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Inferring hidden equations using Quasi-Geostrophic theory guided machine learning

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Inferring hidden equations governing dynamical systems from data has always been one of the challenging problems in the interplay between physics and data science. It was just a matter of time before the recent advancements in machine learning and in computational capacities come in hand and spark off a series of works dedicated to address this problem.

In this work we present a Quasi-Geostrophic numerical model coded using differentiable operators thus permitting the use of automatic differentiation libraries (e.g. Tensorflow). This makes the model flexible and suited for parameter optimization, especially using neural networks. We illustrate the relevance of the proposed architecture through an example of a regression problem where we show how can we obtain the parameters of the potential vorticity equation using only consecutive scenes of Sea Surface Height. This can be of interest for finding the closest QG-like approximation to a given ocean simulation model or help exploring the effect of adding new operators in the potential vorticity equation. The code we provide is suitable for GPU implementation and therefore can allow for faster execution and profit from the quick advancements in GPU development.

We expect that the directions of research we suggest will help in bringing more interest in applied machine learning to ocean numerical modeling.