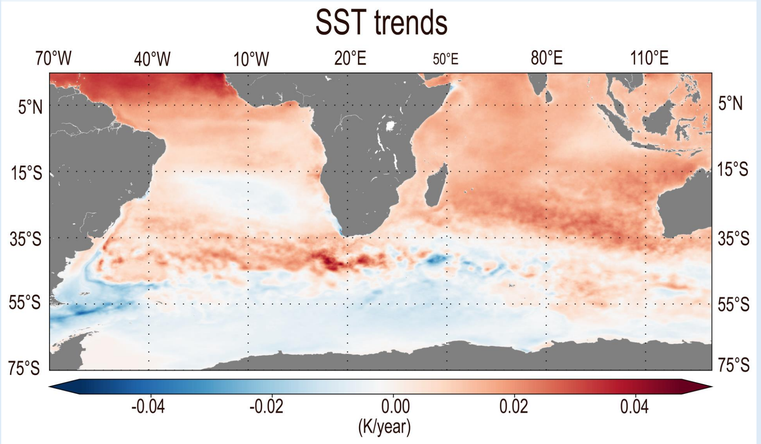


METHODS

Satellite data will be used to analyse surface proprieties of the water masses: Sea surface temperature (SST), geostrophic velocities and surface heat fluxes are used up to now. Resolution of every dataset is $0.25° \times 0.25°$. Climatology will be the time mean of the dataset; trends will be the slope of a linear interpolation performed for every pixel.

For heat fluxes: solar radiation is the heat coming from the Sun through radiation, thermal radiation is the heat loss due to the thermal emission (black body). Latent heat flux is the heat loss through evaporation and sensible heat flux is the heat lost due to convection with the atmosphere. Results are also in [2]. Work in collaboration with ISMAR-CNR (Rome).





RESULTS

Sea surface temperature climatology (*ESACCI 1982-2018*) shows the **position** of the cold and relatively fresh STF, that flows eastward.

Sea surface temperature trend map highlights a growing behavior in the retroflection region, meaning a **south-shifting** of the sub-tropical front.

A south-shift of the sub-tropical front implies a wider gap between Africa and the Antarctic Circumpolar Current. This **increases** Agulhas Leakage [1].

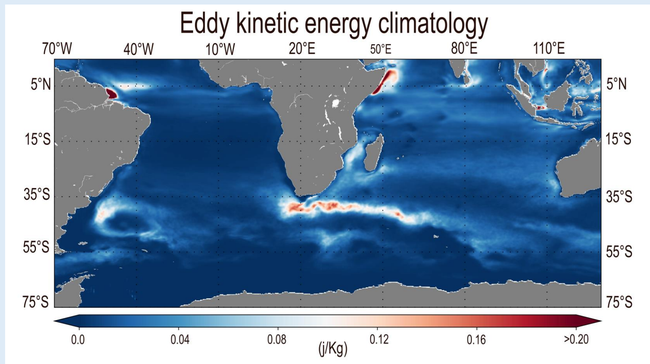
Sub-Tropical Front south-shifting and an eddy kinetic energy positive trend in the South Atlantic are proofs of an **increase** in the Agulhas Leakage, since it means that more Agulhas rings are shed.

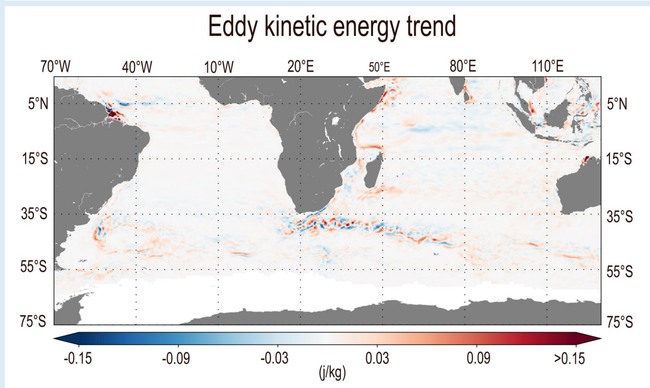
Eddy kinetic energy, or turbulent kinetic energy is defined as

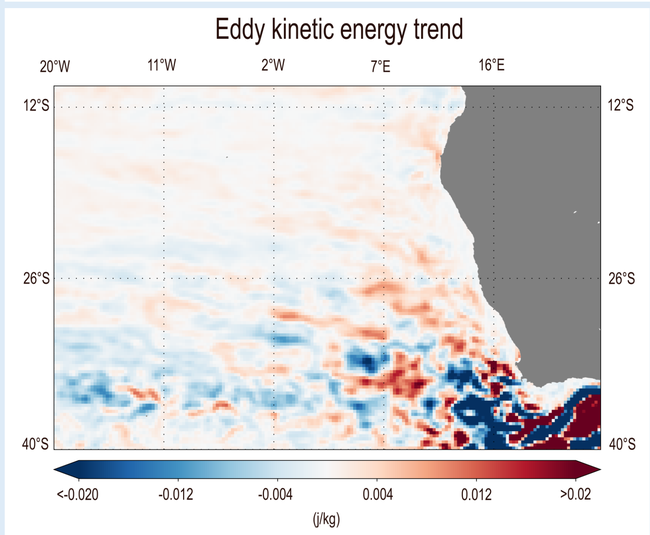
$$EKE = \frac{u^2 + v^2}{2} - \frac{\bar{u}^2 + \bar{v}^2}{2}$$

