UNIVERSITY OF CAMBRIDGE

MATHEMATICAL TRIPOS Part III

Friday 6 June 2008 1.30 to 4.30

PAPER 89

THE POLAR OCEANS AND CLIMATE CHANGE

Attempt no more than ***THREE*** *questions.*

There are ***FOUR*** *questions in total.*

The questions carry equal weight.

STATIONERY REQUIREMENTS
Cover sheet
Treasury Tag
Script paper

SPECIAL REQUIREMENTS
None

You may not start to read the questions printed on the subsequent pages until instructed to do so by the Invigilator.

1 Describe the mechanisms of growth, starting from open water, that produce the resulting fabric of (a) first-year congelation ice, (b) pancake ice, (c) Antarctic consolidated pancake ice. Describe the mechanisms of brine drainage and compare their relative efficacy.

2 Write down the equations relating the thickness achieved by sea ice in the Maykut-Untersteiner model to the incident fluxes and snow thickness. In qualitative terms, explain the sensitivity of the equilibrium thickness to (a) ocean heat flux, (b) annual snow fall, (c) changes in surface albedo. In summer 2007 the Arctic ice cover retreated to its lowest-ever area, and local buoy measurements recorded 2 m of bottom melt from floes during the summer months (June-September). Estimate the equivalent average heat flux to the ice bottom and comment on the likely cause(s) for such a high value.

3 Show how the rate of change of the probability density function $g(h)$ of ice thickness h in a polar sea is governed by the thermodynamic growth rate dh/dt, the velocity vector $\mathbf{v}$ and a mechanical redistribution function. Show the impact of each process upon a typical curve of $g(h)$ versus h. Given that the high-thickness end of the $g(h)$ curve is a negative exponential distribution, show how this can be attained by the contributions of a negative exponential distribution of pressure ridges of congruent shape, and relate mean ridge slope to the exponential decay parameter. In qualitative terms, state what is known about the distributions of ridge spacings and of the widths and spacings of leads.

4 Estimate the relative importance of air stress, water stress, Coriolis force, internal ice stress and sea surface tilt in determining the motion of sea ice. Considering a unit area of sea ice, write down the equations governing its response to forcing. Describe the equilibrium free drift motion of an isolated floe acted on by the wind in still water, and calculate the turning angle of the motion in relation to the applied wind, as a function of surface wind speed, top and bottom drag coefficients, Coriolis parameter and other necessary parameters. What does this imply about the relative trajectories of icebergs and sea ice floes under similar forcing?

END OF PAPER