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Interactive comment on "The role of grain-size evolution on the rheology of ice: Implications for reconciling laboratory creep data and the Glen flow law" *by* Mark D. Behn et al.

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Behn et al. provide an interesting model to reconcile apparently contradictory laboratory creep data from ice samples and Glen's power law for glacier and ice-sheet flow. For the latter, a stress exponent of n=3 is usually assumed, as the authors correctly state. A stress exponent of n≈3 is actually also reported for many experiments (see for example Table 1 in Weertman, 1983). However, Goldsby and Kohlstedt (2001) and Goldsby (2006) presented experimental results that indicate that the stress exponent can achieve different values depending on the active deformation mechanism, with n=1.8 for grain boundary sliding and n=4 for dislocation creep. Glen (1955) actually

already noted that under natural conditions n should be higher than his experimentally determined n≈3.2. The main point of this comment is that a discrepancy between the stress exponent in nature and experiment may not exit. In a recent study, Bons et al. (2018) used data from a large area covering the northern part of the Greenland Ice Sheet and obtained a value of n≈4, which is consistent with dislocation glide according to experimental data by Goldsby and Kohlstedt (2001) and Goldsby (2006). There are only a few such studies that actually attempted to determine the stress exponent directly from ice sheets or glaciers. Instead, Glen's law with n=3 is usually assumed uncritically and other parameters, such as basal friction coefficients are derived instead. Behn et al. should therefore also consider the literature that suggests the possibility that n≈4 actually best describes the bulk rheology of ice sheets. The authors may also wish to consider the paper by Roessiger et al. (2014), which points out that the grain growth constant (K_gg in Eq. 3) is not a constant, but depends on the microstructure. This has two relevant consequences for the paper under consideration. First, when the microstructure changes during an experiment, the resulting grain growth exponent (p in Eq. 2) is probably wrong if it is derived with the assumption that K_gg is a constant. Second, it can be assumed that the microstructure is a function of the relative contribution of dislocation creep (n≈4) and grain boundary sliding (n≈1.8). If so, K_gg will depend on that relative contribution. Taking the above into consideration would make the paper by Behn at al. much more interesting and worthwhile.

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