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A method for estimating the age–depth relationship of Dome Fuji Ice Core using a sequential Monte Carlo method

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A technique for estimating the age–depth relationship and its uncertainty in ice cores has been developed. The age–depth relationship is mainly determined by the accumulation of snow at the site of the ice core and the thinning process due to the horizontal stretching and vertical compression of an ice layer. However, both the accumulation process and the thinning process are not fully known. In order to appropriately estimate the age as a function of depth, it is crucial to incorporate observational information into a model describing the accumulation and thinning processes. In the proposed technique, the age as a function of depth is estimated from age markers and time series of δ^{18}O data. The estimation is achieved using a method combining a sequential Monte Carlo method and the Markov chain Monte Carlo method as proposed by Andrieu et al. (2010). In this hybrid method, the posterior distributions for the parameters in the models for the accumulation and thinning processes are basically computed using a way of the standard Metropolis-Hastings method. Meanwhile, sampling from the posterior distribution for the age–depth relationship is achieved by using a sequential Monte Carlo approach at each iteration of the Metropolis-Hastings method. A sequential Monte Carlo method normally suffers from the degeneracy problem, especially in cases that the number of steps is large. However, when it is combined with the Metropolis-Hastings method, the degeneracy problem can be overcome by collecting a large number of samples obtained by many iterations of the Metropolis-Hastings method. We will demonstrate the result obtained by applying the proposed technique to the ice core data from Dome Fuji in Antarctica.