On the 36-year cycle in solar activity

© M.G. Ogurtsov[1,2]

[1]Ioffe Institute,
194021 St. Petersburg, Russia
e-mail: maxim.ogurtsov@mail.ioffe.ru

Received May 14, 2023
Revised July 21, 2023
Accepted October, 30, 2023

A series of data on the flux of cosmogenic ^{10}Be in an ice core recovered from Fuji Dome Station (East Antarctica) covering the period 700−1876 was analyzed. Fourier analysis and wavelet analysis showed the presence of cyclicity in this series with a period of about 36 years. Since flux of ^{10}B contains information about variations in cosmic radiation entering the Earth's atmosphere, mainly associated with changes in solar activity, the identified periodicity may be the result of the corresponding solar cycle. The possible climatic origin of the 36-year variation is also discussed.

Keywords: solar activity, solar paleoastrophysics, climate.

DOI: 10.61011/TP.2023.12.57744.f228-23

Introduction

In addition to the known 11-year and 22-year solar cycles, there are indications of variations in solar activity with a period of 31−36 years. For example, in the Ap index in the period 1932−1982 a variation with a period of 31.1 years [1] was found. Veretenenko et al. [2–3] identified a predominant periodicity of about 36 years in the data on the occurrence of strong and moderate magnetic storms with a gradual onset in the period from 1878 to 2015. Raspopov et al. [4] suggested that this solar variation may be the cause of the well-known that this solar variation may be the cause of the well-known Brückner climate cycle with a period close to 35 years. But most of the evidence for the 35-year solar periodicity comes from analyzing relatively short experimental data. In the paper [5], a 31-year fluctuation was reported in a number of data on the concentration of nitrates (ions NO_3^-) in the Guliya ice core on the Qinghai-Xizang Plateau, covering 1032 years. However, the concentration of ions in ice depends not only on the manifestations of solar activity (mainly solar proton events), but also on deposition processes and post-deposit effects, which are seriously influenced by meteorological processes. And inasmuch as the Brückner cycle has been identified in many climate series, it is unclear whether the 31-year variation in nitrate concentrations in Guliya is related to solar activity or climate. In this study, the possibility of a 36-year variation in solar activity is investigated using ^{10}Be data obtained in Central East Antarctica. This solar activity indicator has two advantages:

(a) East Central Antarctica is a region of high climatic stability. Cyclones rarely, if ever, penetrate far inland in this part of the continent [6,7]. Thus, the climatic contribution to the temporal course of the 10Be concentration here should be minimal.

(b) Beryllium, which is deposited at high latitudes, has a significant local tropospheric component. According to [8], at least 20% of the beryllium deposited at latitude 77 was formed at latitudes 60−90°. Inasmuch as the 35-year cycle has been detected in geomagnetic activity and nitrate concentrations, it is the high-latitude part of the globe that seems to be the most suitable for searching for manifestations of this periodicity over long time intervals. Indeed, this region is a zone where the threshold of geomagnetic clipping is low, and the penetration of cosmic particles into the atmosphere, which affect geomagnetic activity and ion formation, is greatly facilitated.

1. Data

Solar paleoastrophysics provides the information about variations in solar activity on long time scales. In this study, we used a series of data on the flux ^{10}Be, measured in ice core from the Fuji Dome Station located in the inland part of East Antarctica (77°19′S, 39°42′E, 3810 m above sea level). This time series [9] is shown in Figure 1, *a*. Its temporal resolution is 6−11 years.

2. Results and Discussion

The spectral properties of the reconstruction [9] were studied using wavelet analysis and Fourier analysis. The second-order polynomial trend was preliminarily subtracted. The results of the analysis are presented in Fig. 1, *b–d*.

As can be seen from the figure, a significant temporal variation with a period of 33−37 years occurs in the ^{10}Be flow periodically. It was most vividly manifested in the 15th−18th centuries, though in other centuries as well. The main question is whether the observed 33−37-year variation is the result of a climate cycle. A concentration of 18O (a measure of surface air temperature) measured in the same core [10] can help clarify this question. However, the available data set for δ^{18}O at Dome Fuji station (Fig. 2)

