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Modelling Wind-Driven Oceanic Gyres

The atmospheric winds drive the oceans from above and create gyre dynamics and western boundary currents throughout the World's oceans. The Quasi-Geostrophic (QG) model is a very simple model for ocean dynamics that has clearly demonstrated that it is the winds and dissipation at the large scale that are essential for creating these gyres. One limit of the classical theories of wind-driven gyres focused on linear dynamics in very simple geometries.

In this work, we investigate wind-driven gyres in the context of a one-layer QG model that includes complex geometries, something that is relatively easily done using the Finite Element library Firedrake. First, we present wind-driven gyre solutions to the QG model that can include bottom drag, lateral viscosity and nonlinear advection. Second, we compute the basin mode solutions that exist in the context of these numerical solutions. One of the motivations of this research is to bridge the gap between idealized models and realistic real-world calculations. We have written software that is freely available that we hope will enable researchers and students alike to more easily investigate the dynamics of wind-driven gyres.