The timeliness of the Pleistocene climate and sun paces

In the Pleistocene was a remarkable phenomenon in the very large variations in climate data and solar proxies, namely a pace of 1470 years in the temperature rises and the maxima of the sun. This pace is a cycle that not always 'get through' but it is constantly present. So the time between overhaul, are multiples of 1470 years, with only minor deviations. One could accurately capture these Pleistocene paces. In the Holocene, after 11,400 years BP, this however is more difficult. Yet some paces also are here to be traced, especially the last two. It is remarkable that in our present era, the Holocene, they indicate no maxima, but state minima. Importantly, now comes a new pace. The year 2060 falls in the Holocene in the range of a few cold climate paces, preceded by decreasing solar activity.

I come to these conclusions after studying some of the work of the climatologists G. Bond, S. Rahmstorf, H. Braun et al. They found in research of the climate parameters the existence of 1470 year paces in the occurrence of warm periods during the last Ice Age, the interstadials, or the Dansgaard - Oeschger events. We are talking here about warm intervals in the ice ages with rises in temperature to 15 degrees which lasted one to several millennia. At this the temperature increased in 1 to 2 centuries to a maximum which was only a little cooler than at present in the Holocene. After some centuries the temperature went down to the normal glacial level, but sometimes to a temporally even colder climate. The decreases in temperature were slower and more irregular than the increases. All this is according to measurements with water isotopes from the ice of Greenland. Also is evidence of these sharp temperature fluctuations in many other areas from research on ia organic matter. These fluctuations were probably all over the planet, but they are only well measurable with the isotopes from the ice cores, so in the polar areas. The synchronicity of the events with ever enormous fast climate change all over the world however is debated, because of insecurities in the measurements and mainly in comparing the dating of the research matter from very remote areas. Due to the large temperature differences in a short time (up to 10 degrees per century as measured at the Greenland ice cores), these paces are to post exactly in time, specified by the short periods of fast temperature increase. All the interstadials follow the paces of multiples from 1470 year, usually with only minor deviations, but far from all paces led indeed to an interstadial. This makes the existence of this rhythm in the Pleistocene climate anyway highly statistically significant, as **S. Rahmstorf** pointed out. Later **H. Braun** linked between these climatic cycles and the sun. The sun indeed is the only source of energy for the climate systems on earth, but science has little knowledge about the causes of the variability of the sun. Also is unknown the measure of this solar variability over many millennia. Further exists only limited insight in physical devices by which the various forms of solar activity may change the climate. So many uncertainties stand in the light for conclusive judgments. Nevertheless observation of covariation of sun and climate factors makes causal connections probable, because of the dominant presence of the sun in the climate and energy systems on earth. So **H. Braun** indicated the periodicity in solar variability as a cause for the averaged 1470 year paces. Although the 1470 year period is by itself not a solar cycle, it may arise in the course of solar variation as an interference of two well-known solar cycles, the Gleissberg and deVries cycles; 1470 indeed is 17 x 86.5 and 7 x 210, which are about the average periods of these cycles. So the theory is that the Gleissberg and the de Vries cycles reinforce each other often, but not always, after 1470 year, the paces. Not always, because the actual length of these solar cycles is very variable the reinforcement after 1470 year often is missed. Also is the actual length of the 1470 pace somewhat variable, but this variability is less than that of the basic solar cycles. This relationship of the sun with these periods of huge climate heating in the Pleistocene is my view strongly supported by the research of **RC Finkel**. He gives some more direct information about solar variation by his research at the 10Be concentrations in the GISP2 (Greenland) ice cores over the period 40 000 - 3000 years BP. Also in the 10Be are much larger variations in the Pleistocene than in the Holocene and they are closely correlated with the large temperature differences of the interstadials and thus with the paces (**Figure 1**). This research indicates therefore 10Be paces of 1470 years directly in solar activity. In the Holocene, the variations in temperature and solar proxies are much smaller and also is the relationship between the sun and temperature variation in the Holocene smaller. During the Holocene, the solar fluctuations are not at random Poisson distributed in the time and they are clustered, but there is no apparent periodicity in the occurrence of maxima and minima in the sun and climate variations. Although iit is possible that It remains possible that the fairly irregular extremes in the Holocene occur based on interference of various cycles and the paces in fact also continue in the Holocene, they are not statistically evident herein the curves of the temperatures and the solar proxies. Few research reports so of ca 1500 year paces or cycles in the Holocene. **G. Bond** did so, but his work is critical, (**J. Bütikofer**). G. Bond researched material from two bore holes in the bottom of the North Atlantic. On the basis of organic material, he could estimate the temperature of the sea water and some sand grains gave him information about the extending of the sea ice in the past. Here he found there was a cycle in the minimum temperatures and this was continued from the Pleistocene into the Holocene. The period length is 1470 years, on average, however with deviations up to 530 years! Later described **S. Rahmstorf** for a period of 40ky (40,000 years) in the Pleistocene the paces in short, rapid heatings, so other events and at other time points than the paces at the minima of **G. Bond**. In the Pleistocene the cooling periods lasted longer and were more irregular, so that in that era no (Bond) paces at the minima are to be detected, except perhaps with very large deviations. In the Holocene, there are no rapid heatings, so that in this era the Rahmstorf paces are in fact not present.

