Master 2 Research Internship in polar oceanography

Title: Observability of mesoscale eddies under Antarctic sea ice from synthetic Argo and altimetry data.
Supervisors: Carolina Dufour, Matthis Auger and Camille Lique.
Location: Laboratoire d'Océanographie Physique et Spatiale (LOPS)/Ifremer, Plouzané.
Gratification: 900 euros/mois.
Duration: 5 to 6 months.
Start date: Between February and April 2026.
Context: This internship is part of an ongoing 4-year research project and can lead to a PhD.

Motivation and context

Within the past ten years, the Southern Ocean and Antarctic regions have been undergoing some rapid changes. Notably, a warming of the subsurface ocean was observed followed by an abrupt decline of the sea ice around 2016, and an unprecedented minimum in the sea ice extent in 2023 (Purich and Doddridge, 2023). Concurrently, westerly winds increased and shifted poleward imparting more energy to the ocean at a higher latitude, a trend which is expected to continue into the future and will enhance the ocean mesoscale eddy field (Beech et al. 2025). Ocean mesoscale comprises dynamical features such as eddies and fronts characterized by temporal scales of a few days to months and spatial scales of O(10 km). Mesoscale eddies are known to contribute in particular to the lateral and vertical transfer of heat in the ocean with potential implications for the sea ice. In polar regions, however, mesoscale eddies remain difficult to observe due to their small spatial and temporal scales, and limited observations. Since the early 2000s, the Argo autonomous profiling floats have been providing invaluable information about the top 2 km of the ocean but the number of floats has remained relatively small in polar regions. On the other hand, satellite altimetry has provided long-term repeated observations of the ocean including within sea ice covered regions, yet these observations are limited to the surface. In this context, many questions remain on the characteristics and role of these mesoscale eddies: Have mesoscale eddies become more numerous? How have their characteristics changed over the past two decades? How do mesoscale eddies contribute to bringing heat towards and up to the sea ice? How do mesoscale eddies interact with sea ice ?

In this project, we will leverage numerical modelling to investigate the complementarity between Argo float and satellite altimetry measurements in the characterization of the mesoscale eddy field and of its evolution through time within the Antarctic sea ice region.

Methodological approach

We will detect mesoscale eddies under Antarctic sea ice using a **high-resolution numerical ocean-sea ice model**. First, the eddy kinetic energy will be computed to select regions with high eddy activity. Second, we will investigate the thermohaline characteristics over the vertical of eddies detected from the sea level anomalies (SLA) of the model following the approach used with satellite altimetry by Auger et al. (2023;

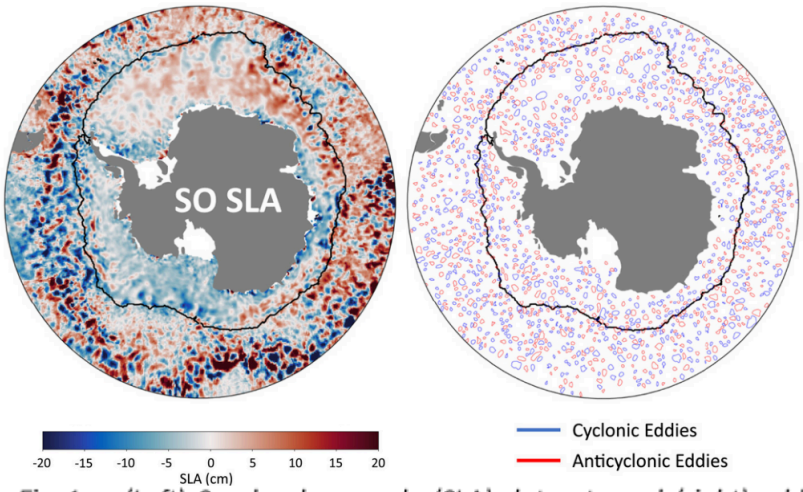

Fig 1 - (Left) Sea level anomaly (SLA) dataset and (right) eddy detected from this dataset (figure adapted from Auger et al. 2023).

see Fig. 1). We will then compare these vertical profiles with that obtained from *virtual* Argo floats deployed within the eddies detected by SLA and advected by the model velocity field. Third, we will randomly deploy *virtual* Argo floats within the selected regions and examine the SLA signature of eddies detected from the floats only. Through a cross-analysis of the eddy characteristics within these different datasets we will try to infer a relationship between SLA and thermohaline structures for eddies below sea ice, and discuss how this knowledge could be transferred to the *actual* Southern Ocean.

Requirements

- Knowledge in physical oceanography and geophysical fluid dynamics.
- Technical abilities in data analysis and scientific programming (Python).

Contact

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References

Auger, M., Sallée, J.-B., Thompson, A. F., Pauthenet, E., & Prandi, P. (2023). Southern Ocean ice-covered eddy properties from satellite altimetry. *Journal of Geophysical Research: Oceans*, 128, e2022JC019363. https://doi.org/10.1029/2022JC019363

Beech, N., Rackow, T., Semmler, T. *et al.* High-latitude Southern Ocean eddy activity projected to evolve with anthropogenic climate change. *Commun Earth Environ* **6**, 237 (2025). https://doi.org/10.1038/s43247-025-02221-4

Purich, A., Doddridge, E.W. Record low Antarctic sea ice coverage indicates a new sea ice state. *Commun Earth Environ* **4**, 314 (2023). https://doi.org/10.1038/s43247-023-00961-9