Is it possible to study Solar Proton Events in the past centuries and millennia with 10Be research?

This question is answered affirmative by some well-known researchers such as IG Usoskin and SK Solanki. They found a not entirely obvious confirmation in the Dye 3 ice core (Greenland) data. However, one must therefore have material with high time resolution, ie with approximately one observation per year. The material of the ice sheets must also allow a precise dating. This study seems to me as very important: By this one can indeed investigate the frequencies and intensities of explosive events on the Sun over many centuries and more and these events often are associated with magnetic storms. As we know, the largest magnetic storms can cause substantial damage to for instance our electrical grid and satellites. It is possible to protect a lot of the equipments for this. The usefulness of this protection, however, depends on the frequency of these events, so one has to know everything about these explosive events on the Sun in the last centuries. Nevertheless, in other, more recent studies 10Be in ice cores with high temporal resolution no link is made to the SPEs, ie the influence of cosmic rays in our own solar system on the cosmic radionuclides.

With a different reason, namely to study the meaning and reliability of the 10Be data from the ice cores, I looked for 10Be data with high time resolution, because thereby the course of the 10Be as a solar proxy can be compared to the eleven year cycle in the sunspots. So seeking I found about yearly 10Be data from the ice core from Siple Dome (Antarctica) from a study of K Nishiizumi and others whose results are not published, but the raw data are nevertheless on the Internet. Later on was published a study of AM Berggren ea at the annual 10Be concentrations and fluxus from the NGRIP (Greenland) ice core. The tables with all these data also are available on internet. So by the data of the tables I made meters long curve for comparison and study the solar proxies with high time resolutions. This study has been described on my internet site under 'The sun and the deluge' page 52 – 76. Here are some examples explained.

FIG 1: The purple curve of the Siple Dome 10Be concentration quantities from the tables of K. Nishiizumi are again multiplied by -1 for to make the negative correlation of galactic cosmic rays with the magnetic solar activity positive for better comparison with the sun spots counted. Indeed is a good relationship with the long-term variation of the Sun: So is the "valley" of the Dalton minimum is clearly visible. Consistency with the 11-year cycle in the annual sunspot numbers of the red curve, however is less pronounced and there are extreme fluctuations with observations of very high concentrations of 10Be during three solar maxima. It seemed that this might be caused by confounding factors, unrelated to the production of the radionuclide in the atmosphere. It turned out however that at these time points were historically described magnetic storms. The first one in 1806 was described by Alexander von Humboldt and the last is the familiar large magnetic disturbance of 1859, described by R. Carrington. It seems likely therefore that these magnetic storms were accompanied by large SPE's which in a short time produced very much 10Be in the atmosphere, especially at high latitude. In the course of several months was a consequent increase in 10Be deposition in the ice. These large quantities are only present in a thin layer of ice. By examination of 10Be from ice sheets that formed about 10 years no influences of these variations are found and only the fluctuations in the galactic cosmic rays are traced then. The red curve is the sum sunspots (GSN).

FIG 2: Here, the purple curve with the -10Be concentration in more detail in comparison with the monthly sunspot numbers and the observed magnetic storms following the old index of St. Petersburg, C9, from the publication of Heikki Nevanlinna. The so-called Carrington storm thus coincides with a markedly increased deposition of 10Be. So here the deep -10Be curve does not indicate a large quantity of galactic cosmic radiation by low solar activity, but cosmic radiation by the sun self so by its high activity. according to the -10Be data, there should be still a major SPE in 1861 that was not accompanied by a CME so without magnetic disturbances on earth. So there are good indications for reconstruction of the 10Be production by the galactic cosmic radiation and by the non galactic corpuscular solar radiation (SPE's). Note there are gaps in the 10Be data in Fig 1 and 2.

FIG 3: Also from material of the NGRIP (Greenland) are ice core determinations of the annual 10Be concentrations according to the research of AM Berggren ea. The black curve of the 10Be (x-1) here is for comparison with the blue curve of the Siple Dome 10Be, Antarctica. All the strong fluctuations in the 10Be during the 19th century in the Siple Dome curve are not easily to recognize in the NGRIP curve. Comparison of the both curves gives anyway indications for reconstruction of the 10Be production by galactic and solar radiation. But there are also differences in deposition and perhaps problems with the dating of the material from the NGRIP ice core. I suppose the deposition in Antarctica are more suitable for high time resolutions. Because the wind in Antarctica is almost always in the same direction, the snow layer is more steadily formed there and so the individual layers of the

years and seasons may remain better separated, while they may be more mixed at the NGRIP location. The examination of the Siple Dome ice core extends over 300 years, but with large gaps, especially in the data from the 20th century. The annual 10Be concentrations of the NGRIP ice core even are over the last 600 years. The curve of this study with 600 determinations in the article of AM Berggren is only about 12 cm wide, rendering it unreadable. On page 103 – 125 from 'Climate and sun compilation' here these studies are fully described in English and drawn in meters long curves.