These paces of S. Rahmstorf now, in my opinion, are very important for insights into the variability of the sun and its impact on the climate. It is likely that the rapid heatings in the Pleistocene are triggered by the sun, or they may be even directly caused by the sun if there were in these era's of the interstadials much larger variations in the EM radiation of the sun than we can measure now in our era. All these climatologists are thinking of triggering at which is a strong positive feedback to the influence of increasing solar activity on the climate. Because it is generally accepted that solar irradiation is (nearly) constant throughout millions of years, however without any evidence, few or none scientist thinks the sun should have had an important energetic influence to the fast climate changes in the more remote past. Nevertheless solar influence is generally accepted and to this the theory of H. Braun is plausible that the period of 1470 years is based on the interference of more or less sinus like Gleissberg and de Vries cycles. If this hypothesis is correct, it gives a new insight into the average length of these cycles, which than is 86.45 years and 210 years and it makes possible to place the cycles on the timeline. Finally, the consistency of the paces with very large fluctuations in the 10Be concentration suggests the sun driving of the interstadials with possibly larger variation in the activity of the sun in the Pleistocene, then we know of our era the Holocene. It is anyway a reason for more research to solar variability over longer periods in the remote past, because this 10Be examination may suggest something but it does not provide evidence. Indeed, together with the magnetic activity of the sun are several other factors that influence the 10Be concentrations. Therefore the signal of the sun by this 10Be proxy information must be traced properly by comparing some more studies with the same high temporal resolution and from different locations like Greenland and Antarctica. That is not done for the Pleistocene. Also comparing with Δ14C data is useful, but this is not possible in a very large time frame, because of the short half-life of 14C. Now, as far as I could ascertain, only one other 10Be study from the Pleistocene with such time resolution exists: that of the GRIP ice core, also in Greenland. This is the work of the French - Swiss group with group **F. Yiou** et al. In this study also are large fluctuations in the 10Be concentration, which however show much less consistency with the temperature fluctuations of the interstadials. This research has major problems, however, as the authors themselves point out. There are various filters used at the isolation of the 10Be and they give very different results. These filters were not used uniformly in time: variations in the 10Be here is based in part on differences in the determinations! Nevertheless, in the article of **R. Muscheler** ea. the relationship between 10Be solar proxy and the interstadials is described as not persistent and unproven, solely on the basis of data from the GRIP ice core, the research of their group, without any reference or comparison to the GISP2 ice core 10Be research by the other group. So by little research that still exhibits gaps, the uncertainties about the interpretation of the 10Be data is strengthened and protects the good the old science for dramatic conclusions about the variability of the sun and solar climate driving in the Pleistocene. An important issue here further is whether the 10Be concentration, or the10Be fluxus is a better indication of the 10Be production in the atmosphere. It amazes me so that no more research is done because of the overriding importance that we have in understanding the causes of climate change.

