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Effects of nonlinear rheology and anisotropy on the relationship between age and depth at ice divides

C. Martin and G. H. Gudmundsson
British Antarctic Survey, United Kingdom (cama@bas.ac.uk)

Ice-cores need to be accurately dated to reveal, in detail, past environmental conditions. The ice-core chronology is always incomplete because of ice stratigraphy thinning and distortion due to flow, and timeline extraction is often reliant on simplified models to predict the age of ice. Through numerical modelling using a full Stokes solver and a non-linear anisotropic rheology, we investigate the effects of ice flow on the age versus depth relationship at ice divides. We compare our results with analytical approximations commonly employed in age-depth prediction. Our main findings are: Firstly, once the ice has developed a significant single maximum or vertical girdle fabric, the analytical approximations tend to underestimate the age of ice. Secondly, ice fabric enhance the effect of the bedrock topography on the ice flow. We show that the presence of single maximum fabric close to the bedrock affects strongly the ice stratigraphy and the age-depth relationship. We also study the coupling between anisotropic viscosity and internal heating. It does produce a warm spot and softer ice at the base of the divide when compared with surrounding areas. Finally we study the age-depth distribution in divides that show double-peaked Raymond bump in their radar stratigraphy. They provide ideal locations fore ice-core drilling as they have been stable for a long time when compared with their characteristic time (ice thickness divide by accumulation). Our model shows that the ice in these areas can be up to one order of magnitude older that ice at the same depth both at the flanks of the divide area or on similar divides that have not been stable for that long.