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SUMMARY OF PROPOSAL / RÉSUMÉ DE LA PROPOSITION

In the space provided below, state the objectives of the proposed research project and summarize the scientific approach, highlighting the novelty and expected significance of the work to a field or fields in the natural sciences and engineering. Note that NSERC supports research in the natural sciences and engineering (other than the health sciences).

Dans l'espace prévu ci-dessous, énoncez les objectifs du projet de recherche proposé et résumez la démarche scientifique, en soulignant l'originalité et l'importance prévue des travaux dans un ou plusieurs domaines des sciences naturelles ou du génie. Veuillez noter que le CRSNG appuie la recherche dans le domaine des sciences naturelles et du génie, à l'exception des sciences de la santé.

Ocean fronts separate waters of different temperatures and salinities over distances ranging from a few tens of kilometres down to hundreds of meters, a range called submesoscale. The ocean surface is populated with a convoluted web of submesoscale fronts, featuring rapid subsurface vertical velocities of 10 to 100 m/day, an order of magnitude stronger than in the rest of the ocean. They may therefore play an important part in the exchange of heat and gases between the atmosphere and the ocean interior, and in the supply of nutrients to the euphotic layer. However, computing performances will not be sufficient for the foreseeable future to resolve submesoscales in global ocean models. We must therefore develop parameterizations that realistically reproduce the collective effect of submesoscale processes on the resolved larger scales.
Submesoscale-resolving numerical simulations are now being run in idealized or regional settings, but observations of submesoscale processes have remained sparse. The most detailed observations have been obtained from sporadic, ship-borne campaigns, due to the necessity of sampling the vertical and horizontal structure of the upper ocean at high resolution over extended areas. There is a lack of long-term, continuous observations to provide a statistical view of submesoscale dynamics in a wide range of environmental conditions. One of the goals of this proposal is to start filling this observational void.
As a first step, in the next five years, I propose to use the Lower St-Lawrence Estuary (LSLE) as an ideal natural laboratory to conduct long-term, continuous observations of submesoscale processes, in order to answer the following specific questions:
1) What are the relative contributions of mesoscale strain, surface wind and buoyancy forcings in driving frontogenesis/frontolysis and the associated strong vertical motions?
2) How much energy is being transferred by frontal submesoscale instabilities from mesoscales to small scales at which energy is dissipated? If significant, can this energy sink be accounted for in coarse-resolution numerical models by adequate parameterizations?
3) Can the subsurface vertical velocities developing at submesoscale fronts be reconstructed from surface observations only, using idealized dynamical models of the upper ocean circulation?

The LSLE presents all the ingredients to address question 1, which forms the basis to answering questions 2 and 3: it is laterally stratified, and is regularly populated with mesoscale eddies, leading to favourable conditions for strain-driven frontogenesis; it is vertically stratified, with strong seasonal variations in mixed-layer depth and stratification intensity underneath; it is subject to a wide range of surface wind and buoyancy forcings. Mesoscale eddies in the LSLE have been observed to persist at the same location for weeks, allowing to observe entire life cycles of submesoscale frontogenesis/frontolysis (which typically last only a few days) with Eulerian measurements, avoiding the need to track the fronts using ships or autonomous underwater vehicles. I therefore propose to deploy High-Frequency radars on the LSLE shores to map the 2-D surface current field with 1-km spatial resolution and hourly temporal resolution, and a Vertical Profiling System to sample the vertical structure of the water column and currents with a 1-m vertical resolution and 3-hour temporal resolution, at a suitably chosen location to optimize sampling of fronts. Additionally, sporadic surveys will be conducted with instruments towed by rapidly-deployable small vessels to resolve the horizontal variations in the vertical structure of fronts detected by satellite imagery and the Eulerian instruments. This unprecedented observational set-up will allow continuous, high-resolution observations of submesoscale processes over two annual cycles, spanning various environmental conditions. In addition to providing new observations to test existing, and help develop new, theories, models and parameterizations of submesoscale processes, the results of this program could have even broader implications: a positive answer to question 3, if it could be applied to the rest of the ocean (this would need to be tested), would allow to assess the global impacts of submesoscale fronts using existing or planned high-resolution satellite observations of sea surface temperature, salinity and height.