Proposed PhD Research Project:
Conundrum of Multiple Jets and Eddies: Large-Scale Flow Effects

1. Statement of the Problem

Despite attracting continuous theoretical interest, synoptic turbulence on rotating planets remains enigmatic. In the terrestrial ocean this turbulence is underpinned by a miriad of latent and alternating zonal jets, whereas in the weather layer of Jupiter similar jets take form of powerful banded currents. The oceanic jets are generated by the "oceanic weather" (mesoscale eddies), and coexist and interact with it, depending on a multitude of physical factors such as planetary rotation, vertical density stratification, and boundary conditions. The main goal of this Project is to focus on the effects of large-scale, quasi-two-dimensional currents and understand their contributions to the conundrum of multiple jets and eddies. No systematic studies have been ever carried out, although the existing evidence suggests the leading-order effect on all properties of the jets and eddies.

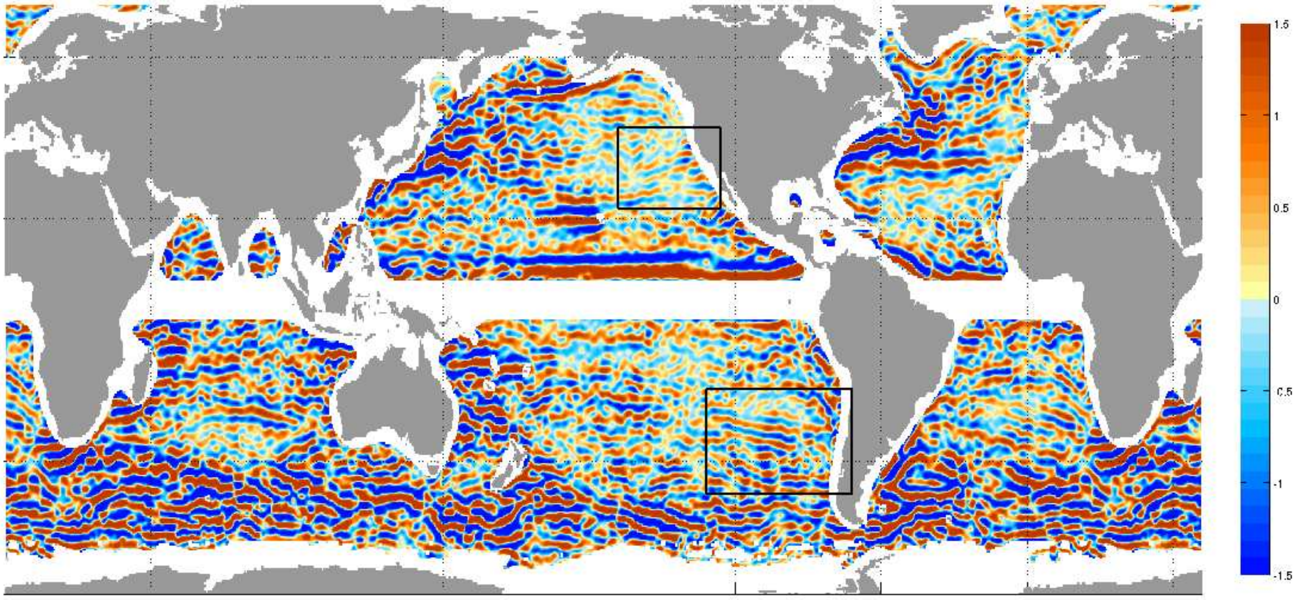

Figure 1: Observational evidence of latent jets that populate all parts of the global ocean is the most significant oceanographic discovery of the last decade. The jets can be viewed as a "hidden skeleton" inside the powerful "oceanic weather" turbulence (filtered away on this figure), which consists of thousands of transient synoptic eddies. The "oceanic weather" induces the jets through variety of nonlinear processes, but the jets feed back and modify many properties of the "weather" — all these complex interactions evolve inside unstable large-scale currents that alter and modulate all the dynamical processes involved.

2. Milestones of Analysis

This work will involve substantial scientific computations with a hierarchy of geostrophic balanced models of baroclinic turbulence on rotating sphere. We will systematically proceed from the simplest to more realistic large-scale background flows and understand properties of the jets and eddies, as well as the nonlinear interactions involved. The research agenda will involve (1) linear analyses of various background flows, (2) energy balances and conversions, (3) wave/mean-flow nonlinear interactions and feedbacks.

A challenging and ambitious part of this project is to develop a dynamically constrained stochastic forcing process that can excite the dynamically active part of the eddy spectrum responsible for maintaining the jets, in the typical climate-model situation of under-resolved and over-damped eddies.

The student will benefit from the interdisciplinary nature of the Project that combines Geophysical Fluid Dynamics, Applied Mathematics, and Numerical Modelling. The Project will also benefit from interaction with ocean modellers from the University of Miami (USA).

References

Berloff, P., S. Karabasov, J. Farrar, and I. Kamenkovich, 2011: On latency of multiple zonal jets in the oceans. *J. Fluid Mech.*, **686**, 534–567.