The question seems justified: are these Pleistocene climate and sun paces of 1470 years, as described by **Rahmstorf S** and **H. Braun**, also of importance for the Holocene and so current for our time and future? When studying the evolution of the-Δ14C solar proxy, the investigation of SK Solanki, and the 10Be-sun proxy according to **Finkel**, the course of several temperature data it is easily noticeable that in the Holocene many small fluctuations exist with many minima in solar activity and in the temperatures(**Figure 2a and 2b**). This shows immediately that many grand minima and grand maxima in the Holocene are placed outside of the Pleistocene paces, so that in the Holocene the paces cannot be verified statistically. Since the 1470 year paces are identifiable in the Pleistocene, so over a very much longer period than the Holocene, there is still a good reason for assuming any continuation of it into the Holocene and for attempting to visualize them. The problem than however is that this continuation of the Pleistocene cadence in the Holocene at comparing with the variations in the solar proxies, the impression arises that the paces exhibit no longer solar maxima in the Holocene, but now state minima. So there must have been a phase inversion in the solar cycles! That is remarkable and raises questions. The right direction of the phases is more obvious when the Gleissberg and de Vries cycles are placed between the paces. The right position of these cycles on the timeline is just posted by the coincident maxima and minima every 1470 years (**Figure 3**). Assuming this phase reversal, the last maximum pace was 11,650 years BP. This was coupled with the last rapid warming. Since then, the climate remained warm with relative small fluctuations. According to the -10Be data of Finkel the same holds for the sun. After 1470 years, so 10180 BP there was a grand minimum, with a deviation of about 100 year on the pace. Further the paces in the Holocene are difficult or impossible noticeable, until 2830 BP than again a grand minimum emerges at the pace with a