Experimental and theoretical diagnoses of yearly-scale nitrate ion spikes observed in a Dome Fuji shallow ice core

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Analyses on ice cores obtained at Dome Fuji station have shown that precipitation environment around there is very unique. An apparent evidence for this comes from tritium content fallout from nuclear bomb tests in the 1960s. A compilation for the tritium concentrations has been reported for 17 snow pit samples observed both in Antarctica and in Greenland (Fourree et al., 2006), and it is confirmed that the tritium content at the Dome Fuji site is overwhelmingly high in Antarctica[1]. This is direct evidence that stratospheric constituents are more dominant in the precipitation environment at Dome Fuji than at those other sites. Moreover, chemical characteristics obtained at Dome Fuji are known to be completely different from those of sea-salt (Takahashi et al., talk, this session; Iizuka et al., 2006; Kamiyama et al., 1989), supporting further this evidence. It is therefore reasonable, at least phenomenologically, to expect stratospheric events to be recorded in Dome Fuji ice cores.

In this talk, we investigate the origin of yearly-scale nitrate ion (NO_3^-) spikes that were observed in ionic records with a temporal resolution of about 1 year in a shallow Dome Fuji ice core drilled in 2001 (Takahashi et al., talk, this session). Emphasized here is that these nitrate spikes were identified not on daily scale so that they may not be attributed to depositional process (Wolff et al., 2008), and that the spikes again not on weekly scale so that may not be related to solar proton events (e.g., McCracken et al., 2001). We consider here galactic supernova explosions as a possible source, and will diagnose the yearly-scale nitrate ion spikes obtained at Dome Fuji in the following experimental and theoretical points of view: data precision and reproducibility, coincidence with the other anion and cation events, contamination possibility, coincidence with water isotope events, ice core dating uncertainty, current supernova understanding; the amount and duration of γ-ray emission, radiation and chemical reactions in the stratosphere that are induced by nearby supernova γ-rays, energetics of nitrogen oxide (NO) production against solar UV, global atmospheric circulation and the effect of PSCs (Polar Stratosphere Clouds), correspondent historical supernova records, snow deficit probability after deposition, chance occurrence of the spikes to occur in the expected dating uncertainty range in the core, and difference with other annually-resolved core records.

Post-depositional loss of nitrate in surface snow layers should be taken into consideration but is out of scope in this talk. We just note here that the loss ratio of the nitrate ion concentrations observed at Dome Fuji is at least several times smaller than that at Dome C reported in the literature.

References

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Wolff, E.W., et al., (2008), The interpretation of spikes and trends in concentration of nitrate in polar ice cores, based on evidence from snow and atmospheric measurements. Atmos. Chem. Phys., 8, 5627–5634.

[1] Note that in Table 1 of Fourree et al. (2006), the highest value reported for Dome C (4200 TU) is wrong and that is for Dome Fuji. In Kamiyama et al. (1987) quoted for that value, the Dome Fuji site was called the "DC" site, because Dome Fuji station had not yet been constructed. The abbreviation "DC" was by mistake translated to "Dome C" in Fourree et al. (2006).