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Improved synchronization of deep ice-core records by geophysical methods

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In this study we present a new combination of existing methods to identify the origin of internal layers in an ice sheet by unprecedented accuracy. Most continuous internal reflection horizons observed by radio-echo sounding are known to form isochrones and can be followed over large distances. With an ice core at either end of the profile, the reflection horizons present time markers that are used to synchronize the ice-core records. Using electrical properties along an ice core as input to a numerical model which simulates the propagation of electromagnetic waves in the ice we reproduce the reflection characteristics of a radar profile near the ice core. The depth of origin of reflections are identified by removing individual peaks in conductivity in the input record, thus also removing the corresponding reflections in the synthetic radargram. A pilot study at the EPICA drilling site in Dronning Maud Land, Antarctica, shows that it is possible to locate the origin of internal reflections with an accuracy of 0.5 m in a depth of 2000 m and more. Our approach imposes little constrains on the input records, making it applicable to a number of drilling sites, and has several advantages over usual methods where merely reflector traveltimes (respective depths) and ice-core profiles are compared. Both, dielectric profiling and electrical conductivity measurements can be used as electrical model input. As we use pronounced series of reflections to calibrate the traveltime-depth relation, only a coarse density record is required. In addition, as we do not require explicite electromagnetic wave speeds, systematic physical errors in the ice-core or radio-echo sounding data have no effect on the final result. Application of this method to deep-drilling locations in Antarctica connected by radio-echo sounding will improve their relative synchronization and will help to answer the question of phase relations of climate changes observed in the

ice-core records at different locations.