FIG 1

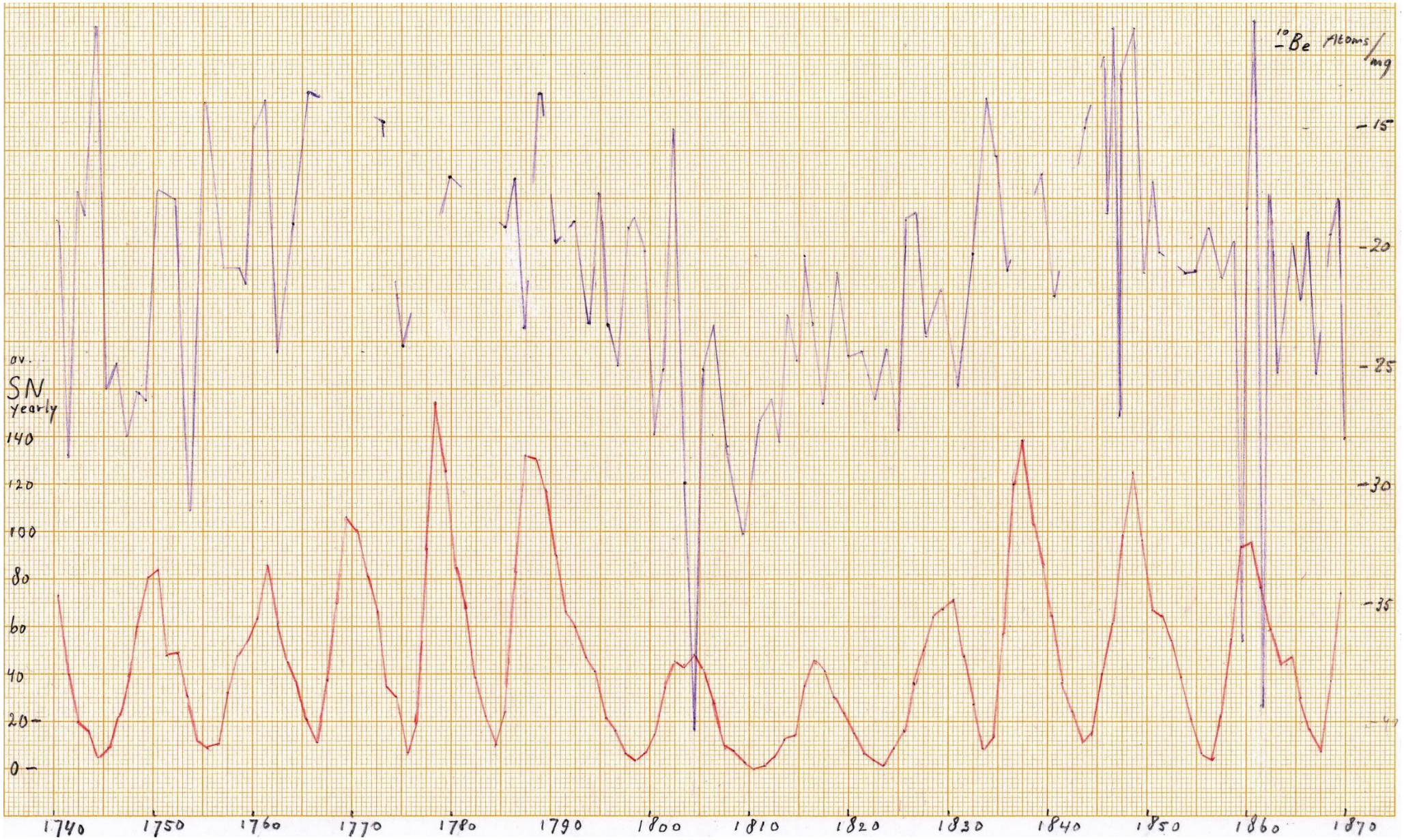
