The ERC Synergy project WHIRLS – an optimal testbed for fine-scale parameterizations

GEOMAR

Arne Biastoch (GEOMAR, Kiel)
Sabrina Speich (ENS, Paris)
Sebastiaan Swart (Univ. Gothenburg)
Sarah Fawcett (Univ. Cape Town)

The new European Research Council (ERC) Synergy Project WHIRLS

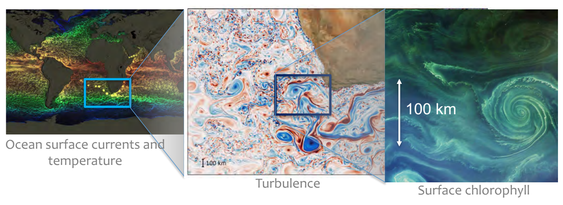
(1) observes & simulates fine-scale ocean processes,

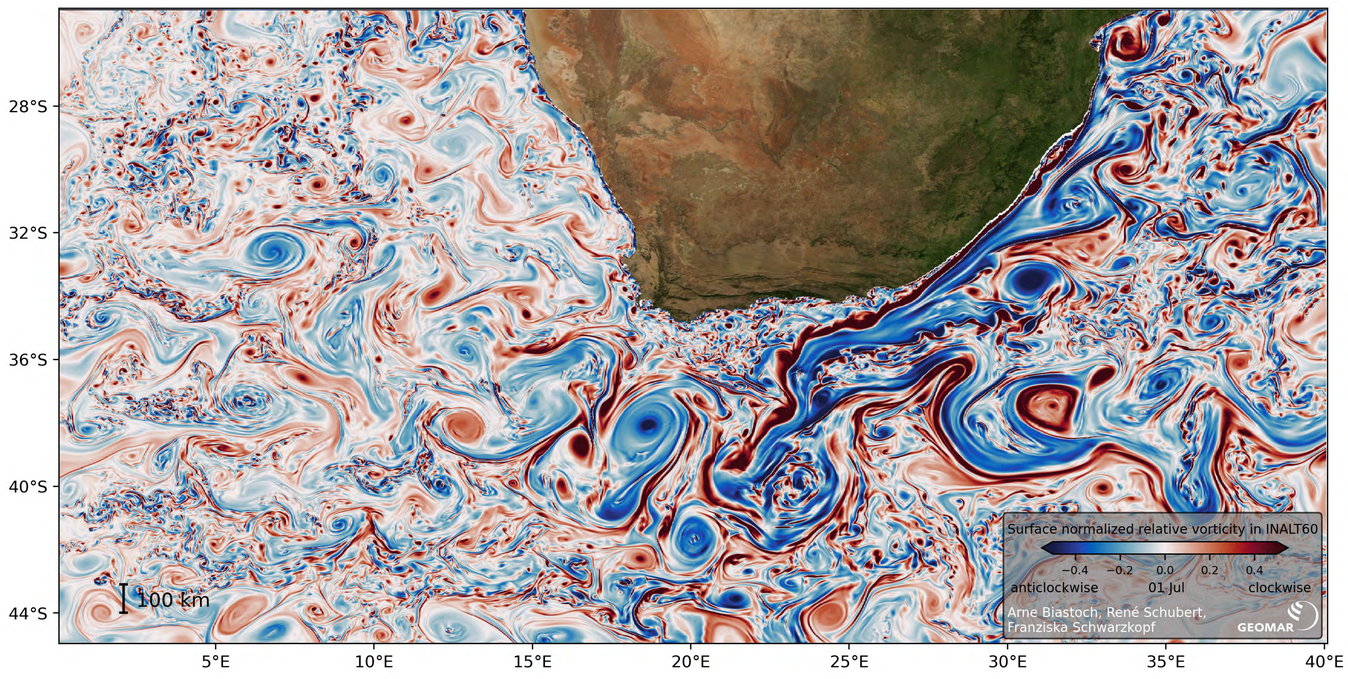
(2) quantifies their role & impact on global ocean circulation, air-sea exchange of heat & carbon, and the marine biome,

(3) develops representation of fine-scale processes in Earth system models to improve climate prediction.

