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A proxy for decadal solar cycles from AD 1600 to 1900 based on nitrate concentrations in a Dome Fuji (Antarctica) ice core

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Ice cores yield information about astronomical phenomena as well as information about climate changes of the past. We applied time-series analyses to variations in nitrate ion concentrations in one segment of an ice core drilled at the Dome Fuji station in East Antarctica, corresponding to the historical period from AD 1600 to 1900. Our analyses revealed clear evidence of periodicities of ~ 11 years, ~ 22 years, and ~ 90 years, comparable to the 11-year Schwabe, 22-year Hale, and to the ~ 90-year Gleissburg solar cycles, respectively. Our result thereby shows for the first time that nitrate ion variations in an ice core can certainly be used as a proxy for past solar activity on a decadal time scale. This finding may be attributed to the advantage of precipitation environment of the Dome Fuji site. Furthermore, we found an 11-year periodicity in the nitrate ion variations even during AD 1645 – 1715, the period of the grand Maunder minimum when sunspots were almost not observed. Although our evidence for an 11-year periodicity during the Maunder minimum is less strong statistically than that for the periods from AD 1600 to 1645 and from AD 1715 to 1900, the discovery of the 11-year periodicity during the Maunder minimum was unexpected. This discovery may indicate that an 11-year periodicity existed in solar UV radiation even during the Maunder minimum and reconfirms the observation that the solar dynamo retains cyclic behavior even during grand solar minima, as suggested by studies of 10Be content in ice cores.

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