Four solar proxies and the temperature in the Holocene

In **FIG 8** part 1 and 2 was made a more specified graphics of the proxies in the Holocene.

FIG 8 part 1

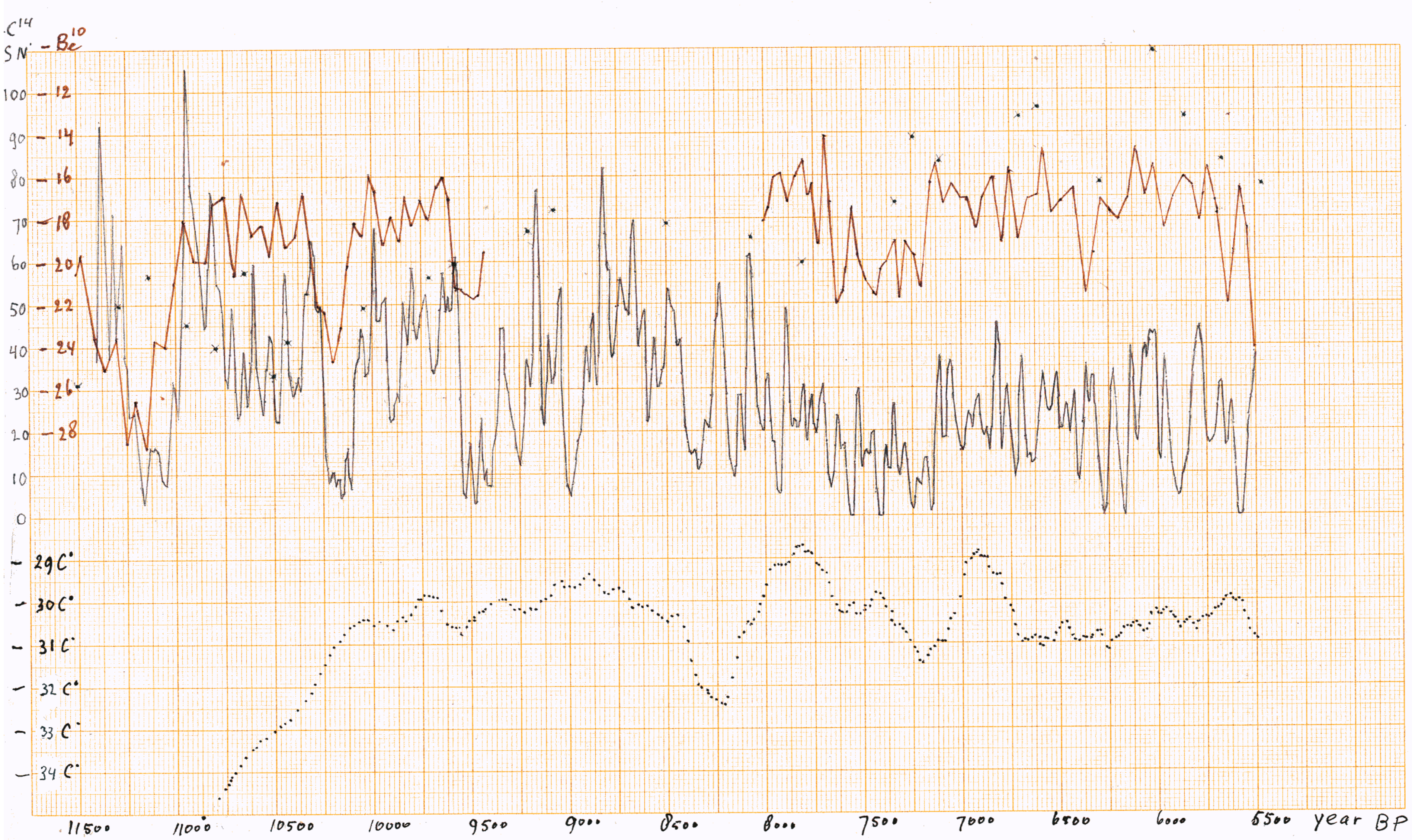
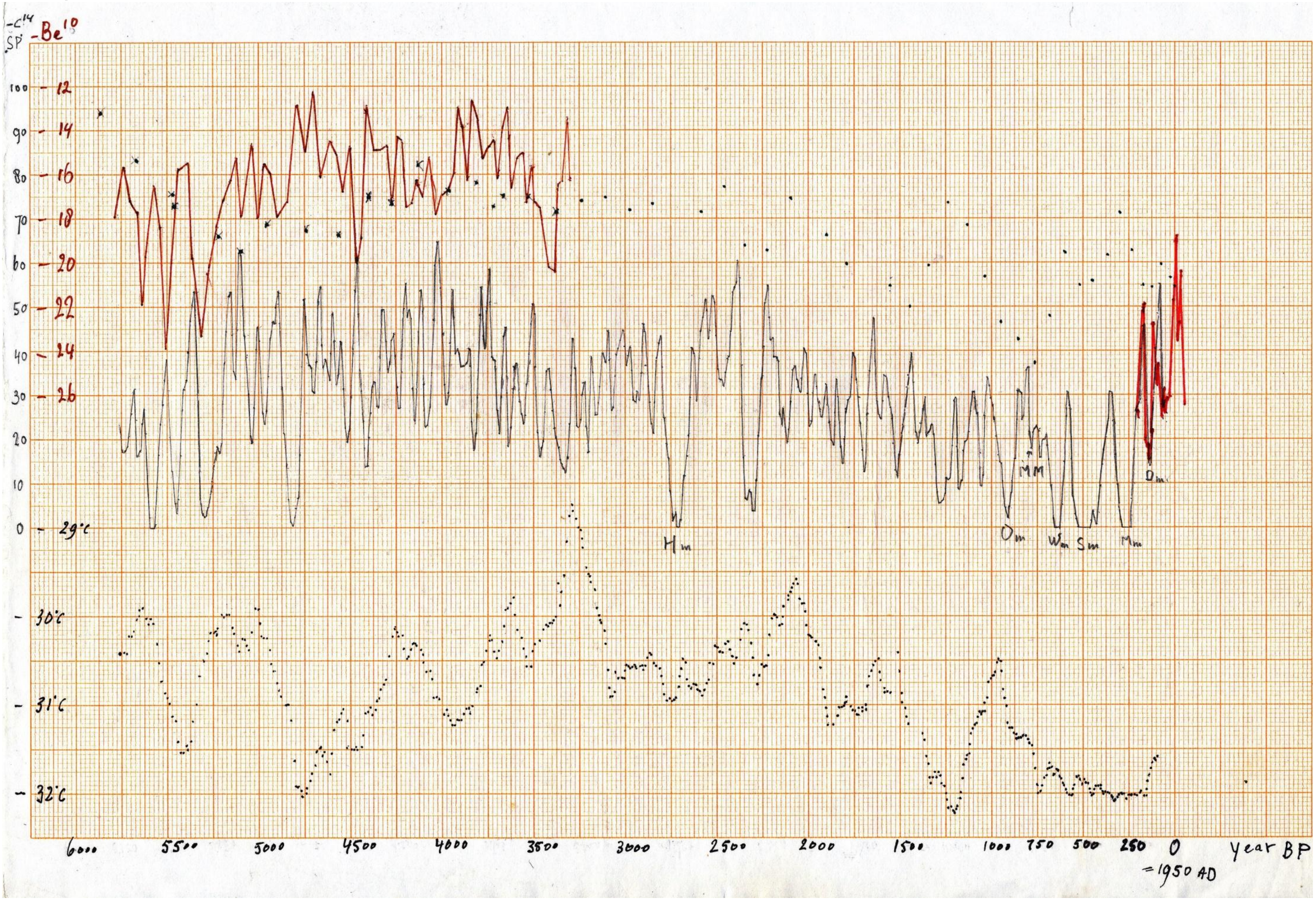


