Data Driven Reduced Order Model for the Quasi-Geostrophic Equations

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Abstract

We propose a novel data-driven framework combining Proper Orthogonal Decomposition (POD) and Artificial Neural Networks (ANNs) for developing a reduced-order model of the Quasi-Geostrophic Equation (QGE). In Girfoglio et al. [2023] Girfoglio et al. [2023], the authors introduced a linear filtering-based Large Eddy Simulation (LES) approach. Building upon this, our study employs the interaction with POD to extract dominant modes and efficiently reduce the system's dimensionality.

Artificial Neural Networks (ANNs) are then utilized to model the nonlinear relationships between the reduced modes and the system's dynamics. This approach replaces the need for traditional closure models by leveraging simulation data to train the ANN. Using high-fidelity data from OpenFOAM simulations, the potential of the POD-ANN framework is demonstrated on the classical double-gyre wind forcing benchmark case.

Our results highlight the effectiveness of the POD-ANN approach in accurately capturing the dynamics of QGE while significantly reducing computational costs, paving the way for scalable and efficient reduced-order modeling of geophysical systems.

References

Michele Girfoglio, Annalisa Quaini, and Gianluigi Rozza. A linear filter regularization for pod-based reduced-order models of the quasi-geostrophic equations. *Comptes Rendus. Mécanique*, 351(S1):1–21, 2023.

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