

## **Week 1 summary September 30, 2008.**

Herron, M.M. and C.C. Langway. 1980. *J. Glac.* 25(93), 373-385

Herron and Langway developed an empirical firn-densification model that assumes that the proportional change in air space is linearly related to the change in stress due to the weight of overlying snow. Their model, like most firn models, divides the firn into 3 regimes of densification divided by 2 critical points at 550 and  $\sim 800 \text{ kg/m}^3$ . Their empirical equation (1) is not derived from first principles, but integrates (by fractions) to produce a remarkably linear relationship between the depth and natural log of the adjusted density (see their Appendix).

Equations are presented for firn densification with time and depth in the upper two regimes, tuned to fit the data, based on variations in the temperature and accumulation rates at 17 different sites. Temperature and accumulation rate affect the firn in different ways. Increasing the temperature increases the densification rate and decreases the depth of the firn pack. Increasing the accumulation-rate decreases the time required for densification to reach the critical points, and increases the depth of the firn pack. In the first stage of firn densification, which includes densities up to  $550 \text{ kg/m}^3$ , the depth-density profile is independent of accumulation rate and is a function only of temperature.

Their inferred activation energies for compaction seem to be lower than expected for other ice processes. A suggestion by Sigfus Johnsen that reconciles this problem is not explained adequately.

One lesser-discussed aspect of the Herron and Langway paper is the climate inferences that may be made from variations in the density profile. At the end of the paper, a climate anomaly is identified and seen in several Antarctic cores studied in the paper.

The Herron and Langway model is popular for its ease of computation but is limited to times where steady-state assumptions hold, i.e., it fails for glacial-interglacial transitions when large jumps in accumulation and temperature take place.

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