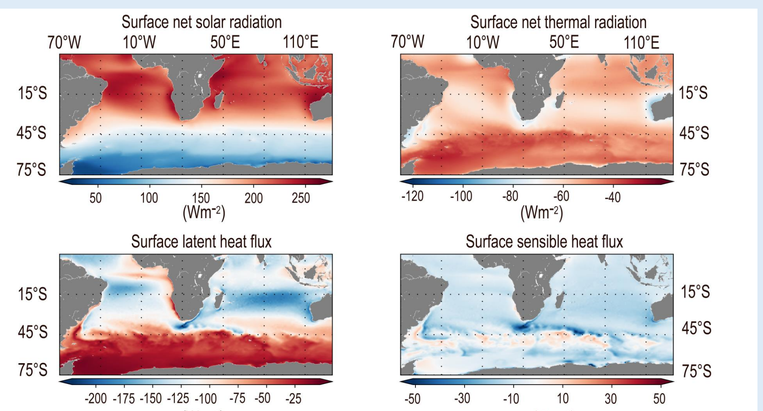
Agulhas retroflection region is clearly turbulent and a brighter shade of higher eddy kinetic energy sheds into the South Atlantic.
CMEMS 1993-2019 data.

In the South Atlantic region, West from the Agulhas Leakage, an average **positive trend in eddy kinetic energy** has ben evaluated (see also [3]).





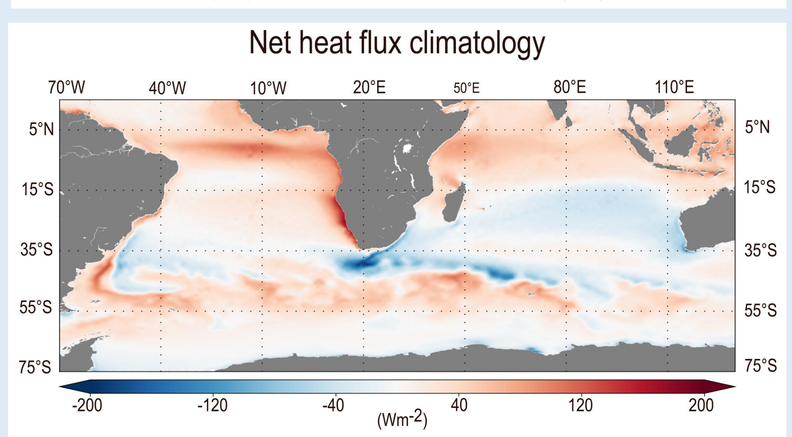


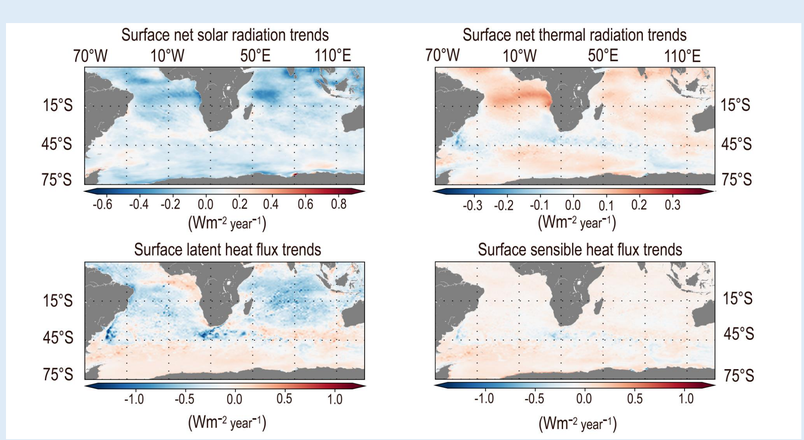


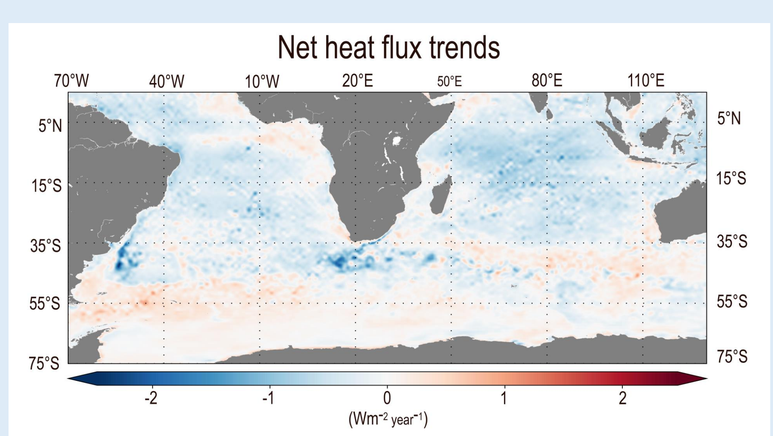
Surface heat fluxes datasets come from *ERA5 1979-2019*. Solar and thermal radiation are on top, latent and sensible heat flux are on bottom.

Latent and sensible surface heat fluxes, as well as the net flux, indicates a strong **heat loss** in the Agulhas retroflection region due to evaporation and atmosphere convection respectively.

Warm water diffusion in the Atlantic can compete with the Greenland contribute: one **strengthening** and one reducing the Atlantic Meridional Overturning Circulation [4]







Future tasks:

- **Wind stress analysis:** winds have a big role on the proprieties of every west boundary current. Westerlies and the latitude of their maximum can affect STF shifting and AC transport.
- **Lagrangian analysis:** through the use of Lagrangian simulations we could track water from the leakage and see whether they diffuse in the whole Atlantic or they stay confined in the South hemisphere, determining the influence on the Atlantic Meridional Overturning Circulation and on the global climate.

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3. Beal, L., Elipot, S. Broadening not strengthening of the Agulhas Current since the early 1990s. *Nature* **540,** 570–573 (2016)
4. Beal, L., De Ruijter, W., Biastoch, A. *et al.* On the role of the Agulhas system in ocean circulation and climate. *Nature* **472,** 429–436 (2011)