Optimal data filtering within coupling algorithms for ocean-atmosphere simulations

Master (1st year) internship proposal

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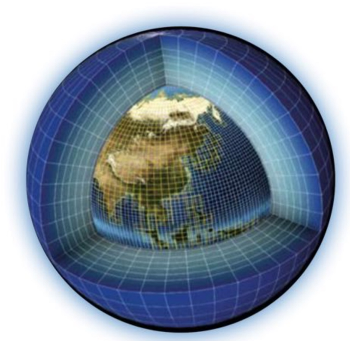
Keywords Scientific computing, model coupling, PDEs, ocean-atmosphere interactions

Context The interactions between atmosphere and ocean play a major role in many geophysical phenomena, covering a wide range of temporal scales (e.g. daily weather, tropical cyclones, global climate...). Therefore the numerical simulation of such phenomena requires coupled atmospheric and oceanic models, which properly represent the behavior of the boundary layers encompassing the air-sea interface and their two-way interactions.

Two types of coupling algorithms are currently used in operational models : local-in-time algorithms, which exchange information at the each time step, and global-in-time algorithms, which exchange averaged information at the end of time windows of one to several hours. We have shown that, in all cases, these algorithms have flaws related to their stability or to the synchronization of the models, and we have proposed an iterative version (Schwarz-like method) which allows a much better mathematical consistency and eliminates a significant numerical error.

However, to our knowledge, one aspect has never been investigated, namely the filtering of data transmitted from one model to another. Indeed, current practices consist in providing either raw data or data averaged over one or several hours. However, a numerical argument seems quite clear : only information compatible with the effective resolution of a model should be transmitted to it, since information at higher frequencies is only noise. Temporally, this effective resolution is $2\Delta t$ according to the Shannon theorem, probably more of the order of $10\Delta t$ in practice because of numerical errors. Moreover, physical constraints may exist, linked to the time scales of the phenomena that we represent and the possible underlying hypotheses to the parameterizations used.

Objectives In this context, we wish to clarify this aspect, by analyzing from a theoretical point of view the effects of filtering the data transmitted at the ocean-atmosphere interface, and by proposing alternatives to the current systematic use of a simple averaging operator. The objective is to investigate if this is a possible improvement in the quality of the solutions, and if so, to ask the question of its effective implementation. Numerical tests will be carried out on a simplified model (1-D vertical model of two coupled Ekman layers), and on the 1-D version of the Météo-France climate model.



Prerequisites some knowledge in PDEs and numerical analysis, programming skills

References

Marti O., S. Nguyen, P. Braconnot, S. Valcke, F. Lemarié and E. Blayo, 2021 : A Schwarz iterative method to evaluate ocean-atmosphere coupling schemes. Implementation and diagnostics in IPSL-CM6-SW-VLR. *Geoscientific Model Development*, **14**, 2959-2975, `https://doi.org/10.5194/gmd-14-2959-2021`.

Thery S., C. Pelletier, F. Lemarié and E. Blayo, 2021 : Analysis of Schwarz waveform relaxation for the coupled Ekman boundary layer problem with continuously variable coefficient. *Numerical Algorithms*, doi 10.1007/s11075-021-01149-y.