deviation of about 20 year. This grand solar minimum is called the Homeric minimum and had major consequences for the climate, such as is described by **B van Geel**. His research with soil material and that of many others also shows that the temperature and other climate fluctuations during the Holocene were larger in areas with temperate and subtropical climate than in the extreme cold climate of Greenland, which is drawn here in the curve (**Figure 2a and 2b**) at the solar proxies. Also in 1360 BP, or AD 590 (1950 = 0 Before Present) is a solar minimum coupled with temperature decrease with a small deviation in the pace, as ie **G. Bond** points out. Also acts a little earlier, 536 AD a sudden violent cold, which, however, is attributed to other causes, source **Wikipedia** 16. Furthermore, according to the study of **G. Bond** in the North Atlantic temperatures also evidence exists for temperature minimums earlier in the Rahmstorf Paces at 4300 years BP and 5900 years BP, at which however in the solar proxies are no obvious grand minima. One gets the impression that late in the Holocene the paces from the Pleistocene again become more important but indicate now grand minima, because of the phase inversion. The next climate pace is in 2060 AD, probably with a deviation and preceded by decreasing activity of the Sun. That is, given the developments in the last few millennia, a clue to an upcoming grand minimum, perhaps deeper than the Maunder minimum, which was the last grand minimum of the sun until now.

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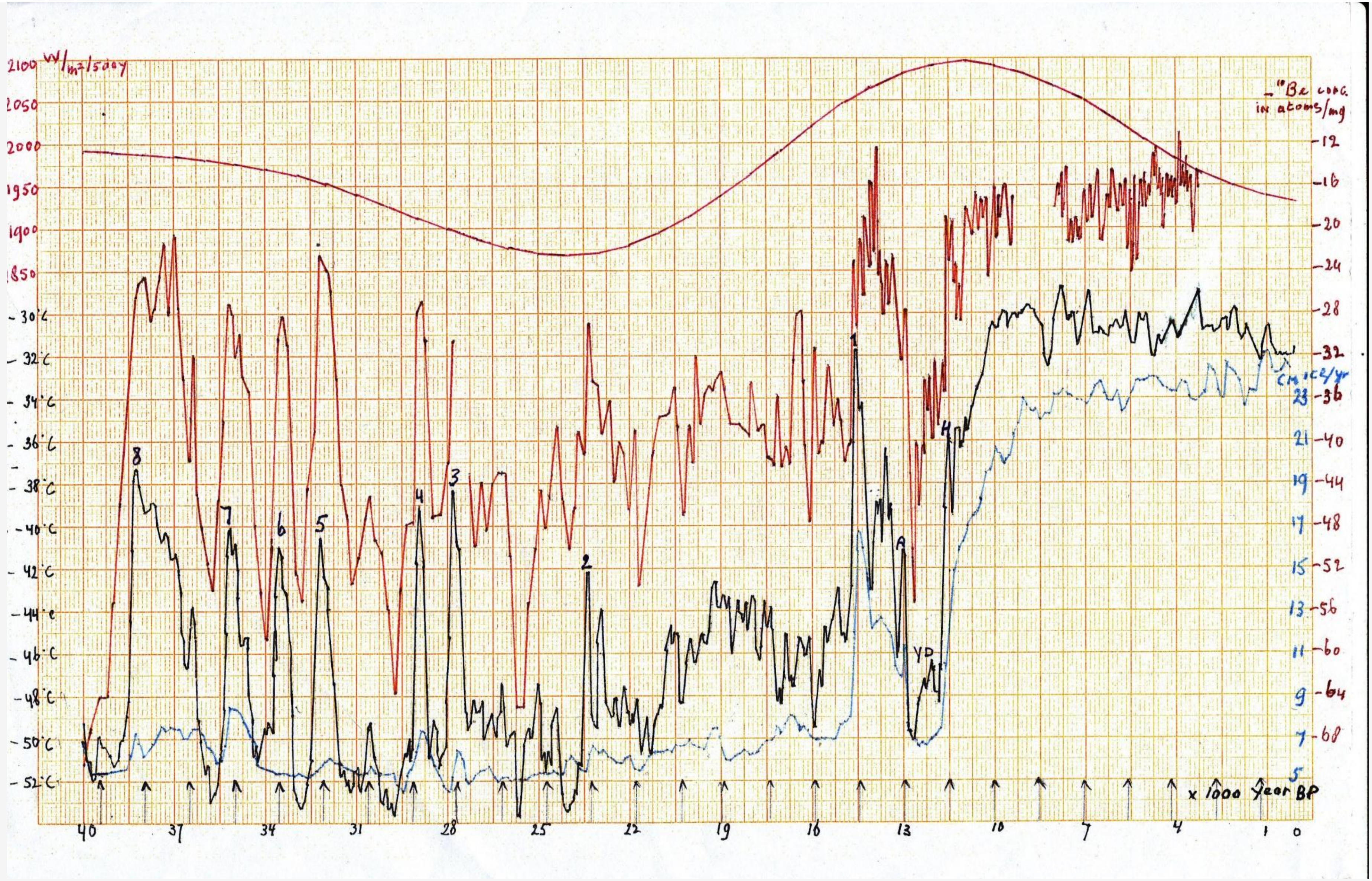

Figure 1: The black curve represents the temperature following the water isotopes in the GISP2 ice core from the research of RB Alley. The blue curve is the accumulation of ice in that same research. The brown-red curve shows the -10Be concentration in the study of RC Finkel. The arrows at the bottom are on the paces of S. Rahmstorf. The purple top curve shows the variation in summer insolation at 70° N by the Earth's orbit, according to the study of A. Berger.

