Fluid Dynamics of Climate (M24)

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Understanding the Earth's climate and predicting its future evolution is one of the great scientific challenges of our times. Fluid motion in the ocean and atmosphere plays a vital role in regulating the climate system, helping to make the planet hospitable for life. The dynamical complexity of this fluid motion and the wide range of space and time scales involved is one of the most difficult aspects of climate prediction.

This course, focusing on the large-scale behaviour of stratified and rotating flows, provides an introduction to the fluid dynamics necessary to build mathematical models of the climate system. The course begins by considering flows which evolve on a timescale which is long compared with a day, where the Earth's rotation plays an important role. The rotation is felt through the Coriolis force (a fictitious force arising from use of a frame of reference rotating with the Earth) which causes a moving parcel of fluid to experience a force directed to its right in the Northern hemisphere (or its left in the Southern hemisphere), introducing a rich wealth of new dynamics, particularly in combination with stable density stratification. Canonical models are introduced and studied to illustrate phenomena such as adjustment to a state of geostrophic balance, where Coriolis force balances pressure gradient, new wave modes that can communicate dynamical information on both regional and global scales, and new hydrodynamic instabilities that lead to atmospheric weather systems and ocean eddies.

The course then moves on apply these basic ideas to important aspects of the large-scale dynamics of the atmosphere and the oceans that directly impact the global climate system. Specifically, we will examine the structure and hence the effects of ocean eddies and atmospheric weather systems, the dynamics of the meridional (north/south) circulation in the ocean and atmosphere and the associated transport of heat and of chemical and biological tracers. The final part of the course will consider the special dynamics of tropical regions which give rise to phenomena such as El Nino.

Prerequisites

Undergraduate fluid dynamics

Literature

The following provide some introductory reading and will also complement the detailed presentation of material given in lectures.

1. G.K. Vallis, *Atmospheric and Oceanic Fluid Dynamics.* Cambridge University Press, 2017.
2. A.E. Gill, *Atmosphere-Ocean Dynamics.* Academic Press, 1982.
3. J. Marshall and R.A. Plumb, *Atmosphere, Ocean, and Climate Dynamics.* Academic Press, 2008.

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a revision class in the Easter Term.