GEOMAR supports the sea-going & autonomous observations around South Africa with a series of numerical ocean and climate models.

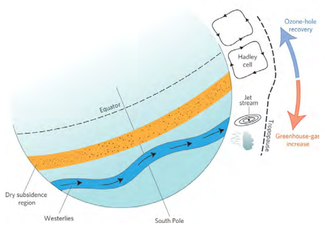
Project period: 2024-2030 | Budget: 11,9 Mio. EUR



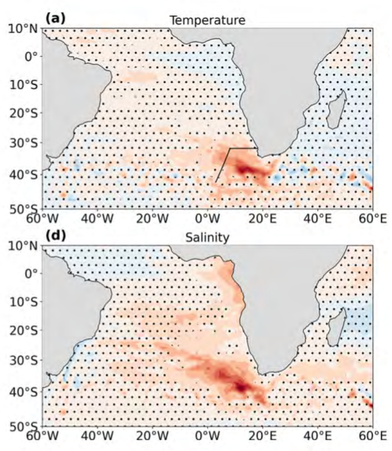


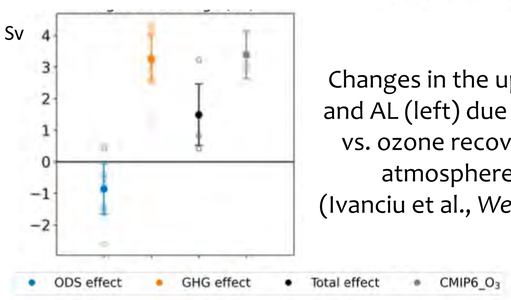
The Importance of Submesoscale Processes for the Large-scale Circulation. An Example:

- Agulhas leakage (AL), the amount of warm and saline waters from the Indian Ocean into the Atlantic, will increase under global warming.
- This leads to (fast) wave and (slow) advective responses. In particular the positive salinity/density anomaly strengthens the AMOC on longer timescales.
- Simulating the correct amount of Agulhas leakage depends on the representation of submesoscale processes and a fully resolved mesoscale around South Africa.



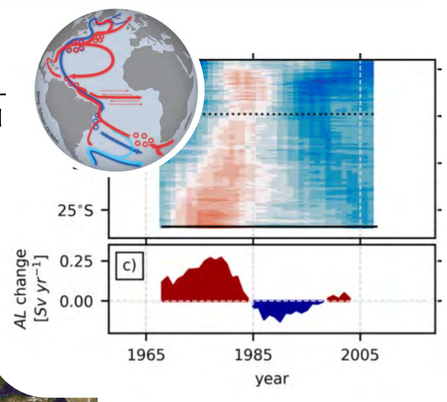
Westerlies in response to GHG gases and ozone recovery

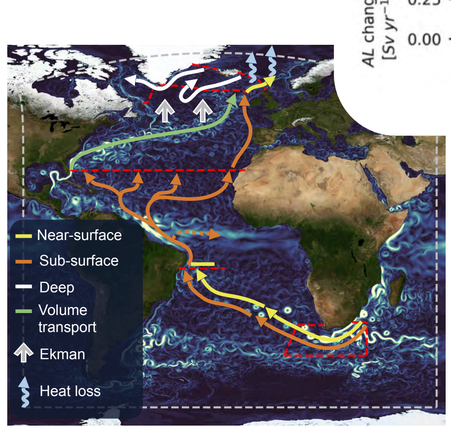


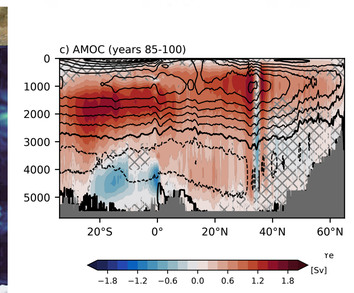


Changes in the upper 1000 m T/S (up) and AL (left) due to greenhouse gases vs. ozone recovery in a 1/10° ocean-atmosphere Agulhas model (Ivanciu et al., *Weather Clim. Dyn.* 2022)

