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Supernova signatures in polar ice cores

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Gamma rays, X-rays and UV radiation arising from solar activity and supernova explosions in our galaxy cause changes in the chemical composition of the stratosphere from ~10 - 50 km altitude. The effect of radiation on the stratosphere is then recorded in the chemical composition of terrestrial ice. The effect observed in the ice cores which we have obtained from the Dome Fuji research station in Antarctica is much greater than the effects observed in any of the ice cores that have been studied in the northern and southern hemispheres (e.g., Fourré et al., 2006; Motizuki et al., 2017).

In this presentation, we discuss one possible source of yearly-scale peaks that are present in nitrate ion (NO3-) concentration profiles with a temporal resolution of about 1 year in a shallow Dome Fuji ice core drilled in 2001. It will be emphasized that the yearly-scale peaks, not being on a weekly-scale, cannot be attributed to solar proton events (e.g., McCracken et al., 2001); nor, being on a daily-scale, can the yearly-scale peaks be related to a depositional process (Wolff et al., 2008). We consider here galactic supernova explosions, and diagnose our yearly-scale NO3- peaks with respect to data precision, reproducibility, coincidence with other anionic and cationic events, uncertainties in ice-core dating, and possible contamination. We also consider the amount and duration of gamma-ray emissions from a galactic supernova, the effects on chemical reactions induced in the stratosphere, and the energetics of the production of nitrogen oxides by gamma-ray emissions from galactic supernova explosions compared with production by solar UV radiation.

Since several NO3- concentration peaks are almost coincident with the dates of galactic supernova explosions that have occurred in the last millennia, we propose that the yearly-scale NO3- concentration peaks in ice cores drilled at Dome Fuji station be treated as a candidate proxy for supernova explosions that have occurred in our galaxy.

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