2018-00664 - Coupling hydrostatic and nonhydrostatic ocean circulation models - [PhD Campaign Inria Grenoble Research center, campagne doctorants]

Contract type: Public service fixed-term contract
Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

About the research centre or Inria department
Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

Context
Hosting team: INRIA project team AIRSEA
Head: Laurent Debreu
Supervisors: Eric Blayo and Laurent Debreu
Research topics: Mathematics and computing applied to oceanic and atmospheric flows
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Assignment
The overall context of this PhD thesis is the development of numerical forecast systems for the ocean and the atmosphere. The scientific activities of the AIRSEA team in Grenoble are focused on the design of mathematical and numerical methods for such systems.

Similarly to atmospheric models, ocean circulation models have been developed for decades, and are used for numerous applications, like long term climate simulations, seasonal forecasting, or short range operational forecast, either at global or regional scales. Let mention for instance the operational European forecast center Mercator-Ocean (https://www.mercator-ocean.fr).

These models are increasingly sophisticated, and there is in particular a present coordinated effort in France toward the development of a community model for regional and coastal applications. This model, called CROCO (http://www.croco-ocean.org), will include the capability for very high resolution local zooms in regions of particular interest. Such regions are in particular areas where some usual physical assumptions (hydrostatic flow, Boussinesq approximation) are no longer valid, i.e. where a more complex physics is required for the model to be relevant.

Main activities
Most ocean circulation models are based on the so-called "primitive equations", i.e. Navier-Stokes equations for a stratified fluid in a rotating frame, with hydrostatic and Boussinesq assumptions. The hydrostatic approximation neglects the vertical acceleration and results in a balance between the vertical pressure gradient and the gravity. From a dynamical point of view, this is justified by the fact that oceanic flows are generally characterized by large differences between horizontal and vertical scales and by a strong vertical stratification that limits vertical mixing. From a computational point of view, the hydrostatic approximation decreases the computational burden by one order of magnitude w.r.t. solving the nonhydrostatic equations.

However, as mentioned previously, continuous improvement in numerical modeling and in computing resources leads to more and more sophisticated ocean modeling systems, which aim at...
representing the full ocean physics. A natural idea is thus to build systems that couple a local nonhydrostatic compressible set of equations to a larger scale hydrostatic (almost) incompressible one. Such a coupling is quite delicate from a mathematical point of view, due to the different nature of the two sets of equations (where, for instance, the vertical velocity is either a diagnostic or a prognostic variable).

Blayo and Rousseau (2016) performed a first work in this direction, which analyzes the conditions to be satisfied at the interface between hydrostatic and nonhydrostatic models, and derives possible interface conditions to be used in an iterative coupling algorithm. This work was however limited to incompressible non stratified systems, with no numerical implementation.

In this context, the objectives of this PhD are:

- to analyze, from a mathematical point of view, the coupling between nonhydrostatic compressible equations and hydrostatic Boussinesq ones;
- to design a coupling algorithm;
- to perform a numerical implementation of those ideas
  - to run some validation testcases, possibly in the context of the CROCO system.

Références


Blayo E. and A. Rousseau, 2016: About Interface conditions for coupling hydrostatic and nonhydrostatic Navier-Stokes flows, Discrete and Continuous Dynamical Systems - Series S, 9, 1565--1574.


Keywords : PDEs, coupling methods, ocean models, numerical simulation

Skills

Master in applied mathematics, with some knowledge in numerical analysis and programming skills

Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration


Monthly salary after taxes : around 1596,05€ for 1st and 2nd year. 1678,99€ for 3rd year. (medical insurance included).