Waveform iteration for ocean-atmosphere-sea-ice coupling

Philipp Birken (Lund University), Valentina Schüller, Eric Blayo, Florian Lemarié

Within Earth system models (ESM), many differential and algebraic equations are coupled together. Thereby, different submodels are implemented in separate codes that use their own discretization and time step, a so called partitioned approach. Here, we consider the coupling between ocean, atmosphere and sea ice. The first two models are based on PDEs on separate but connected domains, and exchange information via boundary conditions. The sea ice model is a lower dimensional PDE, coupled to the ocean solver.
Our general aim is to understand the coupling error caused by this approach, and to suggest improvements. To this end, we treat this as part of a waveform relaxation method. These consider two coupled ODEs and solve them iteratively, given data from the respective other equation. Note that in ESM, only one iteration is performed.
We implemented a true waveform relaxation method in the single column version of the European ESM EC-Earth [1]. This way, we can get a reference solution per time window, and thus observe the coupling error. We see that there is a small but clearly noticable coupling error for pure ocean-atmosphere coupling, and that the inclusion of sea-ice makes this worse.

References

1. R. Döscher, et al., *The EC-Earth3 earth system model for the coupled model intercomparison project 6*, Geoscientific Model Development, 15 (2022), pp. 2973–3020.

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