Annual rate of change AMOC and annual rate of change in AL strength in a 1/20° ocean model (Rühs et al., *Nature Commun. Earth. Environ.* 2022)



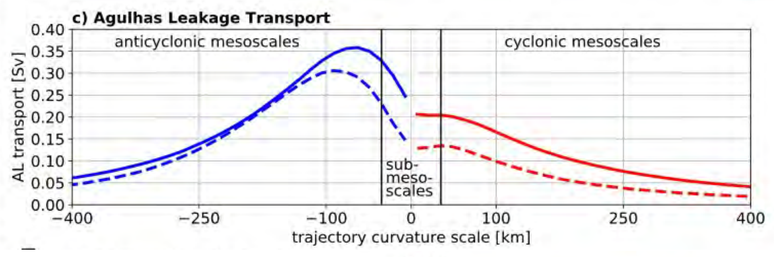




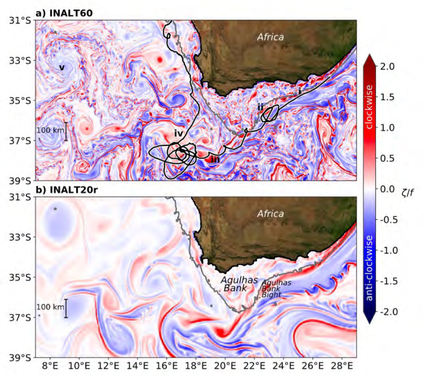
Pathways of AL in a 1/10° ocean-atmosphere Atlantic-wide model and AMOC change in response to enhanced SH westerlies (Schulzki et al., *Ocean Sci.*, 2024)

Increase in AL from 1/20° to 1/60°: 3.6 Sv (=40%)

(0.5 Sv submesoscale, 1.1 Sv cyclonic mesoscale, 0.5 Sv anticyclonic mesoscale, 1.5 Sv straight)

