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ESS 533
Recap of lecture – 23 May 2018

We finished reviewing the Essery *et al.* (2013) paper on snow models by discussing their JIM model. The JIM model is organized around albedo, energy balance, hydrology, and compaction. The parameters for each of these components can be treated in three ways: physically (option 0), empirically (option 1), or as constants or ignored (option 2).

We then discussed the constitutive relation for snow:

$$\dot{\varepsilon}_{ij} = \frac{1}{2\eta}\left[\sigma_{ij} - \left(1 - \frac{2\eta}{3k}\right)\frac{\sigma_{kk}}{3}\delta_{ij}\right] \#(1)$$

This is analogous to Glen's flow law for ice (rather than snow) flow. $\sigma_{kk}/3$ is the mean stress, and so the term in square brackets is equivalent to τ_{ij}. Here, the nonlinearity comes from the shear viscosity (η) and the bulk viscosity (k), which vary with age, stress, density, and other factors which influence the microstructure of snow. We considered a uniaxial stress test on an unconfined block of snow, and defined Poisson's ratio:

$$\nu = -\frac{\dot{\varepsilon}_{22}}{\dot{\varepsilon}_{11}} = \frac{1}{2}\left[\frac{3k - 2\eta}{18\eta k}\right] \#(2)$$

Poisson's ratio can vary between -1 and ½ but I didn't catch why ☹ We also considered the viscous analog of Young's modulus (η_E) and substituted this into our constitutive relation:

$$\dot{\varepsilon}\eta_E = \sigma \rightarrow \dot{\varepsilon}_{ij} = \frac{1}{\eta_E}\left[(1+\nu)\sigma_{ij} - \nu\sigma_{kk}\delta_{ij}\right] \#(3)$$

We applied this to a snowfield, where there are no confining stresses, and found:

$$\sigma_{22} = \sigma_{33} = \left(\frac{\nu}{1-\nu}\right)\sigma_{11} \#(4)$$

which tells us that snow is under tensile stress – when snow tries to contract, other snow prevents it from doing so.

We concluded the lecture with a discussion of Johannesson *et al.* (1989) on glacier response time scales.