A consistent finite-volume discretization of air-sea interactions in ocean-atmosphere coupled models

Master of applied mathematics (research) (*A PhD funding is foreseen*)

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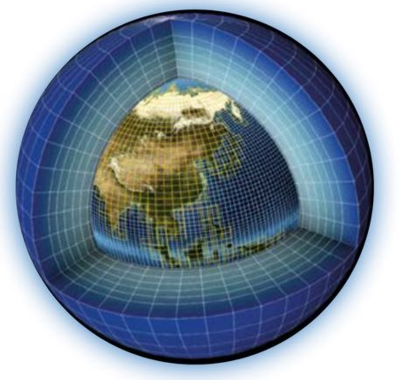
Context

While climate change is causing many changes that affect our society, the numerical climate models assessed by the scientists in the framework of the IPCC (Intergovernmental Panel on Climate Change) are an indispensable tool for anticipating future risks. The development of the numerical models used in this context generally dissociates the dynamical kernel, which handles the resolved scales, from the physics, that account for under-resolved processes (e.g. Lemarié et al., 2015). However, both components are strongly connected since there is a permanent back and forth transfer between the dynamics and the physics so that the dynamical core must not violate physical principles. In this internship we propose to work on the proper linking between the dynamics and the physics within ocean-atmosphere coupled models.

Objectives

In this work we will consider the coupling between two one-dimensional diffusion equations representing the turbulent mixing in the oceanic and atmospheric boundary layers. For this problem, the boundary conditions at the ocean-atmosphere interface are computed through a so-called wall law which predicts a logarithmic profile for the solution in the vicinity of the interface (e.g. Mohammadi & Pironneau, 1994). The objective is to derive a spatial discretization of this coupling problem that ensures a consistent interplay between the physics (i.e. the wall law) and the dynamics (i.e. the diffusion equation) as well as the proper regularity (i.e. the continuity of the fluxes) of the coupled solution through the air-sea interface.



Within the framework of finite volume methods, the idea would be to consider a convenient sub-grid reconstruction of the solution for the grid cells away from the air-sea interface and to consider a reconstruction coherent with the wall law in the cells in the vicinity of the interface. Then, the value of the fluxes at the interface between the computational cells can be obtained by imposing a given regularity (e.g. the continuity of the solution and of the first derivative) to the reconstructed solution.

Depending on the progress of this work, we could, then, study how the computation of the coupled solution using a consistent finite volume discretization influences the convergence speed of iterative coupling methods like the global-in-time Schwarz method (a.k.a. Schwarz waveform relaxation, e.g. Lemarié et al., 2013) as well as the behavior of the coupled solution when spatial resolution is increased.

Prerequisites

- Solid background in numerical analysis and finite volumes/differences methods

References :

• Lemarié F., E. Blayo & L. Debreu (2015) *Analysis of Ocean-atmosphere Coupling Algorithms: Consistency and Stability.* Procedia Computer Science, 51, pp. 2066-2075
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