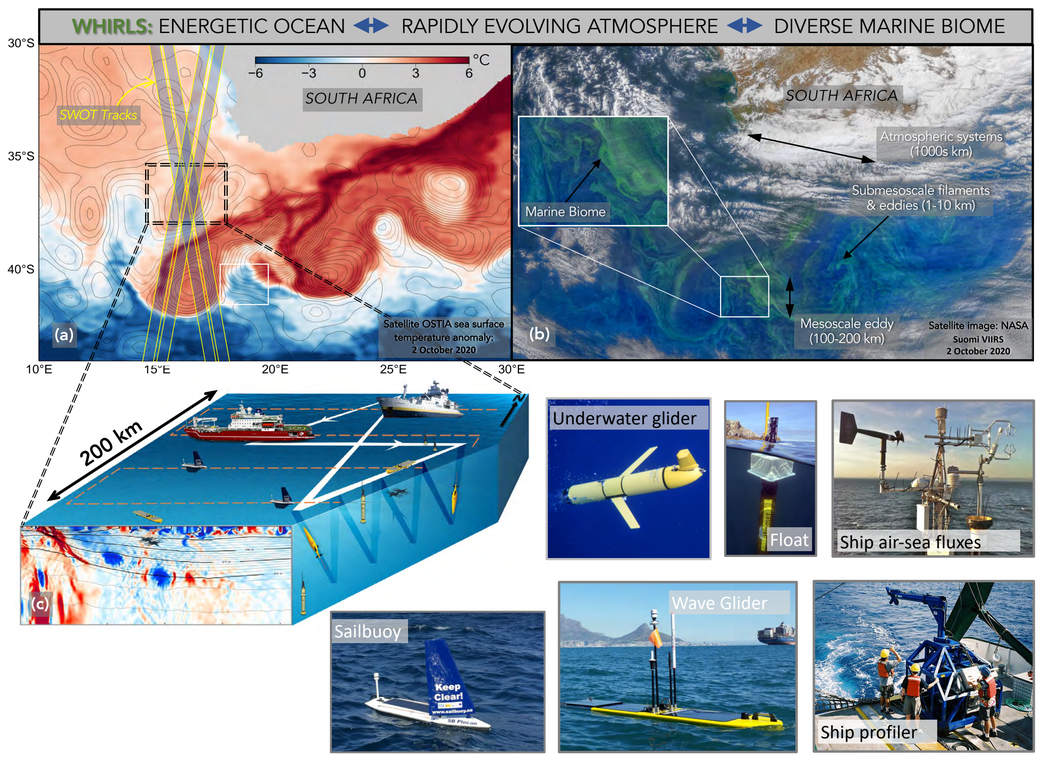


Agulhas leakage transport decomposed into its contributions for 1/60° (solid) and 1/20° (dashed) models (Schubert et al., *Nat. Commun. Earth Environ.* 2021 and further refs)

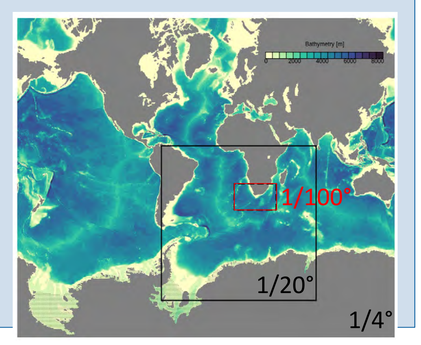


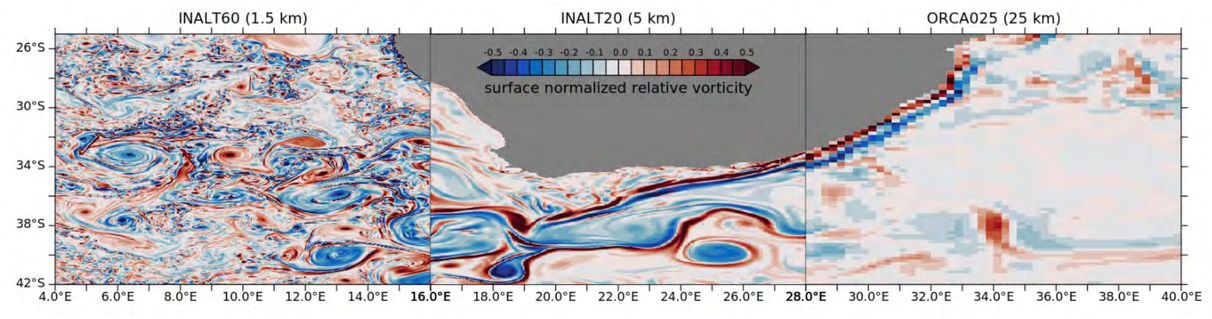
WHIRLS Observational Campaign and Model Hierarchy

- WHIRLS plans a multidisciplinary-multiplatform-multination effort with two ships and several autonomous instruments for austral winter 2026 to sample ocean, atmosphere & biogeochemistry parameters, distributed under FAIR principles.



- WHIRLS observations are accompanied by a hierarchy of coupled models down to the km-resolution to
  - study submesoscale processes in the upper ocean and their impacts on air-sea exchange, the large-scale circulation, weather and climate, and biogeochemistry,
  - provide data to support planning of the observational campaigns,
  - provide data to expand the spatio-temporal range of observations, to guide their interpretation and understanding, and to quantify and scale up,
  - use data science methods, e. g. to detect submesoscale structures, train AI-based submesoscale parameterizations, and to fuse observations with models,
  - following an open data approach & encouraging collaboration!





Name	Grid @34S	Processes	Equiv.	Ocean	Atmosphere	Biogeochemistry
eORCA025	23 km	eddy-active	CMIP6	NEMO	OpenIFS	PISCES (24 tracers),
eINALT20	5 km	eddy-rich	CMIP7	v4.2	OpenIFS	MOPS (NPZD+CO_2+O_2)
eINALT60	1.5 km	submesoscale-		AGRIF	OpenIFS	PISCES
eINALT100 (new)	<1 km	active				

Funded by the European Union

European Research Council
Established by the European Commission

This project has received funding from the European Union's Horizon Europe ERC Synergy Grant programme under grant agreement No 101118693 - WHIRLS. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

HELMHOLTZ