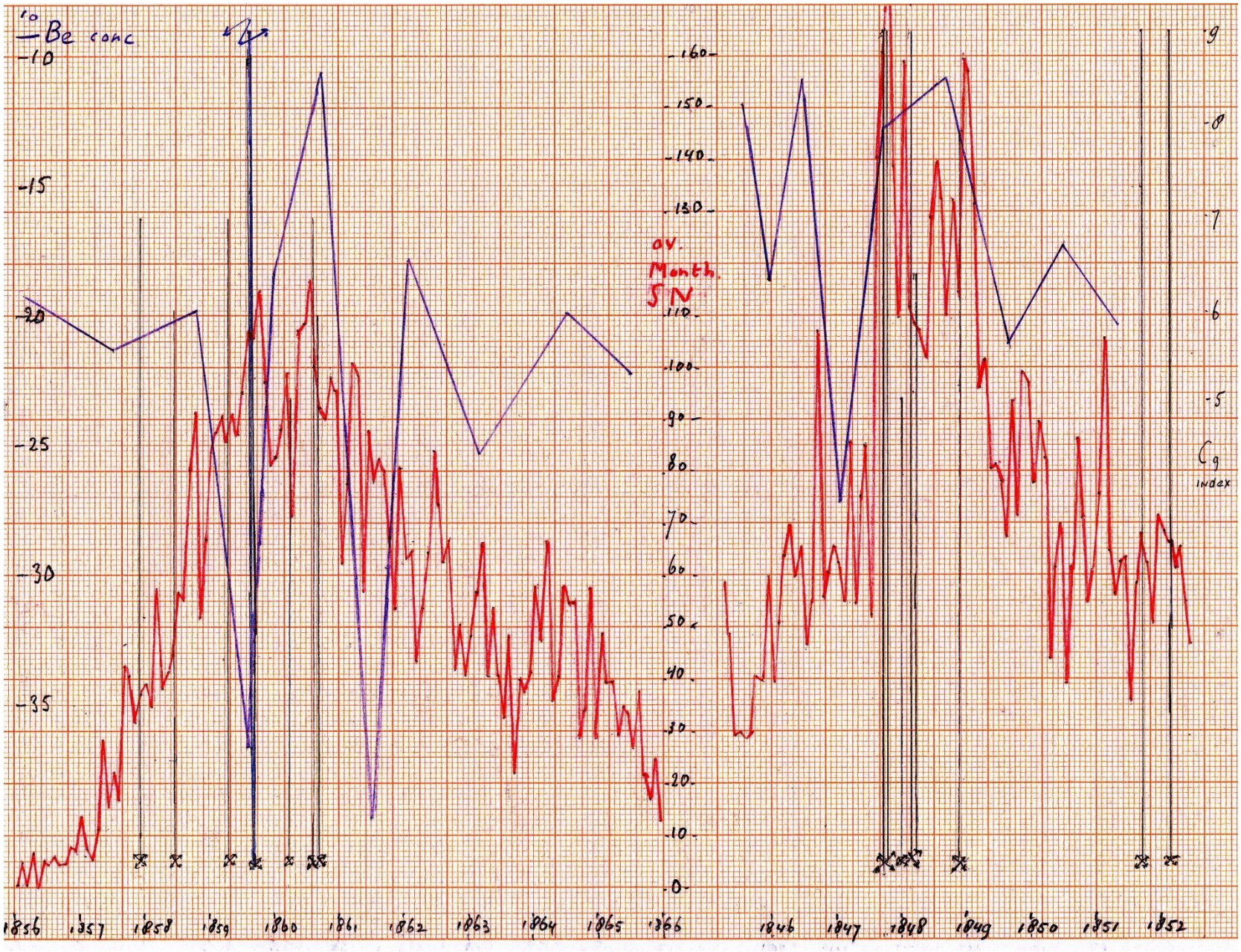


