Summary: In this paper, we present a global-in-time non-overlapping Schwarz method applied to the Ekman boundary layer problem. Such a coupled problem is representative of large-scale atmospheric and oceanic flows in the vicinity of the air-sea interface. Schwarz waveform relaxation (SWR) algorithms provide attractive methods for ensuring a “tight coupling” between the ocean and the atmosphere. However, the convergence study of such algorithms in this context raises a number of challenges. Numerous convergence studies of Schwarz methods have been carried out in idealized settings, but the underlying assumptions to make these studies tractable may prohibit them to be directly extended to the complexity of climate models. We illustrate this aspect on the coupled Ekman problem, which includes several essential features inherent to climate modeling while being simple enough for analytical results to be derived. We investigate its well-posedness and derive an appropriate SWR algorithm. Sufficient conditions for ensuring its convergence for different viscosity profiles are then established. Finally, we illustrate the relevance of our theoretical analysis with numerical results and suggest ways to improve the computational cost of the coupling. Our study emphasizes the fact that the convergence properties can be highly sensitive to some model characteristics such as the geometry of the problem and the use of continuously variable viscosity coefficients.

MSC:
- 65-XX Numerical analysis
- 86-XX Geophysics
- 76-XX Fluid mechanics

Keywords:
- Schwarz waveform relaxation
- variable coefficients
- multiphysics coupling
- coupled Ekman problem
- numerical climate modeling

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