FIG 8 part 2



-C14
SP
-Be10
100 - 12
90 - 14
80 - 16
70 - 18
60 - 20
50 - 22
40 - 24
30 - 26
20
10
0 - 29°C
- 30°C
- 31°C
- 32°C
Hm
MM
Om
Wm
Sm
Mm
Dm
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
750
500
250
0
Year BP
=1950 AD

The black curve of **FIG 8** are the calculated sunspot numbers (SN); this is the well-known curve of Solanki, S.K. , Usoskin I.G. ea [Litt 1], the same as on **FIG 5** in 'the sun and the deluge'. Now however the curve was made more specified, making use of the tables [1] . The SN were calculated by a model and this calculation exclusively is based on ^{14}C measurements and dating with tree rings. So the SN actual are negative or inverse ^{14}C quantities and as solar proxies comparable with the negative ^{10}Be concentrations. The SN of the table are the 10 year averaged sunspot numbers and in the tables distinctive years for the 10 year intervals are given at the SN values. So the resolution of the black SN curve is consequently 1 in 10 year. Some distinct events are noticed at the black curve, as the recent large solar minima: the Homeric minimum (Hm), the Oort m. (Om), the Wolf m. (Wm), the Spörer m. (Sm), the Maunder m. (Mm), the relative Dalton m. (Dm) and the medieval maximum (MM). The light red curve over the end of the black calculated SN are the real counted 10 year average SN from 1740 to 2009. This light red curve has been made independent from Solanki ea, with use of the published sunspot data [2] [Litt 2]. In this work it came true that the real counted sunspot numbers were systematically higher than the calculated SN. For the period 1750-1900 the counted SN were at average a factor 1,43 larger than the calculated SN. So I divided the counted SN by 1,43 for better comparison. So the impression rose that the large solar maximum of 1957 indeed was large in the Holocene but not extreme.

The **red brown curve** at the top of **FIG 8** part 1 and 2 is the -^{10}Be concentration; the same data as on **FIG 7** now are given more specified over this period. The tables of R.C. Finkel ea [Litt 3] give the averaged ^{10}Be concentrations from 40000 year to 3300 year BP, with a gap between 9400 and 8000 BP. The intervals of which the ^{10}Be concentrations are determined is somewhat variable and increases from 20 year at 3300 Bp to sometimes 60 year at the begin of the Holocene and back to 40000 BP are some intervals of nearly 200 year. In the table the intervals are given and in the curve here I noted the values in the median years of the intervals. So the resolution of the red curves of **FIG 8** part 1 and 2 is about 20 to 60 year.

The **fine dotted** line under in **FIG 8** part 1 and 2 are the temperature measurements following the table of P.B Alley [Litt 4]. The values of each of the distinctive years as given in the table here are noted with a dot. The **thick dots** at the top of **FIG 8** part 1 and 2 however are the -10Be values from Taylor Dome, Western Ross, Antarctica (77^{o} South; 158^{o} East). The tables are from E.J. Steig ea [3] [Litt 5]

As R.C. Finkel ea already pointed out the correlation between this ^{10}Be determinations and the^{14}C of M. Stuiver [4] [Litt 6] in 1993 is very good, certainly if you take account of some aspects. They found a constant lag in that the ^{14}C followed the

[1] Solanki et al 11000 year sunspot number reconstruction. IGBP Pages/world data center for paleoclamitology. Noaa/NGDC paleoclimatogogy program Boulder Co, USA. Data contribution series 2005-015, see ftp://ftp.ncdc.noaa.gov/pub/data/paleo/climate_forcing/solar_variability/solanki2004-ssn.txt . and Solanki S.K ea Nature October 2004 Vol 431, pp 1084-1087.

[2] See www.ngdc.noaa.gov/stp/SOLAR/ftpsunspotnumber.html and www.sflorg.com/spaceweather/sunspot.html

[3] Steig, EJ ea in Geografiska Annaler and in Science of 1998, 282: 92-95: Synchronous Climate changes in Antarctica and the North Atlantic, see www.sciencemag.org/cgi/content/abstract/282/5386/92 and for the table see: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/taylor/betd.txt

[4] M. Stuiver ea in Radiocarbon 35, 215-230, 1993.

