Mathematical aspects of the coupling problem at the air-sea interface in numerical climate models

Charles PELLETIER, Univ. Grenoble-Alpes, Inria, LJK

Éric BLAYO, Univ. Grenoble-Alpes, Inria, LJK

Florian LEMARIÉ, Univ. Grenoble-Alpes, Inria, LJK

Mots-clés : Model coupling, eddy parameterization, Schwarz algorithm, climate modelling.

Accurate numerical climate modelling is considered crucial for better understanding climate change, which, in recent years, has gathered significant attention from a large part of the scientific community. More specifically, the influence of coupling mechanisms at the air-sea interface is of great importance for obtaining better long-term global climate predictions. Due to numerical restrictions, both atmospheric and oceanic models typically use boundary conditions derived from empirically-tuned turbulence closure parameterization (see [1], and [2] for a review), aimed at taking into account highly-influential sub-grid scale dynamics. In the vicinity of the air-sea interface, the evolution of physical quantities of interest (e.g. momentum, temperature, humidity) can be modelled as a non-stationary diffusion equation, for whom these parameterizations take form as highly nonlinear boundary conditions. Schwarz waveform relaxation algorithms have been proved to constitute a good framework for coupling multi-model, non-stationary problems (see [3] for a similar example in a different context). The air-sea coupled problem, excluding the boundary layer parameterizations, has already been studied from a mathematical point of view (e.g. [4]). Extending [5], we now aim at developing efficient coupling at the air-sea interface, embracing as much as possible the complexity of the aforementioned physical eddy parameterizations.

Références

[1] A.S. Monin, A.M. Obukhov. *Basic laws of turbulent mixing in the surface layer of the atmosphere*, Trudy Akademii Nauk SSSR Geofizicheskogo Instituta, 1954.

[2] W.G. Large, J.C. McWilliams, S.C. Doney. *Oceanic Vertical Mixing: A Review and a Model with a Nonlocal Boundary Parameterization.* Reviews of Geophysics, 1994.

[3] F. Caetano, M.J. Gander, L. Halpern, J. Szeftel. *Schwarz Waveform Relaxation Algorithms with Nonlinear Transmission Conditions for Reaction-Diffusion Equations*, Domain Decomposition Methods in Science and Engineering XIX, Lecture Notes in Computational Science and Engineering, Springer-Verlag, 2010.

[4] J.-L. Lions, R. Temam, S. Wang. *Mathematical Theory for the Coupled Atmosphere-Ocean Models (CAO III)*, Journal de Mathématiques Pures et Appliquées, 74, 1995.

[5] F. Lemarié, L. Debreu, E. Blayo. *Toward an optimized global-in-time Schwarz algorithm for diffusion equations with discontinuous and spatially variable coefficients. Part 2 : the variable coefficients case.* Electronic Transactions on Numerical Analysis, 40, pp. 170-186, 2013.

Charles PELLETIER, Laboratoire Jean Kuntzmann, 51, rue des Mathématiques, F-38000 Grenoble
`charles.pelletier@imag.fr`
Éric BLAYO, Laboratoire Jean Kuntzmann, 51, rue des Mathématiques, F-38000 Grenoble
`eric.blayo@imag.fr`
Florian LEMARIÉ, Laboratoire Jean Kuntzmann, 51, rue des Mathématiques, F-38000 Grenoble
`florian.lemarie@imag.fr`