MASTER 2 in physical oceanography
Characterizing the spatio-temporal variations of the Greenland Sea gyre over the altimetric era

Supervisors:
Camille Lique (LOPS, Ifremer) (camille.lique@ifremer.fr)
Nicolas Kolodziejczyk (nicolas.kolodziejczyk@univ-brest.fr)
Matthis Auger (matthis.auger@utas.edu.au)

Location: Laboratoire d'Océanographie Physique et Spatiale (LOPS – IUEM, Brest).
Duration: 5 to 6 months.

The Greenland Sea is the site of key processes for the global ocean circulation and the equilibrium of our climate. It is one of the few areas on the planet where surface waters are ventilated and subsequently sink into the deep ocean through convection, thereby influencing the formation of dense waters and the vertical redistribution of heat, freshwater, carbon, oxygen, and nutrients as well as contributing to the meridional overturning circulation. Based on *in situ* observations, recent studies have documented the variability in both the deep convection and the water masses in the Greenland Sea (Almeida et al. 2023, 2025; Brakstat et al. 2019). These studies point out the role of the variability of the Greenland gyre through two mechanisms: (i) the intensity of the cyclonic gyre determines at first order a favorable environment to trigger deep water formation (known as preconditioning) through isopycnals doming in the center of the gyre, thereby bringing weakly stratified waters of the ocean interior close to the surface; and (ii) the variability in intensity and shape of the gyre modulates the advection of heat and freshwater from the surrounding basins to the Greenland Sea, which in turn further affects the stratification in the deep convection site. Despite this importance for the global ocean, a complete description of the Greenland gyre and its variability is still lacking.

The goal of this project is to document the spatio-temporal variations of the Greenland gyre, making use of the unique decade-long dataset of sea level anomaly (SLA) from satellite altimetry (https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/gridded-sea-level-heights-and-derived-variables.html). We will first describe the changes in shape, position and intensity of the gyre following the methodology of Regan et al. (2019) or Foukal et al. (2017). Second, we will quantify the barotropic and baroclinic contributions to these changes, making use of two gridded products derived from Argo measurements (ISAS for the hydrography and ANDRO for the velocity field at 1000m). In fine, these investigations will contribute to a better understanding of the mechanisms driving the variability in deep convection at high latitude.

Almeida, L., Lique, C.,Kolodziejczyk, N., & Desbruyères, D. (2025). Drivers of water mass volume changes in the Nordic Seas (2005–2020). Journal of Geophysical Research: Oceans, 130, e2024JC022209. https://doi.org/10.1029/2024JC022209

Almeida, L., Kolodziejczyk, N., & Lique, C. (2023). Large scale salinity anomaly has triggered the recent decline of winter convection in the Greenland Sea. Geophysical Research Letters, 50(21), e2023GL104766. https://doi.org/10.1029/2023GL104766

Brakstad, A., Våge, K., Håvik, L., & Moore, G. (2019).Water mass transformation in the Greenland Sea during the period 1986–2016. Journal of Physical Oceanography, 49(1), 121–140. https://doi.org/10.1175/JPO-D-17-0273.1

Foukal, Nicholas P., and M. Susan Lozier (2017). "Assessing variability in the size and strength of the North Atlantic subpolar gyre." Journal of Geophysical Research: Oceans 122.8: 6295-6308.

Regan, H.C., C. Lique and T. W. Armitage, 2019: The Beaufort Gyre extent, shape, and location between 2003 and 2014 from satellite observations, Journal of Geophysical Research: Oceans, 124. https://doi.org/10.1029/2018JC014379