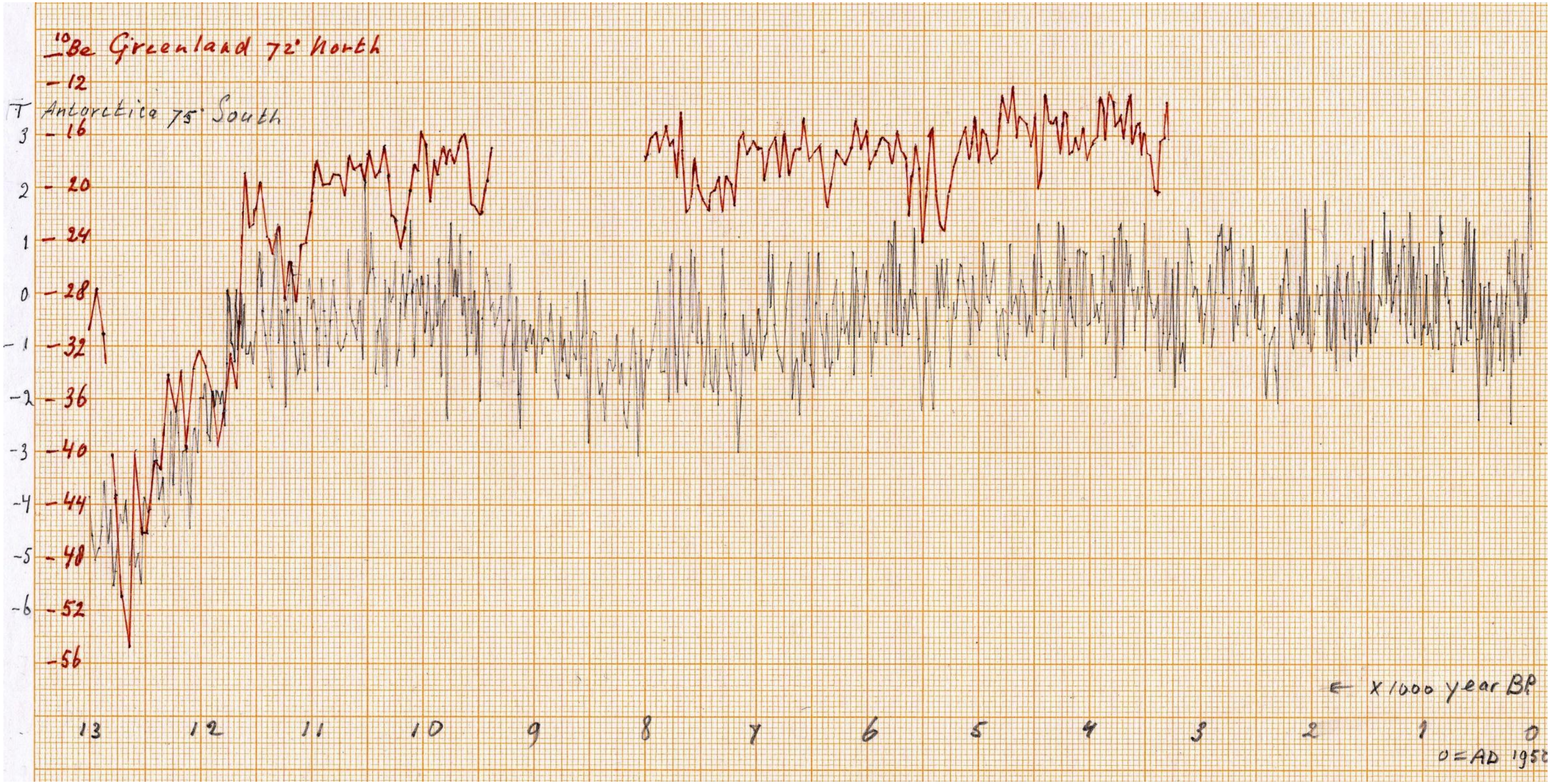
^{10}Be after 100 year mainly, in the total period of their research of 40ky, as is described here in 'The dominant Sun in the Pleistocene climate system'. In this comparison of only the Holocene in **FIG 8a and b** also the ^{14}C reacts later. In these curves the lag however is not constant and is often about 50 year. The time resolution in the Holocene data of R.C. Finkel, however is much larger than in the Pleistocene data. Besides problems in the absolute calibration of the dating, which must be very difficult in such a scale, this also can have a physical cause: The residence time of the ^{10}Be in the atmosphere is 1 to 2 year. The ^{14}C remains of course much longer in the atmosphere and the carbon cycle. The highs and lows of the red curve mostly are to be seen in about the same formation with the lag in the black curve. Some excursions of the black line are however not present in the red one, but mostly than is to guess that they now are skipped by the minor resolution. Further are sometimes substantial differences in the amplitudes. Also this can be attributed to the difference in resolution, but non solar factors on the ^{10}Be concentrations may be important here as well. So the conclusion is that a common cause here is very probable for the resembling variations in the -^{14}C and the -^{10}Be and this indicates the Sun, because the other common causes, the Earth's magnetic field and the primary sources of the cosmic radiation do not make excursions like this, whereas variations in the atmosphere will definitely not change ^{14}C quantities in this way.

