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Chemical analysis of a re-drilled ice core on Dunde Ice Cap, western China.

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In the present study we analyze major ion concentrations in the Dunde ice core to reveal principal paleo-environmental signals. This 51 m deep ice core was re-drilled on the Dunde Ice Cap of western China in 2002 (previous ice core was obtained in 1987 by American team). According to a previous study (based on water stable isotopes and dust perticles), this ice core covers the last 150 years and experienced intense melting since 1987 possibly due to climate warming in the region. Analysis of the present study was focused mainly on concentrations of major ions (Cations: Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}; Anions: Cl^-, SO_4^{2-}, NO_3^-, $HCOO^-$, CH_3COO^-), which were obtained with a Ion Chromatograph. Elements of a desert origin (Na^+, Mg^{2+}, Ca^{2+}, Cl^-) accounted for more than 90 % of all ionic composition. This could be identified as a component of regional arid area source. It was found that ion peaks had been shifted downward by melt waters from depths of dust peaks. Moreover, there was some difference in peak positions for each type of ions (magnitude of downward shift decreases as follows: $NO_3^- > SO_4^{2-} > Ca^{2+} > Na^+ > Cl^- > K^+ > Mg^{2+}$). This finding suggests that involved melting processes were different for each type of element.
Concentrations of Ca^{2+}ions and small dust particles show recent decreasing trends throughout the ice core whereas Na^+, $Cl^-$and large dust particles concentrations were increasing during the last 20 years (since 1983). Since it is known that large size dust particles fall within relatively close areas in general, ions of $Na^+$and Cl^-could be attributed to the same sources as large dust particles. These trends in the chemical composition demonstrate changes of meteorological and/or land cover conditions in western China.
20-year average of K^+, CH_3COO^-, and $HCOO^-$ion concentrations (calculated for 150 years) also showed an increasing trend during the last 20 years (since 1983). Two high peaks of $CH_3COO^-$and $HCOO^-$concentrations were found at depth range between 2 m and 4 m, and at the depth of around 6.5 m. Concentration profile of $HCOO^-$was found to be higher than CH3COO$^-$profile at the depth range of 2-4 m. These elements, known as a proxy for biomass-burning, indicate recent increase of areas covered by fields and pastures, and population growth of the region. At the 6.5 m depth the concentration profile of $HCOO^-$was lower than the one for the CH_3COO^-. This indicates that 6.5 m spike had a different source than the peak at the depth range of 2-4 m. In addition, at the same depth (6.5 m) another two high peaks of $K^+$and Cl^-ions were found. Probably, these signals could be related to products of burning and traced to activities of the previous ice-core drilling team in 1 987.
It was found, that a 10-year moving average profile for NO3$^-$obtained during this study was different in trend from the NOx changes for the East Asia and indicating that effects of air pollution associated with the recent development of China's east coast are negligible at the site due to the prevailing westerlies.
Though melting features were found, obtained and analyzed records of major ions and dust concentration in the re-drilled Dunde ice core provids valuable information on paleo- and recent environmental conditions over the region of western China.

Keywords: Ice core