Fluid dynamics of the solid Earth (L24)

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The dynamic evolution of the solid Earth is governed by a rich variety of physical processes occurring on a wide range of length and time scales. The Earth's core is formed by the solidification of a mixture of molten iron and various lighter elements, a process that drives compositional convection in the liquid outer core, thus producing the geodynamo responsible for Earth's magnetic field. On million-year timescales, the solid mantle convects, and as it upwells to the surface it partially melts leading to volcanism. At the surface, convection drives the motion of brittle plates, which are responsible for the Earth's topography as can be felt and imaged through the seismic record. In the Earth's crust, fluids flow through porous rocks, forming groundwater aquifers that feed streams and rivers that erode the solid surface. On the Earth's surface, similar physical processes of viscous and elastic deformation coupled to phase changes govern the evolution of the Earth's cryosphere, from the solidification of polar oceans to form sea ice to the flow of glacial ice over land and the ocean.

This course will use observations of the solid Earth to motivate mathematical models of physical processes that play key roles in many other environmental and industrial processes. Mathematical topics will include the onset and scaling of convection, the coupling of fluid motions with changes of phase at a boundary, the thermodynamic and mechanical evolution of multicomponent or multiphase systems, the coupling of fluid flow and elastic flexure or deformation, and the flow of fluids through and deformation of porous materials. The focus will be on the generation and solution of mathematical models motivated by observational data.

The course will cover a selection of topics including:

- Growth of Earth's inner core
- Groundwater flows
- Formation and evolution of sea ice
- Carbon capture and storage
- Stability of marine ice sheets

Prerequisites

Mathematical methods, particularly the solution of ordinary and partial differential equations. An understanding of viscous fluid dynamics.

Literature

1. M.G. Worster. *Solidification of Fluids.* In Perspectives in Fluid Dynamics: a Collective Introduction to Current Research. Edited by G.K. Batchelor, H.K. Moffatt and M.G. Worster. pp. 393–446. CUP (2000)

2. H.E. Huppert. *Geological fluid mechanics.* In Perspectives in Fluid Dynamics: a Collective Introduction to Current Research. Edited by G.K. Batchelor, H.K. Moffatt and M.G. Worster. pp. 393–446. CUP (2000)

3. D.L. Turcotte, G. Schubert. Geodynamics, second edition. CUP (2002)

Additional support

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