So the general **conclusion** from these curves and some other on this site is a good correlation between the various solar proxies from different sources and more studies on this site about the course of other solar proxies confirms this. The connection between the temperature in Greenland and the solar proxies is obvious for the major fluctuations and is here in the Holocene less than in the Pleistocene with its huge fluctuations in temperature and solar proxies. Also are indications that in areas with a moderate climate, as the research of B. van Geel[5] describes, the climate fluctuations are larger than in the extreme cold climate of Greenland. This literature also indicates the importance for people the climate fluctuations during the Homeric minimum had. This emphasizes the importance of the sun – climate connections in these ice core data.

Northern solar proxy and southern temperature.
In Fig 18 is drawn again the red curve of the 10Be concentration in the GISP2 ice core (Greenland) following the tables of R. Finkel [Litt] now with the fine black temperature curve of the EPICA Dome C ice core on 75^{o} South in Eastern Antarctic. The table with the data has been published on the NOAA site and the research is described by J. Jouzel ea in the Science of july 2007 [Litt]. The temperature interpretation of the research is on the base of the δD. The zero point is the average value in the last 1000 year. The obvious covariations in the curves are more than by chance, so indicating statistical correlation. This correlation is strong in the period of the large temperature increase at the transit to the Holocene era. Also the larger fluctuations in the variation of both data are well related despite the differences in time resolution. This connection cannot be biased by the influence of atmospheric variations on the ^{10}Be concentrations, because atmospheric variations as in precipitation that may change the 10Be deposition in Greenland cannot influence the temperature in Antarctica. So this very likely indicates solar variation as the common cause of the change in the Northern ^{10}Be concentrations and the Southern temperatures.

[5] van Geel, B. http://cio.eldoc.ub.rug.nl/FILES/root/2004/JArchaeolScivGeel/2004JArchaeolScivGeel.pdf and http://lasp.colorado.edu/sorce/news/2005ScienceMeeting/presentations/fri_am/vanGeel.pdf

FIG 18



Literature:

1 Solanki, SK et al. Unusual activity of the Sun during recent decades compared to the previous 11,000 years. *Nature*, Vol. 431, No. 7012, pp. 1084 - 1087, 28 October 2004.
http://mirage.mps.mpg.de/projects/solar-mhd/pubs/solanki/Solanki_et_all_2004_nature.pdf

2 Site van NOAA met gegevens over zonnevlekken: ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS en de Site van SIDC Brussel met gegevens over zonnevlekken: http://sidc.be/sunspot-data

3 Finkel, R.C. and K. Nishiizumi, 1997, Beryllium 10 concentrations in the Greenland Ice Sheet Project 2, ice core from 3-40 ka. Journal of geophysical research 102: 26699 – 26706, ice core tables: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/cosmoiso/ber10.txt

4 Alley, RB: The younger dryas cold interval as viewed from Central Greenland, Quaternary Science Reviews, 2000, 19: 213 – 266

5 Steig, EJ ea in Geografiska Annaler and in Science of 1998, 282: 92-95: Synchronous Climate changes in Antarctica and the North Atlantic, see www.sciencemag.org/cgi/content/abstract/282/5386/92 and for the table see: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/taylor/betd.txt

6 Stuiver, M. ea in Radiocarbon 35, 215-230, 1993

7 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.

8 Uchida, T: American Geophysical Union, Fall meeting 2007. See: http://adsabs.harvard.edu/abs/2007AGUFMPP33A1006U

9 Geel van, B: Climate change and the expansion of the scytian cultere after 850 BC, Journal of archeological science 31, 2004. http://cio.eldoc.ub.rug.nl/FILES/root/2004/JArchaeolScivGeel/2004JArchaeolScivGeel.pdf and a presentation http://lasp.colorado.edu/sorce/news/2005ScienceMeeting/presentations/fri_am/vanGeel.pdf

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