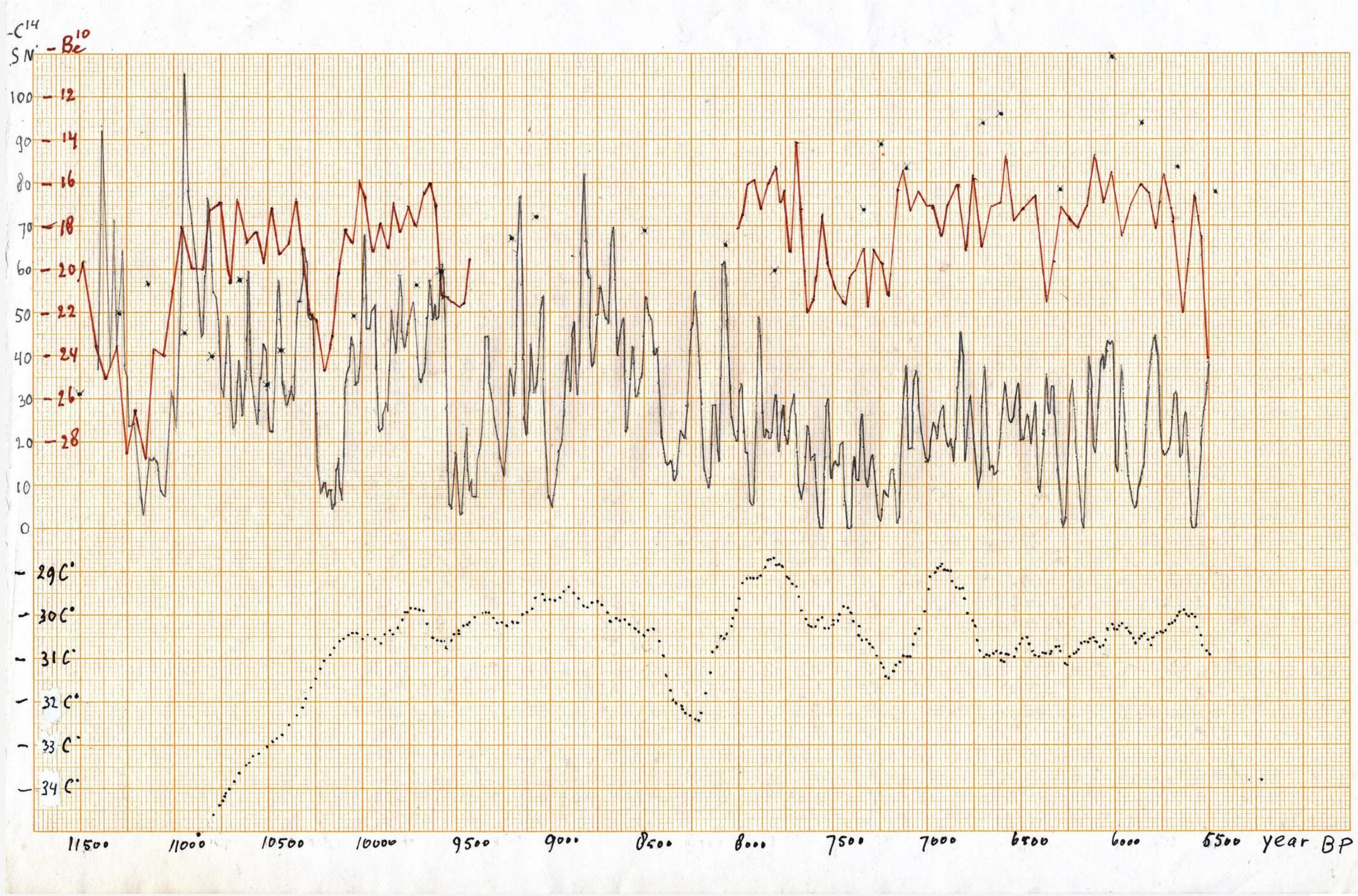

Figure 2a: The arrows are on top are the Paces of S. Rahmstorf, but here as minima. The brown-red curve shows the 10Be concentration in the study of RC Finkel. The black curve shows the-Δ14C, or the reconstruction of the sunspot numbers from the study of SK Solanki. The dotted line shows the temperature according to RB Alley.

