ESS 533 /ATMS 512 Dynamics of Ice Masses

Homework on Constitutive Relations for Ice

Please solve the following homework problems. You will need to use what you know about the deformation behavior of ice.

1. Power-law coefficients

a) Describe a cold-room experiment or series of experiments, by which you could collect your own data to derive the activation energy Q, softness pre-factor A_0, and power-law exponent n for the creep of ice.

b) Explain how you would derive Q, A_0, and n from your experimental data.

2. Softness coefficient at really low temperature

Table 5.2 (page 97) in Paterson, W.S.B., 1994, *The physics of glaciers* (3rd ed.) or Table 3.4 (page 75) in Cuffey and Paterson, 2010, (4th ed.) show $A(T)$ at a range of temperatures T.

a) Using numbers from the table, find a value of $A(T)$ at T= -100°C. Explain how you get your answer.

b) Who would care about deformation of ice at -100°C, and why?

3. Ice-cube Squashers' Dilemma

Isabelle is a graduate student planning to write her PhD thesis by producing a "deformation map", on which she can plot the deformation rate of ice as a function of stress and temperature, based on experimental data that she will produce using uniaxial loads on (originally) isotropic ice samples. She plans to span a temperature range of -10°C to -60°C, and a deviatoric stress range of 0.05 bars to 5 bars (5×10^3 Pa to 5×10^5 Pa). This covers the range of deviatoric stresses typically encountered in ice masses on Earth.

(a) She plans to run all samples to tertiary creep. Roughly how much must she strain her samples?

(b) How long must she run her experiment at -10°C and 5 bars deviatoric stress to reach tertiary creep?

(c) How long must she run her experiment at -10°C and 0.05 bars deviatoric stress?

(d) How long must she run her experiment at -60°C and 5 bars deviatoric stress?

(e) How long must she run her experiment at -60°C and 0.05 bars deviatoric stress?

(f) Suppose Isabelle revises her plan by running experiments only to the stage of minimum strain rate in order to save time. How long will she have to run her experiment at -60 deg C and 0.05 bars deviatoric stress?

Explain how you get your answers in (b) through (f).