Geophysical Research Abstracts,
Vol. 11, EGU2009-10818, 2009
EGU General Assembly 2009

Measurements of Antarctic snow compaction compared with model predictions

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We describe in-situ measurements of the compaction of Antarctic snow. The rate of compaction in the upper twenty meters was recorded automatically at several sites in Antarctica. The measurements were taken hourly over a time period of up to two years. Measurements were made in boreholes over depth intervals of 0–5 m, 0–10 m, and 0–20 m. Auxiliary measurements of air temperature, snow temperature and snow accumulation were also recorded using automatic weather stations. At our measurement sites, the snow compacts through a slow, viscous deformation of the snowpack. We did not observe any significant contribution from the sudden collapse of weak layers. Our data also exhibit a strong seasonality, consistent with a temperature-dependent sintering mechanism. We recover the activation energy of this mechanism, and obtain values of about 60–70 kJ mol^{-1} at two lower-temperature sites, and about 100 kJ mol^{-1} at a warmer site. We also compared our observations with predictions from models of snow compaction taken from the literature. These underestimate the amplitude of the seasonal cycle. We obtain a good match to our observations with a semi-empirical model based upon rate expressions appropriate for Nabarro-Herring (lattice diffusion) creep within a porous medium, combined with normal grain growth, although the diffusion inferred from this model is much higher than published values, and other sintering mechanisms cannot be ruled out.