UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Midterm exam in GEF2610 – Introduction to Physical Oceanography
Day of exam: Wednesday 12 Oct. 2016
Exam hours: 10-11
This examination paper consists of 2 page(s).
Appendices:
Permitted materials: None

Make sure that your copy of this examination paper is complete before answering.

Problem 1: Air-sea fluxes

a) Name and describe the four types of heat fluxes we can have between atmosphere and ocean.

b) Discuss briefly how the presence of sea ice impacts air-sea momentum fluxes. How, qualitatively, does this impact vary as a function of sea ice concentration?

Problem 2: Stratification and potential energy

a) What do we mean by vertically (statically) stable and unstable water columns? What happens during vertical convection?

b) Explain why we can have a fluid which is vertically stable but from which we can still extract potential energy (into kinetic energy). In other words, explain what we mean by the term 'slantwise convection'.

Problem 3: Derivatives

a) What is the Eulerian derivative? What is the Lagrangian or material derivative?

b) Say two people are measuring the ocean surface temperature. One is stationary (not moving), and finds that the temperature is dropping at 0.01 degrees/hour. The other is in a raft, drifting eastward with the ocean currents at 100 m/hour. Her measurements suggest that the temperature is not changing at all. Explain this apparent paradox.

c) What is the temperature gradient in the eastward direction?

Problem 4: Simplified equations for large-scale flows

a) What is the original equation of motion from which we get the hydrostatic approximation? What were the requirements we used to arrive at this approximation? Write down the final expression.

b) Scale the x-momentum equation (from the primitive equations). Then divide by the size of the Coriolis term and show that we get Rossby and Ekman numbers.

c) Assume the values $U = 0.1$ m s^{-1}, $f = 10^{-4}$ s^{-1}, $W = 1$ cm s^{-1}, D (depth) $= 10^3$ m. If we ignore friction, for what values of L (horizontal length scale) and T (time scale) is the geostrophic assumption valid to within an error of about 10% or better?

Problem 5: Observations

a) Mention three methods to obtain observations of the ocean flow (velocity) field.

b) Explain how satellite observations of sea surface height can be used to deduce surface velocities. What part of the velocity field can we get from such observations (i.e. what do we call such velocities)?

c) How have marine mammals been used to help collect ocean observations? What advantage(s) do they offer over more traditional observation methods?