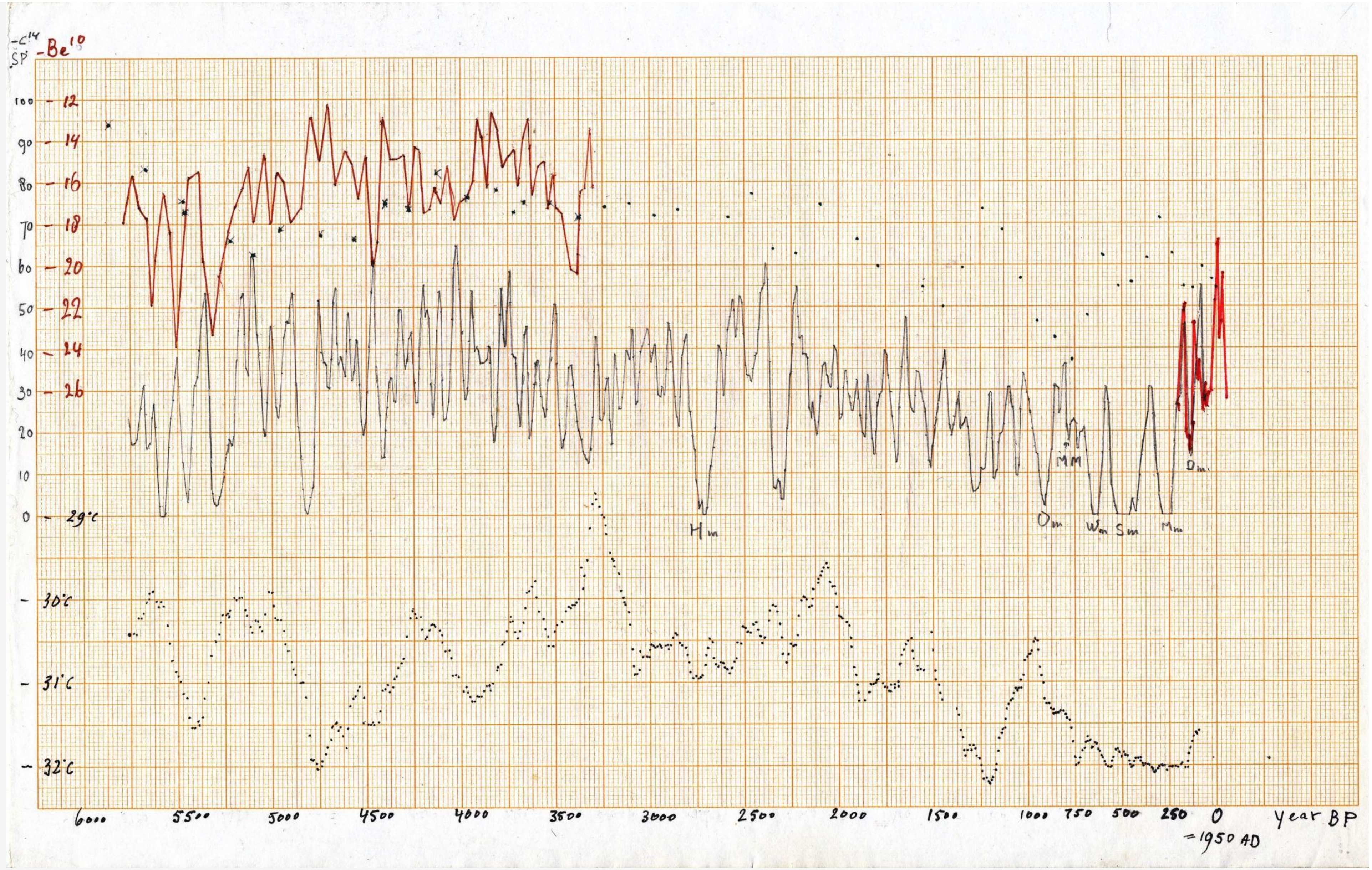

Figure 2b: Refer to Figure 2a. Furthermore, the minima indicated under the curve of the -Δ14C from Solanki: Homeric minimum, Oort minimum, Wolf minimum, Spörer minimum, Maunder minimum, Dalton minimum and medieval maximum. The red curve shows the actual counted sunspots.

