PROBLEM SET 3

EPS 253

1. Jokulhlaups

Jokulhlaups are catastrophic outburst floods that occur when a subglacial lakes grows large enough to float its overlaying ice. Once water can escape, turbulent melting grows conduit sizes in a positive feedback. An absurd amount of water escapes through a nascent conduit. Fluxes have been observed to be on the order of the flow of the entire Amazon river for a period of a few days.

The heat generated by this flow greatly overwhelms the ability of the ice to creep closed. First, write down the conduit governing equation in this limit. Hold hydropotential gradient Ψ fixed and solve for the flux Q. This should lead to an integrable expression and a final answer that expresses $Q(t)$.

The expression for Q as a function of time will depend on the potential gradient Ψ. Use the following data points from a recent Icelandic Jokulhlaup to estimate Ψ: at $t = -15$ d, Q=200 m^3/s. At $t = -10$ d, Q=1000 m^3/s. At t=-5d, Q=8000 m^3/s (!)

Provide a plot with some commentary on your results.

2. Temperature distribution in glaciers

We consider a glacier that is everywhere below the freezing temperature, where heating due to internal ice deformation is localized to the bed, and where horizontal advection and diffusion is neglected. With these assumptions, the ice sheet temperature profile is the solution to the one dimensional heat equation,

$$\frac{\partial T}{\partial t} = k\frac{\partial^2 T}{\partial z^2} - w\frac{\partial T}{\partial z}$$

First, Assume that the ice sheet is in steady state. Then use the vertical strain rate profile derived in class to solve the heat equation. Integrating twice and using the same geothermal boundary condition as in class gives a solution in terms of the so called "error function" erf, defined by

$$erf(z) \equiv \frac{2}{\sqrt{\pi}}\int_0^z \exp(-y^2)dy.$$

Plot temperature-depth solutions over a useful range of parameters.