AM Internship: Portable High-Performance Ocean Simulations

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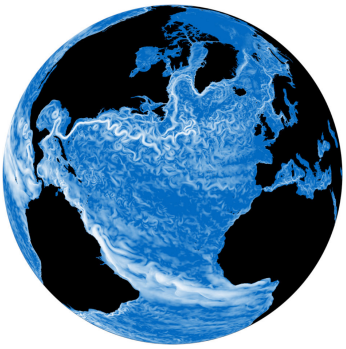
Location: Laboratoire Jean Kuntzmann, AIRSEA team, IMAG building, 700 avenue Centrale, 38401 Saint Martin d'Hères.

Numerical models simulating the oceanic circulation are essential to several research and operational applications on scales ranging from coastal environments to global (paleo-)climate with strong societal impacts.

Oceanic models are an essential building block of weather forecasting systems over various scales of interest through their interactions with the atmosphere, sea ice, biogeochemistry, and sediments. Due to their computational complexity, oceanic simulations are executed on large-scale supercomputers, with costs sometimes even exceeding 100 Mio. Euros. This raises the economic desire to optimize these simulations on supercomputers, which turns out to be a highly interdisciplinary task: On the one hand, one needs to work on reformulating the mathematical parts to reduce the wall clock time for the simulations. On the other hand, an *efficient execution and in particular programmability* on nowadays heterogeneous computer architectures are required to ensure that the multi-million investment is used most efficiently.



Ocean simulation performed with the NEMO code.

1 Goal

The codes which are of main interest are the NEMO[1] and Croco[2] ocean simulation codes. NEMO is widely used for climate and operational global ocean forecasting applications, while Croco is the basis of several coastal operational systems and is extensively used by the research community. The main focus of the project will be on one of these developments.

2 Objectives

Oceanic simulation codes consist of many lines of code and require a particular strategy for successful and robust code optimization. We target the following objectives:

1. Objective "**Mini apps**":
   Working on a fully developed ocean simulation code would pose serious challenges to step-by-step performance optimizations ("Not to see the forest for the trees"). Therefore, instead of working on the fully blown code, smaller parts of the ocean simulations should be extracted first.

2. Objective "**POSEIDON**":
   The previous objective sets the prerequisites for the POSEIDON development. POSEIDON is a software that allows one to parse the entire fluid dynamics solver within the ocean model. Here, we target multiple objectives, such as

[1] `https://www.nemo-ocean.eu/`
[2] `https://www.croco-ocean.org/`

- performance portability (CPUs, GPUs, FPGAs),
- optimized communication for large-scale systems,
- hardware-aware optimizations,
- development of a domain-specific language,
- automatic differentiation for ensemble runs,
- etc.

in an automatic way (**no hand-tuning of code**!). This is possible by analyzing the code with POSEIDON and doing further optimizations based on a source-to-source compiler (based on PSyclone).

Since POSEIDON is actively developed, the current state and particular objective of this project will be discussed either during the application for this project or at the beginning of this project.

3 Prerequisites

In order to ensure a successful internship for you as well as for us, please ensure that you fulfill all or at least most of the following prerequisites. Please point out your qualifications in the application letter (see below).

- Familiar with PDE solvers
- Basic understanding of High-Performance Computing (e.g., OpenMP / MPI / GPUs / ...)
- Willingness to also work independently (maybe previous experience in an internship/lab/etc.)

4 Application

To apply to this internship, send an Email to martin.schreiber@univ-grenoble-alpes.fr, including your CV, a transcript including all your grades (Bachelor + Master), and a brief explanation of why you are interested in this project.