An efficient computational framework for atmospheric and ocean flows

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Numerical simulations of geophysical flows are an essential tool for ocean and weather forecast. Moreover, they could also provide insights on the mechanisms governing climate change. However, often long time intervals have to be simulated, making the computational cost prohibitive. We propose two different strategies to reduce such computational cost:

(i) The development of a Reduced Order Model (ROM) with the aim to lower the computational cost of the numerical simulations without a significant loss in terms of accuracy. In this context, we consider the 2D Navier-Stokes equations in terms of stream function and vorticity as Full Order Model, which represents an attractive alternative to the model in primitive variables for geophysical fluid dynamics applications. We present a novel POD-Galerkin ROM where different reduced coefficients for the vorticity and stream function fields are considered. A global POD basis space obtained from a database of time dependent full order snapshots related to sample points in the parameter space. The performance of our ROM strategy is tested against the classical vortex merger benchmark [2].

(ii) The development of a Large Eddy Simulation (LES) approach that allows to use a coarser mesh than the one required by a Direct Numerical Simulation by modeling the effect of the small scales that do not get resolved. Here, we refer to the Quasi-Geostrophic equations, which is a toy problem describing the main features of geophysical flows under certain simplifying assumption. We propose a novel variant of the so-called BV-α model [3] that introduces nonlinear indicator function to identify the regions of the domain where the flow needs regularization [1]. In order to assess the performance of the proposed LES approach, we consider the double-gyre wind forcing benchmark.

References

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