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Absolute dating of ice cores based on the impact of local insolation on pore space geometry

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Ice core records of the total air content (TAC) and molecular fractionation (FRAC, e.g. O_2/N_2) in the air bubbles from low accumulation sites such as Vostok, Dome C and Dome Fuji, Antarctica, co-vary with local summer insolation. The latter is driven by the orbital $\sim$20ka precession and $\sim$40ka obliquity cycles. This link between TAC, FRAC and insolation has recently been used to orbitally tune ice core time scales. However, an absolute dating as such requires a physical explanation of this link, and thus the knowledge of potential inherent time lags. We propose that the anisotropy of the pore space geometry in firn could explain both, the observed TAC and FRAC link with insolation. This anisotropy results from the temperature gradient metamorphism of snow in the top meters of the snow pack, which in turn is modulated by changes in local insolation. As recent micro tomography results indicate, the anisotropy is preserved down to the pore close off depth, where it affects TAC and FRAC. We present sensitivity studies with a numerical model describing the temperature gradient metamorphism, the resulting pore space anisotropy and its impact on TAC and FRAC records including the inherent time lags. The goal of these studies is to quantify the impact of uncertainties in model input parameters such as observed temperature and accumulation rates (deduced from the stable isotope records) on the modelled TAC and FRAC records under various climatic conditions. These uncertainties propagate into the uncertainties in absolute time scales of ice cores based on TAC and FRAC records and elucidate the potential and limitation of this method.