Numerical simulation of an idealized coupled ocean-atmosphere model

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We present numerical simulation of an idealized climate model. Our climate model belongs to the class of intermediate coupled models which are much simpler than the coupled general circulation models of the ocean-atmosphere system but still allow to study the fundamental aspects of ocean-atmosphere interactions. Our model couples an atmospheric system, described by the compressible two-dimensional (2D) Navier-Stokes equations and an advection-diffusion equation for temperature, to an ocean system, given by 2D incompressible Navier-Stokes equations and an advection-diffusion equation for temperature. Finite element method is used to discretize the system of PDEs representing the climate model on a 2D unit-square periodic domain and the implementation is done using Firedrake∗, which is an efficient automated finite element method library. To ensure the accuracy of simulation results of the coupled model, we have carried out detailed numerical investigation of its atmospheric and ocean components separately (without coupling) and tested our codes against different benchmark problems available in the literature. Our final aim is to incorporate stochasticity into the coupled ocean-atmosphere model following the Hasselmann's paradigm [1] and use the model to study important climate phenomena like El-Nino Southern Oscillation (ENSO) [2] which occur in the tropical eastern Pacific Ocean as a result of strong ocean-atmosphere interactions. This will be the subject of our future work.

References:

[1] Klaus Hasselmann. "Stochastic climate models part I. Theory". In: tellus 28.6 (1976), pp. 473–485.

[2] Henk A Dijkstra. Nonlinear physical oceanography: a dynamical systems approach to the large scale ocean circulation and El Nino. Vol. 28. Springer Science & Business Media, 2005.