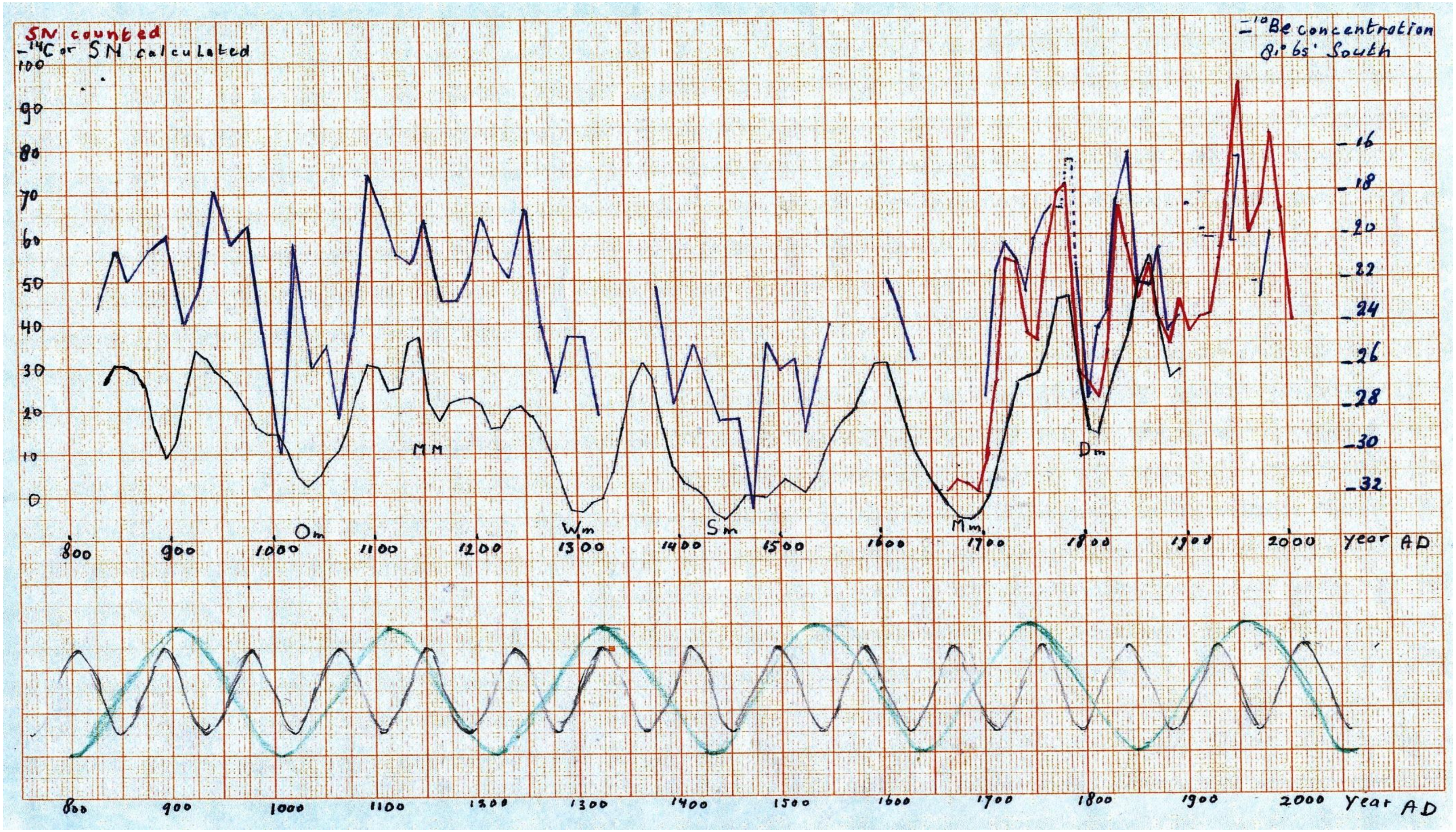

Figure 3: The black curve shows the-Δ14C, or the reconstruction of the sunspot numbers from the study of SK Solanki. The red curve shows the actual counted number of sunspots. At the top is a curve of the -10Be-concentrations from the Siple Dome ice core (Antarctica). The sinusoids at the bottom represent the deVries and Gleissberg cycles, placed on the timeline according to the paces of S. Rahmstorf and the theory of the interference of H. Braun. The phases are reversed relative to the Pleistocene paces, so that at the pace of 2060 the minima of the cycles coincide. There is one point in 1325 where the maxima in the cycles coincide. Note that the -Δ14C values indicate the magnetic solar fluctuation with a delay of about 50 year because of the long residence time of CO2 in the atmosphere and the carbon cycle.

A general solar cycle?