FIG 2


10Be conc
-10
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-20
-25
-30
-35
av. Month. SN
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150
140
130
110
100
90
80
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60
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40
30
20
10
0
9
8
7
6
5
Cg index
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1857
1858
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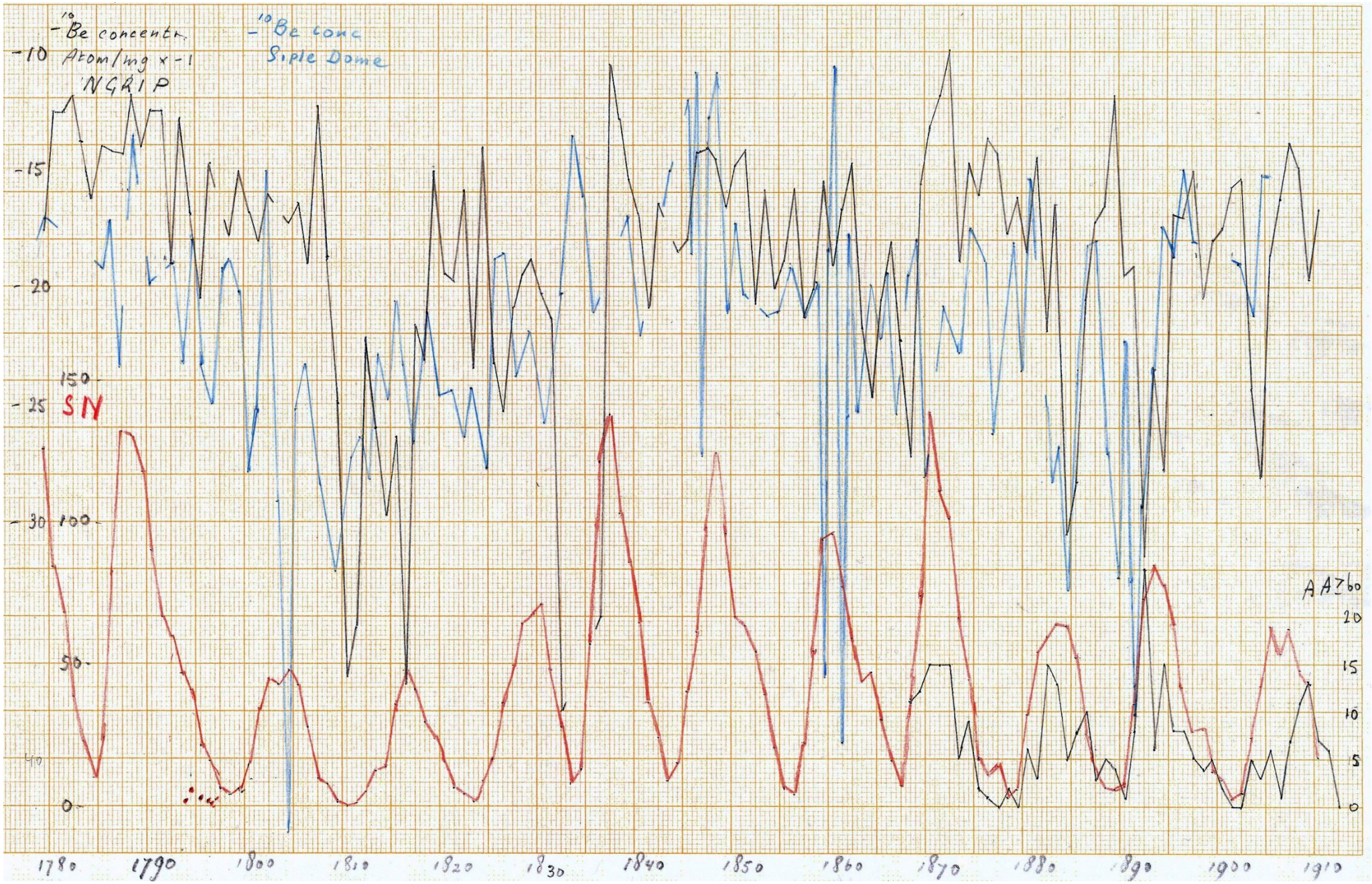
FIG 3


^{10}Be concentr.
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NGRIP
^{10}Be conc
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-20
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150
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5
0
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1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910

Literatuur:

IG Usoskin en SK Solanki: Solar proton events in cosmogenic isotope data, GEOPHYSICAL RESEARCH LETTERS, VOL. 33, 2006

Nishiizumi, K and R. Finkel, 2007. Cosmogenic radionuclides in the Siple Dome A icecore. Boulder, Colorado, USA: National Snow and Ice Data Centre, Digital media. See also: http://nsidc.org/data/nsidc-0307.html Also the dating of the depth of the layers is given on this site.

Nevanlinna, H: Results of the Helsinki magnetic observatory 1844 -1912, in Annales Geophysicae (2004) 22: 1691–1704, http://hal.archives-ouvertes.fr/docs/00/31/73/52/PDF/angeo-22-1691-2004.pdf

Berggren,AM, J Beer ea in the geophysical Research Letters, Vol 36, 2 june 2009, http://www.eawag.ch/organisation/abteilungen/surf/publikationen/2009_berggren.pdf, A 600 year 10Be record from the NGRIP ice core, Greenland.