SIO212C Syllabus

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The goal of SIO212C — a third course on geophysical fluid dynamics — is to provide physical oceanography and other interested students with the background required to work at the frontier of research on unbalanced processes. Some of these were once balanced but have ceased to be so (e.g. frontal instabilities), some were never balanced (e.g. internal waves), and some are nonlinear interactions between the two. These topics are of increasing community interest and are central to many ongoing SIO research projects, but are not accommodated in parts I and II of the geophysical fluid dynamics sequence SIO 212. Most of these topics are not covered in any pedagogical textbooks, and students (and PIs!) are left to pick up what they can from individual research papers. Here we hope to put together a systematic treatment, a broad intellectual framework in which to understand many of these hot topic issues. This material is intended primarily for second year and above students who have at least taken the first year Fluids and GFD I courses.

This 4 unit class meets twice per week for 80 minutes a session. The classes will involve a combination of formal lectures on the underlying theoretical framework with discussion of how various cutting edge papers fit in, or not, to that framework. We expect 9 hours of homework/preparation per week.

Possible topics include:

(a) The kinematics of passive scalars and passive vectors. Stirring, mixing, gradient amplification and enhanced dispersion.

(b) Boussinesq potential vorticity (PV) conservation. PV impermeability. Geostrophically balanced flows with prescribed PV (mostly uniform) — momentum coordinates.

(c) Quasigeostrophic frontogenesis. Two-dimensional semi-geostrophic frontogenesis. Balanced frontogenesis — the Hoskins & Bretherton model. Unbalanced frontogenesis — Blumen's model.

(d) Frontal and mixed layer instabilities; symmetric instability.

(e) Very unbalanced motion — not even hydrostatic. The Craik-Leibovich vortex force and Langmuir turbulence. The Stokes-Coriolis force and its modification of Ekman layer dynamics. Anti-Stokes flow.

(f) Frictional flows in the mixed layer — "turbulent thermal wind" and frontolysis.

(g) Internal waves beyond the first year: generation, propagation, triad interactions and dissipation

(h) Topography and loss of balance: internal lee waves and island/headland wakes

(i) Interaction of balanced flow with internal waves.