If indeed the Gleissberg and deVries cycle reinforce each other often during the common limit this indicates that these cycles are a physical phenomenon with a substantial clock. Although there is much variation in the length of individual cycles, there is than a constant average, and thus a constant number of cycles over longer periods. Furthermore are exact average period lengths in the Gleissberg and deVries cycle to be determined, if the theory of H. Braun of the interference is really. Based on these of 86.47 and 210 years for the length of the Gleissberg and deVries cycles following the interference, the rather accurate length of the Schwabe and Hale cycles, I have tried with some simple math to link the various well-known cycles. Surprisingly quickly, I found that link, at least in a formula that describes the algebraic relationship between 4 known solar cycles. This correlation may be coincidental, but it is possible indeed a general formula describing or approaching the general sun cycle . This formula is **$\ln \mu_n = c.(1,2)^n$,** so that **$\mu_n = e^{c(1,2)^n}$,** where **$c = \ln 22,13$.** Among them the period length is μ_n. So, if n=0, ln $\mu_0 = c(1,2)^0 = c$, so that μ_0= 22,13, the Hale cycle. Als n=2, than ln $\mu_2 = c(1,2)^2$, so that μ_2= 86,45 the Gleissberg cycle. Als n=3, than ln $\mu_3 = c(1,2)^3$, so that μ_3= 210,92 the deVries cycle. Als n=5, than is ln $\mu_5 = c(1,2)^5$, zodat μ_5=2222,0 the Halstatt cycle. The constant c is therefore the natural logarithm of the period length of the Hale cycle. According to current physical insights, the Hale cycle is considered fundamental for all the periodic changes. **Thus we see that the logarithm (with base e =2,718…) of the length of the solar periods increases with a constant factor, as it is described in years**. Here 2 cycles that are lacking in the well-know solar cycles. If n = 1, then ln μ_1 = c (1,2), so that μ_1 = 41.11 and when n = 4, ln $\mu_4 = c\,(1,2)^4$, so μ_4 = 615.11. These 'lacking' cycles are possibly still present and detectable in research on solar and climate variability. Especially for the cycle of about 615 years, I found some evidence in the investigation to the variation in the solar proxies at the Figures 2a and 2b. If these 'lacking' periods indeed are demonstrably true, that would be a confirmation for the theory of this formula. The problem of this formula however is that in this form (and logarithmic base) only is valid when the time is expressed in years of the earth and the orbit of our little planet cannot be important for the activity of the Sun. Therefore it appears that this formula cannot say anything about the physical processes in the changes of solar activity. One can make another formula more general valid for the length of the cycles as a function of the time, but this formula will become much more complicated and thus provides little insight. The main thing however is that these numbers as exponential relationships are generally valid, even if they do not express a unit of time. Moreover, the constant c is particular, c = ln22, 13 = 3.0969.. ≈ π = 3.1416.. The constant c, derived from the length of the Hale cycle period in years so happens to have a value that is close to π, where c = π x 0.985784758... Similarly, we can write $\mu_n = e^{\pi (1.2) ^ n}$, or more precisely $\mu_n = e^{0.986.. \pi (1.2) ^ n}$. This last formula is the 'relationship', or rather the exponential relation between the cycle lengths of the sun, regardless of the measure of time, expressed as a function of the known constants π and e. With $\mu_n = e^{\pi(1.2) ^ n}$ the ratios of these period lengths are approached fairly decent with this exponential numbers row of π. But in the ratio range of **$\mu_n = e^{\pi (1.2) ^ n}$** the basal value $\mu_0 = e^{\pi}$ = 23.14 is too large. However also the physical Schwabe and Hale cycles are longer than the length of the periods measured the time between the SN maxima indicates. During the solar minima the new cycle begins with its new sun spots at high latitudes when the old cycle is still active with some sun spots near the equator. So there is an overlap of the physical cycles of the basic Schwabe - Hale cycle and perhaps that also occurs in the other cycles. The agreement between the exponential series of π and the observed sun periods may be primarily spatial, physically related to the spreading of the magnetic activity within the spherical solar body and secondarily temporal as a the cycles of the sunspots, that are observed on the solar surface. The relation by the formula **$\ln \mu_n = c.(1,2)^n$** may be coincidental, but it can also be based on a physical basis. It seems anyway useful to analyze this further. Moreover the exponential nature of the changes in the magnetic activity of the Sun is indicated by the evolution of the normal Sunspot Number curves. The increases in the SN's are ever faster than their decreases. Because of this the curves of the Schwabe cycles have an asymmetrical aspect, but it also is present in the longer term variation at the other cycles. This points to increases and decreases with a (more or less) constant factor, so exponentially, or with a constant factor in the exponent, so exponetial-exponentially.