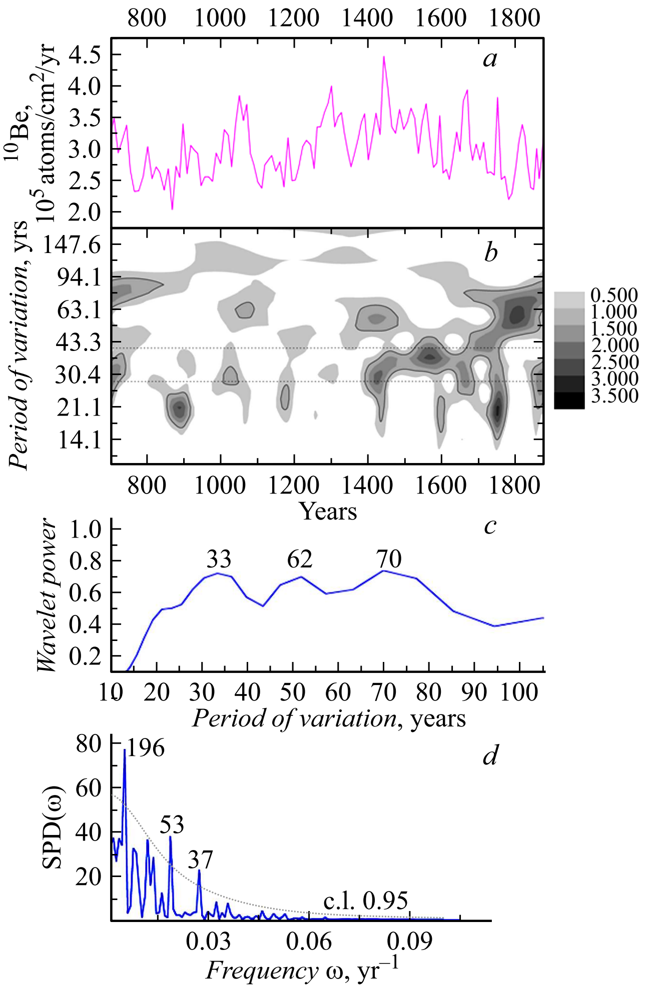

Figure 1. *a* — the ^{10}Be flux in the Dome Fuji [9] ice core; *b* — the local Morlet wavelet spectrum of the ^{10}Ve. The spectrum is normalized to a confidence level of 0.95 calculated for red noise with AR(1) = 0.9. The band corresponding to the periods 28–38 years is dotted; *c* — the global wavelet spectrum of the Morlet stream ^{10}Be. The lines delineate an area with a confidence level greater than 0.95; *d* — Fourier flux spectrum ^{10}Be. The confidence level is calculated for red noise with AR(1) = 0.9.

has a low temporal resolution of 22–42 years. Based on these data, we can only conclude that the series ^{10}Be and δ^{18}O do not correlate on multi-decade and longer time scales (correlation coefficient between decades-interpolated series $R_l = 0.11$). This is quite consistent with the general idea that the local climate of central Antarctica has a weak influence on beryllium concentration, but it is hardly possible to draw an unequivocal conclusion about the non-climatic nature of the 33–37-year periodicity.

Conclusions

Data analysis on the concentration of the cosmogeneous nuclide ^{10}Be in ice core recovered from the Fuji Dome station (East Antarctica) showed the presence of variation

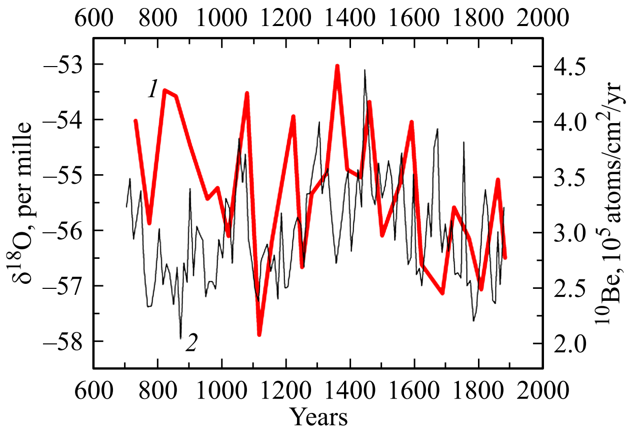

Figure 2. Line *1* — concentration of ^{18}O in the Dome Fuji ice core [10]; line *2* — flow ^{10}Be in the Dome Fuji ice core [9].

with a period of about 36 years for at least several centuries. This variation may reflect a corresponding change in the flux of cosmic radiation entering the atmosphere. However, the possibility that this periodicity is of a climatic nature has not yet been ruled out. In this connection, it can be noted that there is no clear 36-year variation in the data on beryllium concentration in Greenland ice. Further research is needed on new solar and climate reconstructions in Central Antarctica and other high-resolution locations.

Conflict of interest

The author declares that he has no conflict of interest.

References

[1] A.L. Cl'ua de Gonzalez, W.D. Gonzalez., S.L. Dutra., B.T. Tsurutani. J. Geophys. Res., **98**, 9215 (1993). DOI: 10.1029/92ja02200

[2] S. Veretenenko, M. Ogurtsov, V. Obridko. J. Phys.: Conf. Ser., **1400**, 022038 (2019). DOI: 10.1088/1742-6596/1400/2/022038

[3] S. Veretenenko, M. Ogurtsov, V. Obridko. J. Atmos Solar-Terr. Phys., **205**, 105295 (2020). DOI: 10.1016/j.jastp.2020.105295

[4] O.M. Raspopov, O.I. Shumilov, E.A. Kasatkina, E. Turunen, M. Lindholm. Proc. In *1st Solar and Space Weather Euroconference, „The Solar Cycle and Terrestrial Climate"* (Santa Cruza de Tenerife, Tenerife, Spain, 2000), p. 517–521. SP-463.

[5] N. Wang, T. Yao, L.G. Thompson. Chinese Sci. Bull., **43** (10), 841 (1998). DOI: 10.1007/bf03182750

[6] R.J. Murray, I. Simmonds. Aust. Meteor. Mag., **39**, 167 (1991).

[7] R. Massom, M. Pook, J. Comiso, N. Adams, J. Turner, T. Lachlan-Cope, T.T. Gibson. Climate, **17**, 1914 (2004). DOI: 10.1175/1520-0442(2004)017¡1914:POTIEA¿2.0.CO;2

[8] U. Heikkila, J. Beer, J. Feichter. Atmos. Chem. Phys., **9** (2), 515 (2009). DOI: 10.5194/acp-9-515-2009

[9] K. Horiuchi, Y. Uchida, A. Sakamoto, A. Ohta, H. Matsuzaki, Ya. Shibata, H. Motoyama. Quat. Geochron., **3** (3), 253 (2008). DOI: 10.1016/j.quageo.2008.01.003

[10] R. Uemura, H. Motoyama, V. Masson-Delmotte, J. Jouzel, K. Kawamura, K. Goto-Azuma, Sh. Fujita, T. Kuramoto, M. Hirabayashi, T. Miyake, H. Ohno, K. Fujita, A. Abe-Ouchi, Y. Iizuka, Sh. Horikawa, M. Igarashi, K. Suzuki, T. Suzuki, Y. Fujii. Nature Commun., **9** (1), 961 (2018). DOI: 10.1038/s41467-018-03328-3

Translated by 123